Appendix I
WEST Consultants Recontamination Model

Technical Memorandum
Mass Balance Model

Duwamish/Diagonal Sediment Remediation Project

Prepared for:

Elliot Bay/Duwamish
Restoration Program Panel

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1 Introduction

1.1 Purpose

It is well known that sediment "footprints" exist adjacent to a number of discharges to the Duwamish River. Examples include the Norfolk (prior to mediation) and Duwamish/Diagonal (D/D) sites. These "footprints" exhibit elevated sediment concentrations of a number of contaminants including mercury, PCBs, PAHs, and phthalates.

There have been a number of studies that have attempted to define the formation of the observed sediment "footprint" through modeling the physical and chemical processes involved at the discharge locations. Examples include the application of a comprehensive, three-dimensional hydrodynamic, sediment, and transport and fate model to the Duwamish River and Elliott Bay, the application of mixing models, like the EPA model CORMIX3, at the Norfolk site, and applications of the sediment recontamination model, METSED, at both the Norfolk and D/D sites.

These models have yielded useful results in terms of larger-scale processes or defining some of the characteristics of the sediment distribution. However, none of them have defined, even roughly, the distributions of chemicals observed in the "footprints". The reason is that none of the models are able to resolve, either temporally or spatially, the detailed processes in the near field adjacent to the discharges. In this region, a discharge may flow across an intertidal mud flat, or to either the upper or lower water column. These are regions of complex velocities distributions, influenced by salinity gradients and near-bank and near-bottom profiles. It would require a very fine-detailed model and a large computer to adequately describe all of the important, complex processes.

So the problem becomes, "is there another way to determine the relationship between the discharges and the distributions observed in the sediment footprints"? The purpose of this study is to investigate the relationship between chemicals being discharged from the Combined Sewer Outflow (CSO) and Storm Drain (SD), at the D/D site, to the amount of chemicals in the bed of the river in the vicinity of these discharges.

1.2 Approach

Instead of using sophisticated, or even simple, numerical models, we will use field observations to try to define the relationship between discharges from the storm drains (SDs) and combined sewer overflows (CSOs) and the nearby

Notwithstanding data errors or lack of information, we can estimate the average discharges from the SDs and CSOs, their sediment loads, and their constituent concentrations. We also can estimate the constituent concentrations in the adjacent "footprints", including the concentrations of constituents deposited beyond the "footprint" (background deposition).

We will evaluate defined compartment volumes of sediment at each sampling location, to estimate the contributions from background sources, SDs and CSOs. Using the assumptions:

1. that sediments from the SDs and CSOs settle in the same proportion as measured in their respective discharges,

2. that there are no chemical transformations or decay of constituents on the sediment (i.e., the contaminants are hydrophobic and inert),

3. that background deposition is uniform and known, and

4. that the "footprint" is in equilibrium with the existing discharges,

we will estimate the amount of sediment from all three sources settling into each defined departments volume. Once this is estimated for several chemicals, we will sum these deposition rates over the entire footprint, and compare the results to see if they are consistent. If there is consistency, we will next use the approach to determine loss (fate) rates for non-hydrophobic constituents, using the deposition rates calculated, and see if they are "reasonable".

Once the process has been "validated", we will estimate the constituent "footprints" following reductions in SD and CSO loads, to determine the amounts of load reduction in order to achieve sediment quality compliance.

1.3 Study Area

The study area is Duwamish River in the vicinity of the Diagonal Way Outfall. The study area is shown in Figure 1-1. The footprint is made up of the data points inside the marked area on the figure. Each station was used to define a specific compartment and surface area that was used to calculate sediment volume for the 27 stations reported in the tables in Appendix C. The compartments are Thiessen polygons around each station determined by ArcView. The background sampling points are marked as 039 and 041.

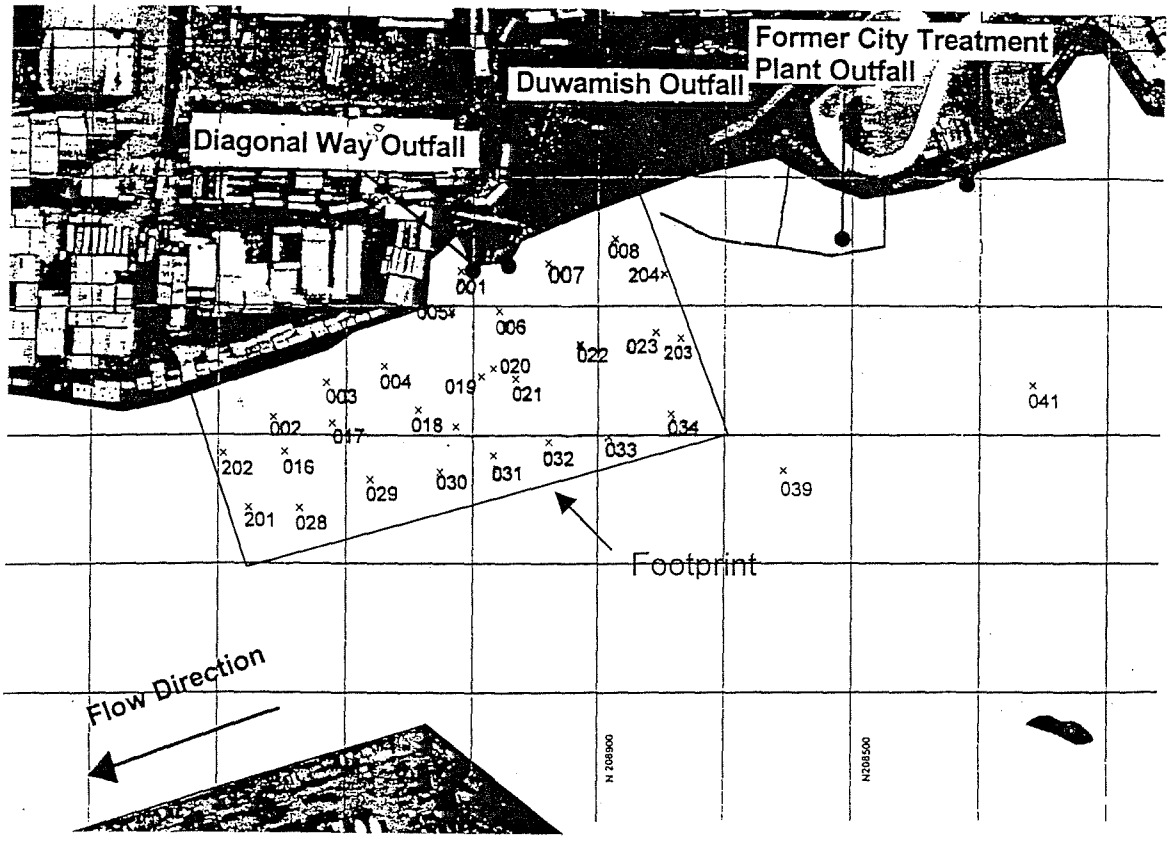


Figure 1-1: Study Area

2 Data Analysis

The object of this study is to investigate the relationship between chemicals of concern being discharged from the CSO and SD at the Diagonal/Duwamish (D/D) site to the amount of chemicals in the bed of the river in the vicinity of the outfall. To remove (or at least reduce) one level of uncertainty in the analysis, the evaluation was first performed using relatively conservative (non decaying) and hydrophobic (bound to sediment) constituents. After reviewing the available data, the following chemicals were selected: chrysene, fluoranthene, pyrene, bis(2-ethylhexyl) phthalate and butyl benzyl phthalate. Once the analysis was performed for these constituents, a single non-conservative and non-hydrophobic (partitions to the water column) chemical was chosen: 1,4-dichlorobenzene. Other constituents were eliminated for various reasons: e.g., very low sediment concentrations, no measurements available from the SD discharge, possible analytical complications, or no clear "footprint" in the sediments in the vicinity of the outfalls.

2.1 Sediment Data

During the D/D site assessment investigation (1994 – 1996), samples were collected from the top 0 – 10 cm of the sediment in the vicinity of the outfalls (Figure 1-1). Appendix A lists results from the sample analysis for the chemicals evaluated in this report. The measurements establish a footprint for each constituent in the neighborhood of the outfall location. Appendix B shows contour plots of the various chemicals included in this analysis. In all cases, the plots show that the maximum concentration is found a short distance downstream of the outfall.

Using the field measurements, the total mass of each constituent deposited over the footprint in an average year can be estimated by summing the contributions for each of defined compartment volume:

$$m = S\rho_w(1-n)\Delta d\sum_{i=1}^{N} C_i A_i \qquad (1)$$

where m is the mass of a constituent deposited in an average year, n, is the porosity of the sediment with specific gravity S, ρ_w, is the density of water, Δd, is the sediment deposition depth per year, N is the number of sampling points, A_i, is the Thiessen's polygon area representing sampling data point i and C_i, is the sampled concentration for the station at the center of the polygon. In the formula, we assume that the specific gravity, the density of the water, the porosity and the sedimentation rate are independent of location in the study area.

The calculations were performed using a time step of one year. The sediment deposited in the area of the footprint, Δd, was estimated at 3.5 cm from the results of the three-dimensional model, EFDC, used to simulate circulation and sediment transport in the Duwamish River and Elliott Bay as part of a comprehensive risk assessment of CSO discharges. Using a porosity, n, of 0.6, a specific gravity, S, of 2.5, the density of water, ρ_w, as 1000 kg/m^3 (the same values used for the three-dimensional model simulations;

Kevin Schock, King County DNR, personal communication, August 1999), the calculations for each component of the equation for each selected constituent are shown in Appendix C, and summarized in Table 2-1.

Table 2-1: Mass of constituents in the footprint area

	Total Area A m^2	Mean Conc. C_{mean} µg/kg - D.W.	Sed. Rate Δd m/year	Sed. Vol. V_T m^3/year	Mean Dens. m / V_T g/m^3	Mass m g/year
Hydrophobic						
Chrysene	25,486	703	0.035	892	0.70	611
Fluoranthene	25,486	1,137	0.035	892	1.14	969
Pyrene	25,486	1,034	0.035	892	1.03	884
Bis(2-ethylhexyl) phthalate	25,486	4,210	0.035	892	4.21	3,752
Butyl Benzyl phthalate	25,486	246	0.035	892	0.25	223
Non-Hydrophobic						
1,4-Dichlorobenzene	25,486	10	0.035	892	0.010	8

2.2 CSO and SD Data

CSO and SD data were obtained from from the King County Department of Natural Resources (KCDNR) (personal communications, Kevin Schock, August 1999) and from Table 3-1 of the report describing sediment recontamination modeling at the D/D site (Schock and Shuman, 1996). The annual average SD outflow was estimated to be about $4.7 \cdot 10^6$ m^3 (1,230 million gallons) based on Runoff Model simulation of 1978 to 1986 and 1994 to 1996 water years. The concentrations for the measured constituents in the SD outflow are shown in Table 2-2.

CSO flows were also obtained from KCDNR (Swarner, personal communication, September 1999). The outflow is the latest estimate from the basin modeling done by King County. The annual flow volume was calculated to be approximately 121,000 m^3/year (32 million gallons). The Hanford CSO data was used to describe the chemical inputs for the CSO located at the Duwamish/Diagonal outfall. The concentrations for the measured constituents in the CSO outflow are shown in Table 2-2.

Estimates for bis(2-ethylhexyl) phthalate were also obtained from Schock and Shuman (1996) as well as from the EFDC 3-D model. Both of these will be used in the calculations in this report. Estimates for butyl benzyl phthalate were obtained from Schock and Shuman (1996) which is based on a total of ten stormwater samples collected from two locations in the Diagonal stormwater drainage basin.

Table 2-2: Measured CSO and SD concentrations

Constituent	CSO Concentration µg/l	SD Concentration µg/l
Chrysene	0.18	0.06
Fluoranthene	0.255	0.43
Phenanthrene	0.346	1.44
Pyrene	0.22	3.59
1,4-Dichlorobenzene	0.404	0.15
Bis(2-ethylhexyl) phthalate[1]	4.92	2.22
Bis(2-ethylhexyl)phthalate[2]	9.45	7.15
Butyl benzyl phthalate[2]	2.2	0.59

[1]Concentrations from the EFDC 3-D model
[2]Concentrations from Schock and Shuman (1996)

The total average annual mass of a constituent discharged from the outfall is:

$$m = CQ \qquad (2)$$

where m is the mass of a constituent discharged in an average year, C, is the average concentration in the outfall and Q is the average flow rate per year. A summary of the calculations for both the CSO and the SD is presented in Table 2-3.

Table 2-3: Mass of constituents discharged from the outfall

	SD			CSO			Sum	Ratio
	Flow m^3/year	C µg/l	Mass g/year	Flow m^3/year	C µg/l	Mass g/year	Mass g/year	SD/CSO
Hydrophobic								
Chrysene	4,656,093	0.06	279	121,133	0.18	22	301	13
Fluoranthene	4,656,093	0.43	2,002	121,133	0.26	31	2,033	65
Pyrene	4,656,093	3.59	16,715	121,133	0.22	27	16,742	627
Bis(2-ethylhexyl) phthalate[1]	4,656,093	2.22	10,337	121,133	4.92	596	10,932	17
Bis(2-ethylhexyl) phthalate[2]	4,656,093	7.15	33,291	121,133	9.45	1145	34,436	29
Butyl Benzyl phthalate	4,656,093	0.59	2,747	121,133	2.20	267	3,014	10
Non-Hydrophobic								
1,4-Dichlorobenzene	4,656,093	0.15	698	121,133	0.40	49	747	14

[1]Concentrations from the EFDC 3-D model
[2]Concentrations from Schock and Shuman (1996)

2.3 Background

The total mass of each constituent deposited over the footprint due to the background sources in an average year can be estimated using a similar equation to Equation (1):

$$m = S\rho_w(1-n)\Delta d_b A C_b \qquad (3)$$

where m is the mass of a constituent deposited in an average year, n, is the porosity of the sediment with specific gravity S, ρ_w, is the density of water, Δd_b, is the sediment

deposition depth per year away from the outfall, C_b, is the background concentration and A is the total area of the footprint. In Equation (3), we assume that the specific gravity, the density of the water, the porosity and the sedimentation rate are independent of location in the study area.

The background sediment deposition rate, Δd_b, was determined from the results of the three-dimensional circulation and sediment transport model to be 2.8 cm/year (0.028 m/year) in the computational cell immediately south of the "footprint". By subtracting this background rate from the rate in the footprint (discussed in Section 2.1) of 3.5 cm/year the outfall contributes about 0.7 cm/year. The background concentrations, C_b, for each constituent was determined by averaging the observed concentrations at two points beyond the extent of the "footprint" (points 039 and 041 in Figure 1-1). An alternative estimate for the background was obtained from the EFDC 3-D model for the bis(2-ethylhexyl) phthalate. This alternative estimate for the bis(2-ethylhexyl) phthalate is approximately one-third of the "measured" background. The calculations are summarized in Table 2-4.

Table 2-4: Mass of constituents from background sources

	Concentration C_b µg/kg - D. W.	Sed. Rate Δd_b m/year	Mass m g/year
Hydrophobic			
Chrysene	622	0.028	444
Fluoranthene	612	0.028	437
Pyrene	740	0.028	528
Bis(2-ethylhexyl) phthalate	846	0.028	604
Bis(2-ethylhexyl) phthalate*	310	0.028	221
Butyl Benzyl	72	0.028	51
Non-Hydrophobic			
1,4-Dichlorobenzene	1.8	0.028	1.2

*From the EFDC 3-D water quality model

2.4 Mass balance in the footprint

The following equation describes the mass balance of constituents in the footprint:

$$m_{footpr} = m_{backgr} + f(m_{SD} + m_{CSO})F \qquad (4)$$

where f is the physical transport deposition factor for each constituent in the footprint, and F describes the loss of chemical through various fate processes, such as partitioning to water and decay.

The deposition factor, f, was first determined for the hydrophobic and conservative constituents by setting the loss rate, F, to one. Using the mass components calculated

from the previous three sections, the deposition factor, f, was found from Equation (4). The results are shown in Table 2-5.

Table 2-5: Comparison of the CSO, SD and the footprint

	CSO g/year	SD g/year	Footprint g/year	Background g/year	fF -	F -
Hydrophobic						
Chrysene	22	279	611	444	0.554	1
Fluoranthene	31	2,002	969	437	0.262	1
Pyrene	27	16,715	884	528	0.021	1
Bis(2-ethylhexyl) phthalate[1]	596	10,337	3,752	604	0.288	1
Bis(2-ethylhexyl) phthalate[2]	1145	33,291	3,752	604	0.091	1
Bis(2-ethylhexyl) phthalate[3]	596	10,337	3,752	221	0.323	1
Bis(2-ethylhexyl) phthalate[4]	1145	33,291	3,752	221	0.103	1
Butyl Benzyl phthalate	267	2,747	223	51	0.057	1
Non-Hydrophobic						
1,4-Dichlorobenzene	48.9	698	8	1.2	0.009	0.064

[1]Concentrations from the EFDC 3-D model and background concentration from the sampled data
[2]Concentrations from Schock and Shuman (1996) and background concentration from the sampled data
[3]Concentrations from the EFDC 3-D model and background concentration from EFDC 3-D model
[4]Concentrations from Schock and Shuman (1996) and background concentration from EFDC 3-D model

The results for the hydrophobic and conservative constituents ($F = 1$) show a deposition from the SD and CSO load between 55.4% and 2.1% ($fF = 0.554$ and $fF = 0.021$). The geometric mean of the remaining deposition factors for the hydrophobic constituents in Table 2-5 is 14% ($f = 0.14$, as $F = 1$).

The results can be extended to an analysis of the single non-hydrophobic constituent, 1,4-dichlorobenzene, by using Equation (4) with $f = 0.14$, and equating $fF = 0.009$. This results in an estimate for the loss rate for 1,4-dichlorobenzene of $F = 0.064$. If we consider that the loss rate, F, represents the fraction of chemical sorbed to sediment, then this can be defined in terms of a partitioning coefficient, P, by:

$$F = \frac{PC_{SS}}{1 + PC_{SS}} \qquad (5)$$

where C_{ss} is the concentration of suspended solids. Using F=0.064 and a partitioning coefficient P = 81 l/kg for 1,4-dichlorobenzene (from Schock, personal communication, August 1999), this would require a concentration of suspended solids, C_{ss}, of about 850 mg/l. This concentration of suspended solids is clearly too high (higher even than the concentration of silts and clays measured in the discharges, e.g. an estimate used in the EFDC 3-D study was 36.5 mg/l). While there is some partitioning to the water column, other factors are probably contributing, including microbial degradation, incorrect estimate of the source reduction term, f, or additional chemical loss processes, such as decay.

3 Estimates of Source Reduction

Now that we have an estimate of the physical transport deposition factor, f, and the loss deposition factor, F, for 1,4-Dichlorobenzene, we can use the data to estimate how much the discharges from the SD and CSO would need to be reduced to not exceed the Sediment Quality Standard, SQS.

The SD discharge is approximately 40 times greater than the CSO discharge (on an annual basis) but the concentrations of chemicals of concern (Table 2-2) are relatively similar. Therefore, in this load-reduction analysis, we assumed that the entire CSO discharge could be dropped from the evaluation. The analysis then focussed on the reduction required in the SD discharge.

The analysis was performed using Equation (4), but reducing the mass of chemical in the footprint, m_{footpr}, by, r, the ratio of the SQS concentration to the maximum concentration observed:

$$rm_{footpr} = m_{backgr} + (1 - R)Ffm_{SD} \qquad (6)$$

where R is the reduction in the discharge from the SD. This ensures that the maximum concentration in the footprint following source reduction equals the SQS concentration. Rearranging Equation (6) to solve for the R, the reduction in the discharge from the SD to meet the SQS:

$$R = (1 - \frac{rm_{footpr} - m_{backgr}}{fm_{SD}F}) \times 100\% \qquad (7)$$

The SQS concentrations are defined in units of "mg/kg OC", whereas the observations in the footprint are reported as "mg/kg". To convert the footprint concentrations to the same units as the SQS concentrations requires multiplying the observations by the fraction of TOC measured in the same sample. The footprint reduction factor, r, is then the ratio of the SQS concentration to the maximum observed concentration, both expressed in units of "mg/kg OC". The SD load reduction factor is then calculated using Equation (7). For the hydrophobic constituents the previously calculated geometric mean value of 0.14 is used for fF as f represents a physical transport process that should be approximately same for all the constituents (F is assumed to be one as previously discussed). The results of the analysis are summarized in Table 3-1.

Table 3-1: Reduction factor (refer to table 2-5 for other variables in Equation (7))

	SQS mg/kg OC	C_{Footpr}^{max} ug/kg	TOC %	C_{Footpr}^{max} mg/kg OC	fF -	r -	R %
Hydrophobic							
Chrysene	110	1,830	4.13%	44	0.14	2.48	-2641%
Fluoranthene	160	3,840	2.94%	131	0.14	1.23	-168%
Pyrene	1,000	3,090	4.13%	75	0.14	13.37	-382%
Bis(2-ethylhexyl) phthalate[1]	47	14,000	3.00%	467	0.14	0.10	116%
Bis(2-ethylhexyl) phthalate[2]	47	14,000	3.00%	467	0.14	0.10	105%
Bis(2-ethylhexyl) phthalate[3]	47	14,000	3.00%	467	0.14	0.10	89%
Bis(2-ethylhexyl) phthalate[4]	47	14,000	3.00%	467	0.14	0.10	97%
Butyl Benzyl phthalate	4.9	2,220	4.13%	54	0.14	0.09	108%
Non-Hydrophobic							
1,4-Dichlorobenzene	3.1	25	3.42%	0.7	0.009	4.2	-6,658

[1]Concentrations from the EFDC 3-D model and background concentration from the sampled data
[2]Concentrations from Schock and Shuman (1996) and background concentration from the sampled data
[3]Concentrations from the EFDC 3-D model and background concentration from EFDC 3-D model
[4]Concentrations from Schock and Shuman (1996) and background concentration from EFDC 3-D model

Of the five hydrophobic constituents evaluated in this mass balance model, only the phthalates require reduction of footprint concentrations (defined as values of $r<1$) to avoid exceeding the SQS. Similarly, load reduction factors, R, less than 0% indicate that the footprint does not exceed SQS for those constituents, and that the load could, at least theoretically, be increased without exceeding the SQS. Values of the load reduction factor in the range $0<R<100\%$ indicate that the SD discharge could be reduced to meet SQS criteria in the footprint (assuming complete elimination of the CSO discharge). However, values for R greater than 100%, indicate that even complete source elimination will not be sufficient to achieve compliance with SQS criteria – that the background deposition alone will cause exceedances. The results for chrysene, fluoranthene, pyrene and 1,4-dichlorobenzene show that these chemicals do not exceed the SQS. On the other hand, the load reduction factor R for butyl benzyl phthalate is greater than 100% as seen in the table. This means that although the SD would be completely shut off, the background concentration would be high enough to exceed the SQS. The same is true for the bis(2-ethylexyl) phthalate in the cases were the background estimates from the sampling data are used (the R is approximately 108%). When the lower background estimates (from the EFDC 3-D model) are used the load reduction factor becomes approximately 95% which means that the SQS could be met by turning off 95% of the SD. The two different estimates for the concentration in the SD and the CSO outfall for the bis(2-ethylexyl) phthalate does change the load reduction factor R by about 8-11% depending on the background concentration.

4 Discussion and Recommendations

There have been a number of studies that have attempted to define the formation of the observed sediment "footprint" in the vicinity of the D/D. Examples include the application of a comprehensive, three-dimensional hydrodynamic, sediment, and transport and fate model to the Duwamish River and Elliott Bay, the application of mixing models (the EPA model CORMIX3, at the Norfolk site), and applications of the sediment recontamination model (METSED, at both the Norfolk and D/D sites). Such analyses, however, are complicated by the size of the sediment "footprint" (compared to the size of a three-dimensional model computational cell, for example) and the complexity of the physical and chemical processes even at this small scale.

This study instead uses direct field observations, supplemented by analytical and numerical results, in an attempt to perform a mass balance between the chemicals observed in the "footprint" and the various sources, including background and discharges from the SD and CSO.

The analysis for hydrophobic and relatively conservative constituents estimated a source mean deposition factor, *f*, of 14%. However, the computed range was 2%-55%, which is relatively large. The deposition factors suggest that of the material discharged from the SD and CSO, only 2-55 percent of the material accumulates in the "footprint" (about 14 percent on average), while the remaining 45-98 percent (86 percent on average) is transported away from the vicinity of the discharges.

It is important to understand the assumptions made in this analysis, as they could limit the usefulness of the results:

1. The background settling rate is uncertain. Rates of 0.6-5 cm/year have been reported in the literature. While the background rate of 2.8 cm/year lies within this "observed" range, the final results would be sensitive to this value.
2. The background concentration is not a well defined estimate as is demonstrated in the analysis by using two estimates for the bis(2-ethylexyl) phthalate, which range from 310-846 ug/kg D.W.
3. The long-term averages for discharges of chemical concentrations from the SD and CSO are uncertain. In some cases, the values come from either other discharges or the average of this and other discharges. In other cases, the values are uncertain as too few measurements were taken for the Diagonal stormwater.
4. There is some uncertainty in the volume discharge from the SD and CSO. During the course of the larger investigation, these values were "refined" as more information and "better" model studies were performed. There still remains a number of complicating factors that reduce the confidence in the accuracy of the flows used because they are based on modeling estimates with limited field flow verifications.

It is clear that it is, and will remain, very difficult to simulate the complex physical and chemical processes that create the "footprint" of chemical from the various discharges to the Duwamish River. It is also clear, that there is uncertainty in the use of observations to accurately account for the relationship between discharges and the "footprint". However, we believe that this uncertainty can be reduced by improving our understanding of components of the chemical mass balance process. We recommend that following component receive attention:

1. The settling rates (both background and as a result of the discharges) in the vicinity of the D/D discharge and other discharges (perhaps Norfolk) should be directly measured.
2. The chemical constituents (including the chemicals of concern as well as other compounds representing a range of chemical properties) should be measured in the Duwamish/Diagonal SDs and CSO. The sampling and analysis procedures should be designed such that: a) the number and size of samples are sufficient to obtain representative loadings and concentrations, and b) analytical variability is not significant either due to field and/or laboratory cross-contamination, or results approaching the analytical method detection limit.
3. The chemical concentration of constituents in the "background" sediment deposition should be better defined.

5 References

Schock, K., King County Department of Natural Resources, Personal Communications, August 1999.

Schock, K. and R. Shuman, "Duwamish/Diagonal Recontamination Modeling Report", King County, Department of Natural Resources, May 1996.

Swarner, B., King County Department of Natural Resources, Personal Communications, September 1999.

Appendix A of Appendix I
List of Sediment Chemistry Results

Sample ID	DUD001		DUD002		DUD003		DUD004		DUD005		DUD006		DUD007		DUD008		DUD016	
Laboratory ID	L4288-30		L4288-1		L4288-2		L4288-3		L4288-31		L4288-5		L4288-6		L4288-7		L4288-34	
Sample Depth (cm)	0-10		0-10		0-10		0-10		0-10		0-10		0-10		0-10		0-10	
Sample Date	8/17/94		8/11/94		8/11/94		8/12/94		8/16/94		8/10/94		8/10/94		8/9/94		8/15/94	
	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.
HPAH (ug/Kg-Dry Weight)	5990		6420		11200		14300		17500		8250		2760		1470		5120	
Fluoranthene	1100		1080	G	1590	G	2580		4440	G	1850		592		307		1070	
Pyrene	996		1010	G	1730	G	2020		3090	G	1180		339		214		921	
Chrysene	692		795		1560		1430		1830		836		513		160		511	
(ug/Kg-Dry Weight)																		
1,4-Dichlorobenzene	8.44	E,G	6.46	E,G	4.9	E,G	9.51	E,G	21.5	E,G	25.4	E,G	6.08	E,G	9.3	E,G	2.3	U,E,G
Other Nonionizable Organics																		
(ug/Kg-Dry Weight)																		
Benzyl Butyl Phthalate	263	B	223		485		447		2220		23	U	66.5		44.3		123	U
Bis(2-Ethylhexyl)Phthalate	5940	B	4820		9610		11300		10400		8360		994		341		1500	B

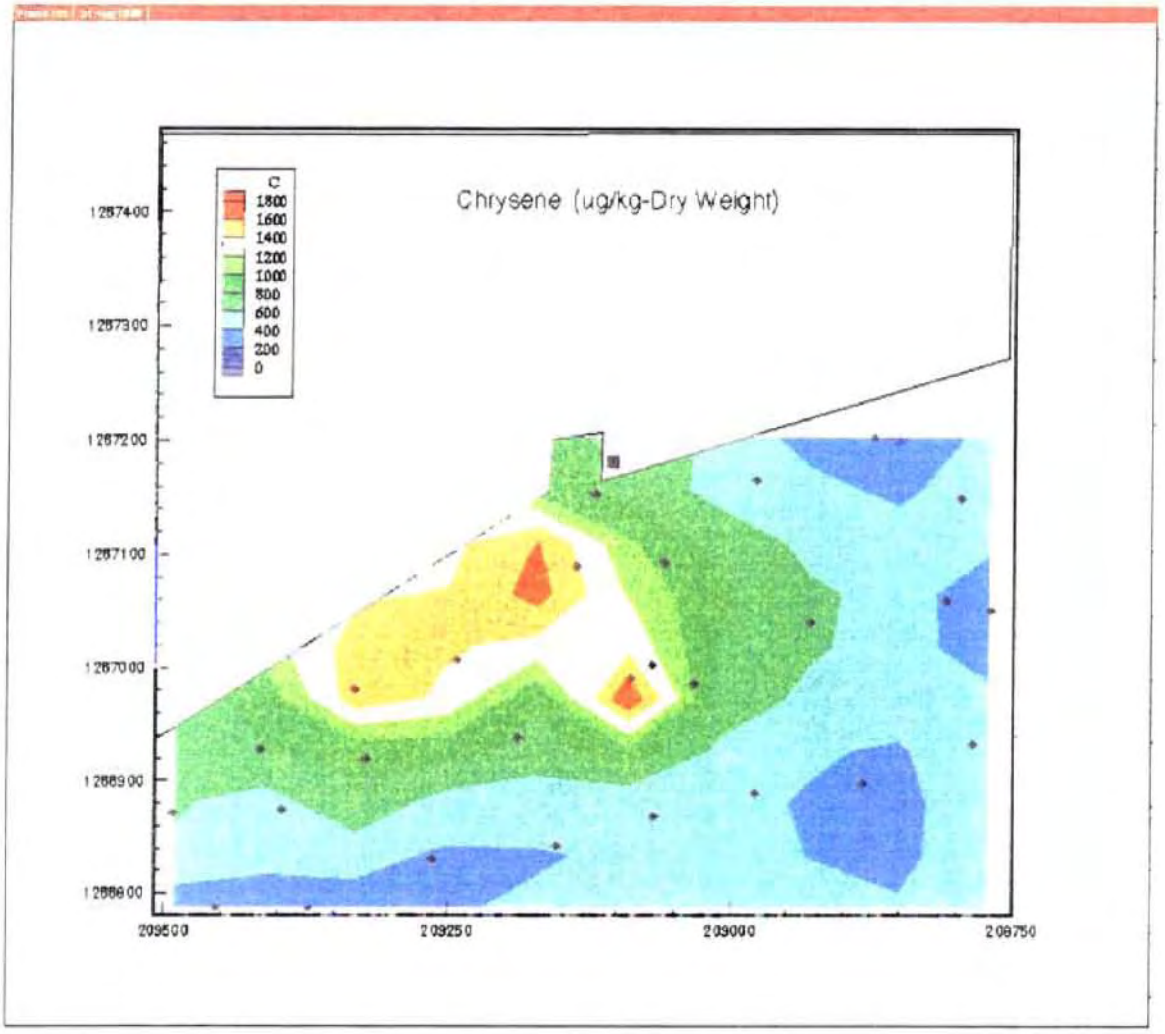
Sample ID	DUD017		DUD018		DUD019		DUD020		DUD021		DUD022		DUD023		DUD028		DUD029	
Laboratory ID	L4288-15		L4288-35		L4288-16		L4378-12		L4288-36		L4288-21		L4288-37		L4288-25		L4288-39	
Sample Depth (cm)	0-10		0-10		0-10		0-15		0-10		0-10		0-10		0-10		0-10	
Sample Date	8/12/94		8/15/94		8/9/94		8/25/94		8/15/94		8/10/94		8/16/94		8/11/94		8/15/94	
	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.
HPAH (ug/Kg-Dry Weight)	8770		6080		18100		8990		6940		6030		5150		3070		2960	
Fluoranthene	1440		851		3840		1800		1090		911		753		546	G	365	
Pyrene	1270		1060		2870		1570	G	1150		871		866		647	G	508	
Chrysene	838		718		1810		950		750		630		577		309		375	
(ug/Kg-Dry Weight)																		
1,4-Dichlorobenzene	18.3	E,G	16.7	E,G	14.4	E,G	22.2	E,G	17.9	E,G	11.4	E,G	11.7	E,G	3.7	E,G	6.16	E,G
Other Nonionizable Organics																		
(ug/Kg-Dry Weight)																		
Benzyl Butyl Phthalate	147		225	B	447		181	B	271	B	203		32	U,B	35	J	89.4	U
Bis(2-Ethylhexyl)Phthalate	4330		3990	B	5210		6170	B	14000	B	9720		2170	B	997		1060	B

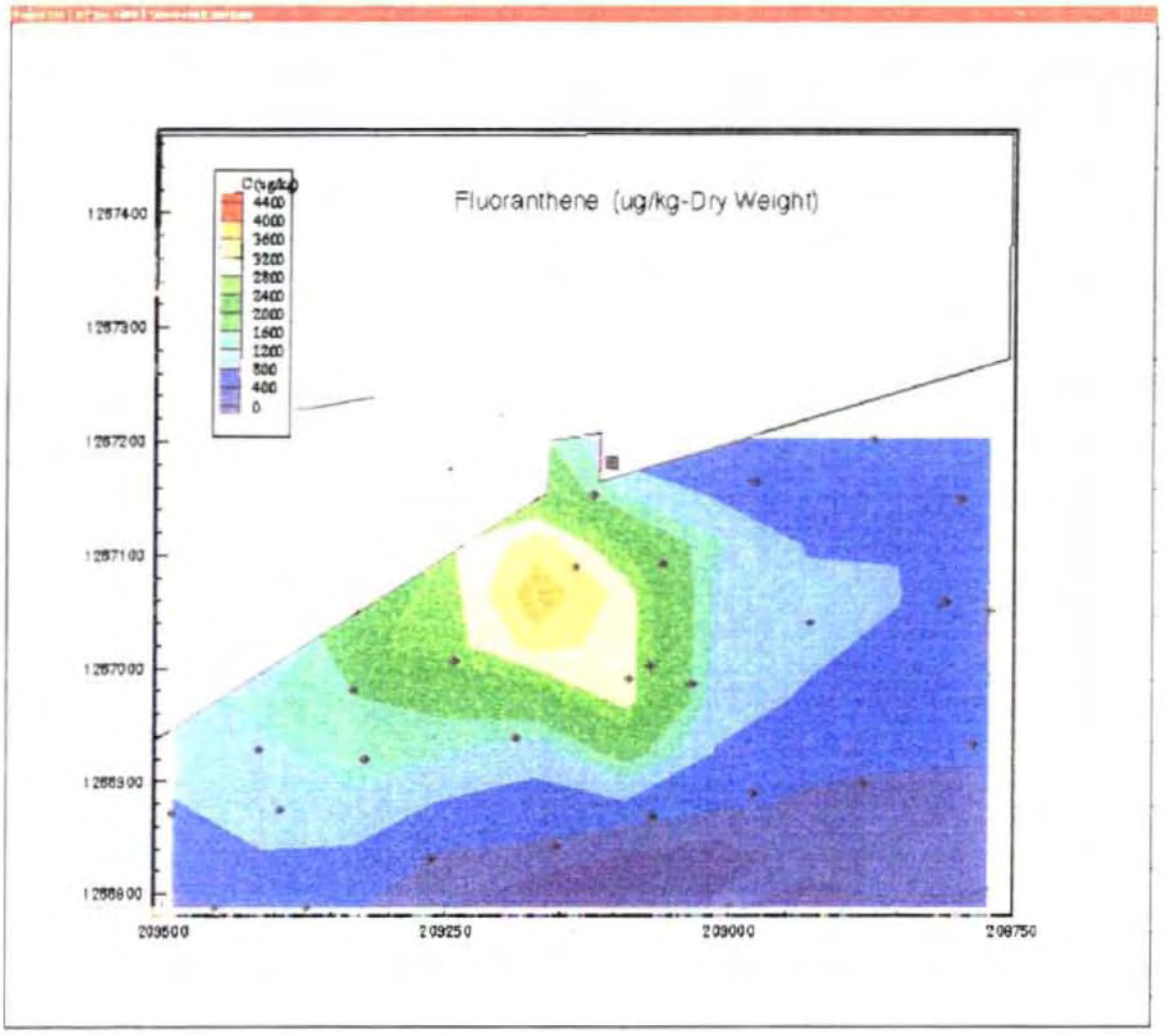
Sample ID	DUD030		DUD031		DUD032		DUD033		DUD034		DUD201		DUD202		DUD203		DUD204	
Laboratory ID	L4288-26		L4288-40		L4288-27		L4288-41		L4288-28		L9443-2		L9443-3		L9443-4		L9443-5	
Sample Depth (cm)	0-10		0-10		0-10		0-10		0-10		0-10		0-10		0-10		0-10	
Sample Date	8/12/94		8/16/94		8/12/94		8/16/94		8/12/94		9/9/96		9/9/96		9/9/96		9/9/96	
	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.	Value	Qual.
HPAH (ug/Kg-Dry Weight)	3170		3180		3990		3250		3970		2130		5080		1300		4350	
Fluoranthene	452	G	458		514	G	325		557		377	G	734	G	239	G	833	G
Pyrene	607	G	490		677	G	608		684		399	G	1020	G	252	G	879	G
Chrysene	387		408		412		348		515		253		627		188		556	
(ug/Kg-Dry Weight)																		
1,4-Dichlorobenzene	4	E,G	4.3	J,E,G	7.18	E,G	2.4	U,E,G	6.79	E,G	2.78	G	11.3	G	1.5	U,G	5.38	G
Other Nonionizable Organics																		
(ug/Kg-Dry Weight)																		
Benzyl Butyl Phthalate	67.2		81.7	U	149		170	U	62.7	U	41	J	189		53	J	297	
Bis(2-Ethylhexyl)Phthalate	1150		1140	B	1480		1250	B	1200	B	625	E	2700	E	833	E	2380	E

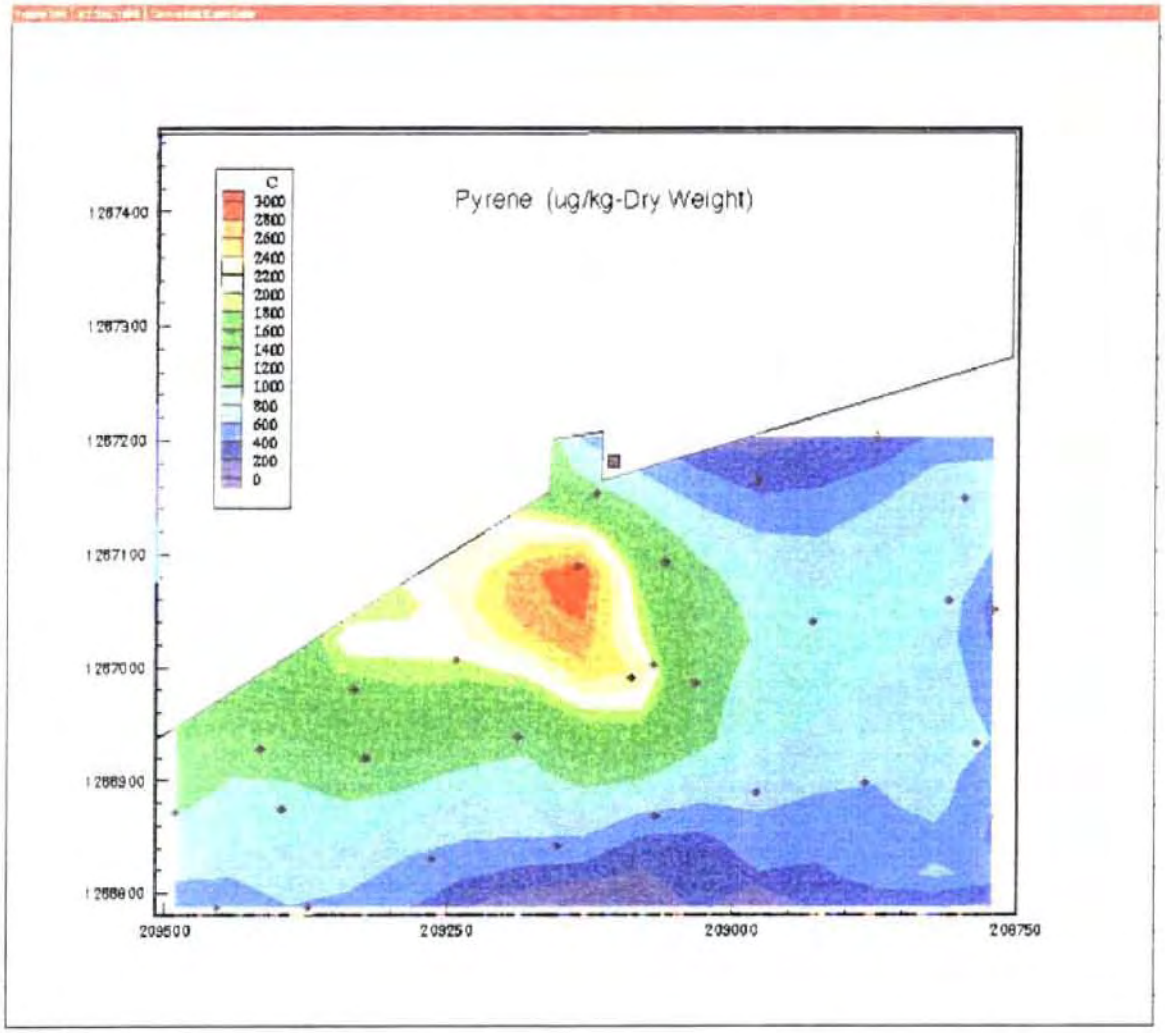
Background Stations

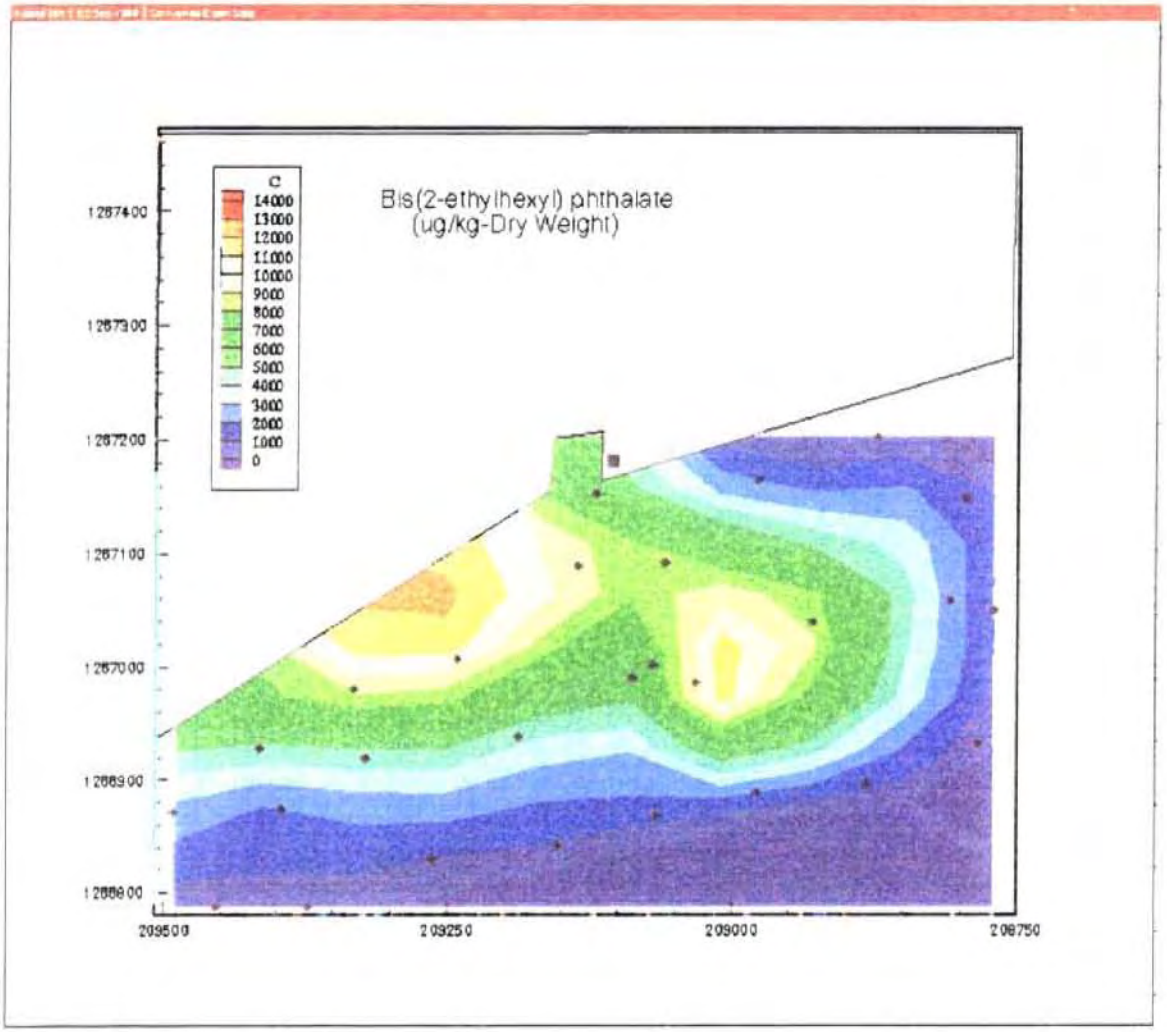
Sample ID	DUD039		DUD041	
Laboratory ID	L7279-8		L7279-10	
Sample Depth (cm)	0-10		0-10	
Sample Date	11/9/95		11/11/95	
	Value	Qual.	Value	Qual.
HPAH (ug/Kg-Dry Weight)	5140		4360	
Fluoranthene	629	G	595	G
Pyrene	764	G	716	G
Chrysene	704	G	540	G
(ug/Kg-Dry Weight)				
1,4-Dichlorobenzene	2.3	J,G	1.2	U,G
Other Nonionizable Organics				
(ug/Kg-Dry Weight)				
Benzyl Butyl Phthalate	83.9		59.9	
Bis(2-Ethylhexyl)Phthalate	756		933	

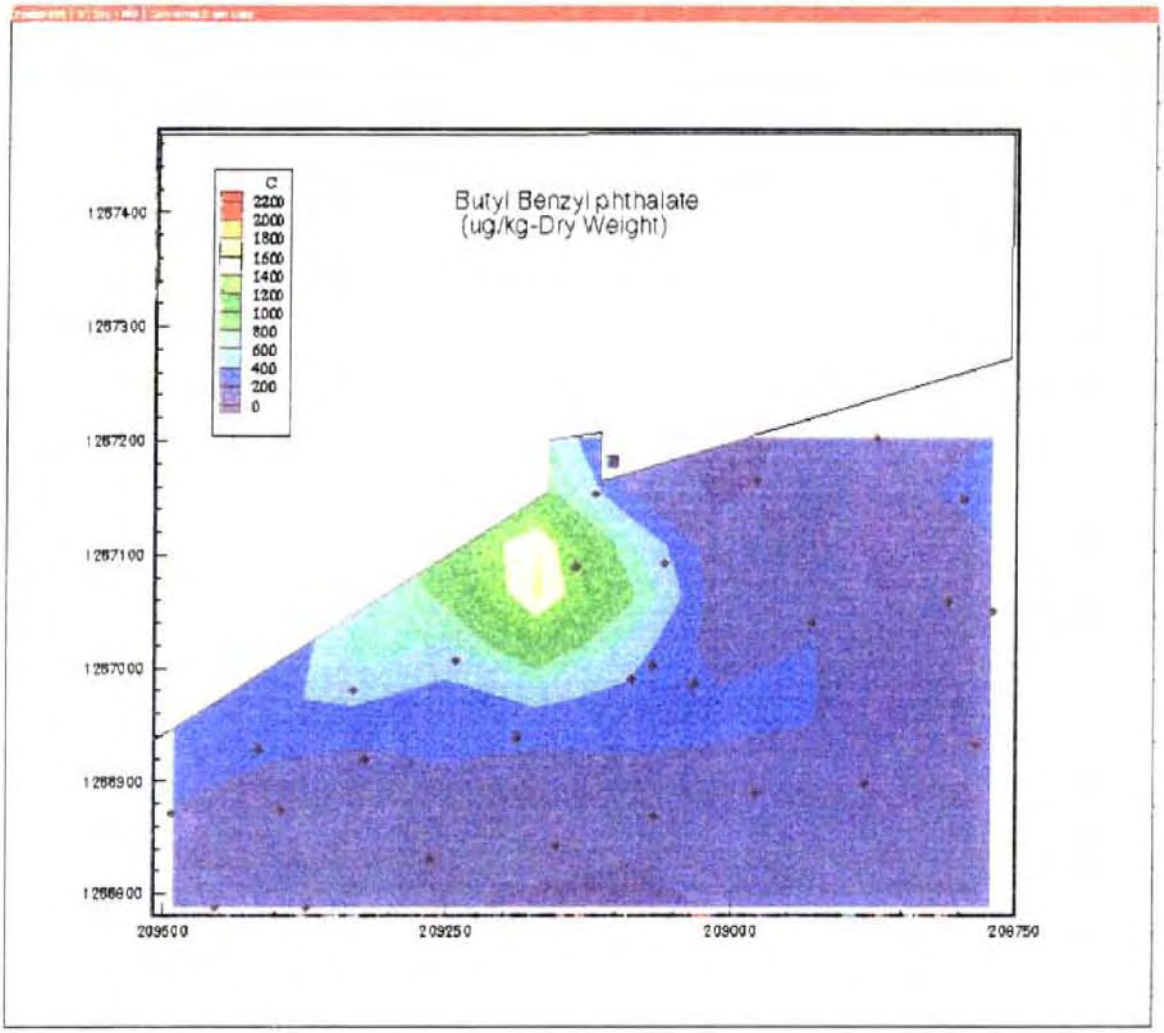
Appendix B of Appendix I
Contour Plots of the Sampled Data

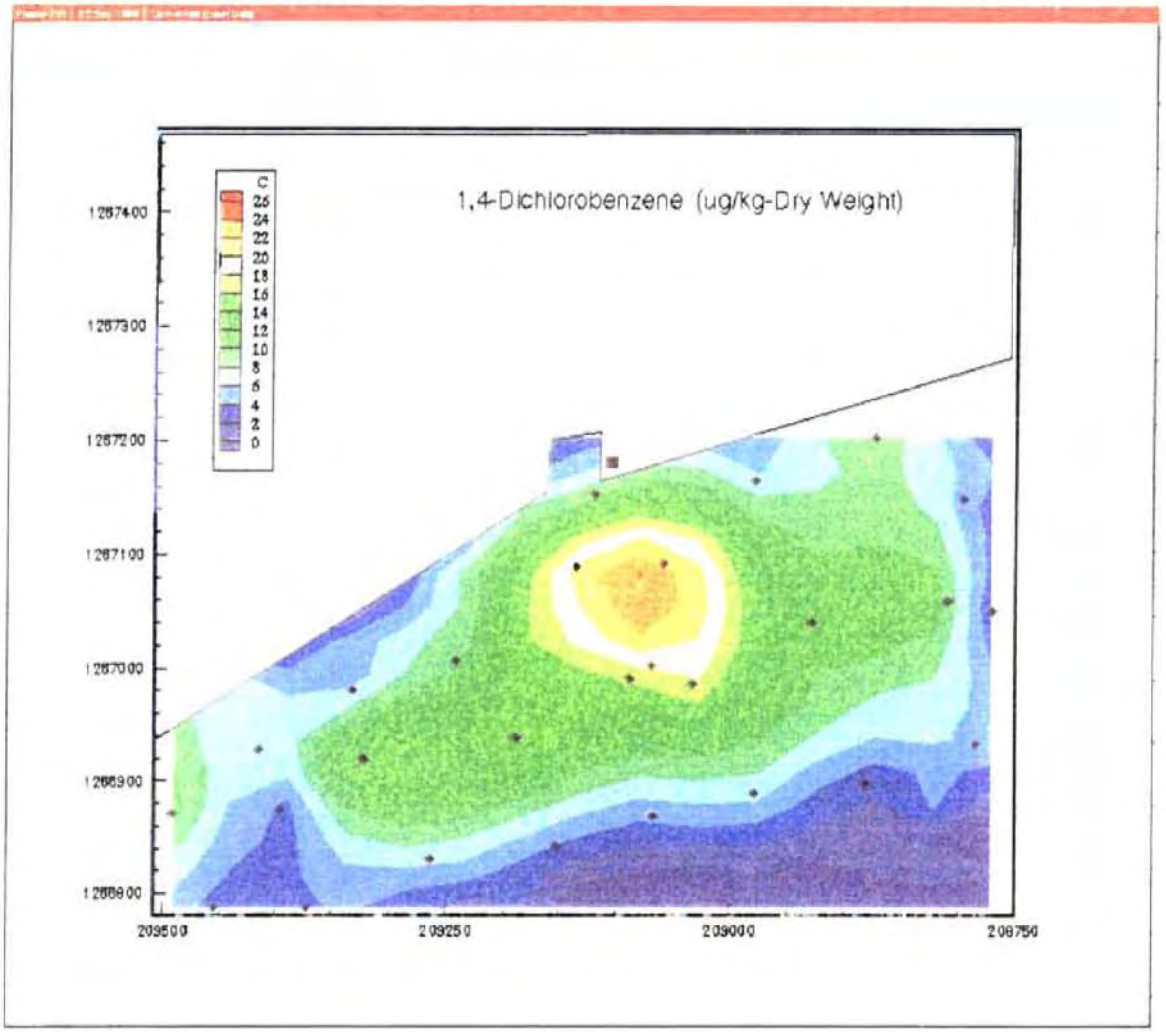

Chrysene (ug/kg-Dry Weight)
C
1800
1600
1400
1200
1000
800
600
400
200
0
1267400
1267300
1267200
1267100
1267000
1266900
1266800
209500
209250
209000
208750


Fluoranthene (ug/kg-Dry Weight)
4400
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
1267400
1267300
1267200
1267100
1267000
1266900
1266800
209500
209250
209000
208750


Pyrene (ug/kg-Dry Weight)
C
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1267400
1267300
1267200
1267100
1267000
1266900
1266800
209500
209250
209000
208750


C
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Bis(2-ethylhexyl) phthalate
(ug/kg-Dry Weight)
1267400
1267300
1267200
1267100
1267000
1266900
1266800
209500
209250
209000
208750


Butyl Benzyl phthalate
(ug/kg-Dry Weight)
C
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1267400
1267300
1267200
1267100
1267000
1266900
1266800
209500
209250
209000
208750


1,4-Dichlorobenzene (ug/kg-Dry Weight)
C
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1267400
1267300
1267200
1267100
1267000
1266900
1266800
209500
209250
209000
208750

Appendix C of Appendix I
Mass Calculations for the Sediment Data

Chrysene								
S	2.5 (Specific Gravity of the sediment)							
n	0.6 (Porosity of the Sediment)							
ρ_{water}	1000 kg/m^3							
Sample ID	Coordinates		Concentration	Area	Sed. Rate	Sed. Vol.	Density	Mass
	x	y	C	A	d	V_T	m_{chem} / V_T	m_{chem}
	(ft)	(ft)	µg/kg - D. W.	(m^2)	(m/year)	(m^3/year)	(g/m^3)	(g/year)
DUD001	209120	1267153	692	994	0.035	34.78	0.69	24.1
DUD002	209414	1266928	795	767	0.035	26.83	0.80	21.3
DUD003	209332	1266981	1,560	846	0.035	29.59	1.56	46.2
DUD004	209241	1267007	1,430	1,276	0.035	44.65	1.43	63.8
DUD005	209135	1267090	1,830	1,000	0.035	35.00	1.83	64.1
DUD006	209059	1267092	836	845	0.035	29.56	0.84	24.7
DUD007	208979	1267165	513	1,427	0.035	49.95	0.51	25.6
DUD008	208874	1267203	160	1,158	0.035	40.53	0.16	6.5
DUD016	209396	1266874	511	635	0.035	22.21	0.51	11.4
DUD017	209322	1266919	838	778	0.035	27.23	0.84	22.8
DUD018	209187	1266939	718	1,050	0.035	36.75	0.72	26.4
DUD019	209087	1266991	1,810	678	0.035	23.74	1.81	43.0
DUD020	209068	1267003	950	293	0.035	10.25	0.95	9.7
DUD021	209032	1266987	750	779	0.035	27.26	0.75	20.4
DUD022	208929	1267040	630	1,504	0.035	52.65	0.63	33.2
DUD023	208809	1267059	577	857	0.035	30.00	0.58	17.3
DUD028	209373	1266787	309	790	0.035	27.67	0.31	8.5
DUD029	209263	1266831	375	1,184	0.035	41.43	0.38	15.5
DUD030	209153	1266843	387	940	0.035	32.89	0.39	12.7
DUD031	209067	1266868	408	966	0.035	33.80	0.41	13.8
DUD032	208978	1266889	412	999	0.035	34.97	0.41	14.4
DUD033	208883	1266897	348	1,086	0.035	38.02	0.35	13.2
DUD034	208785	1266933	515	989	0.035	34.61	0.52	17.8
DUD201	209453	1266787	253	759	0.035	26.57	0.25	6.7
DUD202	209492	1266871	627	932	0.035	32.62	0.63	20.5
DUD203	208770	1267050	188	862	0.035	30.18	0.19	5.7
DUD204	208796	1267149	556	1,093	0.035	38.24	0.56	21.3
Average			703		0.035		0.70	
Sum				25,486		892.00		610.7

Fluoranthene								
S	2.5 (Specific Gravity of the sediment)							
n	0.6 (Porosity of the Sediment)							
ρ_{water}	1000 kg/m^3							
Sample ID	Coordinates		Concentration	Area	Sed. Rate	Sed. Vol.	Density	mass chem.
	x	y	C	A	d	V_T	m_{chem} / V_T	m_{chem}
	(ft)	(ft)	µg/kg - D. W.	(m^2)	(m/year)	(m^3/year)	(g/m^3)	(g/year)
DUD001	209120	1267153	1,100	994	0.035	34.78	1.10	38.3
DUD002	209414	1266928	1,080	767	0.035	26.83	1.08	29.0
DUD003	209332	1266981	1,590	846	0.035	29.59	1.59	47.1
DUD004	209241	1267007	2,580	1,276	0.035	44.65	2.58	115.2
DUD005	209135	1267090	4,440	1,000	0.035	35.00	4.44	155.4
DUD006	209059	1267092	1,850	845	0.035	29.56	1.85	54.7
DUD007	208979	1267165	592	1,427	0.035	49.95	0.59	29.6
DUD008	208874	1267203	307	1,158	0.035	40.53	0.31	12.4
DUD016	209396	1266874	1,070	635	0.035	22.21	1.07	23.8
DUD017	209322	1266919	1,440	778	0.035	27.23	1.44	39.2
DUD018	209187	1266939	851	1,050	0.035	36.75	0.85	31.3
DUD019	209087	1266991	3,840	678	0.035	23.74	3.84	91.2
DUD020	209068	1267003	1,800	293	0.035	10.25	1.80	18.5
DUD021	209032	1266987	1,090	779	0.035	27.26	1.09	29.7
DUD022	208929	1267040	911	1,504	0.035	52.65	0.91	48.0
DUD023	208809	1267059	753	857	0.035	30.00	0.75	22.6
DUD028	209373	1266787	546	790	0.035	27.67	0.55	15.1
DUD029	209263	1266831	365	1,184	0.035	41.43	0.37	15.1
DUD030	209153	1266843	452	940	0.035	32.89	0.45	14.9
DUD031	209067	1266868	458	966	0.035	33.80	0.46	15.5
DUD032	208978	1266889	514	999	0.035	34.97	0.51	18.0
DUD033	208883	1266897	325	1,086	0.035	38.02	0.33	12.4
DUD034	208785	1266933	557	989	0.035	34.61	0.56	19.3
DUD201	209453	1266787	377	759	0.035	26.57	0.38	10.0
DUD202	209492	1266871	734	932	0.035	32.62	0.73	23.9
DUD203	208770	1267050	239	862	0.035	30.18	0.24	7.2
DUD204	208796	1267149	833	1,093	0.035	38.24	0.83	31.9
Average			1,137		0.035		1.14	
Sum				25,486		892.00		968.9

Pyrene								
S	2.5 (Specific Gravity of the sediment)							
n	0.6 (Porosity of the Sediment)							
ρ_{water}	1000 kg/m^3							
Sample ID	Coordinates		Concentration	Area	Sed. Rate	Sed. Vol.	Density	mass chem.
	x	y	C	A	d	V_T	m_{chem} / V_T	m_{chem}
	(ft)	(ft)	µg/kg - D. W.	(m^2)	(m/year)	(m^3/year)	(g/m^3)	(g/year)
DUD001	209120	1267153	996	994	0.035	34.78	1.00	34.6
DUD002	209414	1266928	1,010	767	0.035	26.83	1.01	27.1
DUD003	209332	1266981	1,730	846	0.035	29.59	1.73	51.2
DUD004	209241	1267007	2,020	1,276	0.035	44.65	2.02	90.2
DUD005	209135	1267090	3,090	1,000	0.035	35.00	3.09	108.2
DUD006	209059	1267092	1,180	845	0.035	29.56	1.18	34.9
DUD007	208979	1267165	339	1,427	0.035	49.95	0.34	16.9
DUD008	208874	1267203	214	1,158	0.035	40.53	0.21	8.7
DUD016	209396	1266874	921	635	0.035	22.21	0.92	20.5
DUD017	209322	1266919	1,270	778	0.035	27.23	1.27	34.6
DUD018	209187	1266939	1,060	1,050	0.035	36.75	1.06	39.0
DUD019	209087	1266991	2,870	678	0.035	23.74	2.87	68.1
DUD020	209068	1267003	1,570	293	0.035	10.25	1.57	16.1
DUD021	209032	1266987	1,150	779	0.035	27.26	1.15	31.4
DUD022	208929	1267040	871	1,504	0.035	52.65	0.87	45.9
DUD023	208809	1267059	866	857	0.035	30.00	0.87	26.0
DUD028	209373	1266787	647	790	0.035	27.67	0.65	17.9
DUD029	209263	1266831	508	1,184	0.035	41.43	0.51	21.0
DUD030	209153	1266843	607	940	0.035	32.89	0.61	20.0
DUD031	209067	1266868	490	966	0.035	33.80	0.49	16.6
DUD032	208978	1266889	677	999	0.035	34.97	0.68	23.7
DUD033	208883	1266897	608	1,086	0.035	38.02	0.61	23.1
DUD034	208785	1266933	684	989	0.035	34.61	0.68	23.7
DUD201	209453	1266787	399	759	0.035	26.57	0.40	10.6
DUD202	209492	1266871	1,020	932	0.035	32.62	1.02	33.3
DUD203	208770	1267050	252	862	0.035	30.18	0.25	7.6
DUD204	208796	1267149	879	1,093	0.035	38.24	0.88	33.6
Average			1,034		0.035		1.03	
Sum				25,486		892.00		884.2

Bis(2-ethylhexyl) phthalate								
S	2.5 (Specific Gravity of the sediment)							
n	0.6 (Porosity of the Sediment)							
ρ_{water}	1000 kg/m^3							
Sample ID	Coordinates		Concentration	Area	Sed. Rate	Sed. Vol.	Density	mass chem.
	x	y	C	A	d	V_T	m_{chem} / V_T	m_{chem}
	(ft)	(ft)	µg/kg - D. W.	(m^2)	(m/year)	(m^3/year)	(g/m^3)	(g/year)
DUD001	209120	1267153	5,940	994	0.035	34.78	5.94	206.6
DUD002	209414	1266928	4,820	767	0.035	26.83	4.82	129.3
DUD003	209332	1266981	9,610	846	0.035	29.59	9.61	284.4
DUD004	209241	1267007	11,300	1,276	0.035	44.65	11.30	504.5
DUD005	209135	1267090	10,400	1,000	0.035	35.00	10.40	364.0
DUD006	209059	1267092	8,360	845	0.035	29.56	8.36	247.1
DUD007	208979	1267165	994	1,427	0.035	49.95	0.99	49.6
DUD008	208874	1267203	341	1,158	0.035	40.53	0.34	13.8
DUD016	209396	1266874	1,500	635	0.035	22.21	1.50	33.3
DUD017	209322	1266919	4,330	778	0.035	27.23	4.33	117.9
DUD018	209187	1266939	3,990	1,050	0.035	36.75	3.99	146.6
DUD019	209087	1266991	5,210	678	0.035	23.74	5.21	123.7
DUD020	209068	1267003	6,170	293	0.035	10.25	6.17	63.2
DUD021	209032	1266987	14,000	779	0.035	27.26	14.00	381.7
DUD022	208929	1267040	9,720	1,504	0.035	52.65	9.72	511.7
DUD023	208809	1267059	2,170	857	0.035	30.00	2.17	65.1
DUD028	209373	1266787	997	790	0.035	27.67	1.00	27.6
DUD029	209263	1266831	1,060	1,184	0.035	41.43	1.06	43.9
DUD030	209153	1266843	1,150	940	0.035	32.89	1.15	37.8
DUD031	209067	1266868	1,140	966	0.035	33.80	1.14	38.5
DUD032	208978	1266889	1,480	999	0.035	34.97	1.48	51.8
DUD033	208883	1266897	1,250	1,086	0.035	38.02	1.25	47.5
DUD034	208785	1266933	1,200	989	0.035	34.61	1.20	41.5
DUD201	209453	1266787	625	759	0.035	26.57	0.63	16.6
DUD202	209492	1266871	2,700	932	0.035	32.62	2.70	88.1
DUD203	208770	1267050	833	862	0.035	30.18	0.83	25.1
DUD204	208796	1267149	2,380	1,093	0.035	38.24	2.38	91.0
Average			4,210		0.035		4.21	
Sum				25,486		892.00		3752.3

Butyl benzyl phthalate								
S	2.5 (Specific Gravity of the sediment)							
n	0.6 (Porosity of the Sediment)							
ρ_{water}	1000 kg/m^3							
Sample ID	Coordinates		Concentration	Area	Sed. Rate	Sed. Vol.	Density	mass chem.
	x	y	C	A	d	V_T	m_{chem} / V_T	m_{chem}
	(ft)	(ft)	µg/kg - D. W.	(m^2)	(m/year)	(m^3/year)	(g/m^3)	(g/year)
DUD001	209120	1267153	263	994	0.035	34.78	0.26	9.1
DUD002	209414	1266928	223	767	0.035	26.83	0.22	6.0
DUD003	209332	1266981	485	846	0.035	29.59	0.49	14.4
DUD004	209241	1267007	447	1,276	0.035	44.65	0.45	20.0
DUD005	209135	1267090	2,220	1,000	0.035	35.00	2.22	77.7
DUD006	209059	1267092	23	845	0.035	29.56	0.02	0.7
DUD007	208979	1267165	67	1,427	0.035	49.95	0.07	3.3
DUD008	208874	1267203	44	1,158	0.035	40.53	0.04	1.8
DUD016	209396	1266874	123	635	0.035	22.21	0.12	2.7
DUD017	209322	1266919	147	778	0.035	27.23	0.15	4.0
DUD018	209187	1266939	225	1,050	0.035	36.75	0.23	8.3
DUD019	209087	1266991	447	678	0.035	23.74	0.45	10.6
DUD020	209068	1267003	181	293	0.035	10.25	0.18	1.9
DUD021	209032	1266987	271	779	0.035	27.26	0.27	7.4
DUD022	208929	1267040	203	1,504	0.035	52.65	0.20	10.7
DUD023	208809	1267059	32	857	0.035	30.00	0.03	1.0
DUD028	209373	1266787	35	790	0.035	27.67	0.04	1.0
DUD029	209263	1266831	89	1,184	0.035	41.43	0.09	3.7
DUD030	209153	1266843	67	940	0.035	32.89	0.07	2.2
DUD031	209067	1266868	82	966	0.035	33.80	0.08	2.8
DUD032	208978	1266889	149	999	0.035	34.97	0.15	5.2
DUD033	208883	1266897	170	1,086	0.035	38.02	0.17	6.5
DUD034	208785	1266933	63	989	0.035	34.61	0.06	2.2
DUD201	209453	1266787	41	759	0.035	26.57	0.04	1.1
DUD202	209492	1266871	189	932	0.035	32.62	0.19	6.2
DUD203	208770	1267050	53	862	0.035	30.18	0.05	1.6
DUD204	208796	1267149	297	1,093	0.035	38.24	0.30	11.4
Average			246		0.035		0.25	
Sum				25,486		892.00		223.2

1,4-Dichlorobenzene								
S	2.5 (Specific Gravity of the sediment)							
n	0.6 (Porosity of the Sediment)							
ρ_{water}	1000 kg/m^3							
Sample ID	Coordinates		Concentration	Area	Sed. Rate	Sed. Vol.	Density	mass chem.
	x	y	C	A	d	V_T	m_{chem} / V_T	m_{chem}
	(ft)	(ft)	µg/kg - D. W.	(m^2)	(m/year)	(m^3/year)	(g/m^3)	(g/year)
DUD001	209120	1267153	8.4	994	0.035	34.78	0.01	0.3
DUD002	209414	1266928	6.5	767	0.035	26.83	0.01	0.2
DUD003	209332	1266981	4.9	846	0.035	29.59	0.00	0.1
DUD004	209241	1267007	9.5	1,276	0.035	44.65	0.01	0.4
DUD005	209135	1267090	21.5	1,000	0.035	35.00	0.02	0.8
DUD006	209059	1267092	25.4	845	0.035	29.56	0.03	0.8
DUD007	208979	1267165	6.1	1,427	0.035	49.95	0.01	0.3
DUD008	208874	1267203	9.3	1,158	0.035	40.53	0.01	0.4
DUD016	209396	1266874	2.3	635	0.035	22.21	0.00	0.1
DUD017	209322	1266919	18.3	778	0.035	27.23	0.02	0.5
DUD018	209187	1266939	16.7	1,050	0.035	36.75	0.02	0.6
DUD019	209087	1266991	14.4	678	0.035	23.74	0.01	0.3
DUD020	209068	1267003	22.2	293	0.035	10.25	0.02	0.2
DUD021	209032	1266987	17.9	779	0.035	27.26	0.02	0.5
DUD022	208929	1267040	11.4	1,504	0.035	52.65	0.01	0.6
DUD023	208809	1267059	11.7	857	0.035	30.00	0.01	0.4
DUD028	209373	1266787	3.7	790	0.035	27.67	0.00	0.1
DUD029	209263	1266831	6.2	1,184	0.035	41.43	0.01	0.3
DUD030	209153	1266843	4.0	940	0.035	32.89	0.00	0.1
DUD031	209067	1266868	4.3	966	0.035	33.80	0.00	0.1
DUD032	208978	1266889	7.2	999	0.035	34.97	0.01	0.3
DUD033	208883	1266897	2.4	1,086	0.035	38.02	0.00	0.1
DUD034	208785	1266933	6.8	989	0.035	34.61	0.01	0.2
DUD201	209453	1266787	2.8	759	0.035	26.57	0.00	0.1
DUD202	209492	1266871	11.3	932	0.035	32.62	0.01	0.4
DUD203	208770	1267050	1.5	862	0.035	30.18	0.00	0.0
DUD204	208796	1267149	5.4	1,093	0.035	38.24	0.01	0.2
Average			9.7		0.035		0.010	
Sum				25,486		892.00		8.3

Appendix J
Station Coordinates

Sample ID			Laboratory ID	Sample Date	Sample Depth (cm)	Note	Depth (feet)		
	NAD 83 Data (WA State plane north zone)						Measured	Tide	Corrected
Phase 1	Easting	Northing							
DUD001	209120	1267153	L4288-30	8/17/1994	0-10		13	3	10
DUD002	209414	1266928	L4288-1	8/11/1994	0-10		18	6	12
DUD003	209332	1266981	L4288-2	8/11/1994	0-10		13	4	9
DUD004	209241	1267007	L4288-3	8/12/1994	0-10		10	10	0
DUD005	209135	1267090	L4288-31	8/16/1994	0-10		11	9	2
DUD005-FRep	209135	1267090	L4288-4	8/16/1994	0-10	field replicate	10	9	1
DUD006	209059	1267092	L4288-5	8/10/1994	0-10				
DUD006	209059	1267092	L4378-10	8/25/1994	135-150				
DUD006	209059	1267092	L4378-3	8/25/1994	0-15				
DUD006	209059	1267092	L4378-4	8/25/1994	15-30				
DUD006	209059	1267092	L4378-5	8/25/1994	30-45				
DUD006	209059	1267092	L4378-6	8/25/1994	45-60				
DUD006	209059	1267092	L4378-7	8/25/1994	60-75				
DUD006	209059	1267092	L4378-8	8/25/1994	75-90				
DUD006	209059	1267092	L4378-9	8/25/1994	105-20				
DUD007	208979	1267165	L4288-6	8/10/1994	0-10		11	6	5
DUD008	208874	1267203	L4288-7	8/9/1994	0-10				
DUD009	208785	1267219	L4288-8	8/9/1994	0-10		11	10	1
DUD010	208673	1267246	L4288-9	8/17/1994	0-10				
DUD011	208520	1267183	L4288-32	8/17/1994	0-10				
DUD012	208410	1267160	L4288-10	8/12/1994	0-10		13	4	9
DUD012-FRep	208410	1267160	L4288-11	8/12/1994	0-10	field replicate	10	4	6
DUD013	208325	1267213	L4288-12	8/12/1994	0-10		7	5	2
DUD014	208305	1267283	L4288-33	8/20/1994	0-10	coordinates wrong in QA report			
DUD015	208263	1267232	L4288-13	8/12/1994	0-10		7	6	1
DUD016	209396	1266874	L4288-34	8/15/1994	0-10		30	5	25
DUD016-FRep	209396	1266874	L4288-14	8/15/1994	0-10	field replicate	30	7	23
DUD017	209322	1266919	L4288-15	8/12/1994	0-10		26	6	20
DUD018	209187	1266939	L4288-35	8/15/1994	0-10		25	9	16
DUD019	209087	1266991	L4288-16	8/9/1994	0-10				
DUD020	209068	1267003	L4378-12	8/25/1994	0-15				
DUD020	209068	1267003	L4378-13	8/25/1994	15-30				
DUD020	209068	1267003	L4378-14	8/25/1994	30-45				
DUD020	209068	1267003	L4378-15	8/25/1994	45-60				
DUD020	209068	1267003	L4378-16	8/25/1994	60-75				
DUD020	209068	1267003	L4378-17	8/25/1994	75-90				
DUD021-VRep	209032	1266987	L4288-17	8/15/1994	0-10	variability replicate	28	8	20
DUD021-VRep	209032	1266987	L4288-18	8/15/1994	0-10	variability replicate	27	8	19
DUD021-VRep	209032	1266987	L4288-19	8/15/1994	0-10	variability replicate	27	8	19
DUD021-VRep	209032	1266987	L4288-20	8/15/1994	0-10	variability replicate	27	8	19

Sample ID			Laboratory ID	Sample Date	Sample Depth (cm)	Note	Depth (feet)		
	NAD 83 Data (WA State plane north zone)						Measured	Tide	Corrected
Phase 1	**Easting**	**Northing**							
DUD022	208929	1267040	L4288-21	8/10/1994	0-10		21	3	18
DUD023	208809	1267059	L4288-37	8/16/1994	0-10		28	7	21
DUD024	208715	1267080	L4288-22	8/9/1994	0-10				
DUD025	208637	1267100	L4288-38	8/16/1994	0-10		25	3	22
DUD026	208546	1267097	L4288-23	8/10/1994	0-10		18	1	17
DUD027	208451	1267100	L4288-24	8/10/1994	0-10		17	1	16
DUD028	209373	1266787	L4288-25	8/11/1994	0-10		31	3	28
DUD029	209263	1266831	L4288-39	8/15/1994	0-10		34	7	27
DUD030	209153	1266843	L4288-26	8/12/1994	0-10	coordinates wrong in QA report	39	9	30
DUD031	209067	1266868	L4288-40	8/16/1994	0-10		41	10	31
DUD032	208978	1266889	L4288-27	8/12/1994	0-10		39	8	31
DUD033	208883	1266897	L4288-41	8/16/1994	0-10		38	9	29
DUD034	208785	1266933	L4288-28	8/12/1994	0-10		39	7	32
DUD035	208683	1266971	L4288-29	8/10/1994	0-10		33	2	31
DUDCARR1	733878	1097193	4378-1	8/22/1994	0-10		59	1	58
DUDCARR2	736816	1101218	4378-2	8/22/1994	0-10		57	7	50
Pre-Phase 2	**Easting**	**Northing**							
DUD027	208455	1267106	L7279-1	11/11/1995	0-10	use 1994 coordinates. See Note 1	28	9	19
DUD032	208990	1266889	L7279-2	11/9/1995	0-10	use 1994 coordinates. See Note 1	36		
DUD032	208990	1266889	L7279-3	11/9/1995	0-10	field replicate	38		
DUD036	208245	1267118	L7279-4	11/11/1995	0-10		28	7	21
DUD037	207799	1267302	L7279-5	11/11/1995	0-10		25	7	18
DUD038	208434	1266999	L7279-6	11/9/1995	0-10		40		
DUD038	208434	1266999	L7279-7	11/9/1995	0-10	field replicate	40		
DUD039	208606	1266844	L7279-8	11/9/1995	0-10		40		
DUD040	208414	1266888	L7279-9	11/9/1995	0-10		42		
DUD041	208217	1266977	L7279-10	11/11/1995	0-10		39	8	31
DUD042	209785	1266880	L7279-11	11/11/1995	0-10		30	8	22
DUD043	209602	1266852	L7279-12	11/7/1995	0-10		26	6	20
DUD044	209390	1266698	L7279-13	11/7/1995	0-10		43	8	35
DUD045	209016	1266752	L7279-14	11/7/1995	0-10		46	10	36

Sample ID			Laboratory ID	Sample Date	Sample Depth (cm)	Note	Depth (feet)		
	NAD 83 Data (WA State plane north zone)						Measured	Tide	Corrected
Phase 2	Easting	Northing							
DUD027	208453	1267092	L8542-35	5/21/1996	0-90	use 1994 coordinates. See Note 1	19.5	3	16.5
DUD027	208453	1267092	L8542-36	5/21/1996	90-180				
DUD027	208453	1267092	L9142-2	5/21/1996	180-270	archived, analyzed 1-97			
DUD027-Rep.	208447	1267081	L8542-37	5/21/1996	0-90	field replicate. See Note 1.	27	1	26
DUD027-Rep.	208447	1267081	L8542-38	5/21/1996	90-180	field replicate			
DUD027-Rep.	208447	1267081	L9142-3	5/21/1996	180-270	field replicate			
DUD200	209663	1266859	L9443-1	9/9/1996	0-10				
DUD201	209453	1266787	L9443-2	9/9/1996	0-10				
DUD202	209492	1266871	L9443-3	9/9/1996	0-10				
DUD202	209492	1266871	L9443-8	9/9/1996	0-10	field replicate			
DUD203	208770	1267050	L9443-4	9/9/1996	0-10				
DUD204	208796	1267149	L9443-5	9/9/1996	0-10				
DUD205	208705	1267137	L9443-6	9/9/1996	0-10				
DUD206	208630	1267277	L9443-7	9/9/1996	0-10				
DUD206	208630	1267277	L8542-28	6/3/1996	0-90	see note 2	0		0
DUD207	208595	1267006	L8542-8	7/16/1996	0-10		29.9	0	29.9
DUD208	208342	1267059	L8542-9	7/16/1996	0-10		29.5	-0.5	30
DUD209	208342	1267179	L8542-10	7/16/1996	0-10		9.5	-0.9	10.4
Carr Inlet (Low)	126797	1183526	L9446-1	9/11/1996	0-10	low % fines			
Carr Inlet (High	126943	1185036	L9446-2	9/11/1996	0-10	high % fines			
DUD250	209564	1266871	L8542-12	5/21/1996	0-90		24.4	0	24.4
DUD251	209330	1266874	L8542-13	5/21/1996	0-90		27	2	25
DUD251	209330	1266874	L8542-14	5/21/1996	90-180				
DUD251	209330	1266874	L10112-1	5/21/1996	180-270	archived, analyzed 1-97			
DUD252	209320	1266990	L8542-15	5/21/1996	0-90		21	6	15
DUD252	209320	1266990	L8542-16	5/21/1996	90-180				
DUD252	209320	1266990	L10112-2	5/21/1996	180-270	archived, analyzed 1-97			
DUD253	209127	1266913	L8542-17	5/20/1996	0-90				
DUD253	209127	1266913	L8542-18	5/20/1996	90-180				
DUD253	209127	1266913	L10112-3	5/20/1996	180-270	archived, analyzed 1-97			
DUD254	209131	1267080	L8542-19	5/21/1996	0-90		7	0.1	6.9
DUD254	209131	1267080	L8542-20	5/21/1996	90-180				
DUD254	209131	1267080	L9142-1	5/21/1996	180-270	archived, analyzed 1-97			
DUD255	208946	1266930	L8542-21	5/20/1996	0-90		25.2	1	24.2
DUD255	208946	1266930	L8542-22	5/20/1996	90-180				
DUD255	208946	1266930	L10112-4	5/20/1996	180-270	archived, analyzed 1-97			
DUD255 Rep.	208946	1266930	L8542-23	5/20/1996	0-90	field replicate	21.6	-0.5	22.1
DUD255 Rep.	208946	1266930	L8542-39	5/20/1996	90-180	field replicate			
DUD256	208956	1267106	L8542-24	5/20/1996	0-90		16.8	-0.5	17.3
DUD256	208956	1267106	L8542-25	5/20/1996	90-180				
DUD256	208956	1267106	L10112-5	5/20/1996	180-270	archived, analyzed 1-97			

Sample ID			Laboratory ID	Sample Date	Sample Depth (cm)	Note	Depth (feet)		
	NAD 83 Data (WA State plane north zone)						Measured	Tide	Corrected
Phase 2	**Easting**	**Northing**							
DUD257	208738	1267063	L8542-26	5/21/1996	0-90		21	4	17
DUD257	208738	1267063	L10112-6	5/21/1996	90-180	archived, analyzed 1-97			
DUD257	208738	1267063	L10112-7	5/21/1996	180-270	archived, analyzed 1-97			
DUD258	208772	1267170	L8542-27	5/20/1996	0-90		20	2	18
DUD258	208772	1267170	L10112-8	5/20/1996	90-180	archived, analyzed 1-97			
DUD258	208772	1267170	L10112-9	5/20/1996	180-270	archived, analyzed 1-97			
DUD260	208575	1267150	L8542-29	5/20/1996	0-90		17.2	0.2	17
DUD260	208575	1267150	L8542-30	5/20/1996	90-180				
DUD261	208326	1267150	L8542-31	5/21/1996	0-90		56	-0.5	26.5
DUD261	208326	1267150	L8542-32	5/21/1996	90-180				
DUD262	208441	1267158	L8542-33	5/21/1996	0-90	see note 3			
DUD262	208441	1267158	L8542-34	5/21/1996	90-180				
EPA									
DR005	209821	1266890		8/18/1998	0-10				
DR006	209542	1266904		8/18/1998	0-10				
DR007	209231	1266973		8/18/1998	0-10				
DR008	209057	1267034		8/18/1998	0-10				
DR008	209057	1267034		8/18/1998	61-122				
DR008	209057	1267034		8/18/1998	122-183				
DR009	208948	1267135		8/18/1998	0-10				
DR010	208552	1267205		9/14/1998	0-10				
DR011	208315	1267132		8/18/1998	0-10				
DR012	207819	1267339		8/18/1998	0-10				
DR013	207585	1267434		8/18/1998	0-10				
DR014	207230	1267525		8/18/1998	0-10				
DR015	206887	1267735		8/17/1998	0-10				
DR058	209466	1266759		8/31/1998	0-10				
DR059	208751	1267097		8/18/1998	0-10				
DR060	208077	1267118		8/18/1998	0-10				
DR061	207404	1267433		8/18/1998	0-10				
DR062	206240	1267824		8/17/1998	0-10				
DR080	209361	1266618		8/24/1998	0-10				
DR081	208951	1266815		8/31/1998	0-10				
DR082	208550	1266896		8/31/1998	0-10				
DR083	207802	1267054		8/31/1998	0-10				
DR084	207433	1267228		8/31/1998	0-10				
DR085	207054	1267392		8/31/1998	0-10				

Note 1. This coordinate is different from previous sampling events at this station.

Note 2. Surface grab DUD206 and core DUD 259 had the same coordinates. Core DUD259 has been renamed DUD206.

Note 3. DUD262 was originally intended to replicate DUD012, but was off by 31 feet.

Appendix K
Sample Inventory Logs

Sample	Type	AVS	PSD	Tributyltin	Hg Methyl	Bioassay	TOC	TOTS	BNA-sur	ClPest/PCB	metals
4288-1	grab	X	X	X			X	X	X	X	X
4288-2	grab	X	X	X			X	X	X	X	X
4288-3	grab	X	X	X			X	X	X	X	X
4288-4	grab*	X	X	X			X	X	X	X	X
4288-5	grab	X	X	X			X	X	X	X	X
4288-6	grab	X	X	X			X	X	X	X	X
4288-7	grab	X	X	X			X	X	X	X	X
4288-8	grab	X	X	X			X	X	X	X	X
4288-9	grab	X	X	X			X	X	X	X	X
4288-10	grab	X	X	X			X	X	X	X	X
4288-11	grab*	X	X	X			X	X	X	X	X
4288-12	grab	X	X	X			X	X	X	X	X
4288-13	grab	X	X	X			X	X	X	X	X
4288-14	grab*	X	X	X			X	X	X	X	X
4288-15	grab	X	X	X			X	X	X	X	X
4288-16	grab	X	X	X			X	X	X	X	X
4288-17	grab**	X	X	X			X	X	X	X	X
4288-18	grab**	X	X	X			X	X	X	X	X
4288-19	grab**	X	X	X			X	X	X	X	X
4288-20	grab**	X	X	X			X	X	X	X	X
4288-21	grab	X	X	X			X	X	X	X	X
4288-22	grab	X	X	X			X	X	X	X	X
4288-23	grab	X	X	X			X	X	X	X	X
4288-24	grab	X	X	X			X	X	X	X	X
4288-25	grab	X	X	X			X	X	X	X	X
4288-26	grab	X	X	X			X	X	X	X	X
4288-27	grab	X	X	X			X	X	X	X	X
4288-28	grab	X	X	X			X	X	X	X	X
4288-29	grab	X	X	X			X	X	X	X	X
4288-30	grab	X	X	X	X	X	X	X	X	X	X
4288-31	grab	X	X	X	X	X	X	X	X	X	X
4288-32	grab	X	X	X	X	X	X	X	X	X	X
4288-33	grab	X	X	X	X	X	X	X	X	X	X
4288-34	grab	X	X	X	X	X	X	X	X	X	X
4288-35	grab	X	X	X	X	X	X	X	X	X	X
4288-36	grab	X	X	X	X	X	X	X	X	X	X
4288-37	grab	X	X	X	X	X	X	X	X	X	X
4288-38	grab	X	X	X	X	X	X	X	X	X	X
4288-39	grab	X	X	X	X	X	X	X	X	X	X
4288-40	grab	X	X	X	X	X	X	X	X	X	X
4288-41	grab	X	X	X	X	X	X	X	X	X	X
4378-1	grab					X					
4378-2	grab					X					
4378-3	core	X	X				X	X	X	X	X
4378-4	core	X	X				X	X	X	X	X
4378-5	core	X	X				X	X	X	X	X
4378-6	core	X	X				X	X	X	X	X
4378-7	core	X	X				X	X	X	X	X
4378-8	core	X	X				X	X	X	X	X
4378-9	core	X	X				X	X	X	X	X
4378-10	core	X	X				X	X	X	X	X
4378-11	core			this sample not taken							
4378-12	core	X	X				X	X	X	X	X
4378-13	core	X	X				X	X	X	X	X
4378-14	core	X	X				X	X	X	X	X
4378-15	core	X	X				X	X	X	X	X
4378-16	core	X	X				X	X	X	X	X
4378-17	core	X	X				X	X	X	X	X

AVS = acid volatile sulfide
PSD = particle size distribution
Metals = Ag Al As Ba Be Ca Cd Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Ti Zn
4378-1 = Carr Inlet reference 1
4378-2 = Carr Inlet reference 2

BNA-sur = BNA analysis with TIC compounds
Interstitial salinity was analyzed for all bioassays
* = field replicate
** = variability replicate
4378-11 this sample not taken

Duwamish/Diagonal Pre-Phase II Sediment Cleanup Study
Sample Inventory

Sample	BNAs	PCBs	Butyltins	Metals	Sulfides	Ammonia	PSD	Solids	TOC	Comments
7279-1	X	X	X	X	X	X	X	X	X	
7279-2	X	X	X	X	X	X	X	X	X	
7279-3	X	X	X	X	X	X	X	X	X	Field Replicate of 7279-2
7279-4	X	X	X	X	X	X	X	X	X	
7279-5	X	X	X	X	X	X	X	X	X	
7279-6	X	X	X	X	X	X	X	X	X	
7279-7	X	X	X	X	X	X	X	X	X	Field Replicate of 7279-6
7279-8	X	X	X	X	X	X	X	X	X	
7279-9	X	X	X	X	X	X	X	X	X	
7279-10	X	X	X	X	X	X	X	X	X	
7279-11	X	X	X	X	X	X	X	X	X	
7279-12	X	X	X	X	X	X	X	X	X	
7279-13	X	X	X	X	X	X	X	X	X	
7279-14	X	X	X	X	X	X	X	X	X	

Duwamish/Diagonal Phase II Sediment Cleanup Study
Sample Inventory (Core Samples)

Sample	Locator	Depth	BNAs	PCBs	Metals	Mercury	PSD	Solids	TOC	Comments
8542-12	DUD250	0-3 ft	X	X	X	X	X	X	X	
8542-13	DUD251	0-3 ft	X	X	X	X	X	X	X	
8542-14	DUD251	3-6 ft	X	X	X	X	X	X	X	
8542-15	DUD252	0-3 ft	X	X	X	X	X	X	X	
8542-16	DUD252	3-6 ft	X	X	X	X	X	X	X	
8542-17	DUD253	0-3 ft	X	X	X	X	X	X	X	
8542-18	DUD253	3-6 ft	X	X	X	X	X	X	X	
8542-19	DUD254	0-3 ft	X	X	X	X	X	X	X	
8542-20	DUD254	3-6 ft	X	X	X	X	X	X	X	
8542-21	DUD255	0-3 ft	X	X	X	X	X	X	X	
8542-22	DUD255	3-6 ft	X	X	X	X	X	X	X	
8542-23	DUD255	0-3 ft	X	X	X	X	X	X	X	replicate
8542-24	DUD256	0-3 ft	X	X	X	X	X	X	X	
8542-25	DUD256	3-6 ft	X	X	X	X	X	X	X	
8542-26	DUD257	0-3 ft	X	X	X	X	X	X	X	
8542-27	DUD258	0-3 ft	X	X	X	X	X	X	X	
8542-28	DUD259	0-3 ft	X	X	X	X	X	X	X	intertidal
8542-29	DUD260	0-3 ft	X	X	X	X	X	X	X	
8542-30	DUD260	3-6 ft	X	X	X	X	X	X	X	
8542-31	DUD261	0-3 ft	X	X	X	X	X	X	X	
8542-32	DUD261	3-6 ft	X	X	X	X	X	X	X	
8542-33	DUD012	0-3 ft	X	X	X	X	X	X	X	
8542-34	DUD012	3-6 ft	X	X	X	X	X	X	X	
8542-35	DUD027	0-3 ft	X	X	X	X	X	X	X	
8542-36	DUD027	3-6 ft	X	X	X	X	X	X	X	
8542-37	DUD027	0-3 ft	X	X	X	X	X	X	X	replicate
8542-38	DUD027	3-6 ft	X	X	X	X	X	X	X	replicate
8542-39	DUD255	3-6 ft	X	X	X	X	X	X	X	replicate

Duwamish/Diagonal CSO Outfall Sediment Cleanup Study
Phase II Sample Inventory (Marine Sediment Grabs and Cores)

Sample	Locator	PSD	Solids	Metals	BNAs	PCBs	Comments
9443-1	DUD200	X	X	X	X	X	Sediment Grab
9443-2	DUD201	X	X	X	X	X	Sediment Grab
9443-3	DUD202	X	X	X	X	X	Sediment Grab
9443-4	DUD203	X	X	X	X	X	Sediment Grab
9443-5	DUD204	X	X	X	X	X	Sediment Grab
9553-6	DUD205	X	X	X	X	X	Sediment Grab
9443-7	DUD206	X	X	X	X	X	Sediment Grab
8542-8	DUD207	X	X	X	X	X	Sediment Grab
8542-9	DUD208	X	X	X	X	X	Sediment Grab
8542-10	DUD209	X	X	X	X	X	Sediment Grab
9443-8	DUD202	X	X	X	X	X	Sediment Grab (Field Replicate)
9446-1	Carr Inlet	X	X	X	X	X	Carr Inlet Reference-High % Fines
9446-2	Carr Inlet	X	X	X	X	X	Carr Inlet Reference-High % Fines
9142-1	DUD254	X	X	X	X	X	Sediment Core 6-9 feet
9142-2	DUD027	X	X	X	X	X	Sediment Core 6-9 feet
9142-3	DUD027	X	X	X	X	X	Core 6-9 feet (Field Replicate)

Appendix L
Laboratory QA1 Reports - Chemistry and Bioassay

Chemistry Review

METRO ENVIRONMENTAL LABORATORY

QUALITY ASSURANCE REVIEW

for PHASE 1

DUWAMISH/DIAGONAL SEDIMENT CLEANUP STUDY
ELLIOTT BAY DUWAMISH RESTORATION PROGRAM

December 23, 1994

Metro Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

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METRO Environmental Laboratory Quality Assurance Review

INTRODUCTION

This QA review accompanies data submitted for the Duwamish Diagonal Sampling and Analysis Project. This project is a part of the Elliot Bay/Duwamish Restoration Program. This QA review is organized into the following sections, as follows:

- General Comments
- Conventionals
- Metals
- Organics
- Bioassay

An overview of the approach used for this QA review is detailed in the *General Comments* section which follows. Additional comments specific to each analysis are included in the appropriate section for that analysis.

This QA1 review has been conducted in accordance with guidelines established thorough the PSDDA program, primarily in the *Puget Sound Dredged Disposal Analysis Guidance Manual, Data Quality Evaluation for Proposed Dredged Material Disposal Projects*. Many of the approaches incorporated in this QA1 review have been established through collaboration between METRO and the Washington Department of Ecology Sediment Management Unit. Additionally, this data generation activity is conducted under the guidance of a project specific Sampling and Analysis Plan (SAP). Protocols used and achieved method performance are compared to the guidelines and criteria specified in the project SAP.

GENERAL COMMENTS

SCOPE OF SAMPLES SUBMITTED

This Quality Assurance Review is associated with marine sediment samples taken from August 9, 1994 to August 25, 1994. These samples were taken in support of the Duwamish Diagonal Sampling and Analysis project. Except where noted in the subcontracting sections of this QA review, all analyses have been conducted at the METRO Environmental Laboratory. The data are reported with associated data qualifiers and have undergone QA1 review, as summarized in this narrative report.

COMPLETENESS

Completeness has been evaluated for this data submission and QA review by considering the following criteria:

- Comparing available data with the planned project analytical scheme.
- Compliance with storage conditions, preservation requirements and hold times.
- A complete set of QC samples should be associated with each analysis.

Instances where these conditions are not met are noted in the appropriate section of this narrative. Two cores were taken, in accordance with the project SAP. Eight of nine proposed samples were taken from one of these cores, due to the slightly short core sample depth obtained. This woiuld have been sample 4378-11.

METHODS

Methods are noted in the appropriate sections of this QA review.

TARGET LIST

The reported target list has been compared to both the substances listed on the *Sediment Quality Standards-Chemical Criteria* and the project SAP to ensure that all applicable parameters have been analyzed, reported and included in this QA review.

Note that trubutyl tin and methyl mercury are included in the organics section of this QA review.

DETECTION LIMITS

Achieved detection limits have been compared to both the *Sediment Quality Standards-Chemical Criteria* and the approach and criteria specified in the project SAP to ensure that reported detection limits are sufficient to compare the reported data to the criteria values. This comparison is summarized in the appropriate sections of this report.

The METRO lab distinguishes between the Method Detection Limit (MDL) and the Reporting Detection Limit (RDL).

- The RDL is defined as the *minimum concentration of a constituent that can be reliably quantified.*
- The MDL is defined as *the minimum concentration of a constituent that can be detected.*

Some subcontractor data is available with an MDL only, in accordance with the subcontracting lab policies. All analytical data is reported with either a result or a detection limit.

HOLDING CONDITIONS AND TIMES

Holding conditions and times have been evaluated using criteria specified in the project SAP. These criteria are generally based on guidelines established during the *Third Annual PSDDA Review Meeting*.

METHOD BLANK

Method blanks have been evaluated for the presence of positive results at or greater than the MDL. These instances and the qualification of the associated data are noted in the appropriate section.

STANDARD REFERENCE MATERIAL

Data have been qualified based on available SRM results. Instances of data reported without associated SRM analysis are noted in the narrative.

REPLICATES

Data have been qualified based on replicate results. However, not all replicate data have been used as an indicator for data qualification. Only sets of replicate results which contain at least one result significantly greater than the MDL have been considered for data qualification. Where an RDL is present, only replicate data that contains at least one result greater than the RDL have been considered for data qualification. These guidelines have been used to account for the fact that precision obtained near the MDL is not representative of precision obtained throughout the entire analytical range.

MATRIX SPIKES

Matrix spikes have been used to qualify data for both organics and metals data. Matrix spikes are not required for conventionals parameters.

DATA QUALIFIERS

The data qualification system used for this data submission is listed in Table 3 of this QA review. This system is based on the criteria specified in the project SAP. These data qualifiers address situations which require qualification, according to QA1 guidance. The exact qualifiers used generally conform to QA1 guidance. METRO qualifiers indicating *<MDL* and *<RDL* have been used as replacements for the *T* and *U* specified under QA1 guidance.

Note that several minor modifications have been made to the qualification system proposed in the project SAP. These changes have been made to increase the consistency of approach to data qualification. These changes are discussed further in the conventionals and organics sections of this QA review.

Note that changes made to the SRM data qualification criteria have been discussed with and approved by the Sediment Management Unit of the WA DOE.

UNITS AND SIGNIFICANT FIGURES

Data have been reported in accordance with lab policy at the time of data generation. When an RDL and MDL are reported, data have been reported to three significant figures above the RDL, and two significant figures equal to or below the RDL. Data with only an MDL have been reported to two significant figures.

All inorganic analytical results are reported in mg/Kg on a dry weight basis, whereas organic results are in ug/Kg on a dry weight basis.

Data is stored in a wet weight basis on the data base and converted to dry weight during the reporting process. Should only one reported digit is available, rounding error can be significant. This rounding error can occur during the conversion from wet to dry weight.

Subcontractor data handling procedures are also discussed in this section of the QA review.

SUBCONTRACTING

Analysis which have been subcontracted, and the issues associated with these subcontracted analyses are noted in this narrative. Note that the following parameters have always been submitted to a subcontractor for analysis:

- particle size distribution
- tributyl tin
- methyl mercury
- acid volatile sulfides
- bioassay

AQUATIC TOXICOLOGY

COMPLETENESS

Data have been evaluated for completeness and those comments are noted below. Data are reported for all bioassay samples listed in Table 1. A summary of the bioassay tests conducted is included below. All samples proposed in the project SAP have been analyzed.

NUMBER OF SAMPLES SUBMITTED

PARAMETER	TEST SEDIMENTS	REFERENCE SEDIMENTS	NEGATIVE CONTROLS	REFERENCE TOXICANT
Amphipod (*Rhepoxynius abronius*) 10 day mortality test	12	2	1	$CdCl_2$
Echinoderm (*Dendraster excentricus*) larval mortality/abnormality test	12	2	1	$CdCl_2$
Polychaete (*Neanthes sp.*) 20 day growth test	12	2	1	$CdCl_2$

Dissolved oxygen, pH, salinity, and temperature were measured every 3 days, in accordance with PSEP. The Sampling and Analysis Plan specified daily testing for these parameters in support of the polychaete test. The Day 0 pH was not measured for the polychaete test.

METHODS

Sample collection and analysis was conducted in accordance with current Puget Sound Estuary Program (PSEP) protocols and the Sediment Management Standards (SMS) WAC 173-204-315(2). In addition, these activities have been conducted in accordance with the project SAP. The methods used are cited below:

Test Organisms	Test Type	PSEP 1994
Amphipod (*Rhepoxynius abronius*)	10-day mortality	pp. 20-29
Echinoderm (*Dendraster excentricus*)	mortality/abnormality	pp. 39-47
Polychaete (*Neanthes* sp.)	20-day growth	pp. 63-76

HOLDING CONDITIONS AND TIMES

Sample storage conditions have been evaluated using criteria specified in the project SAP. The conditions are based on PSEP protocols. The criteria used to evaluate storage conditions for these analyses are listed in the table below.

Parameter	Hold time: Refrigerated (4°C, dark)	Sample Size	Container
Amphipod (*Rhepoxynius abronius*) 10 day mortality test	14 days	3L	Polyethylene Bag
Echinoderm (*Dendraster excentricus*) larval mortality/abnormality test	14 days	1L	Polyethylene Bag
Polychaete (*Neanthes* sp.) 20 day growth test	14 days	3L	Polyethylene Bag
West Beach (neg. control)	14 days	5L	Glass

All sediment storage conditions for each species tested met the above criteria for sample storage.

NEGATIVE CONTROLS

West Beach Sand was collected for use as a negative control for both the polychaete and amphipod bioassays, as specified in the project SAP. As noted in the project SAP, sea

water was used for the negative control for the echinoderm test. Performance criteria were met and the data are acceptable for use, based on the performance of these negative controls. Achieved performance criteria are summarized below:

NEGATIVE CONTROLS

BIOASSAY TEST	NEGATIVE CONTROL SAMPLE	# OF REPLICATES	CRITERIA FOR USE	ACTUAL % SURVIVAL	ACCEPTABLE FOR USE
Polychaete (*Neanthes* sp.) 20 day growth test	West Beach	5	90 % survival	100 %	yes
Amphipod (*Rhepoxynius abronius*) 10 day mortality test	West Beach	5	90 % survival	92 %	yes
Echinoderm (*Dendraster excentricus*) larval mortality/abnormality test	Sea Water	5	50 % survival	75.4 %	yes

Note that for the echinoderm test, the final density was 18.5 embryos/mL.

REFERENCE SEDIMENT

In accordance with the project SAP, reference sediment from Carr Inlet was collected for the polychaete and amphipod bioassays. The following table summarizes reference sediments collected for this study:

LOCATION	SAMPLE #
Carr Inlet	4378-01, 02

Criteria for use were not met for the polychaete bioassay. For the polychaete test, the West Beach negative control sample was also used for the reference sediment. Achieved performance criteria are summarized below:

REFERENCE SEDIMENT

BIOASSAY TEST	REFERENCE SAMPLE	# OF REPLICATES	CRITERIA FOR USE	ACTUAL PERFORMANCE	ACCEPTABLE FOR USE
Polychaete (*Neanthes* sp.) 20 day growth test	4378-01	5	> 8.83 mg weight gain*	5.24 mg	no
Polychaete (*Neanthes* sp.) 20 day growth test	4378-02	5	> 8.83 mg weight gain*	6.61 mg	no
Amphipod (*Rhepoxynius abronius*) 10 day mortality test	4378-01	5	75 % survival	92 % survival	yes
Amphipod (*Rhepoxynius abronius*) 10 day mortality test	4378-02	5	75 % survival	96 % survival	yes
Echinoderm (*Dendraster excentricus*) larval mortality/abnormality test	4378-01	5	NA	NA	NA
Echinoderm (*Dendraster excentricus*) larval mortality/abnormality test	4378-02	5	NA	NA	NA

* represents 80% of the weight gain of the negative control, which gained 11.04 mg.

Analysis of the sea water used in the bioassay tests showed no organic (pesticides, PCB's, volatiles, or semi-volatiles), metals (Sb, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Se, Ag, Tl, Zn), total cyanide, or total phenol contamination.

For the Echinoderm larval mortality/abnormality test the reference sediment was used in the statistical evaluation of the test sediments.

POSITIVE CONTROLS

Clean sea water was spiked with $CdCl_2$ in a geometric dilution series providing a series of positive controls which were tested concurrently with each test performed on the test sediments. The design of this study is an accordance with the SAP. However, no LC50 was calculated for the positive control test performed with the echinoderms due to low mortality at the highest concentration. Positive control data is summarized below:

AMPHIPOD

$CdCl_2$ Exposure Conc.	Total Mortalities	Calculated LC 50
0.0 mg/L	2	0.95 mg/L
0.01 mg/L	4	
0.1 mg/L	6	
1.0 mg/L	17	
10.0 mg/L	40	
100.0 mg/L	40	

POLYCHAETE

$CdCl_2$ Exposure Conc.	Total Mortalities	Calculated LC 50
0.0 mg/L	0	39.8 mg/L
0.01 mg/L	1	
0.1 mg/L	0	
1.0 mg/L	0	
10.0 mg/L	2	
100.0 mg/L	7	

ECHINODERM

$CdCl_2$ Exposure Conc.	Total Mortalities	Calculated LC 50
0.0 mg/L	0	Could not be calculated
0.01 mg/L	15	
0.1 mg/L	0	
1.0 mg/L	0	
10.0 mg/L	0	
100.0 mg/L	9	

NOTE: Each treatment was done in replicate. Total mortalities for the two replicates are shown above.

In accordance with the SAP, $CdCl_2$ concentration was not verified by chemical testing.

REPLICATES

5 replicates were tested for each sediment with each organism.

DATA REDUCTION AND INTERPRETATION

Water Quality

The average, standard deviation and coefficient of variation were calculated for each water quality measurement of Temperature, DO., pH, Salinity, Ammonia and Sulfides. This information is included in the data report provided by the subcontractor.

The following table summarizes acceptability ranges for water quality parameters for this study (based on PSSDA guidelines, except as noted):

PARAMETER	AMPHIPOD	ECHINODERM	POLYCHAETE
Dissolved Oxygen	>5 mg/l	>4 mg/l	N/A
Temperature	15 ± 1 °C	15 ± 1 °C *	N/A
pH	8 ± 1	8 ± 1	N/A
Salinity	28 ± 1 °/oo	28 ± 1 °/oo *	N/A
Ammonia	N/A	N/A	N/A
Sulfides	N/A	N/A	N/A

*PSEP limits

Exceedances are noted in the tables below:

TEMPERATURE EXCEEDANCES

PARAMETER	AMPHIPOD	ECHINODERM	POLYCHAETE
Temp <14 °C	NONE	NONE	N/A
Temp >16 °C	NONE	4288-38, Day 1 (16.1°C)	N/A

AMPHIPOD SALINITY EXCEEDANCES

Sample #	Day	Exceedances
4288-35	2-4, 6-8, 10	salinity above 29 °/oo
4288-32	0, 2-9	salinity above 29 °/oo
4288-31	0, 2, 3, 6, 7, 8	salinity above 29 °/oo
4288-38	0, 2-8	salinity above 29 °/oo
4288-34	0, 2-8	salinity above 29 °/oo
4288-33	0, 2-8	salinity above 29 °/oo
4288-36	0, 2-9	salinity above 29 °/oo
4288-40	0, 2-9	salinity above 29 °/oo
4288-39	0, 2, 5-8	salinity above 29 °/oo
4288-30	0, 2, 3, 5-8	salinity above 29 °/oo
4288-41	0, 2, 3, 5-9	salinity above 29 °/oo
4288-37	0, 2, 3, 5-9	salinity above 29 °/oo
4378-01	0, 2-8	salinity above 29 °/oo
4378-02	0, 2-9	salinity above 29 °/oo
W. Beach	0, 2, 3, 5-9	salinity above 29 °/oo

ECHINODERM SALINITY EXCEEDANCE

Sample #	Day	Exceedance
4288-34	2	salinity above 29°/oo
4288-33	2	salinity above 29°/oo
4288-36	2	salinity above 29°/oo
4288-40	2	salinity above 29°/oo

Comment	Amphipods	Echinoderm	Polychaete
pH exceedance of 8 ± 1	4288-35 Day 1 4288-41 Day 0 Above were <7	NONE	N/A

Comment	Amphipods	Echinoderm	Polychaete
Dissolved Oxygen exceedance ≤5 mg/L (amphipods) <4 mg/L (echinoderms)	4288-35, Day 0 4378-01, Day 2	NONE	N/A

Amphipod
Tables of daily counts of individuals emerged from sediments and percent surviving at day 10 were reported for each sediment.

Polychaete
The average, STD, VAR, COV for larval weights, average larval survivorship and t-test value compared to the reference or control sediment were reported in tabular form for each sediment tested.

Echinoderm
The number of abnormal and normal larvae, percent survival and mortality including the average, STD and COV for each of these parameters and the t-test value when compared to the reference sediment were tabulated in the report.

NOTE: Data was reported in tabular form in Lotus and Excel electronic formats. A hardcopy was also provided.

SUBCONTRACTING

All bioassay samples were subcontracted to Beak Consultants, Inc. Beak Consultants, Inc. collected the Echinoderm and Amphipod organisms in addition to the negative control sediments (West Beach Sand). Beak Consultants also conducted the sediment toxicity testing. Reference samples were collected by METRO personnel.

Juvenile polychaete (*Neanthes* sp.) were purchased from Dr. Don Reisch, California State University, Long Beach.

CONVENTIONALS

COMPLETENESS

Results for all requested analytical parameters are included in this report. Data are reported for all parameters as listed in Table 1. All samples are associated with a complete set of QC samples, as defined in the project SAP.

Note that a partial target list has been reported for three Particle Size Distribution (PSD) samples. This is discussed further in the *Methods* section of this QA review.

SUBCONTRACTING

Acid Volatile Sulfide (AVS) and PSD analyses were subcontracted to AmTest, Inc. in Redmond, Washington. Interstitial salinity was determined by Beak Consultants, Inc. in Kirkland, Washington. Interstitial salinity analysis was conducted as part of bioassay testing.

METHODS

Total Organic Carbon (TOC) was analyzed using Puget Sound Estuary Program (PSEP) protocols (page 23) for preparation and EPA Method SW 9060 for analysis. Please note that the *Method Code* on the analytical reports refers to Standard Method (SM) 5310-B. Methods SM 5310-B and SW 9060 are equivalent. SM 2540 was used for analysis of Percent Solids (TOTS). AVS samples were analyzed using EPA (December, 1991) and PSEP methodologies. A Spartan A366ATC refractometer was used in the determination of interstitial salinity.

PSEP (page 9) methodology was used to perform PSD analyses. Matrix interferences caused falsely elevated results for some samples during the hydrometer portion of the PSD analysis. An optional hydrogen peroxide digestion treatment (as referenced in PSEP) was used on these samples to minimize matrix interferences (see attached report from AmTest). The samples listed below were analyzed for PSD using the hydrogen peroxide digestion option.

PSD Samples Analyzed Using the Hydrogen Peroxide Option

L4288-1	L4288-19	L4288-25	L4288-40
L4288-12	L4288-2	L4288-26	L4288-9
L4288-14	L4288-20	L4288-3	L4378-12
L4288-15	L4288-21	L4288-30	L4378-13
L4288-16	L4288-22	L4288-35	L4378-14
L4288-17	L4288-23	L4288-36	L4378-15
L4288-18	L4288-24	L4288-39	L4378-17

Difficulties were encountered during the PSD analysis for samples L4288-27, L4288-34, and L4288-37. Sufficient sample was not available to reanalyze with the hydrogen peroxide digestion option, therefore, the data reported are for the sieve portion of the analysis only.

The methods used for conventional analyses are in agreement with the project SAP. The hydrogen peroxide option was not included in the project SAP but was employed to address analytical difficulties.

TARGET LIST

The reported phi size target list for particle size distribution corresponds to data obtained from the subcontracting laboratory. As noted above, a partial list has been reported for three samples. Note the definition of the following reported phi sizes:

REPORTED PHI SIZE	DEFINITION
p-2.25	larger than p-2.00
p+11.0	smaller than p+10.0

DETECTION LIMITS

Positive results have been reported for all TOTS ,TOC, and interstitial salinity analyses. A positive result or Method Detection Limit (MDL) has been reported for each PSD and AVS analysis as provided by the subcontracting laboratory.

Note that the MDL for both TOC and AVS exceed the SAP-defined detection limits. All TOC results exceed the the reported MDL, therefore, the effect of the higher MDL on these data is non-existent. AVS results were less than the MDL for 3 samples.

HOLDING CONDITIONS AND TIMES

Grab samples analyzed for TOTS and TOC were stored frozen. Grab samples analyzed for AVS, PSD and interstitial salinity were stored refrigerated. Core samples were split one day after collection. The split samples for TOC and TOTS were stored frozen. The split samples for PSD, AVS and interstitial salinity were stored refrigerated.

All analyses for AVS, PSD, TOC and TOTS were completed within the method holding times specified in the project SAP. No holding time was specified for the analysis of interstitial salinity. Samples collected for interstitial salinity were analyzed prior to bioassay analysis. Criteria used to assess holding times are listed in the table below.

PARAMETER	STORAGE CONDITION	HOLDING TIME
Acid Volatile Sulfides	Refrigerate at 4° C	7 Days
Interstitial Salinity	Refrigerate at 4° C	Not Specified
Patricle Size Distribution	Refrigerate at 4° C	6 Months
Percent Solids	Freeze at -18° C	6 Months
Total Organic Carbon	Freeze at -18° C	6 Months

METHOD BLANK

Six method blank analyses have been reported for TOC. There is no indication of positive bias in the method blank results and TOC data have not been qualified. Five blank analyses have been reported for TOTS with no apparent positive bias and TOTS data have not been qualified.

One method blank analysis has been reported for AVS. The method blank results, as well as additional available raw data, indicate that method contamination has not contributed any apparent positive bias to the reported results for this parameter and results were not qualified.

STANDARD REFERENCE MATERIAL

Seven SRM samples have been reported in association with TOC samples. All results were within the acceptable QC range and associated TOC data were not qualified. Note that an acceptance window of 80% to 120% has been used for SRM data qualification. A 95 % confidence acceptability window was proposed in the project SAP. For TOC, this corresponds to an acceptability range of approximately 99.5% to 100.5% recovery. The 80% to 120% acceptance window has been approved by the WA DOE Sediment Management Unit and provides additional consistency to the data qualification process as well as achievable performance criteria.

REPLICATES

Four triplicate samples for TOC analysis have been included in the data submission. The percent relative standard deviations (%RSD) were within the acceptable QC range and TOC data were not qualified.

Five triplicate samples for TOTS analysis have been included in the data submission. The %RSD were within the acceptable QC range and TOTS data were not qualified.

Five triplicate samples for PSD analysis have been included in the data submission. The %RSD for a number of phi sizes were outside the acceptable QC range. Poor precision was observed throughout the phi size range without a consistent pattern. All PSD data were qualified as estimated ("E").

Seven triplicate samples for AVS analysis have been included in the data submission. The %RSD were within the acceptable QC range for five triplicates and outside the acceptable QC range for two triplicates. In many cases, the sample triplicates were analyzed from two different sample containers collected for the same sample. It appears that some of the variability may be associated with sample containers and may not be entirely due to analytical performance (see attached subcontractor note). All AVS data were qualified as estimated ("E").

UNITS AND SIGNIFICANT FIGURES

Data are reported in accordance with laboratory policy (Metro or subcontractor) at the time of data generation. Data from subcontractor laboratories have been reported in two significant figures. Interstitial salinity results have been reported in parts per thousand (ppt).

METALS

COMPLETENESS

Data are reported for all samples as listed in Table 1. These data have been evaluated for completeness, and those comments are noted below.

All metal samples reported in this data submission have been analyzed in association with a complete set of Quality Control Samples, as specified in the Project SAP. Note that the replicate and matrix spike analysis associated with samples L4378-3 through L4378-10 and samples L4378-12 through L4378-17 have been conducted on samples that are not a part of this data submission. These samples are marine sediments and should effectively indicate assignment of data qualifiers.

METHODS

The descriptive heading information "M.Code=" on the data report associates the elements in this data set with the specific method used for trace metals determination. The methods employed for analysis are in accordance with the methods specified in the project SAP. The methods and their associated *M. CODE* used for the analysis of trace metals in this data set are listed in the table below .

Listing of Metals Methods

M.CODE	METHOD
PE	EPA Method 3050/6010
CV	EPA Method 7471

TARGET LIST

The metals reported target list includes all metals specified in the project SAP and contains all *Sediment Quality Standards-Chemical Criteria* metals for all samples. Additional metals have been reported as available.

DETECTION LIMITS

A positive result, MDL and RDL have been reported for all metals. All reported detection limits for metals analysis are below *Sediment Quality Standards-Chemical Criteria* for metals. Detection limits are compliant with those specified in the project SAP.

Note that when sample percent solids is less that 50 % the reported MDL/RDL may exceed the SAP specified MDL/RDL. This is consistent with the method of MDL/RDL calculation as noted in the SAP. The SAP MDL/RDL are based on 50% solids.

HOLDING CONDITIONS AND TIMES

Sample storage conditions have been evaluated using guidelines established during the *Third Annual PSDDA Review Meeting*. The criteria used to evaluate storage conditions for these analyses are listed in the table below. Samples were stored frozen for this project. Sample storage conditions were complaint for all metals samples in this data submission.

Metals Storage Conditions

PARAMETER	FROZEN HOLD TIME	REFRIGERATED HOLD TIME
metals	2 years	6 months
mercury	28 days	not recommended

METHOD BLANK

Method blank contamination was not a factor affecting data quality. All method blank results were below the MDL.

Metals results are not corrected for the concentrations of metals determined in the method blanks.

STANDARD REFERENCE MATERIAL

The reference materials analyzed in association with reported METRO analytical results are listed below:

SRM	Comment
NR CC-PACS 1	does not contain silver

SRM Recovery of less than 80% has not been used as an indicator to qualify associated data. This is due to the fact that the digestion technique used for the reported samples is different from the one used to determine the SRM certified values.

SRM recovery of less than 80% and concurrent/compliant matrix spike recovery of greater than 75% was observed for the following elements: Cd, Cr, Mn and Ni. In accordance with qualification criteria outlined in this section and Table 2, associated data were not qualified.

SRM recovery of less than 50% was observed for Cd, Cr and Sb. Instances where the SRM recovery is below 50% are noted in the table below:

AFFECTED SAMPLES	SRM RECOVERY	MATRIX SPIKE RECOVERY
L4288-1 to L4288-20	Cd = 0% Sb = 33%	Cd = 95% Sb = 25%
L4288-21 to L4288-31	Sb = 35%	Sb = 20%
L4288-32 to L4288-41	Cd = 0% Cr = 49% Sb = 29%	Cd = 94% Cr = 102% Sb = 33%
L4378-3 to L4378-10 L4378-12 to L4378-17	Cd = 0% Cr = 49% Sb = 26%	Cd = 96% Cr = 110% Sb = 37%

Note that the low Cadmium recovery is a function of METRO reporting convention. The concentration of this metal in the SRM is very close to the METRO MDL. Lab data handling procedures result in the 0 % recovery when the SRM result is below the MDL.

REPLICATES

In general, reported RPD's for replicate samples included in this QA review are compliant and have not resulted in data qualification. Data associated with replicate RPD of greater than 20% have been qualified with the data qualifier "E".

Notable RPD, or those RPD greater than 35%, are listed in the table below. This table includes only those replicate samples where at least one value is significantly greater than the reported MDL. The high RPD for samples L4378-3 to L4378-10 and L4378-12 to L4378-17 can be attributed to the observed difficulty is obtaining a homogeneous sub sample from these samples.

AFFECTED SAMPLES	COMMENT
L4288-32 to L4288-41	high RPD values reported for Ca
L4378-3 to L4378-10 L4378-12 to L4378-17	high RPD values reported for As, Cu, Pb

MATRIX SPIKES

Note that matrix spike recoveries have also been included in the SRM recovery discussion.

Data associated with matrix spike recoveries which have not met the 75% to 125% criteria have been qualified with either the "G" or "L" flag, whichever is appropriate. Poor spike recoveries for sample L4378-3 to L4378-10 and L4378-12 to L4378-17 can be attributed to the observed difficulty is obtaining a homogeneous sub sample from these samples.

Matrix spike recoveries of note are listed in the Table below:

SAMPLES	COMMENT
L4288-1 to L4288-20	Sb = 25% matrix spike, qualified with G
L4288-21 to L4288-31	Sb = 20% matrix spike, qualified with G Zn = 69% matrix spike, qualified with G
L4288-32 to L4288-41	Sb = 33% matrix spike, qualified with G
L4278-3 to L4378-10 L4378-12 to L4378-17	Cu = 54% matrix spike, qualified with G Pb = 137% matrix spike, qualified with L Sb = 37% matrix spike, qualified with G Zn = 0% matrix spike, qualified with G

UNITS AND SIGNIFICANT FIGURES

Data are reported in accordance with lab policy at the time of data generation. Metals sample results are reported in units of mg/Kg on a dry weight basis. Date are reported to three significant figures above the RDL and two significant figures when equal to or below the RDL.

Note that quality control samples such as spikes, duplicates and SRM material are reported in units of mg/L. This does not indicate that these quality control samples were performed on a water matrix. Rather, sufficient information was available in the reported format (mg/L) to calculate information such as percent recoveries and qualify the data as needed. Because sufficient information was available to qualify the data, the data has not been calculated on a soil basis. Based on method dilution factors, the reported data may be converted to a soil

basis by multiplying by a factor of 50. This calculation assumes a typical sample size of 1 gram wet weight and a final volume of 50 mL.

ORGANICS

COMPLETENESS

Data are reported for all parameters listed in Table 1. These data have been evaluated for completeness, and those comments are noted below.

As an element of this completeness assessment, available QC samples have been compared to the QC specified in the project SAP. The project SAP specified QC is summarized in the table below:

PARAMETER	BLANK	REPLICATE	TRIPLICATE	MATRIX SPIKE	CRM	SURROGATES
BNA	1 per batch	5% minimum, 1/extraction batch	1/batch of > 20 samples	5% minimum, 1/extraction batch	1 per extraction batch	yes
Pest/PCB	1 per batch	5% minimum, 1/extraction batch	1/batch of > 20 samples	5% minimum, 1/extraction batch	1 per extraction batch	yes
methyl mercury	1 per batch	1 per 20 samples	1 per 20 samples	NA	yes	NA
tributyl tin	1 per batch	NA	NA	MS/MSD per batch	1 blank spike per batch	yes

A summary of the QC completeness assessment for BNA and pesticides/PCB is included below.

Organics QC Summary

SAMPLE NUMBER	BNA QC	PEST/ PCB QC	SAMPLE NUMBER	BNA QC	PEST/ PCB QC	SAMPLE NUMBER	BNA QC	PEST/ PCB QC
4288-1	**	***	4288-20	**	***	4288-39	**	**
4288-2	**	***	4288-21	***	***	4288-40	**	**
4288-3	***	***	4288-22	***	***	4288-41	**	**
4288-4	**	**	4288-23	***	***	4378-3	*	*
4288-5	***	***	4288-24	***	***	4378-4	*	*
4288-6	***	***	4288-25	**	***	4378-5	*	*
4288-7	***	***	4288-26	**	***	4378-6	*	*
4288-8	***	***	4288-27	**	***	4378-7	*	*
4288-9	**	**	4288-28	**	**	4378-8	*	*
4288-10	**	**	4288-29	***	***	4378-9	*	*
4288-11	***	***	4288-30	**	**	4378-10	*	*
4288-12	**	***	4288-31	**	***	4378-12	*	*
4288-13	**	***	4288-32	**	**	4378-13	*	*
4288-14	**	***	4288-33	**	***	4378-14	*	*
4288-15	***	***	4288-34	**	**	4378-15	*	*
4288-16	***	***	4288-35	**	**	4378-16	*	*
4288-17	**	**	4288-36	**	**	4378-17	*	*
4288-18	**	***	4288-37	**	**	none	NA	NA
4288-19	**	**	4288-38	**	**	none	NA	NA

* analyzed with as blank, replicate, matrix spike
** analyzed with a blank, matrix spike, matrix spike duplicate and SRM
*** analyzed with a blank, matrix spike, matrix spike duplicate

A detailed discussion of the QC samples used for data qualification is included in the qualification section of this QA review. This discussion addresses qualification of BNA, pesticide/PCB, methyl mercury and butyl tins.

Reported QC for the tributyl tin analyses is compliant with the QC specified in the project SAP.

Note that available methyl mercury QC differs slightly from that specified in the project SAP. However, sufficient information is available to effectively qualify the data.

A total of 21 samples were submitted to the subcontractor for methyl mercury analysis. These 21 samples were from either the Duwamish Diagonal (this QA review) or the Norfolk site. For purposes of QC batching all of the samples were grouped together. This QC completeness assessment is also conducted grouping all of the samples together. Note that two replicates and a matrix spike (not required) using site specific samples have been reported.

For the 21 samples, two replicates and three SRM are reported, complying with the SAP. A single triplicate is reported, though two would be expected for 21 samples. A total of four method blanks have been reported.

Hold time assessment is an additional element of completeness assessment. Extracts used to determine chlorobenzenes and related compounds by ion trap GC/MS were analyzed after the SAP specified hold time.

METHODS

Analyses were performed in accordance with EPA methods SW-846, -8270 and -8080 for BNA and PEST/PCB, respectively. All BNA sample extracts were also analyzed by GC/MS utilizing ion-trap detection to meet the MDL's for chlorinated benzenes and related compounds as stated in the SAP. The methyl mercury analyses were performed according to the subcontractor's in-house methodology. All of these methodologies are in agreement with the methods specified in the project SAP.

Analysis for butyltin were performed according to the procedure described in "A Method for Analysis of Butyltin Species and Measurement of Butyltins in Sediment and English Sole Livers from Puget Sound" (Marine Environmental Research, Vol. 27, 1989, pp. 1-18). Analyses were performed substituting GC/MS for the GC/FPD instrumentation specified in both the cited method and the project SAP.

TARGET LIST

The BNA target list includes all *Sediment Quality Standards-Chemical Criteria* compounds with the exception of benzo(j)fluoranthene. Note that all three of the benzo-fluoranthene isomers elute in the same region of the chromatogram. The METRO lab organics section has verified that the analytical conditions used are sufficient to calculate a total benzo-fluoranthene result using the *b* and *k* isomers reported.

GC/MS ion-trap has been used to analyze BNA extracts for chlorobenzenes and related compounds. 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene and hexachlorobenzene have been analyzed using this technique.

Tentatively identified compounds have been reported as specified in the project SAP.

Because there are no *Sediment Quality Standards-Chemical Criteria* for pesticides, this target list has been compared to the PSDDA Chemicals of Concern list. The reported pesticides target list complies with the PSDDA pesticides of concern. It should be noted that DDT, DDE, and DDD have been reported as p,p' isomers. The reported PCB data includes Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Butyl tins have been reported as a total of the following isomers: monobutyl tin trichloride, dibutyl tin dichloride, tributyl tin chloride and tetrabutyl tin. Only positive results have been included in the butyl tin total.

DETECTION LIMITS

An MDL, RDL and analytical result have been reported for BNA and pesticides/PCB. Reported detection limits for BNA compounds are generally below *Sediment Quality Standards-Chemical Criteria* for organics. After initial analysis, all BNA sample extracts were subsequently analyzed for chlorobenzenes and related compounds by GC/MS with ion-trap detection to meet the MDL's as stated in the SAP. This approach is in agreement with the approach to organic detection limits as specified in the project SAP.

An MDL of 1.3 ug/Kg has been achieved for chlorobenzenes and related compounds. At a TOC concentration of 2920 ppm, the achieved TOC normalized detection limit exceeds the SQS for hexachlorobenzene, which has the lowest SQS TOC normalized criteria. Only samples 4288-12 and 4288-13 have TOC values below 2920 ppm.

The MDL for the methyl mercury analysis reported by Frontier Geosciences was approximately 0.005 ug/g as Hg (wet weight). This is based on a 1 gram sample, actual sample weights ranged from 0.8 to 2.2 grams. This detection limit is greater than the detection limit specified in the project SAP. However, a positive result has been reported for all samples for this parameter.

The butyltin MDL was 15 ug/Kg (wet weight), as noted by the subcontracting lab in the data narrative. Either a positive result or a MDL are reported for each of the reported butyl tin isomers. This detection limit was not met for the following samples: L4288-24, L4288-30, L4288-31, L4288-4 and L4288-11. Due to matrix interferences and chromatography problems, these samples required dilution yielding MDL of 120, 75, 75, 62 and 250 ug/Kg (wet weight), respectively.

HOLDING CONDITIONS AND TIMES

Sample storage conditions have been evaluated using guidelines established during the *Third Annual PSDDA Review Meeting*. The criteria used to evaluate storage conditions for these analyses are listed in the table below.

PARAMETER	FROZEN HOLD TIME	REFRIGERATED HOLD TIME	COMMENT
BNA	1 year	14 days	40 days to analyze
pesticides/PCB	1 year	14 days	40 days to analyze
methyl mercury	28 days	no guidance available	none
tributyl tin	1 year	14 days	40 days to analyze

BNA, pesticide/PCB, butyl tin and methyl mercury samples were stored frozen until analysis and were analyzed within the SAP specified hold times. Subsequent analyses by GC/MS with ion-trap detection for chlorinated benzenes in the BNA fraction were all performed beyond the 40 day analysis hold time. All chlorobenzenes and related compounds are qualified with the data qualifier *E*.

METHOD BLANK

Where method blank contamination was detected all samples associated with that extraction batch were qualified with "B" for the contaminant(s) detected. This comment applies to the BNA, pesticide/PCB data and to the tributyl tin data.

No contaminants were detected in any PEST/PCB method blanks.

The BNA compounds di-N-butyl phthalate, benzyl butyl phthalate and bis(2-ethylhexyl)phthalate were detected in at least one method blank.

No contaminants were detected in any method blanks associated with the butyltin analyses.

Recoveries of less than 16% were obtained for all surrogates in the method blank associated with one BNA extraction batch (work group 13749). All compounds detected in all BNA blanks for this data submission [di-N-butyl phthalate, benzyl butyl phthalate and bis(2-ethylhexyl)phthalate] are qualified with the data qualifier *B* in samples associated with this method blank.

A positive result is reported in the methyl mercury data for the blanks associated with these data. The subcontracting lab standard operating procedures are to average blank data and to subtract the response (as a mass) from the sample data. The data reported for this project have been calculated in this manner. Note that all methyl mercury samples from this site exceed the blank concentration by approximately an order of magnitude or greater.

1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, have been detected in at least one method blank and associated data are qualified with a *B*. This contamination is below the RDL but above the MDL.

STANDARD REFERENCE MATERIAL

The marine sediment reference materials analyzed in association with reported analytical results are listed below:

ANALYSIS	SRM	COMMENT
BNA	HS4	Certified by National Research Council of Canada
Pesticides/PCB	HS4	Certified by National Research Council of Canada
Methyl mercury	IAEA	International Atomic Energy Association

Compounds outside of the acceptance window of 80% to 120 % recovery are qualified in the associated data. Note that HS 4 contains a partial list of the target compounds for both BNA and pesticide/PCB.

Note that benzo(b)fluoranthene has not been qualified for SRM recovery. The METRO procedures for this compound provide an accurate sum for total benzofluoranthenes, but are

not designed to yield accurate results for each isomer. This is also discussed in the target list section of this QA review.

REPLICATES

As discussed in the data qualification section of this QA review, data are qualified based on the calculated RPD of either a replicate sample or MS/MSD samples. For three of four pesticide extraction batches, RPD are less than 100% and the data are not qualified. For the fourth batch, sample 4378-6 was analyzed in triplicate. The sample results are significantly lower for this sample than for either of the replicate samples. The surrogate recoveries are also low for this sample. The replicate samples show good agreement. Data are not qualified based on replicate RPD for this sample. However, all pesticide compounds are qualified in sample 4378-6, based on the low surrogate recoveries.

Four BNA extraction batches show good precision with only isolated instances of RPD exceeding acceptance limits of 100%. Associated data are qualified, and the instances of high RPD are summarized in the table below.

SITUATION	COMPOUND	AFFECTED SAMPLES
replicate RPD > 100 % compound qualified with E	Acenapthene not detected in one sample replicate	4378-3 to -10, -12 to -17
replicate RPD > 100 % compound qualified with E	4 nitroanaline RPD of 113 % in MS/MSD	4288-4, -9, -10, -17, -19, -28, -30, -32, -34 to -41;
replicate RPD > 100 % compound qualified with E	aniline and benzoic acid not detected in MSD, yielding high RPD	4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29

Tributyl tin and methyl mercury replicates are compliant with SAP specified acceptance limits for RPD and data are not qualified for replicate RPD for these parameters.

MATRIX SPIKES

Matrix spike recoveries have been reported for methyl mercury and are included in the appendix for this QA review. This QC sample was not required in the project SAP and data are not qualified based on matrix spike recoveries for this parameter. All recoveries have been evaluated, for information purposes, and are within the 50% to 150 % acceptance window for organic parameters.

Due to the data handling procedures used for tributyl tin (summation of reported positive butyl tin congeners) data are not qualified based on matrix spike recoveries. Recoveries outside of acceptance windows are summarized below:

Summary of Butyltin Matrix Spike Recoveries Outside Acceptance Limits

SITUATION	COMPOUNDS	SAMPLES AFFECTED
matrix spike recoveries <10%,	Monobutyltin chloride	4288-21 to -40
matrix spike recoveries <50%,	Monobutyltin trichloride	4288-1 to -20; -41
matrix spike recoveries <50%,	Dibutyltin dichloride	4288-21 to -40
matrix spike recoveries >150%,	none observed	none
matrix spike duplicate recoveries >150%,	tributyl tin, tetrabutyl tin	4288-41

Summary of PEST/PCB Matrix Spike Recoveries Outside Acceptance Limits

SITUATION	COMPOUNDS	SAMPLES AFFECTED
matrix spike recoveries <50%, compounds qualified with G	Endrin aldehyde, Endosulfan sulfate	4378-3 to -10, -12 to -17
matrix spike recoveries >150%, compounds qualified with L	Endosulfan 1, Endosulfan 2, Endrin aldehyde, Aroclor 1260	4288-4, -9, -10, -17, -19, -28, -30, -32, -34 to -41;
matrix spike recoveries >150%, compounds qualified with L	Aroclor 1260	4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29
matrix spike recoveries >150%, compounds qualified with L	Aldrin	4378-3 to -10, -12 to -17
matrix spike recoveries <10%, compounds qualified with X	Endrin Aldehyde	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33

Summary of BNA Matrix Spike Recoveries Outside Acceptance Limits

SITUATION	COMPOUNDS	SAMPLES AFFECTED
matrix spike recoveries >150%, compounds qualified with L	Di-N-Octylphthalate	4288-1 , -2, -4, -9, -10, -12 to -14, -17 to -20, -25 to -28, -30 to -41; 4378-3 to -10, -12 to -17
matrix spike recoveries >150%, compounds qualified with L	3-Nitroaniline	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33
matrix spike recoveries >150%, compounds qualified with L	1,2-Diphenylhydrazine	4378-3 to -10, -12 to -17; 4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29
matrix spike recoveries >150%, compounds qualified with L	Benzo(k)fluoranthene	4378-3 to -10, -12 to -17
matrix spike recoveries >150%, compounds qualified with L	Carbazole	4378-3 to -10, -12 to -17; 4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29
matrix spike recoveries >150%, compounds qualified with L	2,4,6-Trichlorophenol	4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29
matrix spike recoveries >150%, compounds qualified with L	4-Nitrophenol	4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29
matrix spike recoveries <50%, compound qualified with G	N-Nitrosodimethylamine; 1,3-Dichlorobenzene,	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33
matrix spike recoveries <50%, compound qualified with G	Hexachloroethane	4288-1, -2, -4, -9, -10, -12 to -14,-18 to -20, -25 to -28, -30 to -41; 4378-3 to -10, -12 to -17
matrix spike recoveries <50%, compound qualified with G	Hexachlorobutadiene	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33
matrix spike recoveries <50%, compound qualified with G	Hexachlorocyclopentadiene	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33
matrix spike recoveries <50%, compound qualified with G	Aniline	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33; 4378-3 to -10, -12 to -17
matrix spike recoveries <50%, compound qualified with G	4-Chloroaniline	4288-1 to -3, -5 to -8, -11 to -16, -18, -20 to -27, -29, -31, -33; 4378-3 to -10, -12 to -17
matrix spike recoveries <50%, compound qualified with G	Coprostanol	4288-1, -2, -12 to -14, -18, -20, -25 to -27, -31, -33
matrix spike recoveries <50%, compound qualified with G	Phenanthrene, Pyrene	4378-3 to -10, -12 to -17

Summary of BNA Matrix Spike Recoveries Outside Acceptance Limits (continued)

SITUATION	COMPOUNDS	SAMPLES AFFECTED
matrix spike recoveries <50%, compound qualified with G	Di-N-butylphthalate	4288-4, -9, -10, -17, -19, -28, -30, -32, -34 to -41; 4378-3 to -10, -12 to -17
matrix spike recoveries <50%, compound qualified with G	Benzo(ghi) perylene	4288-3 to -11, -15 to -17, -19, -21 to -24, -28 to -30, -32, -34 to -41; 4378-3 to -10, -12 to -17
matrix spike recoveries <50%, compound qualified with G	3,3'-Dichlorobenzidine	4288-4, -9, -10, -17, -19, -28, -30, -32, -34 to -41
matrix spike recoveries <50%, compound qualified with G	4-Nitroaniline	4288-3, -5 to -8, -11, -15, -16, -21 to -24, -29
matrix spike recoveries <10%, compounds qualified with X	Hexachlorocyclopentadiene	4288-3 to -11, -15 to -17, -19, -21 to -24, -28 to -30, -32, -34 to -41; 4378-3 to -10, -12 to -17
matrix spike recoveries <10%, compounds qualified with X	Benzo(a)pyrene	4378-3 to -10, -12 to -17
matrix spike recoveries <10%, compounds qualified with X	4-Nitroaniline	4378-3 to -10, -12 to -17
matrix spike recoveries <10%, compounds qualified with X	Aniline	4288-4, -9, -10, -17, -19, -28, -30, -32, -34 to -41
matrix spike recoveries <10%, compounds qualified with X	4-Chloroaniline	4288-4, -9, -10, -17, -19, -28, -30, -32, -34 to -41

Of note are matrix spike recoveries for the ion trap chlorobenzene analysis. These recoveries are generally below 50 %. All of the chlorobenzene and related compound data are qualified with the data quaifier G.

DATA QUALIFIERS

In general, data are qualified in accordance with the project SAP. In some instances, completeness issues or a perspective provided from evaluation and interpretation of the data have necessitated an approach to data qualification that differs from the project SAP. These instances are summarized in this section.

Methyl mercury data are not qualified for positive blank results. These data are corrected for an average blank response in accordance with the subcontractors data handling procedures.

Tributyl tin data are not qualified for matrix spike recovery. This is due to the data handling procedures of summing all of the reported positive butyl tins and reporting a single result. All MS/MSD RPD are within SAP specifications.

For pesticides and BNA, if a sample replicate is not available the MS/MSD RPD are used to qualify data for that analytical batch. The matrix spike recoveries have been used to qualify data, in accordance with the SAP. SRM data are used for associated data when available.

For pesticides and BNA, blank spikes are included in the QC summaries. These are for information and are not used to qualify data. Additionally, a triplicate is available for some batches. The RSD from triplicate analysis has not been used to qualify data. The sample and initial replicate RPD have been used in these cases to qualify data. In general, only RPD from either duplicate or MSD have been used to qualify data for replication of results.

An acceptance window of 80% to 120 % recovery has been used for SRM data qualification. Note that the SAP specifies a 95 % confidence window for SRM data qualification. However, the SRM analyzed is supplied with a 90% confidence window. This

acceptance window has been approved by the WA DOE sediment management unit during a recent phone conversation. This facilitates data qualification and can potentially facilitate data use as well.

Several additional specific instances are also discussed in the QC sample sections. For example, surrogates have been considered in the case of some replicates when deciding which samples are representative of batch precision and should be used to qualify data.

Chlorobenzenes and related compound data are qualified with a method blank and matrix spike recoveries. Surrogate recoveries from the initial BNA scan are used as well to qualify this data.

UNITS AND SIGNIFICANT FIGURES

Data are reported in accordance with lab policy at the time of data generation. Pesticide/PCB and BNA results are reported in ug/Kg on a dry weight basis. Results above the RDL are reported to three significant figures. Results equal to or below the RDL are reported to two significant figures. An MDL, RDL and analytical result are reported for all samples for these parameters.

Tributyl tin and methyl mercury are reported in accordance with subcontracting lab policy. Tributyl tin is reported to two significant figures. A positive result or a detection limit (MDL) are reported for all samples. Methyl mercury is reported to three significant figures. A single MDL is included in the narrative and has been applied to all sample data by the METRO lab. This MDL is for a 1 gram sample, whereas most of the sample weights exceed 1 gram. A positive result has been obtained and reported for all samples for methyl mercury.

Methyl mercury data is reported *as mercury*.

Pesticide QC data is reported on a wet weight basis. BNA QC data is reported on a dry weight basis.

SURROGATES

Sample data have been qualified for non compliant surrogate recovery in accordance with specifications from the project SAP. These specifications are included as Table 3 of this QA review. A summary of qualified data is included below:

Summary of Qualified Data Due to Surrogate Recovery.

SITUATION	SURROGATE	SAMPLES AFFECTED
PEST/PCB Surrogate, recoveries <50% all compounds qualified with E	Decachlorobiphenyl and tetrachloroxylene	4288-8, -41; 4378-6, -7, -14
Butyltin Surrogate, recoveries <50% data qualified with E	Tripropyltin	4288-2
Butyltin Surrogate, recoveries >150% data qualified with E	Tripropyltin	4288-11, -24 to -29, -36, -38, -39, -40

Additional isolated instances of non compliant surrogate recoveries are observed in both the pesticide data and the BNA data. None of these surrogate recoveries are indicative of notable analytical difficulties. This information is summarized in the appendix of this QA review.

Note that low surrogate recoveries were observed in some QC samples for both BNA and pesticides. This information has been considered during the data qualification process and is discussed in this QA review in the appropriate section for the affected QC sample(s).

SUBCONTRACTED ANALYSIS

Analysis for methyl mercury was performed by Frontier Geosciences of Seattle, WA. Analysis for butyl tins was performed by Laucks Testing Laboratories, Inc. of Seattle WA. The data packs received from both laboratories have been evaluated and comments are included in this QA review.

Table 1 page 1 of 2 Sample Inventory

Sample	Type	AVS	PSD	Tributyltin	Hg-Methyl	Bioassay	TOC	TOTS	BNA-Sur	ClPest/PCB	metals
4288-1	grab	X	X	X			X	X	X	X	X
4288-2	grab	X	X	X			X	X	X	X	X
4288-3	grab	X	X	X			X	X	X	X	X
4288-4	grab*	X	X	X			X	X	X	X	X
4288-5	grab	X	X	X			X	X	X	X	X
4288-6	grab	X	X	X			X	X	X	X	X
4288-7	grab	X	X	X			X	X	X	X	X
4288-8	grab	X	X	X			X	X	X	X	X
4288-9	grab	X	X	X			X	X	X	X	X
4288-10	grab	X	X	X			X	X	X	X	X
4288-11	grab*	X	X	X			X	X	X	X	X
4288-12	grab	X	X	X			X	X	X	X	X
4288-13	grab	X	X	X			X	X	X	X	X
4288-14	grab*	X	X	X			X	X	X	X	X
4288-15	grab	X	X	X			X	X	X	X	X
4288-16	grab	X	X	X			X	X	X	X	X
4288-17	grab**	X	X	X			X	X	X	X	X
4288-18	grab**	X	X	X			X	X	X	X	X
4288-19	grab**	X	X	X			X	X	X	X	X
4288-20	grab**	X	X	X			X	X	X	X	X
4288-21	grab	X	X	X			X	X	X	X	X
4288-22	grab	X	X	X			X	X	X	X	X
4288-23	grab	X	X	X			X	X	X	X	X
4288-24	grab	X	X	X			X	X	X	X	X
4288-25	grab	X	X	X			X	X	X	X	X
4288-26	grab	X	X	X			X	X	X	X	X
4288-27	grab	X	X	X			X	X	X	X	X
4288-28	grab	X	X	X			X	X	X	X	X
4288-29	grab	X	X	X			X	X	X	X	X
4288-30	grab	X	X	X	X	X	X	X	X	X	X
4288-31	grab	X	X	X	X	X	X	X	X	X	X
4288-32	grab	X	X	X	X	X	X	X	X	X	X

Table 1 page 2 of 2 Sample Inventory

Sample	Type	AVS	PSD	Tributyltin	Hg-Methyl	Bioassay	TOC	TOTS	BNA-Sur	ClPest/PCB	metals
4288-33	grab	X	X	X	X	X	X	X	X	X	X
4288-34	grab	X	X	X	X	X	X	X	X	X	X
4288-35	grab	X	X	X	X	X	X	X	X	X	X
4288-36	grab	X	X	X	X	X	X	X	X	X	X
4288-37	grab	X	X	X	X	X	X	X	X	X	X
4288-38	grab	X	X	X	X	X	X	X	X	X	X
4288-39	grab	X	X	X	X	X	X	X	X	X	X
4288-40	grab	X	X	X	X	X	X	X	X	X	X
4288-41	grab	X	X	X	X	X	X	X	X	X	X
4378-1	grab					X					
4378-2	grab					X					
4378-3	core	X	X				X	X	X	X	X
4378-4	core	X	X				X	X	X	X	X
4378-5	core	X	X				X	X	X	X	X
4378-6	core	X	X				X	X	X	X	X
4378-7	core	X	X				X	X	X	X	X
4378-8	core	X	X				X	X	X	X	X
4378-9	core	X	X				X	X	X	X	X
4378-10	core	X	X				X	X	X	X	X
4378-11	core	this sample not taken									
4378-12	core	X	X				X	X	X	X	X
4378-13	core	X	X				X	X	X	X	X
4378-14	core	X	X				X	X	X	X	X
4378-15	core	X	X				X	X	X	X	X
4378-16	core	X	X				X	X	X	X	X
4378-17	core	X	X				X	X	X	X	X

AVS = acid volatile sulfides
BNA-sur = BNA analysis with TIC compounds
PSD = particle size distribution
Interstitial salinity was analyzed for all bioassays
Metals = Ag, Al, As, Ba, Be, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Tl, Zn, Hg

* = field replicate
** = variability replicate
4378-1 = Carr Inlet reference 1
4378-2 = Carr Inlet reference 2
4378-11 this sample was not taken

Table 2 Summary of Coordiantes and Sample Depth

		NAD 83 DATA		NAD 27 DATA				
LOCATOR	SHORT NAME	NORTHING	EASTING	NORTHING	EASTING	SAMPLE #	DATA COLLECTED	DEPTH
DUD001-9120/7150-83	DUD001	209120	1267153	209179	1627031	4288-30	8/17/94	0 - 10
DUD002-9410/6930-83	DUD002	209414	1266928	209473	1626806	4288-1	8/11/94	0 - 10
DUD003-9330/6980-83	DUD003	209332	1266981	209391	1626859	4288-2	8/11/94	0 - 10
DUD004-9240/7010-83	DUD004	209241	1267007	209300	1626885	4288-3	8/12/94	0 - 10
DUD005-9140/7090-83	DUD005	209135	1267090	209194	1626968	4288-4	8/16/94	0 - 10
DUD005-9140/7090-83	DUD005	209135	1267090	209194	1626968	4288-31	8/16/94	0 - 10
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4288-5	8/10/94	0 - 10
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-3	8/25/94	0 - 15
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-4	8/25/94	15 - 30
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-5	8/25/94	30 - 45
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-6	8/25/94	45 - 60
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-7	8/25/94	60 - 75
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-8	8/25/94	75 - 90
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-9	8/25/94	105 - 120
DUD006-9060/7090-83	DUD006	209059	1267092	209118	1626970	4378-10	8/25/94	135 - 150
DUD007-8980/7170-83	DUD007	208979	1267165	209038	1627043	4288-6	8/10/94	0 - 10
DUD008-8870/7200-83	DUD008	208874	1267203	208933	1627081	4288-7	8/9/94	0 - 10
DUD009-8790/7220-83	DUD009	208785	1267219	208844	1627097	4288-8	8/9/94	0 - 10
DUD010-8670/7250-83	DUD010	208673	1267246	208732	1627124	4288-9	8/17/94	0 - 10
DUD011-8520/7180-83	DUD011	208520	1267183	208579	1627061	4288-32	8/17/94	0 - 10
DUD012-8410/7160-83	DUD012	208410	1267160	208469	1627038	4288-10	8/12/94	0 - 10
DUD012-8410/7160-83	DUD012	208410	1267160	208469	1627038	4288-11	8/12/94	0 - 10
DUD013-8330/7210-83	DUD013	208325	1267213	208384	1627091	4288-12	8/12/94	0 - 10
DUD014-9200/7050-83	DUD014	209196	1267050	209255	1626928	4288-33	8/20/94	0 - 10
DUD015-8260/7230-83	DUD015	208263	1267232	208322	1627110	4288-13	8/12/94	0 - 10
DUD016-9400/6870-83	DUD016	209396	1266874	209455	1626752	4288-14	8/15/94	0 - 10
DUD016-9400/6870-83	DUD016	209396	1266874	209455	1626752	4288-34	8/15/94	0 - 10
DUD017-9320/6920-83	DUD017	209322	1266919	209381	1626797	4288-15	8/12/94	0 - 10
DUD018-9190/6940-83	DUD018	209187	1266939	209246	1626817	4288-35	8/15/94	0 - 10
DUD019-9090/6990-83	DUD019	209087	1266991	209146	1626869	4288-16	8/9/94	0 - 10

		NAD 83 DATA		NAD 27 DATA				
LOCATOR	SHORT NAME	NORTHING	EASTING	NORTHING	EASTING	SAMPLE #	DATA COLLECTED	DEPTH
DUD020-9070/7000-83	DUD020	209068	1267003	209127	1626881	4378-12	8/25/94	0 - 15
DUD020-9070/7000-83	DUD020	209068	1267003	209127	1626881	4378-13	8/25/94	15 - 30
DUD020-9070/7000-83	DUD020	209068	1267003	209127	1626881	4378-14	8/25/94	30 - 45
DUD020-9070/7000-83	DUD020	209068	1267003	209127	1626881	4378-15	8/25/94	45 - 60
DUD020-9070/7000-83	DUD020	209068	1267003	209127	1626881	4378-16	8/25/94	60 - 75
DUD020-9070/7000-83	DUD020	209068	1267003	209127	1626881	4378-17	8/25/94	75 - 90
DUD021-9030/6990-83	DUD021	209032	1266987	209091	1626865	4288-17	8/15/94	0 - 10
DUD021-9030/6990-83	DUD021	209032	1266987	209091	1626865	4288-18	8/15/94	0 - 10
DUD021-9030/6990-83	DUD021	209032	1266987	209091	1626865	4288-19	8/15/94	0 - 10
DUD021-9030/6990-83	DUD021	209032	1266987	209091	1626865	4288-20	8/15/94	0 - 10
DUD021-9030/6990-83	DUD021	209032	1266987	209091	1626865	4288-36	8/15/94	0 - 10
DUD022-8930/7040-83	DUD022	208929	1267040	208988	1626918	4288-21	8/10/94	0 - 10
DUD023-8810/7060-83	DUD023	208809	1267059	208868	1626937	4288-37	8/16/94	0 - 10
DUD024-8720/7080-83	DUD024	208715	1267080	208774	1626948	4288-22	8/9/94	0 - 10
DUD025-8640/7100-83	DUD025	208637	1267100	208696	1626978	4288-38	8/16/94	0 - 10
DUD026-8550/7100-83	DUD026	208546	1267097	208605	1626975	4288-23	8/10/94	0 - 10
DUD027-8450/7100-83	DUD027	208451	1267100	208510	1626978	4288-24	8/10/94	0 - 10
DUD028-9370/6790-83	DUD028	209373	1266787	209432	1626665	4288-25	8/11/94	0 - 10
DUD029-9260/6830-83	DUD029	209263	1266831	209322	1626709	4288-39	8/15/94	0 - 10
DUD030-8780/7040-83	DUD030	208776	1267040	208835	1626918	4288-26	8/12/94	0 - 10
DUD031-9070/6870-83	DUD031	209067	1266868	209126	1626746	4288-40	8/16/94	0 - 10
DUD032-8980/6890-83	DUD032	208978	1266889	209037	1626767	4288-27	8/12/94	0 - 10
DUD033-8880/6900-83	DUD033	208883	1266897	208942	1626775	4288-41	8/16/94	0 - 10
DUD034-8790/6930-83	DUD034	208785	1266933	208844	1626811	4288-28	8/12/94	0 - 10
DUD035-8680/6970-83	DUD035	208683	1266971	208742	1626849	4288-29	8/10/94	0 - 10
DUDCARR1	DUDCARR1	733878	1097193	733931	1457075	4378-1	8/22/94	0 - 10
DUDCARR2	DUDCARR2	736816	1101218	736869	1461100	4378-2	8/22/94	0 - 10

Table 3. Summary of Data Qualifiers Used

Condition to Qualify	SEDQUAL Qualifier	Organics QC Limits	Metals QC Limits	Conventionals QC Limits	METRO Equivalent Qualifier
very low matrix spike recovery	X	< 10 %	< 10 %	NA	X
low matrix spike recovery	G	< 50%	< 75%	NA	G
high matrix spike recovery	L	> 150%	>125%	NA	L
low SRM recovery	G	< 80%*	NA	< 80%*	G
high SRM recovery	L	>120%*	>120%	>120%*	L
high duplicate RPD	E	>100 %	>20%	> 20 %	E, estimated
high triplicate RSD	E	> 100%	NA	> 20 %	E, estimated
less than the reporting detection limit	T	NA	NA	NA	< RDL
less than the method detection limit	U	NA	NA	NA	< MDL
contamination reported in blank	B	> MDL	> MDL	> MDL	B
very biased data, based on surrogate recoveries	X	all fraction surrogates are <10%	NA	NA	X
biased data, based on surrogate recoveries	E	all fraction surrogates are < 50% or >150%	NA	NA	E, estimated
estimate based on presumptive evidence	N	NA	NA	NA	J# used to indicate the presence of TIC's
rejected, unusable for all purposes	R	NA	NA	NA	R

* Note that PSDDA guidance uses a 95% confidence window for this parameter/qualification.

KING COUNTY ENVIRONMENTAL LABORATORY

QUALITY ASSURANCE REVIEW

for

DUWAMISH/DIAGONAL CSO PRE-PHASE II MARINE SEDIMENT SAMPLING

December 28, 1995

King County Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

INTRODUCTION

This Quality Assurance (QA) review accompanies data submitted in connection with marine sediment sampling at the Duwamish/Diagonal combined sewer overflow (CSO) outfall. The QA review is organized into the four sections listed below.

- General Comments
- Conventionals Chemistry
- Metals Chemistry
- Organics Chemistry

An overview of the approach used for this QA review is detailed in the General Comments section. Additional information specific to each analysis is included in the appropriate analytical section.

This QA review has been primarily conducted in accordance with guidelines established through the Puget Sound Dredged Disposal Analysis (PSDDA) program, outlined in *Puget Sound Dredged Disposal Analysis Guidance Manual, Data Quality Evaluation for Proposed Dredged Material Disposal Projects*. Other approaches incorporated in this QA review have been established through collaboration between the King County Environmental Laboratory (KC Laboratory) and the Washington State Department of Ecology (Ecology) Sediment Management Unit.

GENERAL COMMENTS

Scope of Samples Submitted

This QA review is associated with marine sediment samples collected in November, 1995 during pre-Phase II sampling at the Duwamish/Diagonal CSO outfall. The samples collected and the proposed analytical scheme are summarized in Table 1 of this QA review. Except where noted in the subcontracting sections of this QA review, all analyses have been conducted by the KC Laboratory. The data are reported with associated data qualifiers and have undergone QA1 review, as summarized in this narrative report.

Completeness

Completeness has been evaluated for this data submission and QA review by considering the following criteria:

- Comparing available data with the planned project analytical scheme summarized in Table 1 of this QA review.
- Compliance with storage conditions and holding times.
- Compliance with the complete set of quality control (QC) samples outlined in Table 2 of this QA review.

Methods

Analytical methods are noted in the applicable analytical sections of this QA review.

Target Lists

The reported target lists have been compared to the target analytes listed in *Table 1- Marine Sediment Quality Standards Chemical Criteria* contained in Chapter 173-204 WAC and the PSDDA *Chemicals of Concern* list.

Detection Limits

The KC Laboratory distinguishes between the Reporting Detection Limit (RDL) and the Method Detection Limit (MDL).

- The RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified.*
- The MDL is defined as *the minimum concentration of a chemical constituent that can be detected.*

Some subcontractor laboratory data are available with an MDL only, in accordance with the subcontracting laboratory policies. All analytical data are reported with either a result or detection limit(s).

Storage Conditions and Holding Times

Storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The approach used to evaluate Total Organic Carbon for holding time has been established between the KC Laboratory and Ecology during previous QA1 review efforts.

Method Blanks

Method blanks have been evaluated for the presence of positive analyte results at or greater than the MDL.

Standard Reference Material

Data have been qualified based on available standard reference material (SRM) results. Instances of data reported without associated SRM analysis are noted in the narrative.

Matrix Spikes

Matrix spike results have been used to qualify data for both organics and metals analyses. Matrix spikes are not required for conventionals parameters.

Replicate Samples

Data have been qualified based on replicate results. However, not all replicate data have been used as an indicator for data qualification. Only sets of replicate results which contain at least one result significantly greater than the MDL have been considered for data qualification. Where an RDL is present, only replicate data that contains at least one result greater than the RDL have been considered for data qualification. These guidelines have been used to account for the fact that precision obtained near the MDL is not representative of precision obtained throughout the entire analytical range.

Data Qualifiers

The data qualification system used for this data submission is presented in Table 3 of this QA review. These data qualifiers address situations which require qualification, according to QA1 guidance. The exact qualifiers used generally conform to QA1 guidance. The KC Laboratory qualifiers indicating <MDL and <RDL have been used as replacements for the *T* and *U* specified under QA1 guidance. Changes made to SRM data qualification criteria have been discussed with and approved by the Sediment Management Unit of Ecology.

Units and Significant Figures

Data have been reported in accordance with laboratory policy at the time of data generation. When an RDL and MDL are reported, data have been reported to three significant figures above the RDL, and two significant figures equal to or below the RDL. Data with only an MDL have been reported to two significant figures.

Data are stored in a wet weight basis on the KC Laboratory's data base and converted to dry weight during the reporting process. Should only one reported digit be available, rounding error can be significant. This rounding error can occur during the conversion from wet to dry weight.

Subcontracted Analyses

Analyses which have been subcontracted, and the issues associated with these subcontracted analyses are noted in this narrative.

CONVENTIONALS CHEMISTRY

Completeness

Conventionals data are reported for samples 7279-1 through 7279-14. These samples were analyzed for acid volatile sulfides (AVS), ammonia nitrogen, particle size distribution (PSD), total organic carbon (TOC), total solids, and total sulfides in association with the complete set of QC samples outlined in Table 2.

Subcontracted Analyses

AVS, PSD and total sulfide analyses were subcontracted to AmTest, Inc. in Redmond, Washington.

Methods

AVS analysis was performed in accordance with methodology outlined in *Analytical Method for Determination of Acid Volatile Sulfide and Selected Simultaneously Extractable Metals in Sediment* - EPA, 1991. Ammonia nitrogen analysis was performed in accordance with Standard Method (SM)4500-NH3-H. PSD analysis was performed in accordance with ASTM and Puget Sound Protocols methodologies (*Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* - page 9 - PSEP, 1986). TOC analysis was performed in accordance with SM5310-B. Total solids analysis was performed in accordance with SM2540-B. Total sulfides analysis was performed in accordance with SM4500-S.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all conventionals parameters analyzed by the KC Laboratory. A positive result and/or MDL has been reported for subcontracted analyses. Sample results are reported in units of mg/Kg on a dry weight basis for AVS, ammonia nitrogen, TOC, and total sulfides. Sample results are reported in percent for PSD and total solids. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for conventionals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
AVS	Not Recommended	14 Days
Ammonia	Not Recommended	28 Days
PSD	Not Recommended	6 Months
TOC	6 Months	14 Days
Solids	6 Months	14 Days
Total Sulfide	Not Recommended	14 Days

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks

Method blanks were analyzed in connection with AVS, ammonia nitrogen TOC, total solids, and total sulfides. All method blank results were less than the MDL.

Standard Reference Material and Positive Controls

The SRM analyzed in association with TOC analysis is Buffalo River Sediment. The SRM recovery was within the 80 to 120% QC limits. Laboratory check standards were analyzed in connection with ammonia nitrogen and total sulfide. All recoveries were between 93 and 105%. Spike analysis was performed in connection with ammonia nitrogen and total sulfide analysis. Spike recoveries were all between 95 and 109%

Laboratory Replicate Samples

Laboratory triplicate samples were analyzed for AVS, ammonia nitrogen, TOC, total solids, and total sulfides. Percent relative standard deviation (RSD) for laboratory triplicate results was less than the 20% QC limit for all triplicate analyses.

Two laboratory triplicate samples were analyzed for PSD. The average RSD over all grain size fractions averaged 11.82 and 20.64% for the two triplicate analyses. The RSD for grain size fractions into which the largest percentage of the sample fell were all less than the 20% QC limit. Laboratory triplicate results were reviewed to determine if a consistent difference in triplicate results occurred over all grain size fractions. Variations in triplicate results appear to be random and a function of inherent variations in samples rather than QC problems. As a result, PSD data have not been qualified based on laboratory triplicate analysis.

METALS CHEMISTRY

Completeness

Metals data are reported for samples 7279-1 through 7279-14. These samples were analyzed for mercury and other metals in association with the complete set of QC samples outlined in Table 2.

Methods

Mercury analysis was performed in accordance with EPA Method 7471. All other metals analyses were performed in accordance with EPA Method 3050/6010.

Target List

The reported target list includes all metals specified in *Table 1 - Marine Sediment Quality Standards Chemical Criteria* contained in Chapter 173-204 WAC and the PSDDA *Chemicals of Concern* list. Additional metals have been reported as available.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all metals. Sample results are reported in units of mg/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Analytical results for the method blank, matrix spike, and laboratory duplicate sample are reported in units of mg/L. This does not indicate that these quality control samples were performed on a water matrix. Rather, sufficient information was available in the reported format (mg/L) to calculate information such as percent recoveries and to qualify the data as needed. Because sufficient information was available to qualify the data, the data were not recalculated on a solid basis. Based on method dilution factors, the reported data may be converted to a solid basis by multiplying by a factor of 50. This calculation assumes a typical sample size of 1 gram wet weight and a final volume of 50 mL.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for metals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
Mercury	28 Days	Not Recommended
Metals	2 Years	6 Months

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blank

All mercury and metals method blank results were less than the MDL.

Standard Reference Material

The SRM analyzed in association with samples included in this data submission is PACS 1 obtained from the National Research Council of Canada. This SRM does not contain silver. An SRM recovery less than 80% has not been used alone to qualify data because the digestion technique used for sample analysis is different from the technique used during analysis to determine the SRM certified values.

SRM recoveries less than 80% were reported for cadmium, chromium, manganese, and nickel. Matrix spike recoveries for these metals, however, were all greater than 75% and associated sample results have not been qualified. The SRM recovery for antimony was less than 80% and the matrix spike recovery was less than 75%. Sample results for antimony have been qualified with the *G* flag.

The cadmium recovery of 0% is due to the KC Laboratory's data handling and reporting procedures. The SRM certified value is near the KC Laboratory MDL. A nearly quantitative SRM result for cadmium can result in a reported 0% recovery, should the result be below the MDL.

Matrix Spike

Matrix spike recoveries less than 75% were reported for antimony, iron and sodium. Associated sample results for these metals have been qualified with the *G* flag. A matrix spike recovery greater than 125% were reported for aluminum. Associated sample results for aluminum have been qualified with the *L* flag.

Laboratory Duplicate Samples

RPDs of greater than 20% were reported aluminum and arsenic laboratory duplicate results. Associated sample results for these metals have been qualified with the *E* flag.

ORGANICS CHEMISTRY

Completeness

Organics data are reported for samples 7279-1 through 7279-14. These samples were analyzed for base/neutral/acid extractable semivolatile compounds (BNAs), butyltin isomers, and polychlorinated biphenyls (PCBs) in association with the complete set of QC samples outlined in Table 2.

Subcontracted Analyses

Butyltin analysis was subcontracted to Battelle Marine Sciences Laboratory (Battelle) in Sequim, Washington.

Methods

Analysis of BNAs was performed in accordance with EPA method 8270 (SW-846). BNA extracts were also analyzed by selected ion monitoring (SIM) to attain lower detection limits for chlorinated benzene compounds. Butyltin analysis was conducted in accordance with guidance outlined in *GC Determination of Butyltins in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation* - Unger, et al., 1986. Analysis of PCBs was performed in accordance with EPA method 8080 (SW-846).

Target List

The reported BNA target list includes all compounds specified in *Table 1 - Marine Sediment Quality Standards Chemical Criteria* contained in Chapter 173-204 WAC, with the exception of benzo(j)fluoranthene. The KC Laboratory has verified that analytical conditions are sufficient to calculate a total benzofluoranthenes result using the reported *b* and *k* isomers. Butyltin data include mono, di, tri, and tetrabutyltin isomers. Battelle has indicated that monobutyltin results are for information only due to the low efficiency of extraction of this compound. Reported PCB data include Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all organic compounds analyzed at the KC Laboratory. A positive result and/or MDL have been reported for butyltin analysis. Sample results are reported in units of ug/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for organics analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
BNAs and Chlorobenzenes	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze
Butyltin Isomers	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze
PCBs	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks

All BNA, chlorobenzene and PCB method blank results were less than the MDL. Tributyltin was detected in the method blank associated with butyltin analysis at a concentration of 0.42 ug/Kg. This concentration is less than the target wet weight MDL of 0.5 ug/Kg but greater than the achieved wet weight MDL of 0.24 ug/Kg for this isomer. Because of inherent uncertainty near the MDL, this method blank contamination was not considered significant. Dibutyltin was also detected in the method blank at a concentration of 1.77 ug/Kg. All associated sample results for dibutyltin were greater than five times the blank concentration. Monobutyltin and tetrabutyltin were not detected in the method blank. Associated sample results for total butyltin were not qualified based on method blank results.

Surrogate Recoveries

BNA sample data have been qualified when the average surrogate recovery for either or both the acid and base/neutral fractions is outside QC limits. Average base/neutral and acid fraction surrogate recoveries were within QC limits for all samples in this data submission.

Chlorobenzene sample data have been qualified when the single surrogate recovery was outside QC limits. Sample data have been qualified based on the surrogate recovery data summarized in the following table.

Sample	Situation	Compounds	Flag
7279-1	Surr. recovery <10%	All chlorobenzenes	X
7279-2	Surr. recovery <50%	All chlorobenzenes	G
7279-3	Surr. recovery <50%	All chlorobenzenes	G
7279-4	Surr. recovery <50%	All chlorobenzenes	G
7279-5	Surr. recovery <50%	All chlorobenzenes	G
7279-6	Surr. recovery <50%	All chlorobenzenes	G
7279-7	Surr. recovery <50%	All chlorobenzenes	G
7279-8	Surr. recovery <50%	All chlorobenzenes	G
7279-9	Surr. recovery <50%	All chlorobenzenes	G
7279-10	Surr. recovery <50%	All chlorobenzenes	G
7279-11	Surr. recovery <50%	All chlorobenzenes	G
7279-12	Surr. recovery <50%	All chlorobenzenes	G
7279-13	Surr. recovery <50%	All chlorobenzenes	G
7279-14	Surr. recovery <50%	All chlorobenzenes	G

Surrogate recoveries for tripentyltin chloride were within a range of 95 to 105% for all samples analyzed for butyltin.

PCB sample data have been qualified when both surrogate recoveries (tetrachloroxylene and decachlorobiphenyl) are outside QC limits. Tetrachloroxylene recovery was less than 50% for sample 7279-1, however, the corresponding recovery of decachlorobiphenyl in the same sample was within QC limits. This sample was rerun twice at dilutions of 1 to 20 and 1 to 100. Recovery of tetrachloroxylene was within QC limits for both dilutions and recovery of decachlorobiphenyl was greater than the upper QC limit of 150%. PCB data have not been qualified based on surrogate recovery.

Standard Reference Material

The marine sediment SRM analyzed in association with the reported BNA analytical results is HS4, certified by the National Research Council of Canada. HS4 contains a partial list of compounds for BNA analysis. BNA data for all samples in this data submission have been qualified based on the SRM recoveries summarized in the following table.

Compound	% Recovery	Flag
Phenanthrene	58	G
Anthracene	55	G
Fluroanthene	68	G
Pyrene	67	G
Benzo(a)anthracene	72	G
Chrysene	71	G
Benzo(b)fluoranthene	59	G
Benzo(k)fluoranthene	143	L
Dibenzo(a,h)anthracene	65	G
Benzo(a)pyrene	66	G
Benzo(g,h,i)perylene	64	G

An SRM is not included during SIM analysis of chlorobenzene compounds.

The SRM analyzed in connection with butyltin analysis is PACS-1 obtained from the National Research Council of Canada. This SRM includes certified values for mono, di and tributyltin isomers. The SRM recovery for monobutyltin was within QC limits. The surrogate recoveries for dibutyltin and tributyltin were less than the lower QC limit. Battelle has advised that analysis of a new batch of this SRM indicates a value somewhat lower than certified. As a result, butyltin data were not qualified based on SRM results.

The marine sediment SRM normally analyzed in association with chlorinated pesticide/PCB analytical results is 1941a, certified by the National Institute of Standards and Technology. As this SRM does not contain PCB Aroclors, it was not analyzed in association with these samples.

Matrix Spike

BNA data for all samples in this data submission have been qualified based on the matrix spike recoveries summarized in the following table.

Compound	% Recovery	Flag
Hexachloroethane	47	G
4-Chloroaniline	38	G
Hexachlorocyclopentadiene	3	X
Benzidine	0	X
N-Nitrosodimethylamine	28	G
1,2-Diphenylhydrazine	172	L
Aniline	18	G
Coprostanol	170	L

Chlorobenzene data for all samples in this data submission have been qualified based on the matrix spike recoveries summarized in the following table.

Compound	% Recovery	Flag
1,3-Dichlorobenzene	41	G
1,4-Dichlorobenzene	42	G
1,2-Dichlorobenzene	46	G

Di and tributyltin were spiked in connection with butyltin analysis. Matrix spike recovery of dibutyltin was within QC limits. Recovery of tributyltin (37%) was less than the lower QC limit. Battelle has indicated that the native concentration of this isomer in the analytical sample was higher than the spiked concentration and may have contributed to the reported low recovery. Butyltin data were not qualified based on matrix spike recovery.

The PCB matrix spike recovery (Aroclor 1260) for this data submission was within QC limits.

Laboratory Replicate Samples

The RPDs of laboratory duplicate results for BNA, chlorobenzene and butyltin analyses were all less than the QC limit of 100%. The RPD for Aroclor 1260 in the PCB laboratory duplicate analysis was greater than the QC limit of 100%. The analyst feels that the laboratory duplicate sample may have inadvertently been spiked with this compound. Sample results for Aroclor 1260, however, have been qualified with the *E* flag based on laboratory duplicate results.

TABLE 1
DUWAMISH/DIAGONAL PRE-PHASE II SEDIMENT CLEANUP STUDY
SAMPLE INVENTORY

Sample	BNAs	PCBs	Butyltins	Metals	Sulfides	PSD	Solids	TOC	Ammonia	Comments
7279-1	X	X	X	X	X	X	X	X	X	
7279-2	X	X	X	X	X	X	X	X	X	
7279-3	X	X	X	X	X	X	X	X	X	Field Replicate of 7279-2
7279-4	X	X	X	X	X	X	X	X	X	
7279-5	X	X	X	X	X	X	X	X	X	
7279-6	X	X	X	X	X	X	X	X	X	
7279-7	X	X	X	X	X	X	X	X	X	Field Replicate of 7279-6
7279-8	X	X	X	X	X	X	X	X	X	
7279-9	X	X	X	X	X	X	X	X	X	
7279-10	X	X	X	X	X	X	X	X	X	
7279-11	X	X	X	X	X	X	X	X	X	
7279-12	X	X	X	X	X	X	X	X	X	
7279-13	X	X	X	X	X	X	X	X	X	
7279-14	X	X	X	X	X	X	X	X	X	

TABLE 2
QC SAMPLE FREQUENCY FOR SEDIMENT CHEMISTRY PARAMETERS

Parameter	Blank	Duplicate	Triplicate	Matrix Spike	SRM	Surrogate
Particle Size Distribution	NA	10% of Samples	10% of Samples	NA	NA	NA
Total Solids	NA	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	NA	NA
Total Organic Carbon	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	1 Per Batch	NA
Ammonia Nitrogen	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	NA	NA
Total and Acid Volatile Sulfides	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	NA	NA
Mercury	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Batch	NA
Metals	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Batch	NA
Butyltin Isomers	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Extraction Batch	Yes
BNAs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	1 Per Extraction Batch	Yes
PCBs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	1 Per Extraction Batch	Yes

TABLE 3
SUMMARY OF DATA QUALIFIERS

Condition to Qualify	METRO Data Qualifier	Organics QC Limits	Metals QC Limits	Conventionals QC Limits	Comment
very low matrix spike recovery	X	< 10 %	< 10 %	NA	
low matrix spike recovery	G	< 50%	< 75%	NA	
high matrix spike recovery	L	> 150%	>125%	NA	
low SRM recovery	G	< 80%*	NA	< 80%*	
high SRM recovery	L	>120%*	>120%	>120%*	
high duplicate RPD	E	>100 %	>20%	> 20 %	use duplicate as routine QC for organics
high triplicate RSD	E	> 100%	NA	> 20 %	use triplicate as routine QC for conventionals
less than the reporting detection limit	< RDL	NA	NA	NA	
less than the method detection limit	< MDL	NA	NA	NA	
contamination reported in blank	B	> MDL	> MDL	> MDL	
very biased data, based on surrogate recoveries	X	all fraction surrogates are <10%	NA	NA	use average surrogate recovery for BNA
biased data, based on low surrogate recoveries	G	all fraction surrogates are < 50%	NA	NA	use average surrogate recovery for BNA
biased data, based on high surrogate recoveries	L	all fraction surrogates are >150%	NA	NA	use average surrogate recovery for BNA
estimate based on presumptive evidence	J# used to indicate the presence of TIC's	NA	NA	NA	
rejected, unusable for all purposes	R	NA	NA	NA	
a sample handling criteria has been exceeded	H	NA	NA	NA	Includes container, preservation, hold time, sampling technique

*Note that PSDDA guidance uses a 95% confidence window for this parameter/qualification.

KING COUNTY ENVIRONMENTAL LABORATORY

QUALITY ASSURANCE REVIEW

for

DUWAMISH/DIAGONAL CSO OUTFALL SEDIMENT CLEANUP STUDY
PHASE II MARINE SEDIMENT CORE SAMPLING

August 21, 1996

King County Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

INTRODUCTION

This Quality Assurance (QA) review accompanies data submitted in connection with Phase II marine sediment core sampling at the Duwamish/Diagonal combined sewer overflow (CSO) outfall sediment cleanup study site. The QA review is organized into the four sections listed below.

- General Comments
- Conventionals Chemistry
- Metals Chemistry
- Organics Chemistry

An overview of the approach used for this QA review is detailed in the General Comments section. Additional information specific to each analysis is included in the appropriate analytical section.

This QA review has been primarily conducted in accordance with guidelines established through the Puget Sound Dredged Disposal Analysis (PSDDA) program, outlined in *Puget Sound Dredged Disposal Analysis Guidance Manual, Data Quality Evaluation for Proposed Dredged Material Disposal Projects*. Other approaches incorporated in this QA review have been established through collaboration between the King County Environmental Laboratory (KC Laboratory) and the Washington State Department of Ecology (Ecology) Sediment Management Unit.

GENERAL COMMENTS

Scope of Samples Submitted

This QA review is associated with marine sediment core samples collected May 20 and 21 and June 3, 1996 during Phase II sampling at the Duwamish/Diagonal CSO outfall sediment cleanup study site. The samples collected and the proposed analytical scheme are summarized in Table 1 of this QA review. Except where noted in the subcontracting sections of this QA review, all analyses have been conducted by the KC Laboratory. The data are reported with associated data qualifiers and have undergone QA1 review, as summarized in this narrative report.

Completeness

Completeness has been evaluated for this data submission and QA review by considering the following criteria:

- Comparing available data with the planned project analytical scheme summarized in Table 1 of this QA review.
- Compliance with storage conditions and holding times.
- Compliance with the complete set of quality control (QC) samples outlined in Table 2 of this QA review.

Methods

Analytical methods are noted in the applicable analytical sections of this QA review.

Subcontracted Analyses

Analyses which have been subcontracted, and the issues associated with these subcontracted analyses are noted in this narrative.

Target Lists

The reported target lists have been compared to the target analytes listed in *Table 1- Marine Sediment Quality Standards Chemical Criteria* contained in Chapter 173-204 WAC.

Detection Limits

The KC Laboratory distinguishes between the Reporting Detection Limit (RDL) and the Method Detection Limit (MDL).

- The RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified.*
- The MDL is defined as *the minimum concentration of a chemical constituent that can be detected.*

Some subcontractor laboratory data are available with an MDL only, in accordance with the subcontracting laboratory policies. All analytical data are reported with either a result or detection limit(s).

Storage Conditions and Holding Times

Storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The approach used to evaluate Total Organic Carbon for holding time has been established between the KC Laboratory and Ecology during previous QA1 review efforts.

Method Blanks
Method blanks have been evaluated for the presence of positive analyte results at or greater than the MDL.

Standard Reference Material
Data have been qualified based on available standard reference material (SRM) results. Instances of data reported without associated SRM analysis are noted in the narrative.

Matrix Spikes
Matrix spike results have been used to qualify data for both organics and metals analyses. Matrix spikes are not required for conventionals parameters.

Replicate Samples
Data have been qualified based on replicate results. However, not all replicate data have been used as an indicator for data qualification. Only sets of replicate results which contain at least one result significantly greater than the MDL have been considered for data qualification. Where an RDL is present, only replicate data that contain at least one result greater than the RDL have been considered for data qualification. These guidelines have been used to account for the fact that precision obtained near the MDL is not representative of precision obtained throughout the entire analytical range.

Data Qualifiers
The data qualification system used for this data submission is presented in Table 3 of this QA review. These data qualifiers address situations which require qualification, according to QA1 guidance. The exact qualifiers used generally conform to QA1 guidance. The KC Laboratory qualifiers indicating <MDL and <RDL have been used as replacements for the *T* and *U* specified under QA1 guidance. Changes made to SRM data qualification criteria have been discussed with and approved by the Sediment Management Unit of Ecology.

Units and Significant Figures
Data have been reported in accordance with laboratory policy at the time of data generation. When an RDL and MDL are reported, data have been reported to three significant figures above the RDL, and two significant figures equal to or below the RDL. Data with only an MDL have been reported to two significant figures.

Data are stored in a wet weight basis on the KC Laboratory's data base and converted to dry weight during the reporting process.

CONVENTIONALS CHEMISTRY

Completeness

Conventionals data are reported for samples 8542-12 through 8542-39. These samples were analyzed for particle size distribution (PSD), total organic carbon (TOC), and total solids in association with the complete set of QC samples outlined in Table 2.

Subcontracted Analyses

PSD analysis was subcontracted to AmTest, Inc. in Redmond, Washington.

Methods

PSD analysis was performed in accordance with ASTM and Puget Sound Protocols methodologies (*Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* - page 9 - PSEP, 1986). TOC analysis was performed in accordance with Standard Method (SM)5310-B. Total solids analysis was performed in accordance with SM2540-B.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all conventionals parameters analyzed by the KC Laboratory. A positive result and/or MDL has been reported for subcontracted PSD analysis. Sample results are reported in units of mg/Kg on a dry weight basis for TOC. Sample results are reported in percent for PSD and total solids. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for conventionals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
PSD	Not Recommended	6 Months
TOC	6 Months	14 Days
Solids	6 Months	14 Days

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks

Method blanks were analyzed in connection with TOC and total solids analyses. All method blank results were less than the MDL.

Standard Reference Material and Positive Controls

The SRM analyzed in association with TOC analysis is Buffalo River Sediment. The SRM recovery (noted as "Laboratory Check Standard") for this data set was within the 80 to 120% QC limits.

Laboratory Replicate Samples

Laboratory triplicate samples were analyzed for PSD, TOC, and total solids analyses. Percent relative standard deviation (RSD) for laboratory triplicate results was less than the 20% QC limit for all triplicate results associated with TOC and total solids analyses.

Four laboratory triplicate samples were analyzed for PSD. The average RSD over all applicable grain size fractions averaged 10, 10, 10, and 16% for the four triplicate analyses. Laboratory triplicate results were reviewed to determine if a consistent difference in triplicate results occurred over all grain size fractions. Variations in triplicate results appear to be random and a function of inherent variations in samples rather than QC problems. As a result, PSD data have not been qualified based on laboratory triplicate analysis.

METALS CHEMISTRY

Completeness
Metals data are reported for samples 8542-12 through 8542-39. These samples were analyzed for mercury and other metals in association with the complete set of QC samples outlined in Table 2.

Methods
Mercury analysis was performed in accordance with EPA Method 7471. All other metals analyses were performed in accordance with EPA Method 3050/6010.

Target List
The reported target list includes all metals specified in *Table 1 - Marine Sediment Quality Standards Chemical Criteria* contained in Chapter 173-204 WAC. Additional metals have been reported as available.

Detection Limits, Units, and Significant Figures
Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all metals. Sample results are reported in units of mg/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times
Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for metals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
Mercury	28 Days	Not Recommended
Metals	2 Years	6 Months

The sample holding time for mercury was exceeded for samples 8542-32 through 8542-39. Mercury analytical results for these samples have been qualified with an *XHT* flag indicating an exceedance of holding time. Sample storage conditions and holding times were met for mercury in all other samples and other metals in all samples in this data submission.

Method Blank
All mercury and metals method blank results were less than the MDL.

Standard Reference Material
The SRM analyzed in association with samples included in this data submission is PACS 1 certified by the National Research Council of Canada. This SRM does not contain silver. An SRM recovery less than 80% has not been used alone to qualify data because the digestion technique used for sample analysis is different from the technique used during analysis to determine the SRM certified values.

Recoveries less than 80% were reported for arsenic, cadmium, chromium, manganese, and nickel for the SRM associated with samples 8542-32 through 8542-39. Recoveries less than 80% were reported for cadmium, chromium, manganese, and nickel for the SRM associated with samples 8542-12 through 8542-31. Matrix spike recoveries for these metals in the same QC batches, however, were all greater than 75% and associated sample results have not been qualified. The SRM recovery for antimony was less than 80% and the matrix spike recovery was less than 75% for both QC batches. All sample results for antimony have been qualified with the *G* flag.

Matrix Spike

Sample metals results have been qualified based on the matrix spike recoveries noted below.

Metal	Samples	Situation	Flag
Aluminum	8542-12 through 8542-39	MS Recovery > 125%	L
Antimony	8542-12 through 8542-39	MS Recovery < 75%	G
Mercury	8542-32 through 8542-39	MS Recovery >125%	L
Sodium	8542-32 through 8542-39	MS Recovery < 75%	G

Laboratory Duplicate Samples

RPDs greater than 20% were reported for mercury and lead laboratory duplicate results associated with samples 8542-12 through 8542-31. As analytical results for the original sample and its duplicate for both mercury and lead were below the RDL, however, associated sample results were not qualified.

RPDs greater than 20% were reported for cadmium and silver laboratory duplicate results associated with samples 8542-32 through 8542-39. As the analytical results for the original sample and its duplicate for both cadmium and silver were below the RDL, however, associated sample results were not qualified.

RPDs greater than 20% were reported for copper, lead and mercury for the laboratory duplicate results associated with samples 8542-32 through 8542-39. Associated sample results for these metals have been qualified with the *E* flag.

ORGANICS CHEMISTRY

Completeness

Organics data are reported for samples 8542-12 through 8542-39. These samples were analyzed for base/neutral/acid extractable semivolatile compounds (BNAs), and polychlorinated biphenyls (PCBs) in association with the complete set of QC samples outlined in Table 2.

Methods

Analysis of BNAs was performed in accordance with EPA method 8270 (SW-846). BNA extracts were also analyzed by selected ion monitoring (SIM) to attain lower detection limits for chlorinated benzene compounds. Analysis of PCBs was performed in accordance with EPA method 8080 (SW-846).

Target List

The reported BNA target list includes all compounds specified in *Table 1 - Marine Sediment Quality Standards Chemical Criteria* contained in Chapter 173-204 WAC, with the exception of benzo(j)fluoranthene. The KC Laboratory has verified that analytical conditions are sufficient to calculate a total benzofluoranthenes result using the reported *b* and *k* isomers. Reported PCB data include Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all organic compounds. Sample results are reported in units of µg/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for organics analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
BNAs and Chlorobenzenes	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze
PCBs	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks

Bis(2-ethylhexyl)phthalate was detected in the method blank associated with samples 8542-12 through 8542-18 and 8542-35 through 8542-38. Associated sample results for this compound have been qualified with the *B* flag. BNA method blank results for the remaining samples as well as all chlorobenzene and PCB method blank results were less than the MDL.

It should be noted that the average surrogate recoveries of all BNA method blanks for both the acid and base/neutral fractions were less than the QC limit of 50%. The surrogate recoveries for all chlorobenzene method blanks was less than 10%. The surrogate results for the method blanks are presented for information only and associated sample data were not qualified based on method blank surrogate recoveries.

Surrogate Recoveries

BNA sample data have been qualified when the average surrogate recovery for either or both the acid and base/neutral fractions is outside QC limits. Sample data have been qualified based on the surrogate recovery data summarized in the following table.

Sample	Situation	Compounds	Flag
8542-15	Surrogate recovery < 50%	All base/neutrals	G
8542-16	Surrogate recovery < 50%	All base/neutrals and acids	G
8542-21	Surrogate recovery < 50%	All base/neutrals	G
8542-23	Surrogate recovery < 50%	All base/neutrals	G
8542-26	Surrogate recovery < 50%	All base/neutrals and acids	G
8542-30	Surrogate recovery < 50%	All base/neutrals	G
8542-31	Surrogate recovery < 50%	All base/neutrals and acids	G
8542-34	Surrogate recovery < 50%	All base/neutrals and acids	G
8542-38	Surrogate recovery < 50%	All base/neutrals	G

Chlorobenzene sample data have been qualified when the single surrogate recovery was outside QC limits. Sample data have been qualified based on the surrogate recovery data summarized in the following table.

Sample	Situation	Compounds	Flag
8542-15	Surrogate recovery < 10%	All chlorobenzenes	X
8542-16	Surrogate recovery < 10%	All chlorobenzenes	X
8542-30	Surrogate recovery < 10%	All chlorobenzenes	X

Surrogate recoveries for all other samples in this data submission were greater than 10% but less than 50%. All associated chlorobenzene sample data have been qualified with the *G* flag.

PCB sample data have been qualified when both surrogate recoveries (tetrachloroxylene and decachlorobiphenyl) are outside QC limits. At least one surrogate recovery was within the 50 to 150% QC limits for all samples in this data submission.

Standard Reference Material

The marine sediment SRM analyzed in association with the reported BNA analytical results is HS4, certified by the National Research Council of Canada. HS4 contains a partial list of compounds for BNA analysis. BNA data for all samples in this data submission have been qualified based on the SRM recoveries summarized in the following table.

Compound	% Recovery	Flag
Naphthalene	14	G
Fluorene	23	G
Phenanthrene	41	G
Anthracene	40	G
Fluoranthene	32	G
Pyrene	55	G

Compound	% Recovery	Flag
Benzo(a)anthracene	50	G
Benzo(b)fluoranthene	60	G
Benzo(a)pyrene	49	G
Indeno(1,2,3-c,d)pyrene	49	G
Benzo(g,h,i)perylene	46	G

An SRM is not included during SIM analysis of chlorobenzene compounds.

The marine sediment SRM normally analyzed in association with chlorinated pesticide/PCB analytical results is 1941a, certified by the National Institute of Standards and Technology. As this SRM does not contain PCB Aroclors, it was not analyzed in association with these samples.

Matrix Spike

BNA data for samples 8542-19, 8542-20, 8542-26, and 8542-31 through 8542-34 have been qualified based on the matrix spike recoveries summarized in the following table.

Compound	% Recovery	Flag
Phenol	39	G
Bis(2-chloroethyl)ether	29	G
2-Chlorophenol	34	G
2-Methylphenol	42	G
Bis(2-chloroisopropyl)ether	38	G
4-Methylphenol	45	G
N-nitroso-di-n-propylamine	40	G
Hexachloroethane	28	G
Nitrobenzene	34	G
Isophorone	36	G
2-Nitrophenol	34	G
2,4-Dimethylphenol	49	G
Naphthalene	38	G
4-Chloroaniline	23	G
Bis(2-chloroethoxy)methane	36	G
Hexachlorobutadiene	36	G
2-Methylnaphthalene	45	G
Hexachlorocyclopentadiene	0	X
2-Chloronaphthalene	50	G
3-Nitroaniline	38	G
2,4-Dinitrophenol	43	G
4-Nitroaniline	42	G
Pentachlorophenol	17	G
Benzidine	0	X
N-Nitrosodimethylamine	27	G
Aniline	16	G
Benzyl Alcohol	39	G
Benzoic Acid	40	G

Chlorobenzene data for samples 8542-19, 8542-20, 8542-26, and 8542-31 through 8542-34 have been qualified based on the matrix spike recoveries summarized in the following table.

Compound	% Recovery	Flag
1,3-Dichlorobenzene	30	G
1,4-Dichlorobenzene	32	G
1,2-Dichlorobenzene	29	G
1,2,4-Trichlorobenzene	40	G

The PCB Aroclor 1260 recovery of 36% for the matrix spike associated with samples 8542-19, 8542-20, 8542-26, and 8542-31 through 8542-34 was less than the 50% QC limit. Associated sample data for Aroclor 1260 were qualified with the *G* flag.

BNA data for samples 8542-12 through 8542-18, 8542-21 through 8542-25, 8542-27, 8542-29, 8542-30, and 8542-35 through 8542-39 have been qualified based on the matrix spike recoveries summarized in the following table.

Compound	% Recovery	Flag
Hexachlorocyclopentadiene	27	G
Benzidine	0	X
Aniline	40	G
Benzoic Acid	26	G

Chlorobenzene data for samples 8542-12 through 8542-18, 8542-21 through 8542-25, 8542-27, 8542-29, 8542-30, and 8542-35 through 8542-39 have been qualified based on the matrix spike recoveries summarized in the following table.

Compound	% Recovery	Flag
1,3-Dichlorobenzene	45	G
1,4-Dichlorobenzene	49	G
1,2-Dichlorobenzene	49	G

The PCB Aroclor 1260 recovery of 43% for the matrix spike associated with samples 8542-12 through 8542-18, 8542-21 through 8542-25, 8542-27, 8542-29, 8542-30, and 8542-35 through 8542-39 was less than the 50% QC limit. Associated sample data for Aroclor 1260 were qualified with the *G* flag.

Laboratory Replicate Samples

The RPDs of laboratory duplicate results for BNA, chlorobenzene and PCB analyses were all less than the QC limit of 100%.

TABLE 1
DUWAMISH/DIAGONAL PHASE II SEDIMENT CLEANUP STUDY
SAMPLE INVENTORY (CORE SAMPLES)

Sample	BNAs	PCBs	Metals	Mercury	PSD	Solids	TOC	Comments
8542-12	X	X	X	X	X	X	X	DUD250 - 0 to 3 feet
8542-13	X	X	X	X	X	X	X	DUD251 - 0 to 3 feet
8542-14	X	X	X	X	X	X	X	DUD251 - 3 to 6 feet
8542-15	X	X	X	X	X	X	X	DUD252 - 0 to 3 feet
8542-16	X	X	X	X	X	X	X	DUD252 - 3 to 6 feet
8542-17	X	X	X	X	X	X	X	DUD253 - 0 to 3 feet
8542-18	X	X	X	X	X	X	X	DUD253 - 3 to 6 feet
8542-19	X	X	X	X	X	X	X	DUD254 - 0 to 3 feet
8542-20	X	X	X	X	X	X	X	DUD254 - 3 to 6 feet
8542-21	X	X	X	X	X	X	X	DUD255 - 0 to 3 feet
8542-22	X	X	X	X	X	X	X	DUD255 - 3 to 6 feet
8542-23	X	X	X	X	X	X	X	DUD255 - 0 to 3 feet (Replicate)
8542-24	X	X	X	X	X	X	X	DUD256 - 0 to 3 feet
8542-25	X	X	X	X	X	X	X	DUD256 - 3 to 6 feet
8542-26	X	X	X	X	X	X	X	DUD257 - 0 to 3 feet
8542-27	X	X	X	X	X	X	X	DUD258 - 0 to 3 feet
8542-28	X	X	X	X	X	X	X	DUD259 - 0 to 3 feet (Intertidal)
8542-29	X	X	X	X	X	X	X	DUD260 - 0 to 3 feet
8542-30	X	X	X	X	X	X	X	DUD260 - 3 to 6 feet
8542-31	X	X	X	X	X	X	X	DUD261 - 0 to 3 feet
8542-32	X	X	X	X	X	X	X	DUD261 - 3 to 6 feet
8542-33	X	X	X	X	X	X	X	DUD012 - 0 to 3 feet
8542-34	X	X	X	X	X	X	X	DUD012 - 3 to 6 feet
8542-35	X	X	X	X	X	X	X	DUD027 - 0 to 3 feet
8542-36	X	X	X	X	X	X	X	DUD027 - 3 to 6 feet
8542-37	X	X	X	X	X	X	X	DUD027 - 0 to 3 feet (Replicate)
8542-38	X	X	X	X	X	X	X	DUD027 - 3 to 6 feet (Replicate)
8542-39	X	X	X	X	X	X	X	DUD255 - 3 to 6 feet (Replicate)

TABLE 2
QC SAMPLE FREQUENCY FOR SEDIMENT CHEMISTRY PARAMETERS

Parameter	Blank	Duplicate	Triplicate	Matrix Spike	SRM	Surrogate
Particle Size Distribution	NA	10% of Samples	10% of Samples	NA	NA	NA
Total Solids	NA	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	NA	NA
Total Organic Carbon	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	1 Per Batch	NA
Mercury	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Batch	NA
Metals	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Batch	NA
BNAs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	1 Per Extraction Batch	Yes
PCBs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	1 Per Extraction Batch	Yes

TABLE 3
SUMMARY OF DATA QUALIFIERS

Condition to Qualify	METRO Data Qualifier	Organics QC Limits	Metals QC Limits	Conventionals QC Limits	Comment
very low matrix spike recovery	X	< 10 %	< 10 %	NA	
low matrix spike recovery	G	< 50%	< 75%	NA	
high matrix spike recovery	L	> 150%	>125%	NA	
low SRM recovery	G	< 80%*	NA	< 80%*	
high SRM recovery	L	>120%*	>120%	>120%*	
high duplicate RPD	E	>100 %	>20%	> 20 %	use duplicate as routine QC for organics
high triplicate RSD	E	> 100%	NA	> 20 %	use triplicate as routine QC for conventionals
less than the reporting detection limit	< RDL	NA	NA	NA	
less than the method detection limit	< MDL	NA	NA	NA	
contamination reported in blank	B	> MDL	> MDL	> MDL	
very biased data, based on surrogate recoveries	X	all fraction surrogates are <10%	NA	NA	use average surrogate recovery for BNA
biased data, based on low surrogate recoveries	G	all fraction surrogates are < 50%	NA	NA	use average surrogate recovery for BNA
biased data, based on high surrogate recoveries	L	all fraction surrogates are >150%	NA	NA	use average surrogate recovery for BNA
estimate based on presumptive evidence	J# used to indicate the presence of TIC's	NA	NA	NA	
rejected, unusable for all purposes	R	NA	NA	NA	
a sample handling criteria has been exceeded	H	NA	NA	NA	includes container, preservation, hold time, sampling technique

*Note that PSDDA guidance uses a 95% confidence window for this parameter/qualification.

KING COUNTY ENVIRONMENTAL LABORATORY

QUALITY ASSURANCE REVIEW

for

DUWAMISH/DIAGONAL CSO OUTFALL SEDIMENT CLEANUP STUDY
PHASE II MARINE SEDIMENT GRAB SAMPLING
AND PHASE II MARINE SEDIMENT CORE SAMPLING

November 12, 1996

King County Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

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Prepared by:

Scott J. Mickelson
Environmental Specialist III

November 12, 1996

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INTRODUCTION

This Quality Assurance (QA) review accompanies data submitted in connection with marine sediment sampling and analysis conducted during Phase II of the Duwamish/Diagonal Combined Sewer Overflow (CSO) Outfall Sediment Cleanup Study. The QA review is organized into the four sections listed below.

- General Comments
- Conventionals Chemistry
- Metals Chemistry
- Organics Chemistry

An overview of the approach used for the QA review is detailed in the General Comments section. Additional information specific to each analysis is included in the appropriate analytical section.

This QA review has been primarily conducted in accordance with guidelines established through the Puget Sound Dredged Disposal Analysis (PSDDA) program, outlined in *Puget Sound Dredged Disposal Analysis Guidance Manual, Data Quality Evaluation for Proposed Dredged Material Disposal Projects*. Other approaches incorporated in the QA review have been established through collaboration between the King County Environmental Laboratory (KC Laboratory) and the Washington State Department of Ecology (Ecology) Sediment Management Unit.

GENERAL COMMENTS

Scope of Samples Submitted
This QA review is associated with marine sediment core samples collected May 21, 1996 and marine sediment grab samples collected July 16 and September 9, 1996 at the Duwamish/Diagonal CSO outfall and bioassay reference sediment samples collected September 11, 1996 at Carr Inlet. The samples collected and the proposed analytical scheme are summarized in Table 1. Except where noted in the subcontracting sections of this QA review, all analyses have been conducted by the KC Laboratory. Sediment analytical data are reported with associated data qualifiers and have undergone QA1 review, as summarized in this narrative report.

Completeness
Completeness has been evaluated for this data submission and QA review by considering the following criteria:

- Comparing available data with the planned project analytical scheme summarized in Table 1.
- Compliance with storage conditions and holding times.
- Compliance with the complete set of quality control (QC) samples outlined in Table 2.

Subcontracted Analyses
Analyses which have been subcontracted and the issues associated with these subcontracted analyses are noted in this narrative.

Methods
Analytical methods are noted in the applicable analytical sections of this QA review.

Target Lists
The reported target lists have been compared to the target analytes listed in *Table 1- Marine Sediment Quality Standards Chemical Criteria* and *Table 3 - Puget Sound Marine Sediment Cleanup Screening Levels Chemical Criteria* contained in Chapter 173-204 WAC.

Detection Limits
The KC Laboratory distinguishes between the Reporting Detection Limit (RDL) and the Method Detection Limit (MDL).

- The RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified.*
- The MDL is defined as *the minimum concentration of a chemical constituent that can be detected.*

Some subcontractor laboratory data are available with an MDL only, in accordance with the subcontracting laboratory policies. All analytical data are reported with a numeric result and/or detection limit(s).

Storage Conditions and Holding Times
Storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The approach used to evaluate Total Organic Carbon for holding time has been established between the KC Laboratory and Ecology during previous QA1 review efforts.

Method Blanks
Method blanks have been evaluated for the presence of positive analyte results at or greater than the MDL.

Standard Reference Material
Data have been qualified based on available standard reference material (SRM) results. Instances of data reported without associated SRM analysis are noted in the narrative.

Matrix Spikes
Matrix spike results have been used to qualify data for conventionals, metals and organics analyses. Matrix spikes are not required for some conventionals parameters.

Replicate Samples
Data have been qualified based on replicate results. However, not all replicate data have been used as an indicator for data qualification. Only sets of replicate results which contain at least one result significantly greater than the MDL have been considered for data qualification. Where an RDL is present, only replicate data that contain at least one result greater than the RDL have been considered for data qualification. These guidelines have been used to account for the fact that precision obtained near the detection limit is not representative of precision obtained throughout the entire analytical range.

Data Qualifiers
The data qualification system used for this data submission is presented in Table 3. These data qualifiers address situations which require qualification according to QA1 guidance. The exact qualifiers used generally conform to QA1 guidance. The KC Laboratory qualifiers indicating <MDL and <RDL have been used as replacements for the *T* and *U* specified under QA1 guidance. Changes made to SRM data qualification criteria have been discussed with and approved by the Sediment Management Unit of Ecology.

Units and Significant Figures
Data have been reported in accordance with laboratory policy at the time of data generation. When an RDL and MDL are reported, data have been reported to three significant figures above the RDL, and two significant figures equal to or below the RDL. Data with only an MDL have been reported to two significant figures.

Data are stored in a wet weight basis on the KC Laboratory's data base and converted to dry weight during the reporting process. Should only one reported wet weight digit be available, rounding error can be significant. This rounding error can occur during the conversion from wet to dry weight.

CONVENTIONALS

Completeness

Conventionals data are reported for samples 8542-8 through 8542-10, 9142-1 through 9142-3, 9443-1 through 9443-8, and 9446-1 through 9446-2 . These samples were analyzed for particle size distribution (PSD), total organic carbon (TOC), and total solids in association with the complete set of QC samples outlined in Table 2.

Subcontracted Analyses

PSD analysis was subcontracted to AmTest, Inc. in Redmond, Washington.

Methods

PSD analysis was performed in accordance with ASTM and Puget Sound Protocols methodologies (*Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* - page 9 - PSEP, 1986). TOC analysis was performed in accordance with SM5310-B. Total solids analysis was performed in accordance with SM2540-B.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all conventionals parameters analyzed by the KC Laboratory. A positive result and/or MDL have been reported for subcontracted analyses. Sample results are reported in units of mg/Kg on a dry weight basis for TOC. Sample results are reported in percent for PSD and total solids. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for conventionals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
PSD	Not Recommended	6 Months
TOC	6 Months	14 Days
Total Solids	6 Months	14 Days

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks

Method blanks were analyzed in connection with TOC and total solids analyses. All method blank results were less than the MDL.

Standard Reference Material

An SRM (Buffalo River Sediment) was analyzed in connection with TOC analysis. Percent recoveries for all SRM analyses were within the 80 to 120% QC limits.

Laboratory Replicate Samples

Laboratory triplicate samples were analyzed for all conventionals parameters. The percent relative standard deviation (%RSD) for each TOC and total solids triplicate analysis was less than the QC limit of 20%

The average %RSD over all grain size fractions for each of four triplicate analyses performed in association with PSD analysis ranged from 12 to 32%. Laboratory triplicate results were reviewed to determine if a consistent difference in triplicate results occurred over all grain size fractions. Variations in triplicate results appear to be random and a function of inherent variations in the sample rather than QC problems. As a result, PSD data have not been qualified based on laboratory triplicate analysis.

METALS

Completeness
Metals data are reported for samples 8542-8 through 8542-10, 9142-1 through 9142-3, 9443-1 through 9443-8, and 9446-1 through 9446-2 . These samples were analyzed for mercury and other metals in association with the complete set of QC samples outlined in Table 2.

Methods
Mercury analysis was performed in accordance with EPA Method 7471. All other metals analyses were performed in accordance with EPA Method 3050/6010.

Target List
The reported target list includes all metals specified in *Table 1- Marine Sediment Quality Standards Chemical Criteria* and *Table 3 - Puget Sound Marine Sediment Cleanup Screening Levels Chemical Criteria* contained in Chapter 173-204 WAC. Additional metals have been reported as available.

Detection Limits, Units, and Significant Figures
Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all metals. Sample results are reported in units of mg/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times
Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for metals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
Mercury	28 Days	Not Recommended
Metals	2 Years	6 Months

The 28 day mercury holding time was exceeded for samples 9142-1 through 9142-3 (archived core samples) and 9446-1 through 9446-2 (Carr Inlet reference samples). Associated mercury sample data have been qualified with the *H* flag. Sample storage conditions and holding times were met for all other samples in this data submission.

Method Blank
All mercury and metals method blank results were less than the MDL.

Standard Reference Material
The SRM analyzed in association with samples included in this data submission is PACS 1 obtained from the National Research Council of Canada. This SRM does not contain silver. An SRM recovery less than the QC limit of 80% has not been used alone to qualify data because the digestion technique used for sample analysis is different from the technique used during analysis to determine the SRM certified values. Only those metals for which the SRM recovery was less than 80% and the matrix spike recovery was less than 75% have been qualified. Samples qualified due to SRM results are summarized in the following table.

Samples	Metal	SRM Result	Flag
8542-8 through 8542-10	Cadmium	> 120%	L
8542-8 through 8542-10	Antimony	< 80% + MS < 75%	G
9142-1 through 9142-3	Antimony	< 80% + MS < 75%	G
9443-1 through 9443-8	Antimony	< 80% + MS < 75%	G
9446-1 through 9446-2	Antimony	< 80% + MS < 75%	G

Matrix Spike

Samples qualified due to matrix spike results are summarized the following table.

Samples	Metal	MS Result	Flag
8542-8 through 8542-10	Aluminum	>125%	L
8542-8 through 8542-10	Antimony	< 75%	G
8542-8 through 8542-10	Iron	< 75%	G
8542-8 through 8542-10	Silver	< 75%	G
9142-1 through 9142-3	Antimony	< 75%	G
9142-1 through 9142-3	Silver	< 75%	G
9142-1 through 9142-3	Sodium	< 75%	G
9142-1 through 9142-3	Mercury	< 10%	X
9443-1 through 9443-8	Aluminum	>125%	L
9443-1 through 9443-8	Antimony	< 75%	G
9443-1 through 9443-8	Iron	< 75%	G
9446-1 through 9446-2	Aluminum	< 75%	G
9446-1 through 9446-2	Antimony	< 75%	G
9446-1 through 9446-2	Iron	< 75%	G

Laboratory Duplicate Samples

The relative percent difference (RPD) for cadmium results in the laboratory duplicate analysis associated with samples 9142-1 through 9142-3 was greater than the 20% QC limit. However, as both results were less than the RDL, associated cadmium sample data were not qualified. The RPD for antimony results in the laboratory duplicate analysis associated with samples 9443-1 through 9443-8 was also greater than the 20% QC limit. However, as both results were less than the RDL, associated antimony sample data were not qualified. The RPDs for results from all other metals laboratory duplicate analyses were less than the QC limit of 20%.

ORGANICS

Completeness

Organics data are reported for samples 8542-8 through 8542-10, 9142-1 through 9142-3, 9443-1 through 9443-8, and 9446-1 through 9446-2 . These samples were analyzed for base/neutral/acid extractable semivolatile compounds (BNAs) and polychlorinated biphenyls (PCBs) in association with the complete set of QC samples outlined in Table 2.

Methods

BNA analysis was performed in accordance with EPA method 8270 (SW-846). BNA extracts were also analyzed by selected ion monitoring (SIM) to attain lower detection limits for chlorinated benzene compounds. PCB analysis was performed in accordance with EPA method 8080 (SW-846).

Target List

The reported BNA target list includes all compounds specified in *Table 1 - Marine Sediment Quality Standards Chemical Criteria* and *Table 3 - Puget Sound Marine Sediment Cleanup Screening Levels Chemical Criteria* contained in Chapter 173-204 WAC with the exception of benzo(j)fluoranthene. The KC Laboratory has verified that analytical conditions are sufficient to calculate a total benzofluoranthene result using the reported *b* and *k* isomers. Reported PCB data include Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Detection Limits, Units, and Significant Figures

Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all organic compounds. Sample results are reported in units of µg/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times

Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for organics analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
BNAs and Chlorobenzenes	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze
PCBs	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks

Di-N-butyl phthalate was detected at a concentration of 600 µg/Kg in the method blank associated with samples 9142-1 through 9142-3. Associated di-N-butyl phthalate sample data have been qualified with the *B* flag. Bis(2-ethylhexyl) phthalate and butyl benzyl phthalate were detected at concentrations of 143 and 35.4 µg/Kg, respectively, in the method blank associated with samples 8542-9 and 8542-10. Associated bis(2-ethylhexyl) phthalate and butyl benzyl phthalate sample data have been qualified with the *B* flag. All other BNA method blank results were less than the MDL.

All chlorobenzene and PCB method blank results were less than the MDL.

Surrogate Recoveries

BNA sample data are qualified when the average surrogate recovery for either or both the acid and base/neutral fractions are outside the 50 to 150% QC limits. Average base/neutral and acid fraction surrogate recoveries were within QC limits for all samples in this data submission.

Chlorobenzene sample data are qualified when the single surrogate recovery is outside QC limits. Surrogate recoveries less than the 50% QC limit were reported for all samples in this data submission and all associated chlorobenzene sample data have been qualified with the *G* flag

PCB sample data are qualified when both surrogate recoveries are outside QC limits. One or both PCB surrogate recoveries were within QC limits for all samples in this data submission.

Standard Reference Material

The marine sediment SRM analyzed in association with the reported BNA analytical results is 1941a, certified by the National Institute of Standards and Technology. SRM 1941a contains a partial list of compounds for BNA analysis. BNA sample data have been qualified based on the SRM recoveries less than 80%, summarized in the following tables.

Samples 9142-1 through 9142-3 and 8542-8 through 8542-10

Compound	% Recovery	Flag
Naphthalene	17	G
Fluorene	37	G
Phenanthrene	47	G
Anthracene	32	G
Fluoranthene	52	G
Pyrene	49	G
Benzo(a)anthracene	59	G
Benzo(k)fluoranthene	67	G
Benzo(a)pyrene	39	G
Indeno(1,2,3-c,d)pyrene	56	G
Benzo(g,h,i)perylene	49	G

Samples 9443-1 through 9443-8, 9446-1 and 9446-2

Compound	% Recovery	Flag
Naphthalene	13	G
Fluorene	26	G
Phenanthrene	39	G
Anthracene	37	G
Fluoranthene	43	G
Pyrene	48	G
Benzo(a)anthracene	56	G
Benzo(k)fluoranthene	72	G
Benzo(a)pyrene	50	G
Indeno(1,2,3-c,d)pyrene	31	G
Dibenzo(a,h)anthracene	66	G
Benzo(g,h,i)perylene	26	G

A marine sediment SRM was not analyzed in association with chlorobenzene analysis.

A marine sediment SRM for Aroclor 1254 was analyzed in association with samples 9443-1 through 9443-8 and 9446-1 and 9446-2. The SRM is HS-2 certified by the National Research Council of Canada. Recoveries less than 80% were reported for these SRMs and associated Aroclor 1254 sample data have been qualified with the *G* flag.

Matrix Spike

BNA data for samples in this data submission have been qualified based on the matrix spike recoveries less than 50%, summarized in the following table.

Samples 9142-1 through 9142-3

Compound	% Recovery	Flag
4-Chloroaniline	45	G
Hexaxchlorocyclopentadiene	14	G
Benzidine	0	X
Aniline	35	G

Samples 8542-8 through 8542-10

Compound	% Recovery	Flag
Bis(2-chloroethyl) ether	33	G
4-Methylphenol	48	G
Hexachloroethane	32	G
Nitrobenzene	41	G
Isophorone	49	G
4-Chloroaniline	12	G
Bis(2-chloroethoxy)methane	49	G
Hexachlorobutadiene	47	G
Hexachlorocyclopentadiene	22	G
3-Nitroaniline	38	G
4-Nitroaniline	42	G
Pentachlorophenol	21	G
Benzidine	0	X
3,3'-Dichlorobenzidine	16	G
N-Nitrosodimethylamine	48	G
Aniline	24	G

Samples 9446-1 and 9446-2

Compound	% Recovery	Flag
Hexaxchlorocyclopentadiene	48	G
Benzidine	0	X

Samples 9443-1 through 9443-8

Compound	% Recovery	Flag
N-Nitrosodimethylamine	38	G
Bis(2-chloroethyl) ether	42	G
Hexachloroethane	39	G
Hexachlorocyclopentadiene	0	X
Benzidine	0	X
3,3'-Dichlorobenzidine	20	G
4-Chloroaniline	18	G
3-Nitroaniline	36	G
4-Nitroaniline	36	G
Aniline	32	G

Chlorobenzene data for samples in this data submission have been qualified based on the matrix spike recoveries less than 50%, summarized in the following tables.

Samples 8542-8 through 8542-9

Compound	% Recovery	Flag
1,2-Dichlorobenzene	34	G
1,3-Dichlorobenzene	38	G
1,4-Dichlorobenzene	35	G

Samples 9443-1 through 9443-8

Compound	% Recovery	Flag
1,2-Dichlorobenzene	38	G
1,3-Dichlorobenzene	37	G
1,4-Dichlorobenzene	32	G

Aroclor 1260 was used as a matrix spike for the PCB analysis. A percent recovery greater than 150% was reported for the matrix spike associated with samples 9142-1 through 9142-3. Associated sample data for Aroclor 1260 have been qualified with the *L* flag.

Laboratory Replicate Samples

The RPDs for 1,2-dichlorbenzene, 1,3-dichlorobenzene, 1,2,4-trichlorobenzene, and hexachlorobenzene were greater than the QC limit of 100% for the laboratory duplicate results associated with samples 8542-8 through 8542-10. Associated sample data for these compounds have been qualified with the *E* flag. All other chlorobenzene, BNA and PCB laboratory duplicate results were less than the QC limit.

TABLE 1
DUWAMISH/DIAGONAL CSO OUTFALL SEDIMENT CLEANUP STUDY
PHASE II SAMPLE INVENTORY (MARINE SEDIMENT GRABS AND CORES)

Sample	Locator	PSD	Solids	Metals	BNAs	PCBs	Comments
9443-1	DUD200	X	X	X	X	X	Sediment Grab
9443-2	DUD201	X	X	X	X	X	Sediment Grab
9443-3	DUD202	X	X	X	X	X	Sediment Grab
9443-4	DUD203	X	X	X	X	X	Sediment Grab
9443-5	DUD204	X	X	X	X	X	Sediment Grab
9553-6	DUD205	X	X	X	X	X	Sediment Grab
9443-7	DUD206	X	X	X	X	X	Sediment Grab
8542-8	DUD207	X	X	X	X	X	Sediment Grab
8542-9	DUD208	X	X	X	X	X	Sediment Grab
8542-10	DUD209	X	X	X	X	X	Sediment Grab
9443-8	DUD202	X	X	X	X	X	Sediment Grab (Field Replicate)
9446-1	Carr Inlet	X	X	X	X	X	Carr Inlet Reference - Low % Fines
9446-2	Carr Inlet	X	X	X	X	X	Carr Inlet Reference - High % Fines
9142-1	DUD254	X	X	X	X	X	Sediment Core 6 to 9 feet
9142-2	DUD027	X	X	X	X	X	Sediment Core 6 to 9 feet
9142-3	DUD027	X	X	X	X	X	Sediment Core 6 to 9 feet (Field Replicate)

TABLE 2
QC SAMPLE FREQUENCY FOR SEDIMENT CHEMISTRY PARAMETERS

Parameter	Blank	Duplicate	Triplicate	Matrix Spike	SRM	Surrogate
Particle Size Distribution	NA	10% of Samples	10% of Samples	NA	NA	NA
Total Solids	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	NA	NA
Total Organic Carbon	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	1 Per Batch	NA
Mercury	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Batch	NA
Metals	1 Per Batch	5% Minimum, 1 Per Batch	NA	5% Minimum, 1 Per Batch	1 Per Batch	NA
BNAs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	1 Per Extraction Batch	Yes
PCBs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	NA	Yes

TABLE 3
SUMMARY OF DATA QUALIFIERS

Condition to Qualify	METRO Data Qualifier	Organics QC Limits	Metals QC Limits	Conventionals QC Limits	Comment
very low matrix spike recovery	X	< 10 %	< 10 %	NA	
low matrix spike recovery	G	< 50%	< 75%	NA	
high matrix spike recovery	L	> 150%	>125%	NA	
low SRM recovery	G	< 80%*	NA	< 80%*	
high SRM recovery	L	>120%*	>120%*	>120%*	
high duplicate RPD	E	>100 %	>20%	> 20 %	use duplicate as routine QC for organics
high triplicate RSD	E	> 100%	NA	> 20 %	use triplicate as routine QC for conventionals
less than the reporting detection limit	< RDL	NA	NA	NA	
less than the method detection limit	< MDL	NA	NA	NA	
contamination reported in blank	B	> MDL	> MDL	> MDL	
very biased data, based on surrogate recoveries	X	all fraction surrogates are <10%	NA	NA	use average surrogate recovery for BNA
biased data, based on low surrogate recoveries	G	all fraction surrogates are < 50%	NA	NA	use average surrogate recovery for BNA
biased data, based on high surrogate recoveries	L	all fraction surrogates are >150%	NA	NA	use average surrogate recovery for BNA
rejected, unusable for all purposes	R	NA	NA	NA	
a sample handling criteria has been exceeded	H	NA	NA	NA	includes container, preservation, hold time, sampling technique

*Note that PSDDA guidance uses a 95% confidence window for this parameter/qualification.

KING COUNTY ENVIRONMENTAL LABORATORY

QUALITY ASSURANCE REVIEW

for

DUWAMISH/DIAGONAL CSO OUTFALL SEDIMENT CLEANUP STUDY
PHASE II ARCHIVED SEDIMENT CORE SAMPLES

February 7, 1997

King County Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

KING COUNTY ENVIRONMENTAL LABORATORY

QUALITY ASSURANCE REVIEW

for

DUWAMISH/DIAGONAL CSO OUTFALL SEDIMENT CLEANUP STUDY PHASE II ARCHIVED SEDIMENT CORE SAMPLES

Prepared by:

Scott J. Mickelson
Environmental Specialist III

February 7, 1997

King County Environmental Laboratory
322 West Ewing Street
Seattle, Washington 98119-1507

INTRODUCTION

This Quality Assurance (QA) review accompanies data submitted in connection with marine sediment sampling and analysis conducted during Phase II of the Duwamish/Diagonal Combined Sewer Overflow (CSO) Outfall Sediment Cleanup Study. The QA review narrative is organized into the three sections listed below.

- General Comments
- Conventionals Chemistry
- Organics Chemistry

An overview of the approach used for the review is detailed in the General Comments section. Additional information specific to each analysis is included in the appropriate analytical section.

This QA review has been primarily conducted in accordance with guidelines established through the Puget Sound Dredged Disposal Analysis (PSDDA) program, outlined in *Puget Sound Dredged Disposal Analysis Guidance Manual, Data Quality Evaluation for Proposed Dredged Material Disposal Projects*. Other approaches incorporated in the QA review have been established through collaboration between the King County Environmental Laboratory (KC Laboratory) and the Washington State Department of Ecology (Ecology) Sediment Management Unit.

GENERAL COMMENTS

Scope of Samples Submitted
This QA review is associated with marine sediment core samples collected May 20 and 21, 1996 at the Duwamish/Diagonal CSO outfall. These samples were archived frozen until analysis in January, 1997. The samples collected and the proposed analytical scheme are summarized in Table 1. Except where noted in the subcontracting sections of this QA review, all analyses have been conducted by the KC Laboratory. Sediment analytical data are reported with associated data qualifiers and have undergone QA1 review, as summarized in this narrative report.

Completeness
Completeness has been evaluated for this data submission and QA review by considering the following criteria:

- Comparing available data with the planned project analytical scheme summarized in Table 1.
- Compliance with storage conditions and holding times.
- Compliance with the complete set of quality control (QC) samples outlined in Table 2.

Subcontracted Analyses
Analyses which have been subcontracted and the issues associated with these subcontracted analyses are noted in this narrative.

Methods
Analytical methods are noted in the applicable analytical sections of this QA review.

Target Lists
The reported target lists have been compared to the target analytes listed in *Table 1- Marine Sediment Quality Standards Chemical Criteria* and *Table 3 - Puget Sound Marine Sediment Cleanup Screening Levels Chemical Criteria* contained in Chapter 173-204 WAC.

Detection Limits
The KC Laboratory distinguishes between the Reporting Detection Limit (RDL) and the Method Detection Limit (MDL).

- The RDL is defined as *the minimum concentration of a chemical constituent that can be reliably quantified.*
- The MDL is defined as *the minimum concentration of a chemical constituent that can be detected.*

Some subcontractor laboratory data are available with an MDL only, in accordance with the subcontracting laboratory policies. All analytical data are reported with a numeric result and/or detection limit(s).

Storage Conditions and Holding Times
Storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The approach used to evaluate Total Organic Carbon for holding time has been established between the KC Laboratory and Ecology during previous QA1 review efforts.

Method Blanks
Method blanks have been evaluated for the presence of positive analyte results at or greater than the MDL.

Standard Reference Material
Data have been qualified based on available standard reference material (SRM) results. Instances of data reported without associated SRM analysis are noted in the narrative.

Matrix Spikes
Matrix spike results have been used to qualify organics analyses. Matrix spikes are not required for most conventionals parameters.

Replicate Samples
Data have been qualified based on replicate results. However, not all replicate data have been used as an indicator for data qualification. Only sets of replicate results which contain at least one result significantly greater than the MDL have been considered for data qualification. Where an RDL is present, only replicate data that contain at least one result greater than the RDL have been considered for data qualification. These guidelines have been used to account for the fact that precision obtained near the detection limit is not representative of precision obtained throughout the entire analytical range.

Data Qualifiers
The data qualification system used for this data submission is presented in Table 3. These data qualifiers address situations which require qualification according to QA1 guidance. The exact qualifiers used generally conform to QA1 guidance. The KC Laboratory qualifiers indicating <MDL and <RDL have been used as replacements for the *T* and *U* specified under QA1 guidance. Changes made to SRM data qualification criteria have been discussed with and approved by the Sediment Management Unit of Ecology.

Units and Significant Figures
Data have been reported in accordance with laboratory policy at the time of data generation. When an RDL and MDL are reported, data have been reported to three significant figures above the RDL, and two significant figures equal to or below the RDL. Data with only an MDL have been reported to two significant figures.

Data are stored in a wet weight basis on the KC Laboratory's data base and converted to dry weight during the reporting process. Should only one reported wet weight digit be available, rounding error can be significant. This rounding error can occur during the conversion from wet to dry weight.

CONVENTIONALS

Completeness
Conventionals data are reported for samples 10112-1 through 10112-9 . These samples were analyzed for particle size distribution (PSD), total organic carbon (TOC), and total solids in association with the complete set of QC samples outlined in Table 2.

Subcontracted Analyses
PSD analysis was subcontracted to AmTest, Inc. in Redmond, Washington.

Methods
PSD analysis was performed in accordance with ASTM and Puget Sound Protocols methodologies (*Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound* - page 9 - PSEP, 1986). TOC analysis was performed in accordance with Standard Method (SM) SM5310-B. Total solids analysis was performed in accordance with SM2540-G.

Detection Limits, Units, and Significant Figures
Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all conventionals parameters analyzed by the KC Laboratory. A positive result and/or MDL have been reported for subcontracted analyses. Sample results are reported in units of mg/Kg on a dry weight basis for TOC. Sample results are reported in percent for PSD and total solids. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times
Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for conventionals analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
PSD	Not Recommended	6 Months
TOC	6 Months	14 Days
Total Solids	6 Months	14 Days

Sample storage conditions and holding times were not met for samples in this data submission. The frozen holding time for TOC and total solids was exceeded and frozen storage is not recommended for PSD analysis. Sample data for PSD, TOC and total solids analyses have been qualified with the *H* flag.

Method Blanks
Method blanks were analyzed in connection with TOC and total solids analyses. All method blank results were less than the MDL.

Standard Reference Material
An SRM (Buffalo River Sediment) was analyzed in connection with TOC analysis. Percent recoveries for all SRM analyses were within the 80 to 120% QC limits.

Laboratory Replicate Samples

Laboratory triplicate samples were analyzed for TOC and PSD analyses. A laboratory duplicate sample was included with total solids analysis. The percent relative standard deviation (%RSD) for each TOC triplicate analysis was less than the QC limit of 20%. The relative percent difference (RPD) of the total solids laboratory duplicate results was also less than the 20% QC limit.

The average %RSD over all grain size fractions for the triplicate analysis performed in association with PSD analysis was 25%. Laboratory triplicate results were reviewed to determine if a consistent difference in triplicate results occurred over all grain size fractions. Variations in triplicate results appear to be random and a function of inherent variations in the sample rather than QC problems. As a result, PSD data have not been qualified based on laboratory triplicate analysis.

ORGANICS

Completeness
Organics data are reported for samples 10112-1 through 10112-9 . These samples were analyzed for polychlorinated biphenyls (PCBs) in association with the complete set of QC samples outlined in Table 2.

Methods
PCB analysis was performed in accordance with EPA method 8080 (SW-846).

Target List
Reported PCB data include Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

Detection Limits, Units, and Significant Figures
Data are reported in accordance with laboratory policy at the time the data were generated. A positive result and/or MDL and RDL have been reported for all organic compounds. Sample results are reported in units of µg/Kg on a dry weight basis. Data are reported to three significant figures for results greater than the RDL and two significant figures for results equal to or less than the RDL. For results reported with less than two or three significant figures, significant zeroes are implied.

Storage Conditions and Holding Times
Sample storage conditions and holding times have been evaluated using guidelines established during the Third Annual PSDDA Review Meeting. The criteria used to evaluate storage conditions and holding times for organics analyses are listed in the table below.

Parameter	Frozen Holding Time	Refrigerated Holding Time
PCBs	1 Year to Extract 40 Days to Analyze	14 Days to Extract 40 Days to Analyze

Sample storage conditions and holding times were met for all samples in this data submission.

Method Blanks
All PCB method blank results were less than the MDL.

Surrogate Recoveries
PCB sample data are qualified when both surrogate recoveries are outside QC limits. Both tetrachlorometaxylene and decachlorobiphenyl surrogates were less than the QC limit of 50% for sample 10112-3. Associated PCB sample data have been qualified with the *G* flag. One or both PCB surrogate recoveries were within QC limits for all other samples in this data submission.

Standard Reference Material
A marine sediment SRM for Aroclor 1254 was analyzed in association with PCB analysis. The SRM is HS-2 certified by the National Research Council of Canada. A recovery less than the 80% QC limit was reported for this SRM and associated Aroclor 1254 sample data have been qualified with the *G* flag.

Matrix Spike
Aroclor 1260 was used as a matrix spike for the PCB analysis. The percent recovery was within QC limits.

Laboratory Replicate Samples

The RPDs for Aroclor 1248, Aroclor 1254, and Aroclor 1260 were all greater than the 100% QC limit in the laboratory replicate sample results. Associated sample data for these compounds have been qualified with the *E* flag. It should be noted that sample 10112-3 was chosen randomly for the laboratory replicate. The Aroclor concentrations in this sample were great enough to require reanalysis on a diluted sample aliquot. Aroclor concentrations in the sample and sample dilution may have contributed to the high RPD for laboratory replicate results.

TABLE 1
DUWAMISH/DIAGONAL CSO OUTFALL SEDIMENT CLEANUP STUDY
PHASE II SAMPLE INVENTORY (MARINE SEDIMENT GRABS AND CORES)

Sample	Locator	PSD	Solids	TOC	PCBs	Comments
10112-1	DUD251	X	X	X	X	Archived sediment core - 6 to 9 feet
10112-2	DUD252	X	X	X	X	Archived sediment core - 6 to 9 feet
10112-3	DUD253	X	X	X	X	Archived sediment core - 6 to 9 feet
10112-4	DUD255	X	X	X	X	Archived sediment core - 6 to 9 feet
10112-5	DUD256	X	X	X	X	Archived sediment core - 6 to 9 feet
10112-6	DUD257	X	X	X	X	Archived sediment core - 3 to 6 feet
10112-7	DUD257	X	X	X	X	Archived sediment core - 6 to 9 feet
10112-8	DUD258	X	X	X	X	Archived sediment core - 3 to 6 feet
10112-9	DUD258	X	X	X	X	Archived sediment core - 6 to 9 feet

TABLE 2
QC SAMPLE FREQUENCY FOR SEDIMENT CHEMISTRY PARAMETERS

Parameter	Blank	Duplicate	Triplicate	Matrix Spike	SRM	Surrogate
Particle Size Distribution	NA	10% of Samples	10% of Samples	NA	NA	NA
Total Solids	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	NA	NA
Total Organic Carbon	1 Per Batch	5% Minimum, 1 Per Batch	5% Minimum, 1 Per Batch	NA	1 Per Batch	NA
PCBs	1 Per Batch	5% Min., 1 Per Extr. Batch	1 Per Batch of > 20 Samples	5% Min., 1 Per Extr. Batch	1 Per Extr. Batch	Yes

TABLE 3
SUMMARY OF DATA QUALIFIERS

Condition to Qualify	METRO Data Qualifier	Organics QC Limits	Metals QC Limits	Conventionals QC Limits	Comment
very low matrix spike recovery	X	< 10 %	< 10 %	NA	
low matrix spike recovery	G	< 50%	< 75%	NA	
high matrix spike recovery	L	> 150%	>125%	NA	
low SRM recovery	G	< 80%*	NA	< 80%*	
high SRM recovery	L	>120%*	>120%*	>120%*	
high duplicate RPD	E	>100 %	>20%	> 20 %	use duplicate as routine QC for organics
high triplicate RSD	E	> 100%	NA	> 20 %	use triplicate as routine QC for conventionals
less than the reporting detection limit	< RDL	NA	NA	NA	
less than the method detection limit	< MDL	NA	NA	NA	
contamination reported in blank	B	> MDL	> MDL	> MDL	
very biased data, based on surrogate recoveries	X	all fraction surrogates are <10%	NA	NA	use average surrogate recovery for BNA
biased data, based on low surrogate recoveries	G	all fraction surrogates are < 50%	NA	NA	use average surrogate recovery for BNA
biased data, based on high surrogate recoveries	L	all fraction surrogates are >150%	NA	NA	use average surrogate recovery for BNA
rejected, unusable for all purposes	R	NA	NA	NA	
a sample handling criteria has not been met	H	NA	NA	NA	includes container, preservation, hold time, sampling technique

*Note that PSDDA guidance uses a 95% confidence window for this parameter/qualification.

Bioassay Review

970109 Data Validation Between Raw Data and Summary Tables of MEC Report (EBDRP Phase)

1. Printout of stats analysis showing normality and homogeneity determinations prior to t-tests needs to be included.

Neanthes, Summary Data Tables

1. p.4: error in biomass calculation in rep 2; should be 66.01, not 66.31, and the mean value should be 85.14, not 85.2.
2. p. 9: carryover error from above; rep 2 should be 13.2, not 13.26, and to the right, should be 0.623, not 0.63.
3. p. 17: as done in the raw data sheets, put an asterisk by reps KCEL#9443-5 and 9443-7 indicating these initial salinity values were < 25ppt at the start and were adjusted prior to measuring.
4. Page numbering: p.19 should be numbered as p.20, and p.20 should be numbered as p.21.

Rhepoxynius, Summary Data Tables

1. p.11: KCEL#9444-2, the min salinity should be 28.2, not 28.0.
2. p. 15 should be numbered as p.16, and p. 16 should be numbered as p.17

Echinoderm, Summary Data Tables

1. p.14: for control A, mean salinity is 28.8 and min. salinity should be 26.6.
2. p. 17 should be numbered as p.19, and p. 18 should be numbered as p.20.

Neanthes, Raw Data

1. Need data sheets showing how weights were performed (2 consecutive weights must be obtained which do not differ by more than 0.1mg).
2. Rep 2 initial weights should be 0.814, not 0.754. However, the data is correct in all other calculations and in the summary tables.
3. Rep 2, #C960913.1737A, should be 66.01, not 66.31.
4. #C960911.0837: should be 28.5, not 78.5 salinity. However, summary table and related calculations are OK.
5. #C960913.1037: rep 3 should be 64.01, not 67.01. However, the summary table values are OK.

Rhepoxynius, Raw Data

1. #C960913.1033: p.14, rep 5 measurement not taken.

REVIEW OF NEANTHES DATA FOR DUWAMISH/DIAGONAL 961210

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NOTE: All calculations below have not been verified according to Aquatox QC data review procedures (including calculations from raw data and review by at least two people). Because the summary data have not been verified against raw data (bench sheets), the calculations and conclusions are preliminary.

****

The report from MEC was received Dec. 9 and the following review was performed Dec. 10:

- Comparison of the summary data tables in the report with summary data tables made by KCEL (based on data faxed by MEC). The bench sheet data were reviewed when discrepancies were found between the two tables.
- Water quality summary data tables were reviewed, but not recalculated from raw data.
- The narrative sections in the report (case narrative and SOP) were reviewed and compared with the summary table and/or PSEP protocol.
- The control chart and LC50 value were reviewed.

FINDINGS

Data

The initial biomass table on page 8 has a calculation error. 4.07 mg/5 = 0.81 mg not 0.75 mg. This error does not appear to have been carried through the growth rate calculation, but it should be verified by MEC and all the raw data sheets should be changed. The remaining data appear to have been entered correctly (a thorough comparison between bench data sheets and the MEC summary tables will be performed later).

The negative control met the SMS growth criteria of 0.72 mg/ind/day, but the two reference sediments did not meet SMS growth rate criteria ($\geq$ 80% of negative control). Due to this MEC did not compare the test sediments with the respective reference sediment. One test sediment P9443-7 could have been compared with the control sediment (West Beach). No grain size data were included in the report.

Water Quality Data

The water quality data in the summary table are within acceptable range for each parameter (a thorough comparison between bench data sheets and the MEC summary tables will be performed later). No unit was written in the ammonia table (assumed mg/L). The highest ammonia levels were measured in the control A and B at test termination. No sulfide data were included in the report.

Case Narrative

Typo error. Growth rate written as 0.83 mg/ind/day should be 81 mg/ind/day according to their summary table (page 2 and 9).

Photoperiod is stated as 16 hours light : 8 hours dark on page 20, but in the SOP it is stated to be continuous (page 1).

SOP

The glassware rinsing description differs from the PSEP protocol. MEC rinsed in acetone and distilled water. PSEP recommend distilled water, acetone and methanol or hexane rinse.

LC50 Value

The control chart has six data points with one data point (6.59 mg/L, 6/27/95) outside COE range of 12.5 $\pm$ 5.4 mg/L. The LC50 value of the present study is within the range.

KCEL CALCULATIONS

All the calculations below have not been through the QC procedures in the Aquatox Section, hence the calculations and conclusions are preliminary. In addition the data have not been compared with the bench sheets. Based on grain size station P9443-7 should be compared with West Beach. MEC ran two controls with growth rates of 0.81 and 0.77 mg/ind/day. P9443-7 is statistically different from both controls and the growth rate is less than 70% but greater than 50% of both controls; hence station P9443-7 fails the Biological Effect Criteria but not the Severe Biological Effect Criteria.

Reference station P9446-2 should be used in the comparison for the remaining 6 stations. By comparing the growth rate from P9446-2 with the two controls the following percentages are calculated:

P9446-2 vs Control A : 74%
P9446-2 vs Control B : 78%
P9446-2 vs Control A+B : 76%

If the comparison is carried out between reference station P9446-2 and the six test stations, none of them are significantly different; hence they all pass the SMS biological criteria.

If the comparison is carried out between the negative control (West Beach) and the six stations, the following three stations have a significantly different growth rate and the growth rate is less than 70%, but greater than 50% of the negative control (failing the Biological Effect Criteria): P9443-2, P9443-5 and P9443-6.

REVIEW OF AMPHIPOD (RHEPOXYNIUS) DATA FOR DUWAMISH/DIAGONAL 961210

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NOTE: All calculations below have not been verified according to Aquatox QC data review procedures (including calculations from raw data and review by at least two people). Because the summary data have not been verified against raw data (bench sheets), the calculations and conclusions are preliminary.

****

The report from MEC was received December 9, 1996, and the following review was performed December 10:

- Comparison of the summary data tables in the report with summary data tables prepared by KCEL, which were based on faxed data. Raw (bench sheet) data were reviewed only when discrepancies were found between the two tables; otherwise, no recalculations were performed from raw data.
- Water quality summary data tables were reviewed, but not recalculated from raw data.
- Narrative sections in the report (case narrative and the SOP) were reviewed and compared with the summary table and/or PSEP protocol.
- The control chart and LC50 value were reviewed.

FINDINGS

Data

The data appear entered correctly; a comparison between raw data sheets and MEC summary tables will be performed later.

The negative control (West Beach) met the SMS/PSEP survival criteria of ≤ 10% mean mortality and ≤ 20% mortality in individual replicates, and the two reference sediments P9446-1 and P9446-2 met the SMS survival criteria of < 25% mean mortality.

MEC did not compare the test sediments with the respective reference sediment. One test sediment P9443-7 should have been compared with the control sediment (West Beach) and the remaining six stations with reference sediment P9446-2. No grain size data was included in the report.

Water Quality Data

Water quality data in the summary table are within acceptable range for each parameter. A thorough comparison between bench sheet data and the MEC summary tables will be performed later. The highest ammonia level occurred in test station

P9443-2, but did not appear to affect toxicity. No sulfide data were included in the report.

SOP

The description of the glassware final rinse procedure differs from the PSEP protocol. MEC rinsed with acetone and distilled water, whereas PSEP recommends rinsing with distilled water, acetone, and methanol or hexane.

LC50 Value

The control chart lists 6 data points (11/10/94-3/21/96), all of which fell within the Corps of Engineer's range of 0.79 ± 0.48 mg Cl/L. The LC50 value of the present study is within range.

For the positive control test (reference toxicant), MEC reported that the highest test concentration was measured as 30.8 ppm, whereas the nominal concentrations were in a 0.5 dilution series from 0.125 to 2 ppm. However, given that the calculated EC50 fell within the range recommended by PSEP guidelines, and a normal test organism response was obtained according to the bench sheets, it appears that the test was run at the correct Cd concentrations. Most likely a sample preparation (if done separately) or sample ID error occurred.

KCEL CALCULATIONS

Based on grain size, station P9443-7 should be compared with West Beach controls. MEC ran two controls, which have a mean survival of 97% and 99%, respectively. Mean mortality in station P9443-7 was not statistically different from West Beach and did not exceed SMS criteria; thus, P9443-7 passed the Biological Effects Criteria.

Reference station P9446-2 should be used in the comparison with the remaining 6 test stations. By comparing mean mortality data between reference station P9446-2 and the test stations, only station P9443-5 was both statistically different (Student's t-Test; $p = 0.05$) from the reference station and had an absolute mortality $> 25\%$ of the reference station. Thus, station P9443-5 fails the SMS Biological Criteria.

REVIEW OF ECHINODERM DATA FOR DUWAMISH/DIAGONAL 961210

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NOTE: All calculations below have not been verified according to Aquatox QC data review procedures (including calculations from raw data and review by at least two people). Because the summary data have not been verified against raw data (bench sheets), the calculations and conclusions are preliminary.

****

The report from MEC was received Dec. 9 and the following review was performed Dec. 10:

- Comparison of the summary data tables in the report with summary data tables made by KCEL (based on data faxed by MEC). The calculated combined mortalities and abnormalities in the two tables appear to be similar (just differences in rounding). However, the number can only be verified by going through the bench sheets (there is no intermediate calculation table in the MEC report). The task of comparing summary table with bench sheets will be performed later.
- Water quality summary data tables were reviewed, but not recalculated from raw data.
- The narrative sections in the report (case narrative and SOP) were reviewed and compared with the summary table and/or PSEP protocol.
- The LC50 value was reviewed.

FINDINGS

Data

The larval data appear to have been entered correctly (a thorough comparison between bench data sheets and the MEC summary tables will be performed later). There are small differences in the combined mortalities and abnormalities that MEC calculated and those KCEL calculated but it seems likely due to differences in rounding of numbers in the calculation process.

The initial loading rate was 37.4 embryos/mL, slightly higher than the recommended 20-30 embryos/mL.

The negative control met the SMS combined mortality and abnormality criteria of $\leq$ 30% with a value of 11.82%. In the text on page 3, MEC states another acceptability criteria of > 90% normal development and > 70% survival in seawater. The seawater control was calculated to have a mean of 91% normal development and a mean of 74% survival. KCEL is not sure why they use this criteria and how they arrived at these numbers; however, a clarification of this issue is in progress.

MEC did not compare the test sediments with the respective reference sediment. One test sediment P9443-7 should have been compared with the control sediment (West Beach) and the remaining six stations with reference sediment P9446-2. No grain size data were included in the report.

Water Quality Data

The mean temperature in all water quality chambers was slightly above the recommended 15 $\pm$ 1 °C. This elevated mean temperature seems to be caused by high temperature at test initiation and at test termination ranging from 16.9 to 17.7 °C. However, MEC states that this was only short-term excursions and it does not limit the usefulness of the data. The other water quality data are within the acceptable ranges. No ammonia or sulfide data were included in the report.

Case Narrative

The control normal development for the re-test is stated to be 93.6% (page 2), however, in the table on page 4 the combined mortality and abnormality is 11.82% giving a normal survivorship of 88.18%. A clarification of the difference is in progress. During a phone conversation MEC indicated that they have taken the initial development guideline of >90% embryos with a fertilization membrane as a acceptability criteria, in which case the 93.6% normal development is at test initial not at test termination.

SOP

The glassware rinsing description differs from the PSEP protocol. MEC rinsed in acetone and distilled water. PSEP recommend distilled water, acetone and methanol or hexane rinse.

An inconsistency was discovered in the description of sediment preparation. On page 5 in the SOP it is stated that 20 g of sediment was added to the test chambers and seawater is added up to 1L making a final concentration of 18 g sediment/L. On page 18 in the report MEC state that 18 g of sediment was added to each chamber and 900 mL seawater added. A clarification of whether 18 or 20 g of sediment was added and the volume of water is in progress.

LC50 Value

A control chart was not provided due to low number of data points. The LC50 value of the present study (6.20 mg/L) is within the COE range of 10.1 + 6.5 mg cadmium/L. Verification of the highest concentration (30 ppm) was measured at 10.4 ppm. MEC is stating that improper sample storage and handling is suspected for the differences. Looking at the positive control data KCEL is inclined to believe the LC50 value of 6.20 ppm; high level of abnormal development (100%) was observed in the two highest concentration (15 and 30 ppm), which would not be expected if the concentrations were 10 and 5 ppm. At 5 ppm about half of the larvae should have achieved a normal development.

KCEL CALCULATIONS

All the calculations below have not been through the QC procedures in the Aquatox Section; hence the calculations and conclusions are preliminary. In addition the data have not been compared with the bench sheets. Based on grain size station P9443-7 should be compared with West Beach. MEC ran two controls (West Beach) with combined mortality and abnormality of 30.96% and 15.24%. Depending of which control is used station P9443-7 will pass or fail the Biological Effect Criteria. Compared to control B (15.24%) there is a statistical difference between the control and the test sediment and the combined mortality and abnormality is > 15%. Compared to control A (30.96%) station P9443-7 passes both criteria. If an average is taken over the two controls (23.1%) there is a statistical difference between the controls and the test sediment, but the combined mortality and abnormality is not > 15%.

Reference station P9446-2 should be used in the comparison for the remaining 6 stations. None of the test sediments are significantly different from the reference sediment; hence they all pass the SMS biological criteria.

Duwamish/Diagonal & Norfolk Sediment Remediation Projects

TEAM MEMORANDUM **Project 12602**

DATE: February 11, 1997 **TASK NO:** 240

TO: Tom Belnick
EcoChem, Inc.

FROM: Gene Revelas/Sandy Browing
Striplin Environmental Associates

SUBJECT: DUD Bioassay Review

Tom - Attached find our evaluation of the DUD bioassay data. Note that one of the reference samples (P9446-2) did not quite meet performance criteria (MEC noted it, but Metro assumes it's usable for the SMS evaluation). Ecology could rule that this reference data usable, based on BPJ. However, we generated SMS results for both scenarios (reference data unusable or set aside and control B substituted). As you can see in the attached, if the reference is set aside it changes the SMS outcome of sample P9443-5 (increased to an MCUL failure).

Let us know if you want this info sent on disk or e-mailed (address??).

Call me or Sandy if you have questions.

Gene

Duwamish/Diagonal Sediment Remediation Investigation
Interpretation of the Bioassay Test Results

Scope

The focus of SEA's evaluation was the SMS interpretation of the DUD bioassay data. MEC had previously conducted a QA review of the data. Bioassay data were extracted from MEC's data report, and water quality data were quickly reviewed for purposes of observing trends. SEA performed the calculations, statistics, and appropriate reference-test grain size matches necessary per the SMS. The review was restricted to controls, references, and Samples L9443-1 through L9443-7.

Methods

Two acute effects tests (10-day amphipod and sediment larval) and one chronic effects test (20-day *Neanthes* growth) were performed on seven test sediments (P9443-1 through P9443-7), two control sediments (Control A and Control B), and two reference sediments (P9446-1 and P9446-2). MEC Analytical Systems, Inc. of Carlsbad, California performed the bioassays. Laboratory methods, data quality issues, and test results are presented in a Final report to King County (MEC 1996). The laboratory used methods described in MEC bioassay protocols (#P014.1, #P024.1, and #P042.0) and PSEP (1995).

Findings

The bioassay test results for all three bioassays are shown in Table 1. The results of the grain size analyses, in terms of percent fines, are also shown for purposes of test and reference sediment comparisons.

The evaluation of bioassay data under the Sediment Management Standards (SMS) (Ecology 1995, Michelsen and Shaw 1996) consisted of five steps:

1. Evaluate whether reference and control requirements were met.
2. Select a reference station for each test sample.
3. Compare test response to reference response or to a value specified in the SMS.
4. Transform the data (arcsin transformation for amphipod and sediment larval tests; $\log_{10}$ transformation for *Neanthes* growth test).
5. Determine whether the test and reference sediment responses were significantly different (single-sided t-test, alpha level ≤ 0.05 for amphipod and *Neanthes* growth tests or ≤ 0.10 for the sediment larval test).

Results of the analyses of the bioassay data relative to SMS criteria for each bioassay are provided in Tables 2 through 4. Two assumptions relative to the evaluation of the DUD bioassay data are provided below.

- Sample P9443-7 (8% sand) was compared with Control B, collected from Whidbey Island, in all three bioassays. Sediments from this area have been tested for grain size by the US Army Corps of Engineers and typically contain approximately 5 percent sand.

- Reference samples P9446-1 and P9446-2 failed SMS performance criteria. The reference mean growth rate endpoint (GRE) must be at least 80% of the control mean. The mean GRE for P9446-1 was 0.48 mg/individual/day, and the mean GRE for P9446-2 was 0.60 mg/individual/day. 80% of the Control B (Whidbey Island) mean GRE (0.77 mg/individual/day) is 0.62 mg/individual/day. Reference sample P9446-2 failed the performance criteria by only 0.02 mg/individual/day. Because of this slight exceedance coupled with low standard deviation among replicates, reference sample P9446-2 was used for comparisons with P9443-1 through P9443-6. *However, the usability of this reference data is subject to Ecology approval. SMS guidelines state that "biological tests...shall not be considered valid unless test results for the appropriate control and reference sediments meet the performance standards...."*

- Table 4 contains a footnote, qualifying the use of reference sediment P9446-1. This reference sediment was not used for any test/reference comparisons because its grain size was a poor match for the test sediments. However, its use in the sediment larval test is further constrained by the high variability measured among the five replicates (see Fox and Littleton 1994).

As shown in Table 2, Sample P9443-5 exceeds sediment quality standards (SQS) biological criteria for the amphipod test. Sample P9443-7 exceeds SQS criteria for the *Neanthes* growth test (Table 3a) and sediment larval test (Table 4). Because Sample P443-7 has two SQS exceedances, this sample also exceeds minimum cleanup level (MCUL) criteria (Ecology 1995). *If Ecology determines the reference (P9446-2) is not suitable for use in the Neanthes growth endpoint interpretation, then Sample P9443-5 also exceeds SQS biological criteria by substituting Control B data for reference data. In this scenario, Sample P9443-5 (with two SQS exceedances) would also exceed minimum cleanup level (MCUL) criteria (Ecology 1995).*

References

Fox, David and Therese Littleton. 1994. Interim revised performance standards for the sediment larval bioassay. In the Puget Sound Dredged Disposal Analysis (PSDDA) sixth annual review meeting minutes. Prepared by the US Army Corps of Engineers, Seattle District, Seattle, Washington.

MEC Analytical Systems, Inc. (MEC). 1996. Marine sediment bioassays. Prepared for King County Department of Natural Resources. Prepared by MEC Analytical Systems, Inc., Carlsbad, California.

Michelsen, Dr. Teresa and Travis C. Shaw. 1996. PSDDA Clarification Paper and SMS Technical Information Memorandum. Statistical evaluation of bioassay results. In the Sediment Management Program Biennial Report, Dredging Years 1994/1995. Cooperatively published by (in alphabetical order) U.S. Army Corps of Engineers, Seattle District; U.S. EPA, Region 10; Washington State Department of Ecology; and Washington State Department of Natural Resources.

Puget Sound Estuary Program (PSEP). 1995. Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Final Report. Prepared for EPA, Region 10, Office of Puget Sound, Seattle, Washington. Washington Department of Ecology, Olympia, WA.

Washington State Department of Ecology (Ecology). 1995. Washington State sediment management standards. Chapter 173-204 WAC. Prepared by the Washington State Department of Ecology, Olympia, WA.

Table 1. Duwamish/Diagonal Sediment Remediation Investigation Bioassay Results.

		Amphipod (% Mortality)			20-Day Juvenile Polychaete (Growth Rate - mg/individual/day)			Larval Echinoderm (% Combined Mortality and Abnormality)		
Sample	% Fines	Mean	Range	S.D.	Mean	Range	S.D.	Mean	Range	S.D.
Control A		3	0 - 10	4.5	0.82	0.63 - 1.01	0.17	30.96	15.24 - 43.05	12.49
Control B (WI)	5	1	0 - 5	2.2	0.77	0.50 - 0.99	0.20	15.24	5.88 - 24.33	7.34
Water Control	--	--	--	--	--	--	--	11.82	0.00 - 17.38	6.98
P9443-1	65	13	0 - 20	8.4	0.60	0.36 - 0.76	0.15	32.46	15.78 - 44.92	11.21
P9443-2	50	21	10 - 35	8.9	0.55	0.40 - 0.65	0.09	34.55	28.61 - 40.64	4.50
P9443-3	69	18	15 - 20	2.7	0.62	0.47 - 0.83	0.15	34.97	20.05 - 53.74	13.58
P9443-4	97	22	10 - 50	16.8	0.59	0.47 - 0.71	0.09	32.83	20.05 - 54.01	13.87
P9443-5	91	26	15 - 45	11.9	0.51	0.36 - 0.63	0.10	16.63	1.60 - 30.48	10.41
P9443-6	89	19	0 - 30	11.4	0.54	0.35 - 0.78	0.15	15.88	1.07 - 27.27	11.46
P9443-7	8	4	0 - 10	4.2	0.52	0.47 - 0.59	0.05	34.17	27.54 - 38.24	5.78
P9446-1 (Ref)	21	6	0 - 20	8.9	0.48	0.37 - 0.60	0.09	27.06	9.09 - 67.91	24.8
P9446-2 (Ref)	55	8	5 - 15	4.5	0.60	0.35 - 0.78	0.18	29.04	18.72 - 38.77	8.56

Notes: S.D. = Standard Deviation

WI = Whidbey Island

Table 2. Mean amphipod mortality and probability values (p) for the Duwamish/Diagonal Remediation Investigation. Data were arcsin-transformed prior to statistical significance testing (one-sided t-test, $p \leq 0.05$).

		Amphipod (% Mortality)		
Sample	Reference Match	Mean	p value	SMS Status
Control A		3[a]		
Control B		1[a]		
P9443-1		13[b]	--	Pass
P9443-2		21[b]	--	Pass
P9443-3		18[b]	--	Pass
P9443-4		22[b]	--	Pass
P9443-5	P9446-2 (Ref)	26	0.008	SQS Exceedance
P9443-6		19[b]	--	Pass
P9443-7		4[b]	--	Pass
P9446-1 (Ref)		6[c]		
P9446-2 (Ref)		8[c]		

[a] Control sample passes performance criteria of <10% mortality.

[b] Sample exhibited <25% mortality and therefore passes SMS.

[c] Reference sample passes performance criteria of <25% mortality.

Table 3a. Mean *Neanthes* growth rate endpoint and probability values (p) for the Duwamish/Diagonal Remediation Investigation. Data were $\log_{10}$-transformed prior to statistical significance testing (one-sided t-test, $p \leq 0.05$).

		20-Day Juvenile Polychaete (Growth Rate - mg/individual/day)		
Sample	Reference Match	Mean	p value	SMS Status
Control A		0.82[a]		
Control B		0.77[a]		
P9443-1	P9446-2 (Ref)	0.60[b]	--	Pass
P9443-2	P9446-2 (Ref)	0.55[b]	--	Pass
P9443-3	P9446-2 (Ref)	0.62[b]	--	Pass
P9443-4	P9446-2 (Ref)	0.59[b]	--	Pass
P9443-5	P9446-2 (Ref)	0.51[b]	--	Pass
P9443-6	P9446-2 (Ref)	0.54[b]	--	Pass
P9443-7	Control B	0.52	0.035	SQS Exceedance
P9446-1 (Ref)		0.48[c]		
P9446-2 (Ref)		0.60[c]		

[a] Control sample passes performance criteria of <10% mortality and mean individual growth rate of ≥0.72 mg/individual/day.

[b] Mean growth rate exhibited >70% of mean reference growth rate and therefore passes SMS.

[c] Reference sample fails performance criteria because reference sediment mean individual growth rate is <80% of the mean individual growth rate in the control.

Table 3b. Mean *Neanthes* growth rate endpoint and probability values (p) for the Duwamish/Diagonal Remediation Investigation. Data were $\log_{10}$-transformed prior to statistical significance testing (one-sided t-test, $p \leq 0.05$).

		20-Day Juvenile Polychaete (Growth Rate - mg/individual/day)		
Sample	Reference Match	Mean	p value	SMS Status
Control A		0.82[a]		
Control B		0.77[a]		
P9443-1	Control B	0.60[b]	--	Pass
P9443-2	Control B	0.55[b]	--	Pass
P9443-3	Control B	0.62[b]	--	Pass
P9443-4	Control B	0.59[b]	--	Pass
P9443-5	Control B	0.51	0.049	SQS Exceedance
P9443-6	Control B	0.54[b]	--	Pass
P9443-7	Control B	0.52	0.035	SQS Exceedance
P9446-1 (Ref)		0.48[c]		
P9446-2 (Ref)		0.60[c]		

[a] Control sample passes performance criteria of <10% mortality and mean individual growth rate of ≥0.72 mg/individual/day.

[b] Mean growth rate exhibited >70% of mean reference growth rate and therefore passes SMS.

[c] Reference sample fails performance criteria where reference sediment mean individual growth rate is <80% of the mean individual growth rate in the control.

Table 4. Larval echinoderm combined mortality and abnormality and probability values (p) for the Duwamish/Diagonal Remediation Investigation. When required, data are arcsin-transformed prior to statistical significance testing (one-sided t-test, $p \leq 0.10$).

		Larval Echinoderm (% Combined Mortality and Abnormality)		
Sample	Reference Match	Mean	p value	SMS Status
Control A		30.96		
Control B		15.24		
Water Control		11.82[a]		
P9443-1	P9446-2 (Ref)	32.46[b]	--	Pass
P9443-2	P9446-2 (Ref)	34.55[b]	--	Pass
P9443-3	P9446-2 (Ref)	34.97[b]	--	Pass
P9443-4	P9446-2 (Ref)	32.83[b]	--	Pass
P9443-5	P9446-2 (Ref)	16.63[b]	--	Pass
P9443-6	P9446-2 (Ref)	15.88[b]	--	Pass
P9443-7	Control B	34.17	0.014	SQS Exceedance
P9446-1 (Ref)		27.06[c]		
P9446-2 (Ref)		29.04		

[a] Seawater control passes performance criteria of <30% combined mortality and abnormality.

[b] Sample exhibited combined mortality and abnormality of <15% over mean reference response and therefore passes SMS criteria.

[c] This reference sample exhibited greater than 20% standard deviation (24.8) among the five replicates. The power of the t-test to detect a 20% difference between this reference and a test sediment would not be effective, so this reference is unsuitable for further comparisons.

Appendix M
Phase 1 Results Discussion

DUWAMISH/DIAGONAL CLEANUP STUDY
PHASE I

INTRODUCTION

The goal of the Duwamish/Diagonal cleanup study is to characterize the spatial extent and magnitude of sediment contamination resulting from the discharge of the Duwamish and the Diagonal outfalls into the Duwamish River. Field sampling for the study is being conducted in two phases, Phase I and Phase II. This report is a brief summary of the results from Phase I sampling. Information from this phase of the study will be used to guide Phase II sampling. Phase I sampling included chemical analysis and biological toxicity testing of surface grab samples and chemical analysis of core samples.

The Duwamish/Diagonal site is located in the lower portion of the Duwamish River Waterway at approximately river km 3 in the south industrial section of Seattle. The Metro Duwamish siphon aftbay and pump station overflow structure (Duwamish) outfall and the City of Seattle Diagonal Way storm drain (Diagonal) out fall are located upstream of Harbor Island and immediately downstream of Kellogg Island. The Duwamish outfall is located approximately 20 m south of the Diagonal Way outfall.

The sampling area extends downstream from the Duwamish outfall apporximately 110 m (360 ft), upstream approximately 250 m (820 ft), and offshore approximately 90 m (295 ft). Water depth in the study area ranges from the 0 ft MLLW line to approximately 32 ft deep. Bathymetry of the area shows that downstream of both outfalls the river bottom slopes evenly from the shore toward the middle of the river. Upstream of the outfalls, the bottom slopes steeply from the shore to a depth of 16 to 18 ft and then flattens out for approximately 200 ft before sloping steeply again toward the middle of the river. The bottom topography upstream of the outfalls was probably the result of dredging for the pier that is located at the end of Diagonal Avenue South.

SURFACE CHEMISTRY

The goal of the surface chemistry study is to determine the type and magnitude of contamination in the study area and to determine the boundaries of the cleanup site. The surface study consisted of 41 samples collected at 34 stations including three stations where one field replicate was collected and one station where four variability replicates were collected (figure 1-DUD). The samples were analyzed for base/neutral/acid organic extractables (BNA), tributyltin, pesticides, polychlorinated biphenyls (PCBs), metals, and conventional parameters. Bioassay tests were conducted on surface samples taken from 12 stations. Methyl mercury was analyzed at these 12 bioassay stations.

Methods

Subtidal samples were collected using a 0.1 m^2 Van Veen grab sampler that was operated from a research vessel. A top 10-cm subsample was taken from the grab sample for analysis. Two intertidal stations, 001 and 014, were collected by crew members on the beach at low tide. Again, the top 10-cm were collected. A more detailed methods discussion appears in *Duwamish/Diagonal Sampling and Analysis Plan*, September 1994.

The sampling design for the location of the surface stations was based on depth contour strata and systematic spacing. From the Duwamish and Diagonal outfalls, the sampling grid extended downstream approximately 110 m (360 ft), upstream approximately 250 m (820 ft), and offshore approximately 90 m (300 ft). The first depth strata was a small intertidal mudflat northeast of the Diagonal outfall. The second depth strata was the area between 0 ft MLLW and -10 ft (0 to -3 m). The third depth strata was the area between -10 ft and -25 ft (3 m to 8 m). The last depth strata was the area deeper than -25 ft (8 m) extending to the east edge of the dredged channel. Within each strata, samples were collected at approximately 30 m (100 ft) intervals.

Results

Summary

In 1992, eight chemicals of concern were identified. Five of these chemicals had concentrations above the CSL in 1992. These compounds were butyl benzyl phthalate, bis(2-ethylhexyl)phthalate, benzoic acid, mercury and silver. Three other compounds were chemicals of concern due to SQS exceedances; dibenzo(a,h)anthracene, benzo(g,h,i)perylene and total PCBs.

As a result of the 1994 cleanup study, eleven parameters were found to have concentrations above the CSL and six additional parameters were found above the SQS (figure 2-DUD). Two compounds previously identified as chemicals of concern, benzo(g,h,i)perylene and benzoic acid, were not present in concentrations above the SQS in 1994. Although not regulated by the SMS and not commonly associated with outfalls, tributyltin was added as a potential chemical of concern due to concentrations found in other studies.

Of the 17 compounds found above the SQS and CSL in 1994, only four were found above either criteria in more than five of the samples. These four compounds are butyl benzyl phthalate, bis(2-ethylhexyl)phthalate, total PCBs and mercury. A proposed cleanup area has been developed, based on these chemicals of concern (figure 3-DUD). Of these, the two phthalates are the most regularly found, and bis(2-ethylhexyl)phthalate is the only compound commonly found above the CSL. The distribution of the two phthalates appear to be well connected to the outfalls.

In addition to the widely dispersed contamination, "toxic hotspots" were discovered. A hotspot with very high concentrations and many exceedances of the CSL and SQS was found in the upstream (south) offshore corner. This area is in the vicinity of the Diagonal Avenue South storm drain outfall, a former City treatment plant outfall and a privately-owned cement plant and pier. A lesser hotspot was found in the downstream (north) offshore corner. Furthermore, PCB, tributyltin and some metals concentrations are highest offshore and away from the outfalls, suggesting other sources.

Forty-seven organic chemicals were detected out of 100 that were analyzed and 20 metals were detected out of 22 that were analyzed.

Conventionals

TOC values ranged two orders of magnitude. The lowest values were .08 and .15 percent at the sandy intertidal stations 013 and 015. The highest value of 9.4 percent was at station 027, which was the only station to contain a noticeable amount of wood chips. Most TOC values ranged from 1 to 4 percent. Nearer the outfall, values were typically 2.5 to 3 percent, while values farther away were slightly lower at 1.2 to 2.5 percent.

The nearshore sediments in the vicinity of the Duwamish and Diagonal outfalls and upstream are generally coarse (sand and gravel), with less than 30 percent silt and clay. Large rip-rap boulders downstream of the outfalls required moving many nearshore stations slightly offshore, but the sediments found at the new downstream locations had more fines than the upstream nearshore sediments. Coarse sediments are also found in the upstream nearshore environment, but the band of coarse sediments appears to be interrupted by fine sediments found in the cove behind the cement company pier. Sediment grain size becomes finer moving offshore.

A plume of relatively coarse sediments extends from the Duwamish and Diagonal outfalls towards the river channel. The bathymetry in this area shows a canyon approximately 150 feet wide. This is in the area where the river was dredged and backfilled to install the Duwamish Siphon sewer line.

Metals

Two metals, mercury and silver, were identified as chemicals of concern based on the 1992 preliminary sampling. The 1994 results demonstrate that these two should remain chemicals of

concern, and five others need to be given consideration. These five metals are arsenic, cadmium, chromium, lead, and zinc. The remaining SMS metal, copper, did not exceed the SQS anywhere within the study area.

Mercury and silver exceeded the CSL in three and two samples, respectively. Six additional samples exceeded the SQS for mercury (figure 4-DUD), while no other sample concentration exceeded silver's SQS. Cadmium exceeded the CSL at one station and the SQS at another station; both stations were in the offshore area between the former treatment plant outfall and Diagonal Ave. South outfall. Chromium and lead exceeded the CSL at one station, 027 (figure 13-DUD). Arsenic exceeded the CSL at station 032. The SQS for zinc was exceeded at four stations but there were no CSL exceedances (figure 12-DUD).

Stations 027 and 012 had the highest concentration of most SMS metals and the most exceedances. These two stations are in the offshore southern corner of the study area, in an area slightly upstream of the former City treatment plant outfall and downstream of the Diagonal Avenue S. Outfall. This area is also at the upstream end of the cement loading dock. Station 027 had the highest concentration for all SMS metals except arsenic. Five metals (mercury, cadmium, chromium, lead, silver) exceeded the CSL and one (zinc) exceeded the SQS. Despite an exceedance-free regular sample, the field replicate (FREP) from station 012 exceeded the CSL for mercury and silver and the SQS for cadmium. Cadmium, chromium, lead and silver did not exceed either criteria anywhere but these two samples.

In addition to the exceedances at 027 and 012, mercury exceeded the CSL at 004 and the SQS at six stations: the 016FREP, a 021 variability replicate (VREP), 026, 028, 029, 035. Excluding samples 004 and 012VREP, these exceedances define two areas; one area is the southern offshore corner (defined by stations 012, 026, 027 and 035) and the other area is the northern offshore corner (defined by 016FREP, 028 and 029).

Stations 004 and 021 are in the vicinity of the Duwamish and Diagonal outfalls, but like the 1992 samples, the concentrations of mercury are irregular. Station 004 had the second highest concentration of mercury in the study, 2.11 $^{mg}/_{kg}$. The concentration in the 021VREP (0.422 $^{mg}/_{kg}$) was only slightly higher than the SQS, and the other four surface samples at this station were well below the SQS.

Arsenic exceeded the CSL at station 032 and approached the SQS at station 028, but everywhere else it was less than 33 $^{mg}/_{kg}$, which is substantially lower than the SQS of 57 $^{mg}/_{kg}$.

The SQS for zinc was exceeded by five samples from four stations, with no readily apparent spatial pattern. Zinc exceeded the SQS at 005, 005FREP, 027, 028 and 032. There were no CSL exceedances for zinc.

Polynuclear Aromatic Hydrocarbons

Generally, the highest polynuclear aromatic hydrocarbon (PAH) concentrations were found in front of the Duwamish/Diagonal outfalls and along the shoreline in the first depth strata (figures 5-DUD and 6-DUD). Concentrations decrease with distance offshore and with distance from the outfalls. No low molecular weight PAH (LPAH) parameter exceeded either the SQS or the CSL at any station in the study area. Total high molecular weight PAHs (HPAHs) and fluoranthene exceeded the SQS at station 009, which was located near creosote covered pier supports. Indeno(1,2,3-cd)pyrene and dibenzo(a,h)anthracene exceeded the SQS at station 014, which was located directly in front of a small storm drain from Diagonal Ave. S.

Organic carbon normalized concentrations of total LPAHs at stations 013 and 015 appear higher because of low total organic carbon (TOC). Also because of low TOC at stations 013 and 015, various PAH detection limit exceedances of the sediment quality standards (SQS) and the cleanup screening levels (CSL) occurred. When compared to the dry-weight Apparent Effects Threshold (AET), the detection limits did not exceed the minimum criteria.

Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate was detected in every sample. It exceeded the CSL in 29 samples and the SQS in eight other samples. The row of stations farthest offshore showed lower concentrations than closer inshore (figure 7-DUD). Stations surrounding the Duwamish/ Diagonal outfalls showed a concentration gradient that decreased with distance from the outfalls. This suggests that bis(2-ethylhexyl)phthalate concentrations at these stations are associated with discharges from the Duwamish/Diagonal outfalls or a historic drainage ditch that was used before the current pipe. Three stations upstream (026, 027, and 014), however, show much higher concentrations than surrounding stations, indicating another contamination source, possibly the former City of Seattle Diagonal Way treatment plant outfall or the Diagonal Avenue South storm drain outfall.

Bis(2-ethylhexyl) phthalate was detected in one method blank at a concentration of 46 µg/kg, affecting 16 samples. TOC normalized sample results exceeded either the SQS or CSL for bis(2-ethylhexyl) phthalate in 15 of the affected samples. According to the *National Functional Guidelines for Organic Data Review*, positive sample results should be reported when sample phthalate concentrations are more than 10 times the amount in any blank. All 15 of the samples that exceeded the sediment standards were many times higher than 460 µg/kg dry weight. Method blank contamination, therefore, did not affect these reported results.

Samples from stations 011 and 013 were the only stations where organic carbon normalized values did not exceed the SQS. The organic carbon normalized value exceeded the CSL in the sample from station 015; however, TOC was less than 0.2 percent. When compared to the dry-weight AET, this sample did not exceed the minimum criteria.

Butyl benzyl phthalate

Butyl benzyl phthalate was detected in 33 samples. It exceeded the SQS in 25 samples and exceeded the CSL in one sample at station 026 (figure 8-DUD). Detection limits for the samples from stations 013 and 015 exceeded the SQS but because of low TOC they were compared to the dry-weight AET and did not exceed the minimum criteria. Stations surrounding the Duwamish/Diagonal outfalls showed a concentration gradient that decreased with distance from the outfalls, suggesting that butyl benzyl phthalate concentrations at these stations were associated with the outfalls. Two stations upstream (026 and 014), however, showed much higher concentrations than surrounding stations, indicating another contamination source, possibly the former City treatment plant outfall or the Diagonal Avenue South storm drain outfall.

Like bis(2-ethyhexyl)phthalate, butyl benzyl phthalate method blank contamination affected 16 samples. Reported dry-weight results from stations 016, 025, and 033 were less than ten times the blank contamination and were therefore considered below detection limits and could not be adequately qualified as actual butyl benzyl phthalate concentrations in the samples. Figure 8-DUD shows the reported organic carbon normalized results but does not indicate an SQS exceedance for these stations.

Pesticides

Six pesticides were detected in the study area. They were 4,4'-DDD, 4,4'-DDE, 4,4-DDT, chlordane, dieldrin, and gama BHC (lindane). 4,4'-DDD was detected in 30 samples. At station, 027 DDD was 237 µg/kg dry weight, which was many times higher than any other levels found (figure 9-DUD). Other than the high level at 027, DDD levels were near the detection limits and showed no patterns that would suggest a source.

4,4'-DDE was found in six samples ranging in concentration from 5.31 to 12.3 µg/kg dry weight. DDE was detected at stations (004, 005, 006, 017, 019, 021), which surround the Duwamish/Diagonal outfalls. This suggests that DDE is associated with the outfall discharges.

4,4'-DDT was found in three samples ranging in concentration from 36.8 to 181 µg/kg dry weight. The highest concentration, 181 µg/kg was found in one variability replicate taken at station 021. DDT was undetected in the four other samples taken at this station. The other two stations where DDT was detected (030, 035), were along the row of stations farthest offshore, suggesting a source elsewhere in the river.

Gama BHC (lindane) was detected in three samples at levels near the detection limit. Like DDT, lindane was found at stations that were farthest offshore, suggesting that it is not associated with the Duwamish/Diagonal outfalls.

One other pesticide, dieldrin, was detected in one sample at a level near the detection limit.

Tributyltin

A contract laboratory analyzed all samples for the tributyltin chloride isomer (TBT). TBT was detected in 28 samples with the highest concentration of 418 µg/kg at station 034. All of the highest concentrations were found at the stations farthest offshore (figure 10-DUD). TBT was not detected at any stations immediately surrounding the Duwamish/Diagonal outfalls. Like PCBs, TBT decreased in concentration while moving inshore. This pattern suggests that the source is elsewhere in the river.

PCBs

Four PCBs were detected in the study area. Aroclor 1242 was detected in one sample; aroclor 1248 was detected in 36 samples; aroclor 1254 was detected in 35 samples; and aroclor 1260 was detected in 37 samples. Total PCBs exceeded the CSL in six samples and the SQS in an additional 18 samples (figure 11-DUD).

Two patterns of PCB concentrations emerged. The first pattern shows high levels at a cluster of stations in the upstream end of the study area. The three stations, 012, 026, and 027, are offshore of a former City treatment plant outfall. PCBs were undetected, however, at station 011, directly in front of the former outfall. Dredging may have occurred in the area North of the three stations, thereby accounting for the contrast in concentrations.

The second pattern is high levels along the row of stations farthest offshore. This pattern is opposite of other contaminants, which increase in concentrations while moving toward shore. This suggests that the source is elsewhere in the river.

No other concentration patterns appeared closer to shore. Stations that exceeded the SQS nearshore were generally surrounded by stations that did not. Stations 005, 006, and 019, in front of the Duwamish/Diagonal outfalls, showed no exceedances.

Chlorinated Benzenes

Four chlorinated benzenes were detected in the study area. 1,4-dichlorobenzene was detected at 31 out of 34 stations, exceeded the CSL at station 027, and exceeded the SQS at station 015. 1,2-dichlorobenzene was detected above the method detection limit (MDL) but below the reporting detection limit (RDL) at 11 stations. It was found above the RDL at two additional stations, and exceeded the CSL in the field replicate at station 012. 1,3-dichlorobenzene was found at levels below the RDL at seven stations and above the RDL at two stations. 1,2,4-trichlorobenzene was detected at four stations and exceeded the SQS in the field replicate at station 012.

SUBSURFACE CHEMISTRY

The purpose of core samples is to determine the depth and concentration of contamination in the study area. Cores were taken at two Stations 006 and 020. Station 006 was located approximately 50 feet (15 m) offshore and in front of the Duwamish/Diagonal outfalls. Station 020 was located approximately 150 feet (45 m) offshore and was also in front of the outfalls. More intensive coring will be undertaken in the phase II sampling effort.

Methods

A thin-walled, 4 in (10 cm) diameter aluminum core tube was driven vertically into the sediments by a diver using an pneumatic jackhammer. At Station 006, a 10 ft (3 m) long core tube was hammered into the bottom to a depth of 9 ft (2.7 m) in an attempt to collect at least 6 ft (1.8 m) of sediment for analysis. However, the length of sediment retrieved was only 61 in (1.5 m), which meant the deepest section analyzed was down to 5 ft instead of 6 ft. The deepest core segment that was scheduled to be analyzed, therefore, could not be collected. At Station 020, a six foot long core tube was driven into the bottom in an attempt to collect at least 3 ft of sediment for analysis. A total of 39 in (97.5 cm) was collected. Both cores were divided into 6 in (15 cm) segments for analysis. Segments were analyzed for trace metals, base/neutral/acid extractable (BNA) organics, polychlorinated biphenyls (PCB), pesticides, and conventional parameters. A more detailed methods discussion is available in the *Duwamish/Diagonal Sampling and Analysis Plan* (SAP), September 1994.

Results

Summary

Neither of the cores sampled in the study area went deep enough to determine the maximum depth of contamination. Many parameters exceeded either the SQS or the CSL in the deepest segments of both cores. In addition, many chemicals appeared to continue to increase in concentration with depth particularly in the shorter core at Station 020. Because of this and concentration variability between the core segments, it is also not certain whether the decrease in concentrations of some chemicals in the deepest segments at Station 006 define an actual subsurface peak of contamination.

One possible explanation is that the sediment in the cores is thoroughly mixed as the result of being within an area dredged and backfilled during the installation of the Duwamish Siphon sewer line. Approximately 7 feet of backfill material may be present at station 006, and approximately 20 feet may be present at station 020. The bathymetry in this area shows a canyon approximately 150 feet wide, suggesting that the area was not backfilled to its original depth. If this is the case, then the deep sediments may represent sediments dredged and backfilled approximately 30 years ago, and the upper, less contaminated sediments would represent recent deposition.

Bis(2-ethylhexyl)phthalate, PCB, mercury, cadmium, and lead still exceeded the cleanup screening levels (CSL) in the 4.5-5 ft (135-150 cm) or deepest segment of core 006. In the same segment, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, and 1,4 dichlorobenzene exceeded the sediment quality standards (SQS). Bis(2-ethylhexyl)phthalate, PCBs, mercury, and lead exceeded the CSL in the 2.5-3 ft (75-90 cm) or deepest sediment of core 020. Also in this segment, cadmium and zinc exceeded the SQS.

Overall, 30 BNA organics, four pesticides and four PCBs were detected in the cores. All eight sediment management standard metals were detected as well as 12 other trace metals. Among all segments of both cores, 13 organic parameters and four metals exceeded the CSL and additional eight organic parameters and one metal exceeded the SQS.

Conventionals

Particle size distribution (PSD) for core 006, the core closest to shore, showed that the dominant particle size in all segments were gravel and sand, ranging from 85.1 to 93.9 percent by weight. The remaining fines were mostly silt (5.5 to 14.6 percent) with very little clay (less than 1.4 percent). PSD for core 020, the core farther offshore, showed a much higher percentage of silt and clay than core 006. Silt and clay in all segments of core 006 ranged from 45.2 to 66.6 percent by weight.

Metals

Metals generally showed higher concentrations with depth. Mercury exceeded the CSL in the five deepest segments and exceeded the SQS in the 30-40 cm segment in core 006. In core 020, mercury exceeded the CSL in four segments including the two deepest. Cadmium exceeded the CSL in the five deepest segments in core 006. The deepest segment of core 006 showed the highest concentration of cadmium. Cadmium also exceeded the SQS in the deepest segment in core 020. Lead exceeded the CSL in the five deepest segments in core 006 and the deepest segment in core 020. Lead also exceeded the SQS in the 30-45 cm segment in core 020.

Polynuclear Aromatic Hydrocarbons

Total LPAHs, fluorene, and phenanthrene exceeded the CSL, and acenapthene exceeded the SQS in the 3.5-4 ft (105-120 cm) deep segment of core 006. Also at core 006, total LPAHs, acenapthene, fluoranthene, and phenanthrene exceeded the SQS in the 2.5-3 ft (75-90 cm) deep segment. In all other segments of core 006, no individual LPAHs exceeded the SQS and total LPAHs were less than one half of the SQS. In core 020, no individual LPAHs exceeded the SQS and total LPAHs were less that one third of the SQS.

Total HPAHs and several individual HPAHs exceeded the SQS in the 2.5-3 ft (75-90 cm) deep segment of core 006. Four individual HPAHs exceeded the CSL in the 3.5-4 ft (105-120 cm) deep segment of core 006. In the same segment, total HPAHs and four individual HPAHs exceeded the SQS. In the deepest segment of core 006 [4.5-5 ft (135-150 cm)], five individual

HPAHs exceeded the SQS. There were no HPAH exceedances in the 5 top-most segments of core 006. There were no HPAH exceedance in any segments in core 020.

Phthalates

Bis(2-ethylhexyl)phthalate concentrations exceeded the CSL in all segments of both cores. The method blank associated with these samples did not have contamination. The surrogate recoveries for the method blank were low, however, indicating that possible method blank contamination may not have been detected. A conservative approach would be to use the maximum contamination reported in the other method blanks for the concentration that may have been present in this method blank. According to the *National Functional Guidelines for Organic Data Review*, positive sample results should be reported when sample phthalate concentrations are more than ten times the amount in any blank. Using this approach and comparing ten times the highest blank contamination found in other blanks to sample results shows that possible method blank contamination has no effect on the bis(2-ethyhexyl)phthalate concentrations reported for all segments of both cores.

Butyl benzyl phthalate concentrations exceeded the CSL in the 2-2.5 ft (60-75 cm) deep segment, and exceeded the SQS in four other segments in core 006. Butyl benzyl phthalate also exceeded the SQS in two segments of core 020. As with bis(2-ethylhexyl)phthalate, difficulties with method blank surrogate recoveries create uncertainty in the reported concentrations. In this case, however, reported concentrations that exceed the SQS in the 15-30 cm, 45-60 cm, and the 105-120 cm segments of core 006 and the 0-15 cm segment of core 020 are below ten times the possible method blank contamination, and are therefore considered undetected.

Chlorinated Benzenes

1,4-Dichlorobenzene exceeded the CSL in the 15-30 cm, 30-45 cm, 45-60 cm, and the 75-90 cm segments, and also exceeded the SQS in the 60-75 cm and the 135-150 cm segments of core 006. This compound did not exceed the SQS in any segment in core 020. All BNA sample extracts were also analyzed by GC/MS using ion-trap detection to meet the method detection limits for chlorinated benzenes and related compounds as stated in the project SAP (see the *QA Review for the Duwamish/Diagonal Cleanup Study*, Metro 1994). This compound in all segments in both cores was qualified for low matrix spike recoveries and low surrogate recoveries. Low matrix spike recoveries and low surrogate recoveries indicate that actual 1,4-dichlorobenzene concentrations may be higher than reported.

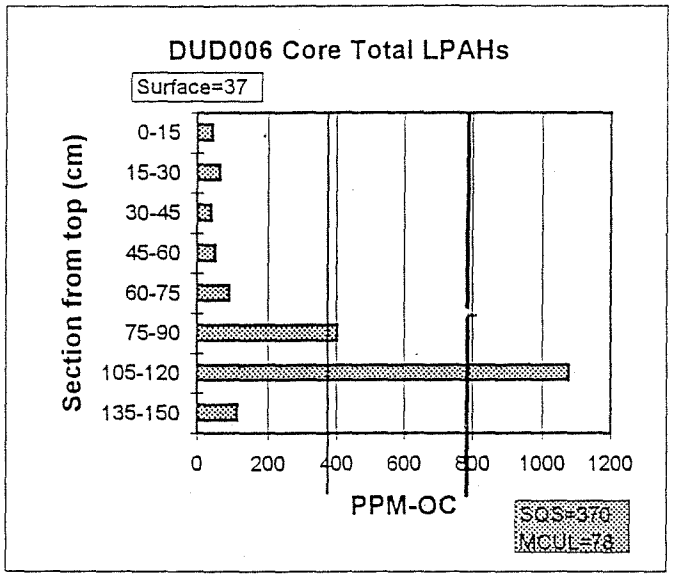
1,2-Dichlorobenzene exceeded the CSL in the 105-120 cm segment in core 006. This segment was qualified for low matrix spike recoveries, low surrogate recoveries, and method blank contamination. The method blank contamination was much lower than the concentrations detected in the core segment, however, and does not represent a significant contribution to the segment concentration.

Polychlorinated Biphenyls

Total PCBs exceeded at least the SQS in all but the top-most segment in core 006. They exceeded the CSL in the 30-45 cm, 75-90 cm, 105-120 cm, and 135-150 cm segments in core 006. In core 020, PCBs exceeded at least the SQS in all but the 30-45 cm segment. PCB also exceeded the CSL in the two deepest segments of core 020.

Other Compounds

N-Nitrosodiphenylamine exceeded the CSL in the 60-75 cm, 75-90 cm, and 105-120 cm segments of core 006. This compound did not exceed the SQS in any other segment in either core.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Section from top (cm)
0-15
15-30
30-45
45-60
60-75
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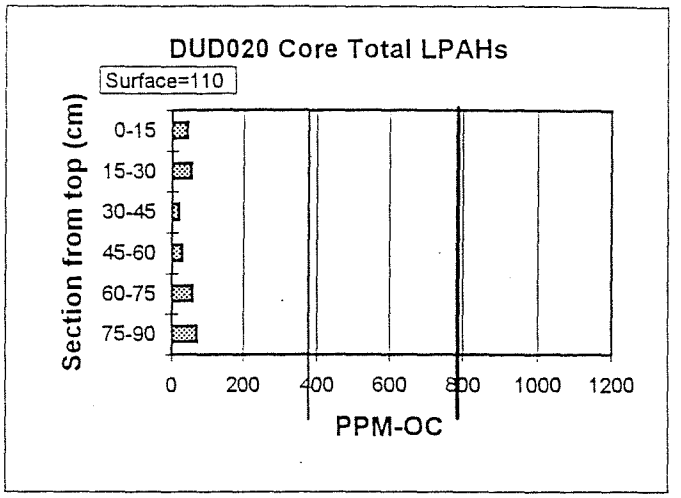
105-120
135-150
0
200
400
600
800
1000
1200
PPM-OC
SQS=370
MCUL=78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Section from top (cm)
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400
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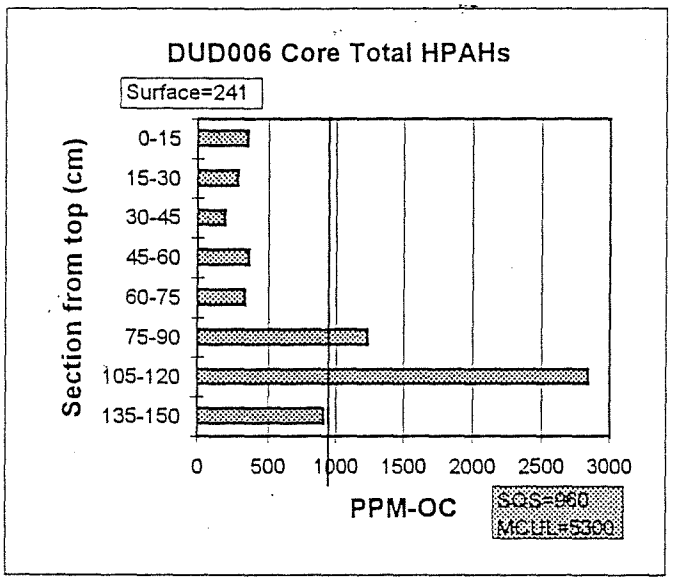
800
1000
1200
PPM-OC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Section from top (cm)
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15-30
30-45
45-60
60-75
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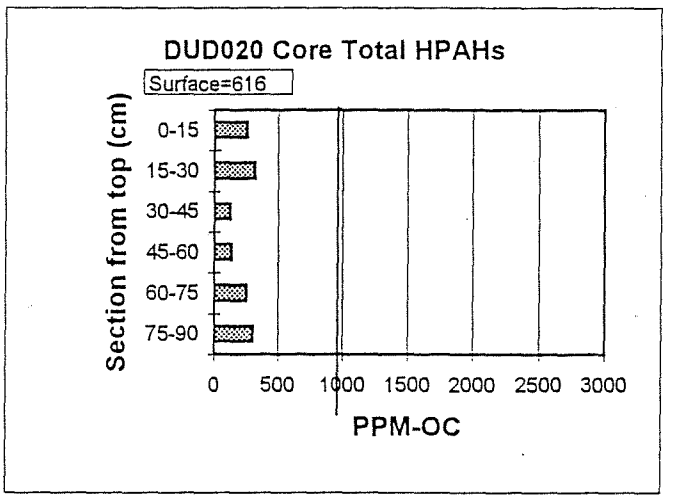
500
1000
1500
2000
2500
3000
PPM-OC
SQS=960
MCUL=5300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Surface=616
Section from top (cm)
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30-45
45-60
60-75
75-90
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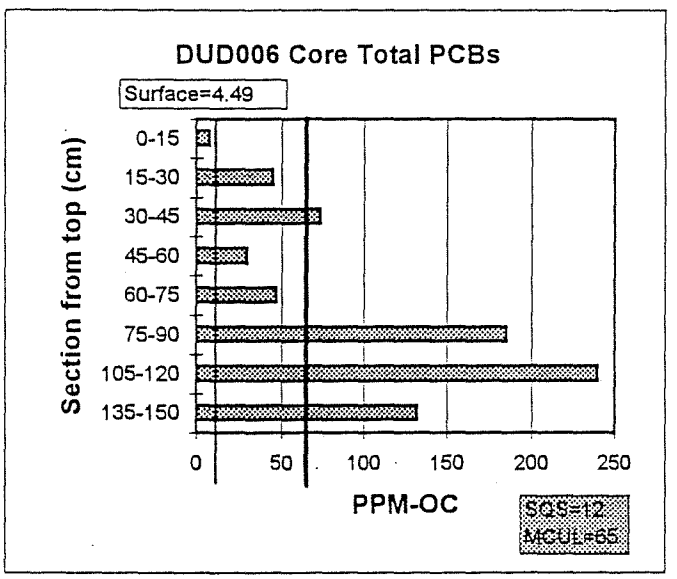
500
1000
1500
2000
2500
3000
PPM-OC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Section from top (cm)
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15-30
30-45
45-60
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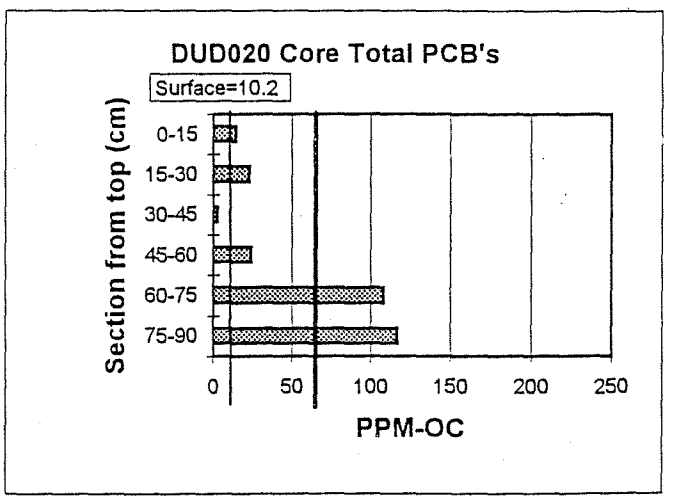
105-120
135-150
0
50
100
150
200
250
PPM-OC
SQS=12
MCUL=65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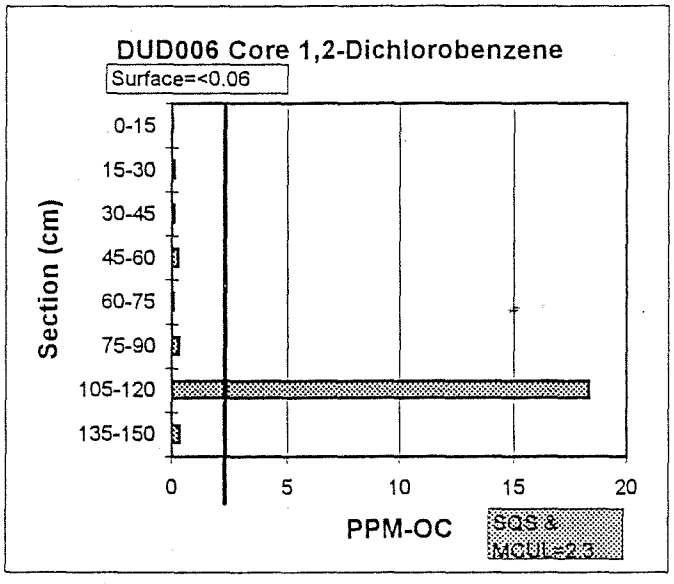
50
100
150
200
250
PPM-OC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Section (cm)
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30-45
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105-120
135-150
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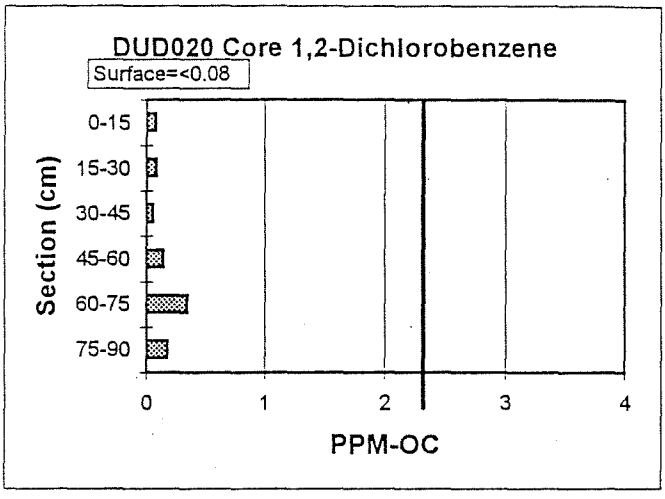
5
10
15
20
PPM-OC
SQS &
MCUL=2.3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Surface=<0.08
Section (cm)
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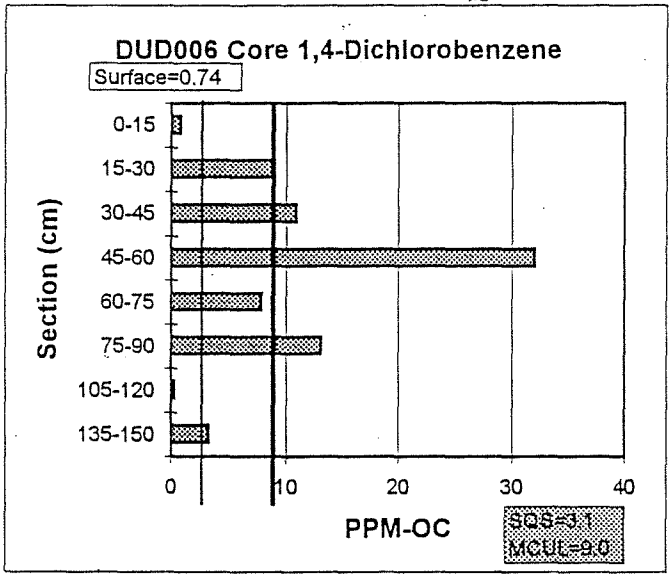
30-45
45-60
60-75
75-90
0
1
2
3
4
PPM-OC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Section (cm)
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30-45
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105-120
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10
20
30
40
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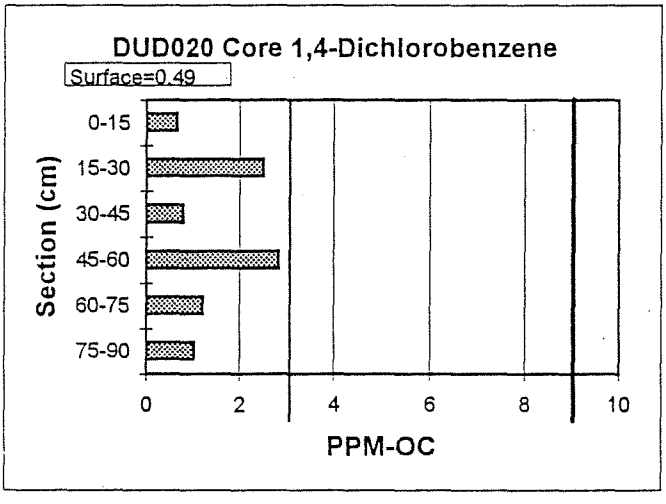
SQS=3.1
MCUL=9.0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Section (cm)
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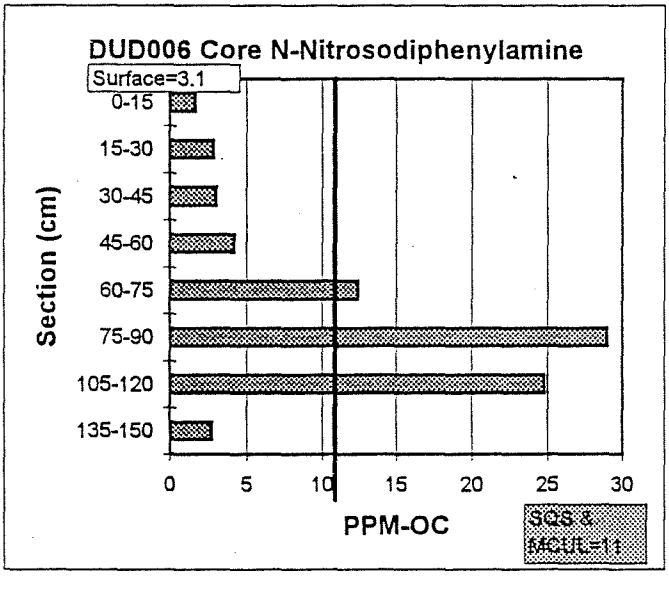
30-45
45-60
60-75
75-90
0
2
4
6
8
10
PPM-OC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Surface=3.1
Section (cm)
0-15
15-30
30-45
45-60
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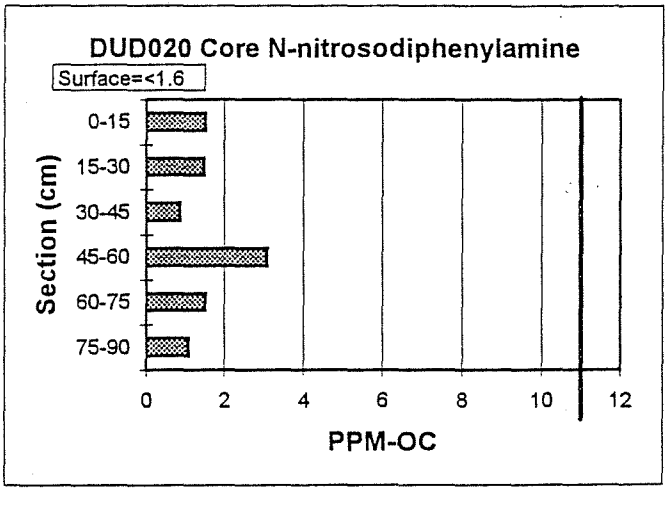
105-120
135-150
0
5
10
15
20
25
30
PPM-OC
SQS &
MCUL=11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Surface=<1.6
Section (cm)
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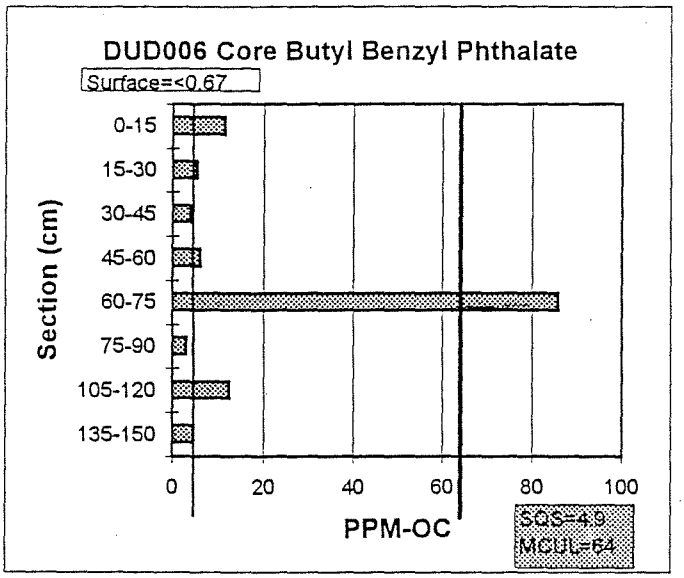
2
4
6
8
10
12
PPM-OC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Surface=<0.67
Section (cm)
0-15
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30-45
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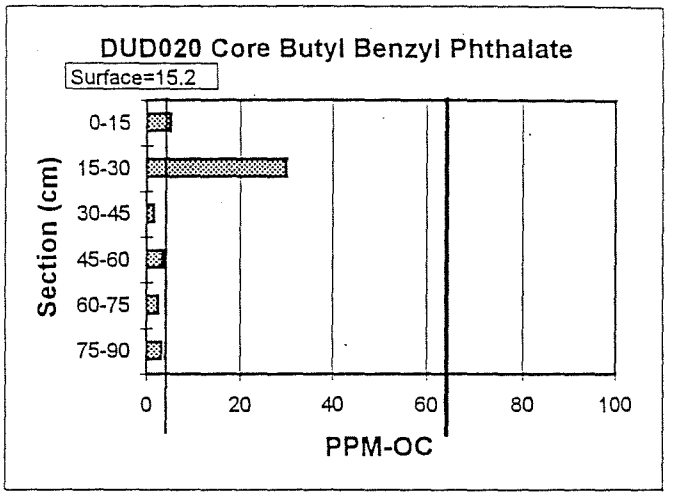
SQS=4.9
MCUL=64


DUD020 Core Butyl Benzyl Phthalate
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Section (cm)
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30-45
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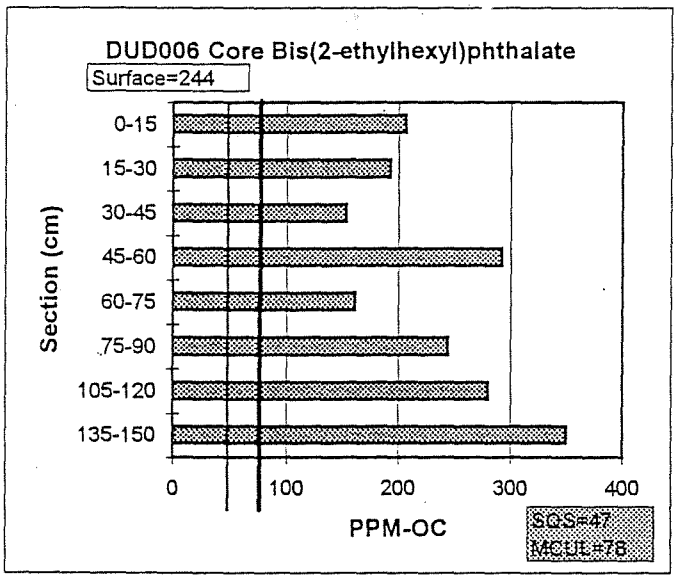
20
40
60
80
100
PPM-OC


DUD006 Core Bis(2-ethylhexyl)phthalate
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Section (cm)
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135-150
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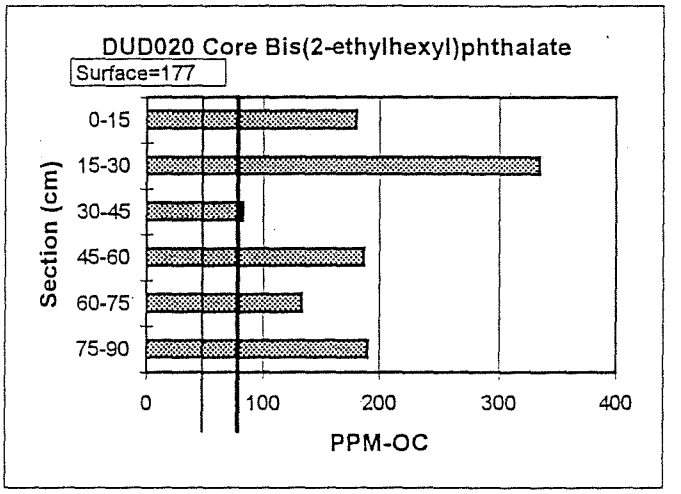
200
300
400
PPM-OC
SQS=47
MCUL=78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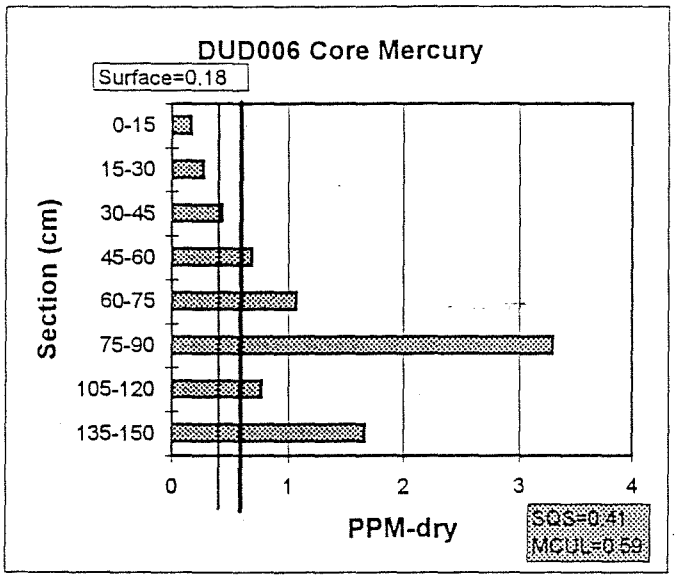
200
300
400
PPM-OC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30-45
45-60
60-75
75-90
105-120
135-150
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2
3
4
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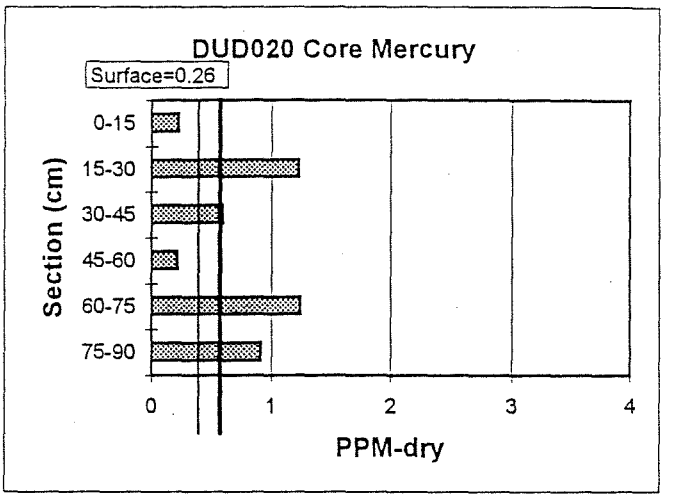
MCUL=0.59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75-90
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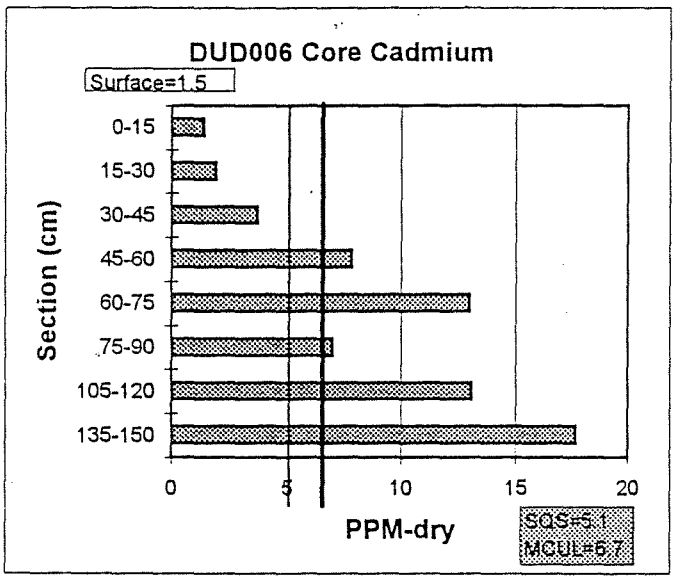
2
3
4
PPM-dry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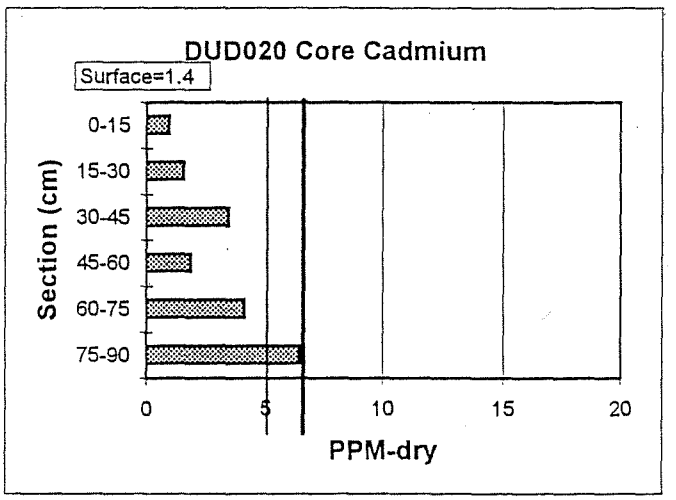
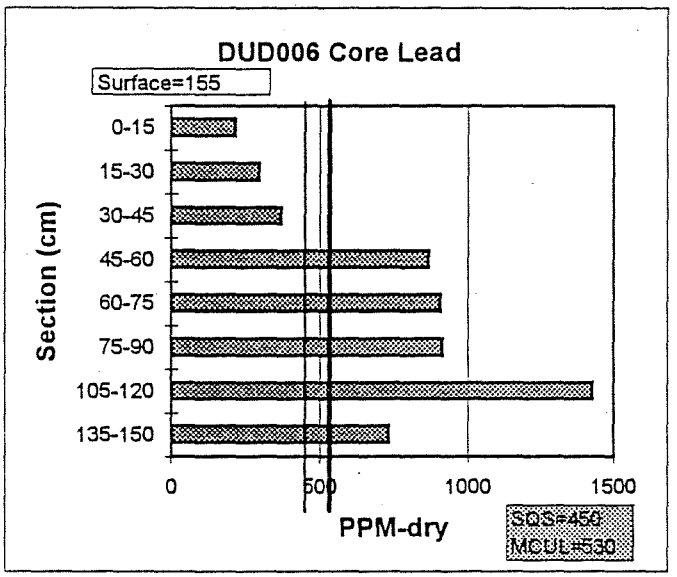
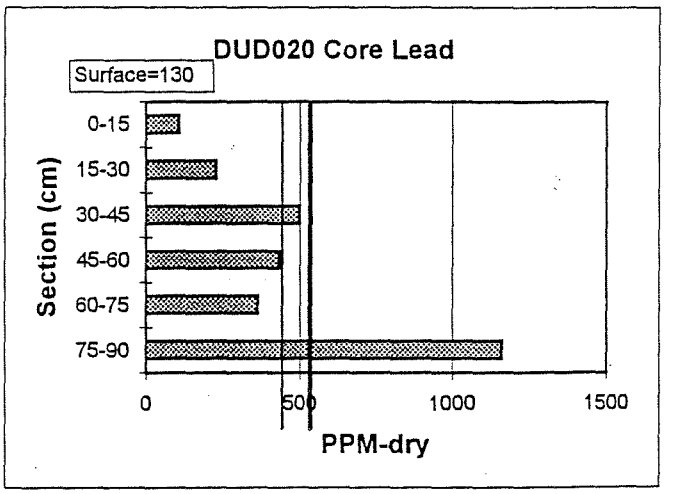
15-30
30-45
45-60
60-75
75-90
105-120
135-150
Section (cm)
0
5
10
15
20
PPM-dry
SQS=5.1
MCUL=6.7


DUD020 Core Cadmium
Surface=1.4
0-15
15-30
30-45
45-60
60-75
75-90
Section (cm)
0
5
10
15
20
PPM-dry


DUD006 Core Lead
Surface=155
0-15
15-30
30-45
45-60
60-75
75-90
105-120
135-150
Section (cm)
0
500
1000
1500
PPM-dry
SQS=456
MCUL=530


DUD020 Core Lead
Surface=130
0-15
15-30
30-45
45-60
60-75
75-90
Section (cm)
0
500
1000
1500
PPM-dry

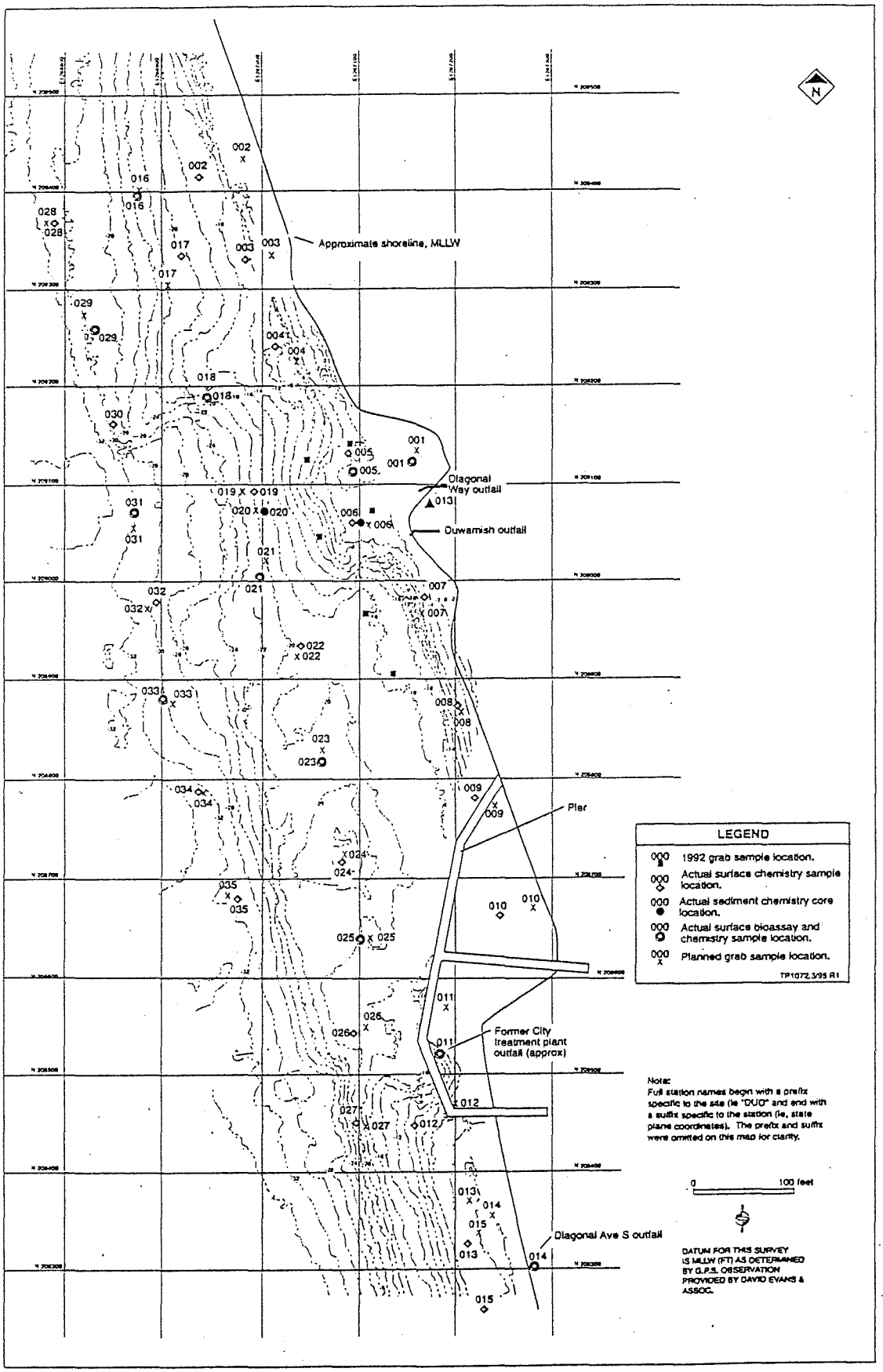


Figure 1-DUD
Duwamish/Diagonal
Sediment Sampling
Locations and
Bathymetry Contours
Showing Planned and
Actual Sediment
Sampling Locations

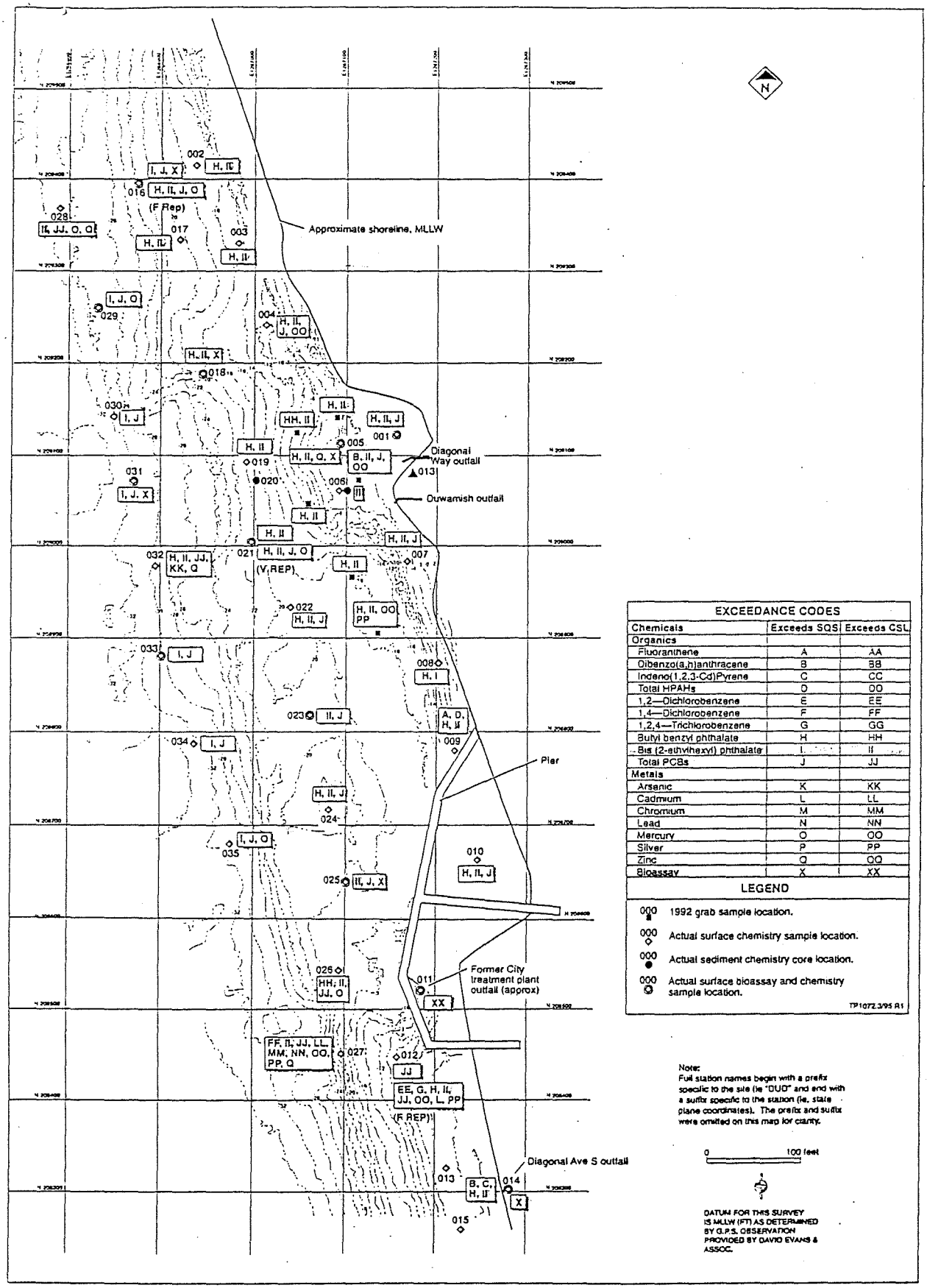


Figure 2-DUD
Duwamish/Diagonal
with Codes of
Chemicals that Exceed
Sediment Standards at
Each Station

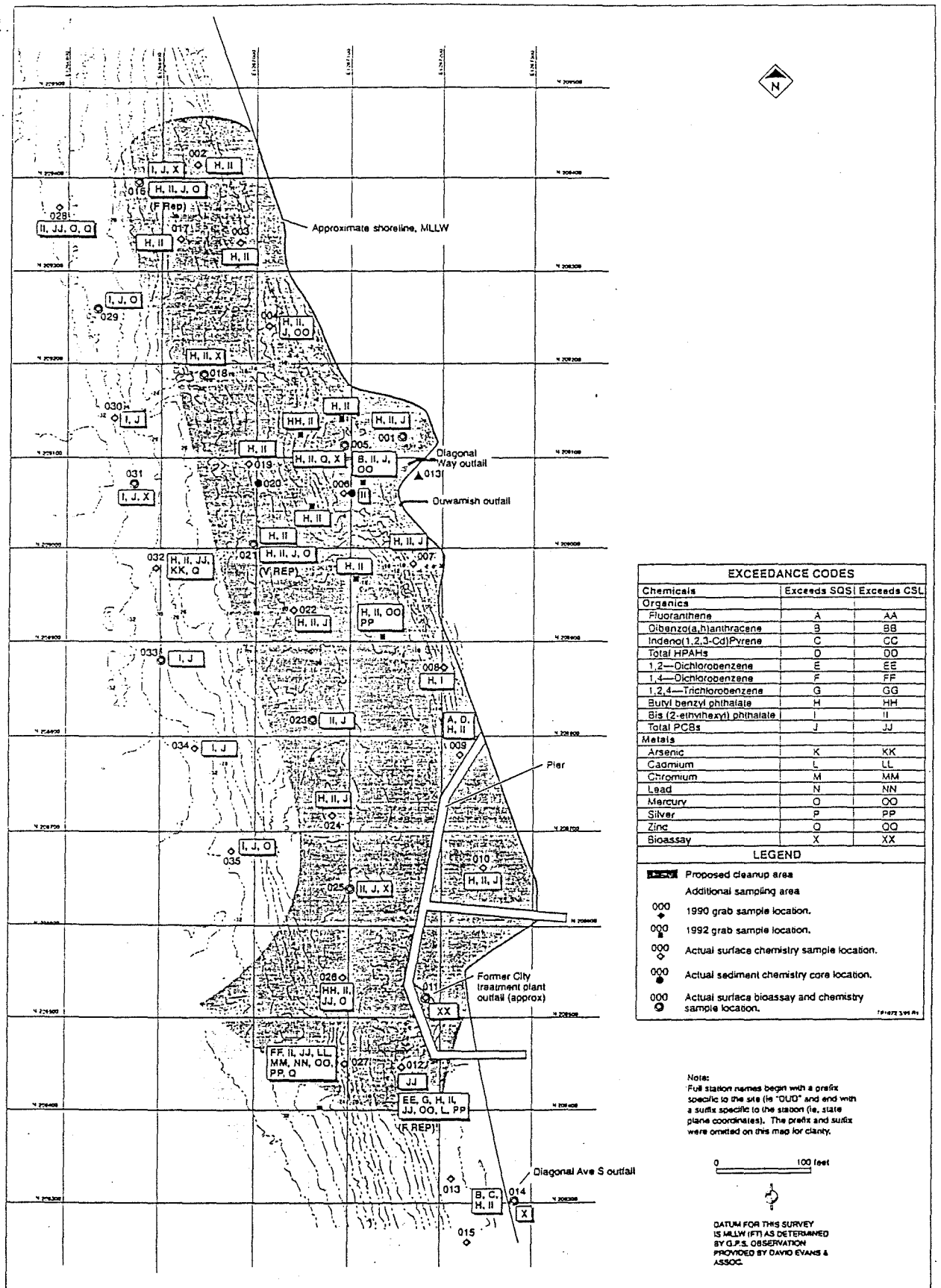


Figure 3-DUD
Duwamish/Diagonal
with Contours Showing
Minimum and Possible
cleanup Area

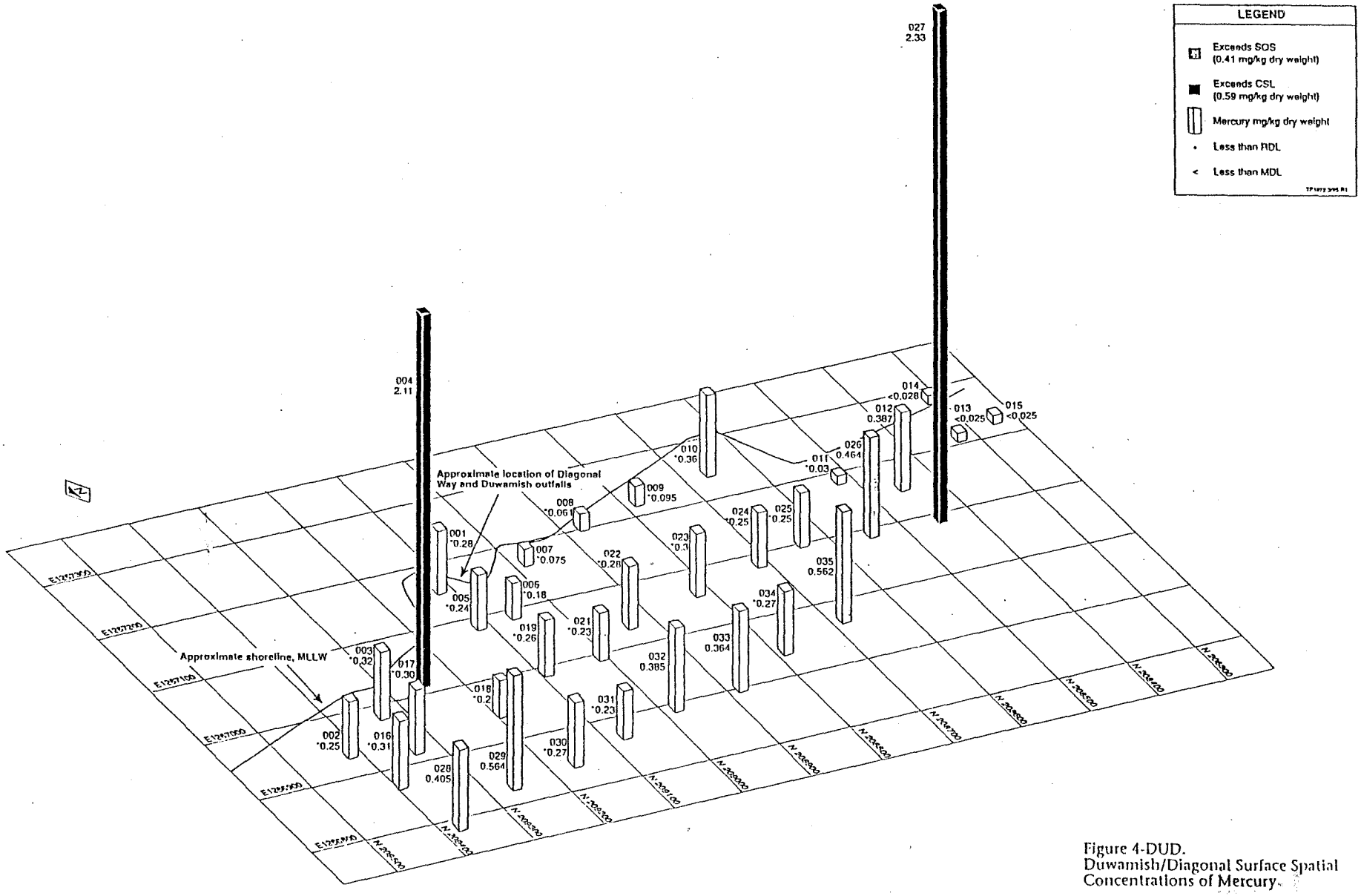


Figure 4-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Mercury.

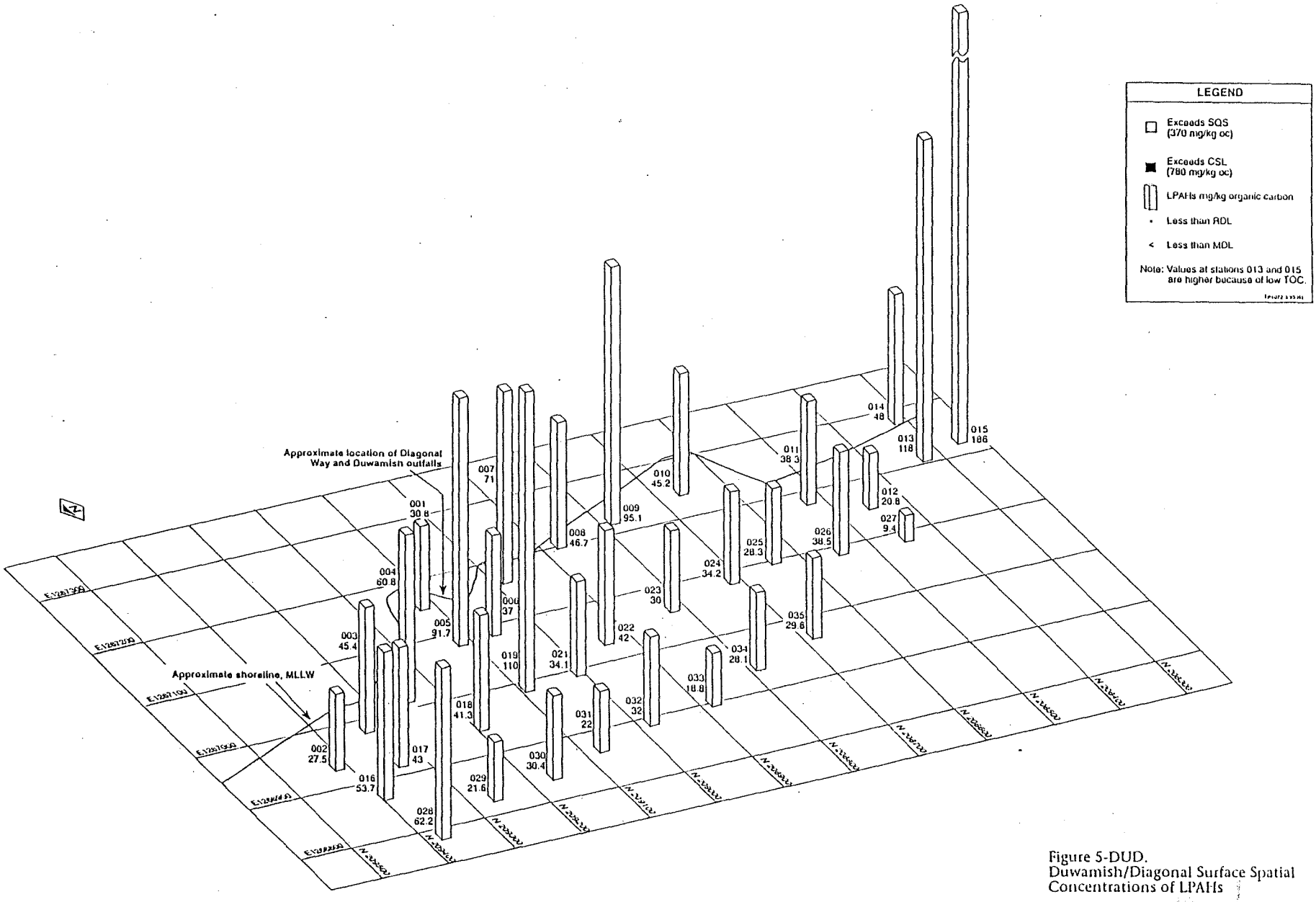


Figure 5-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of LPAHs

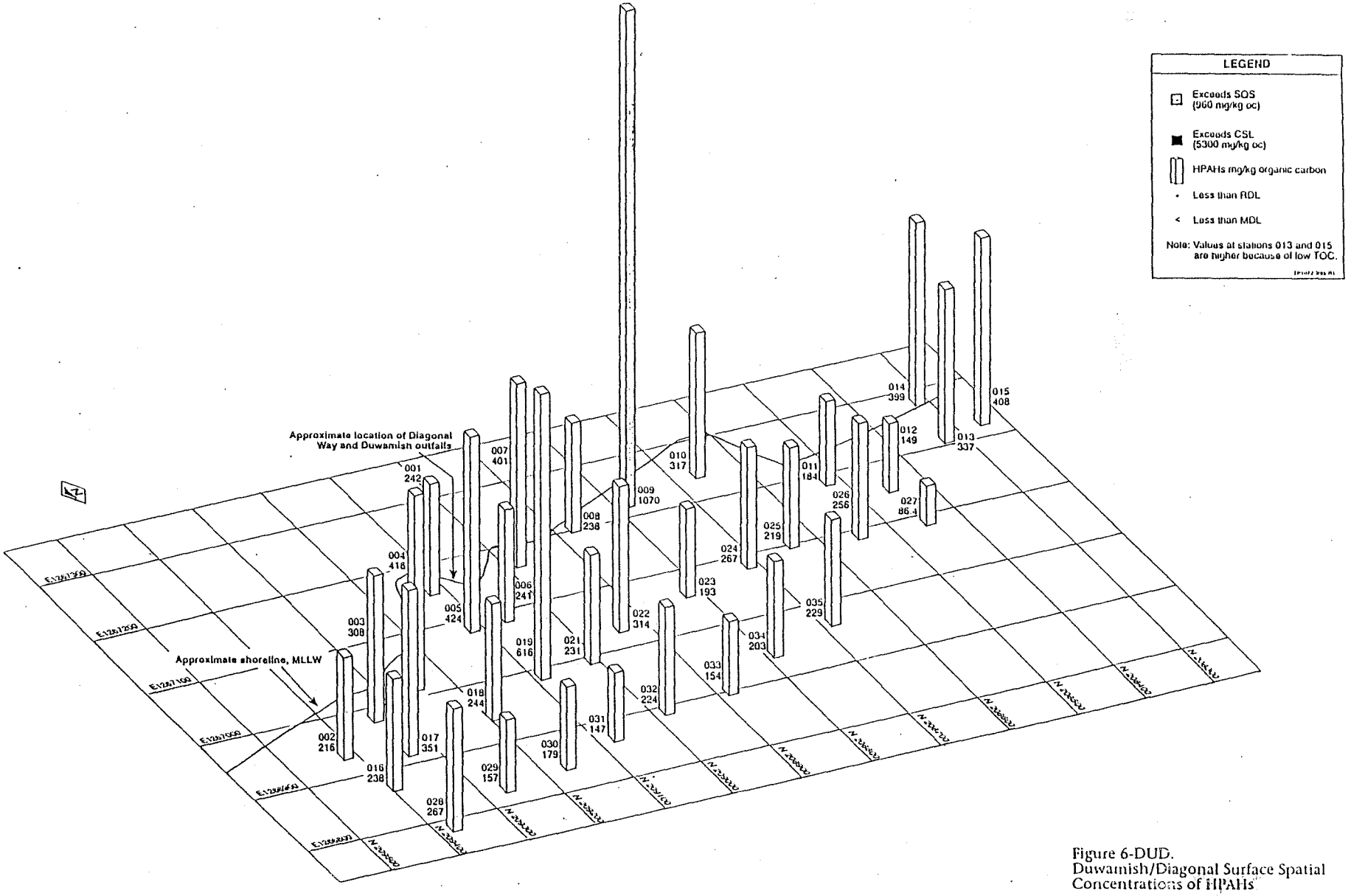


Figure 6-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of HPAHs

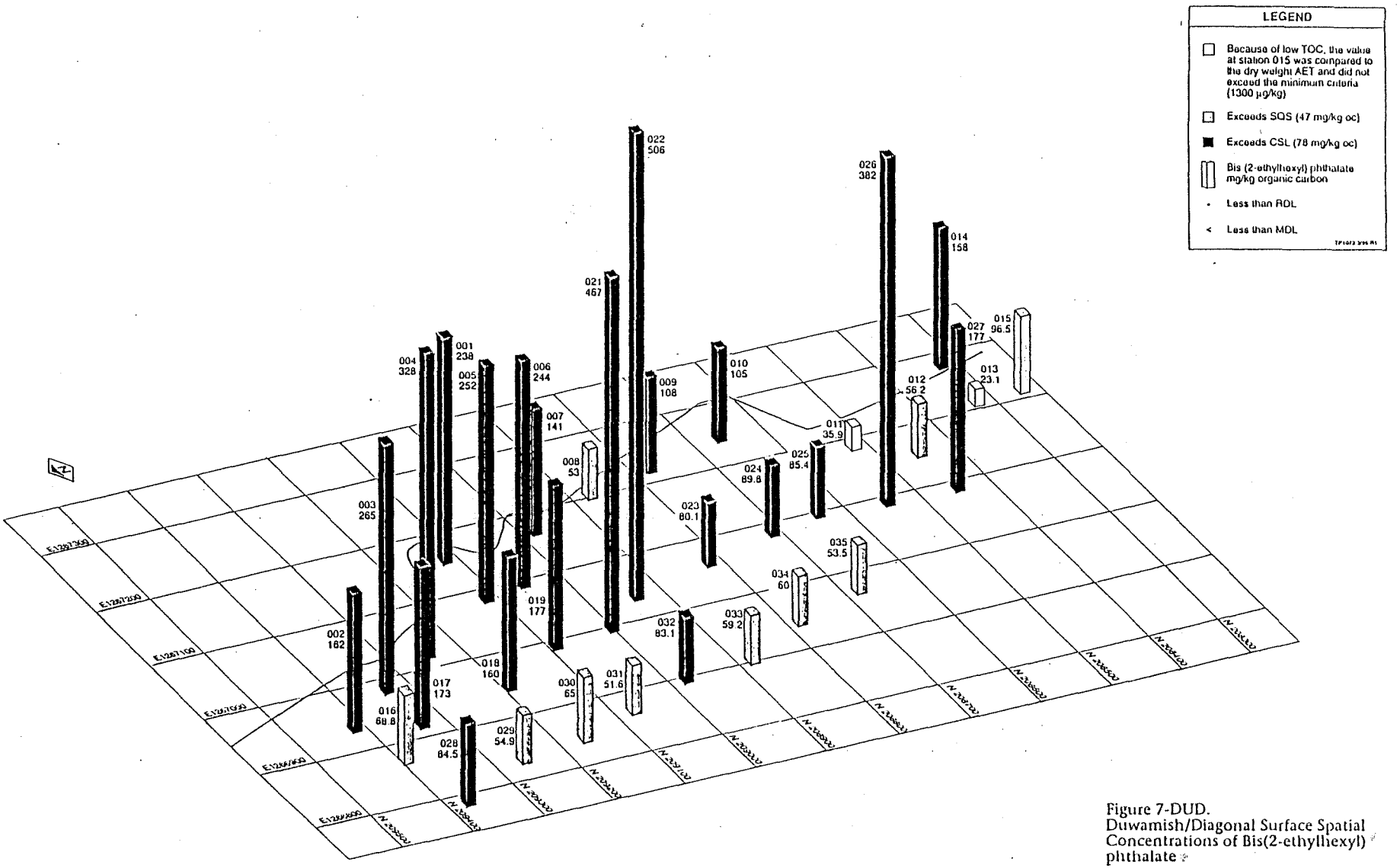


Figure 7-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Bis(2-ethylhexyl) phthalate

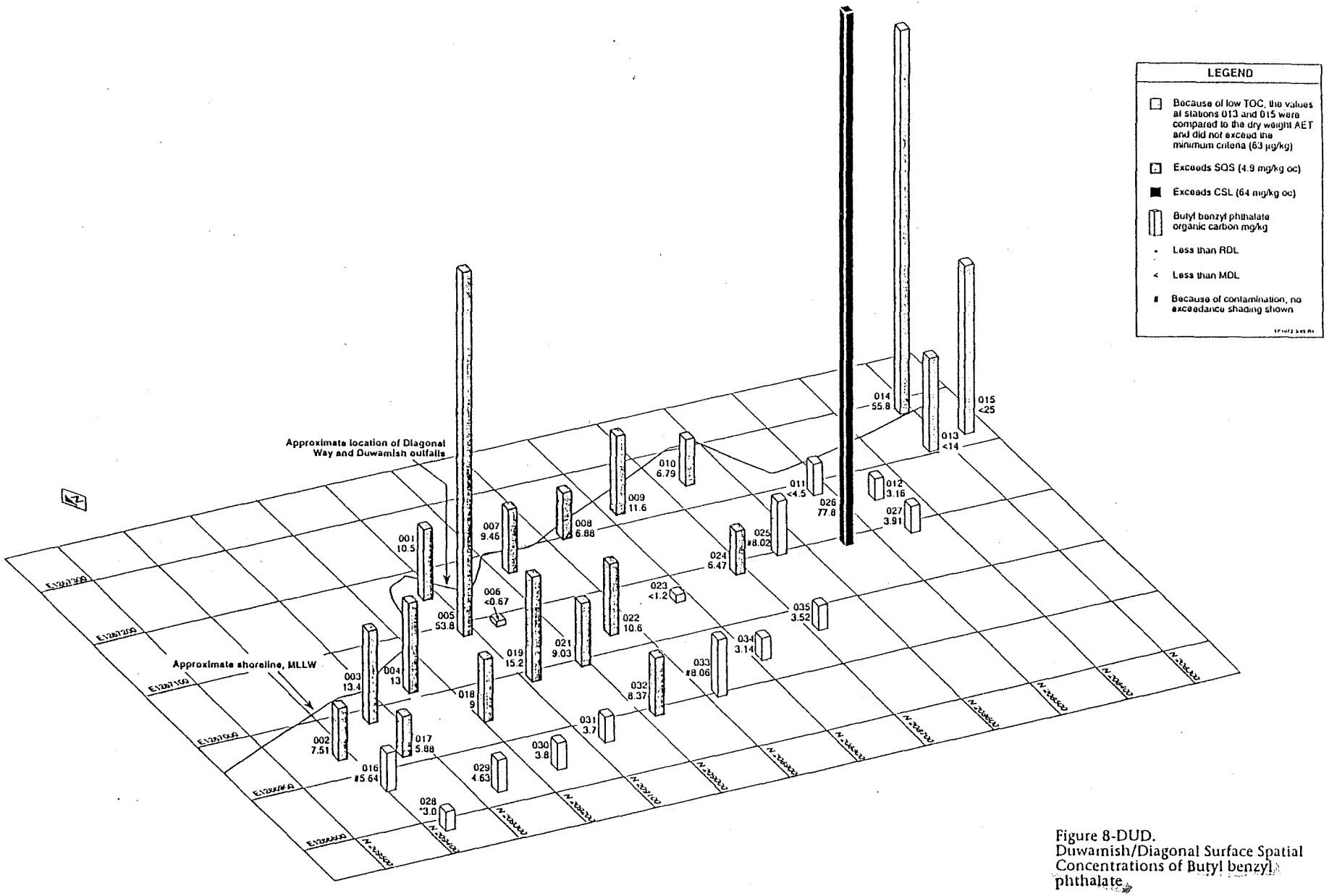


Figure 8-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Butyl benzyl phthalate

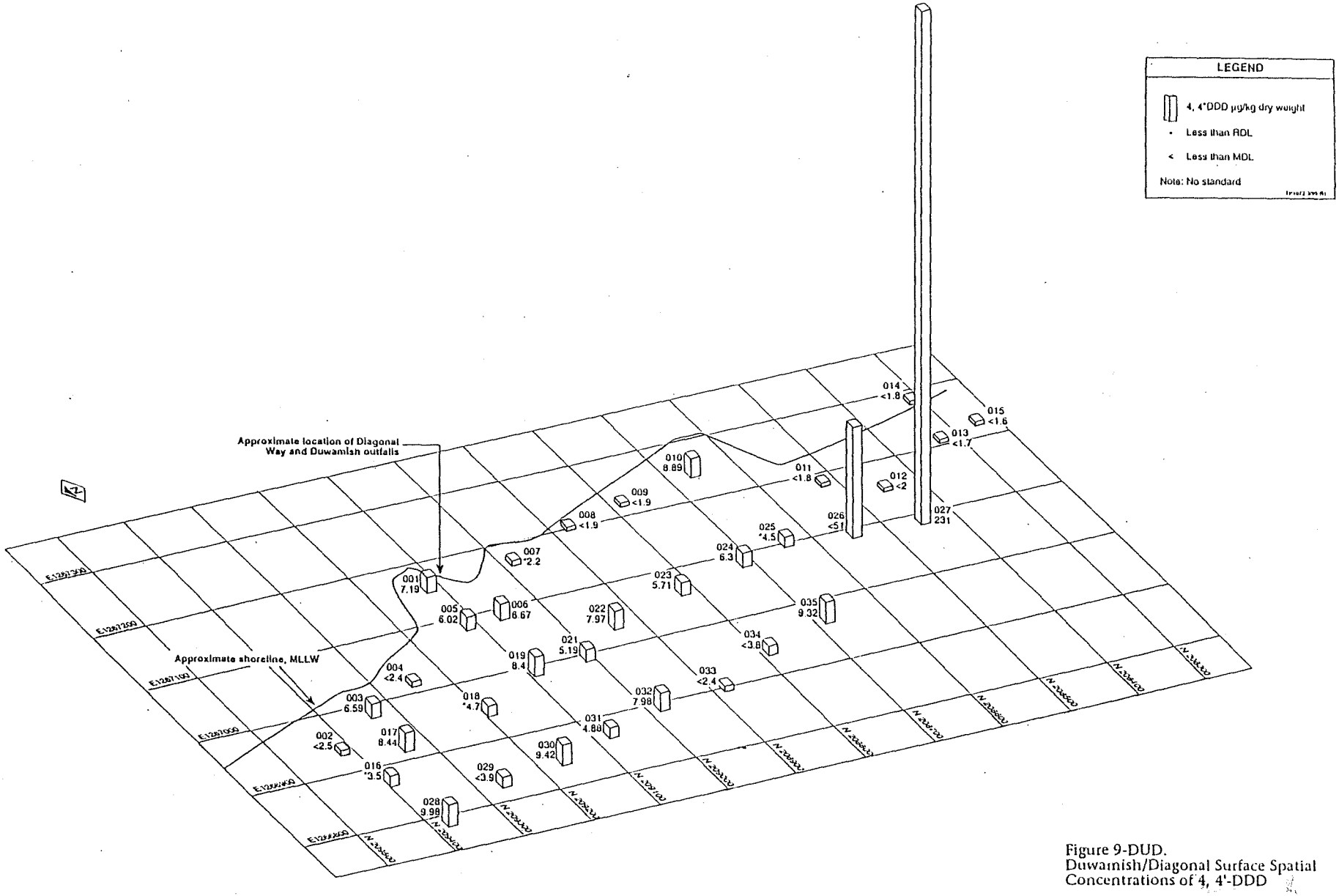
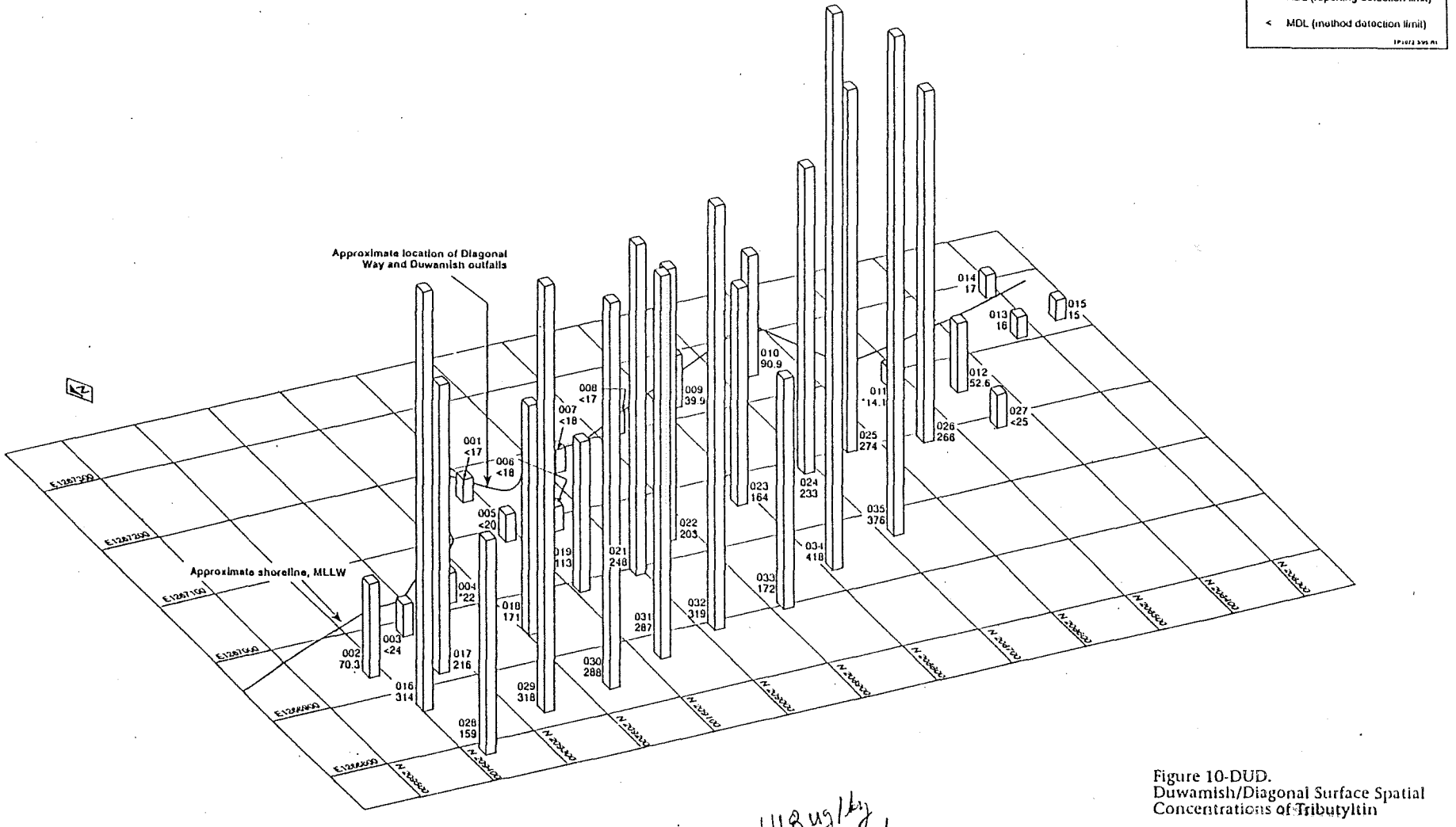


Figure 9-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of 4, 4'-DDD



MAX = 418 ug/kg
0.418 mg/kg

Figure 10-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Tributyltin

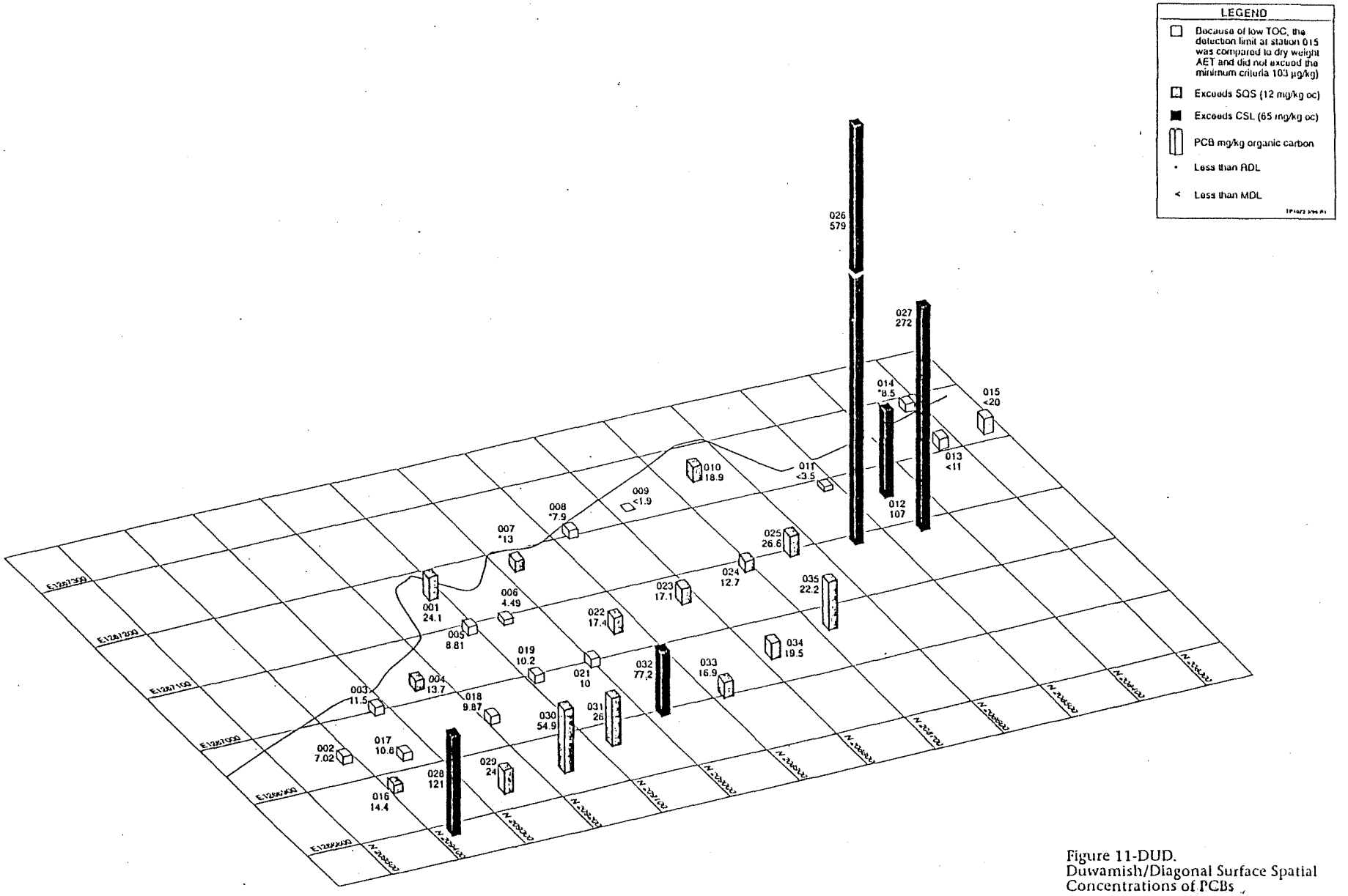


Figure 11-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of PCBs

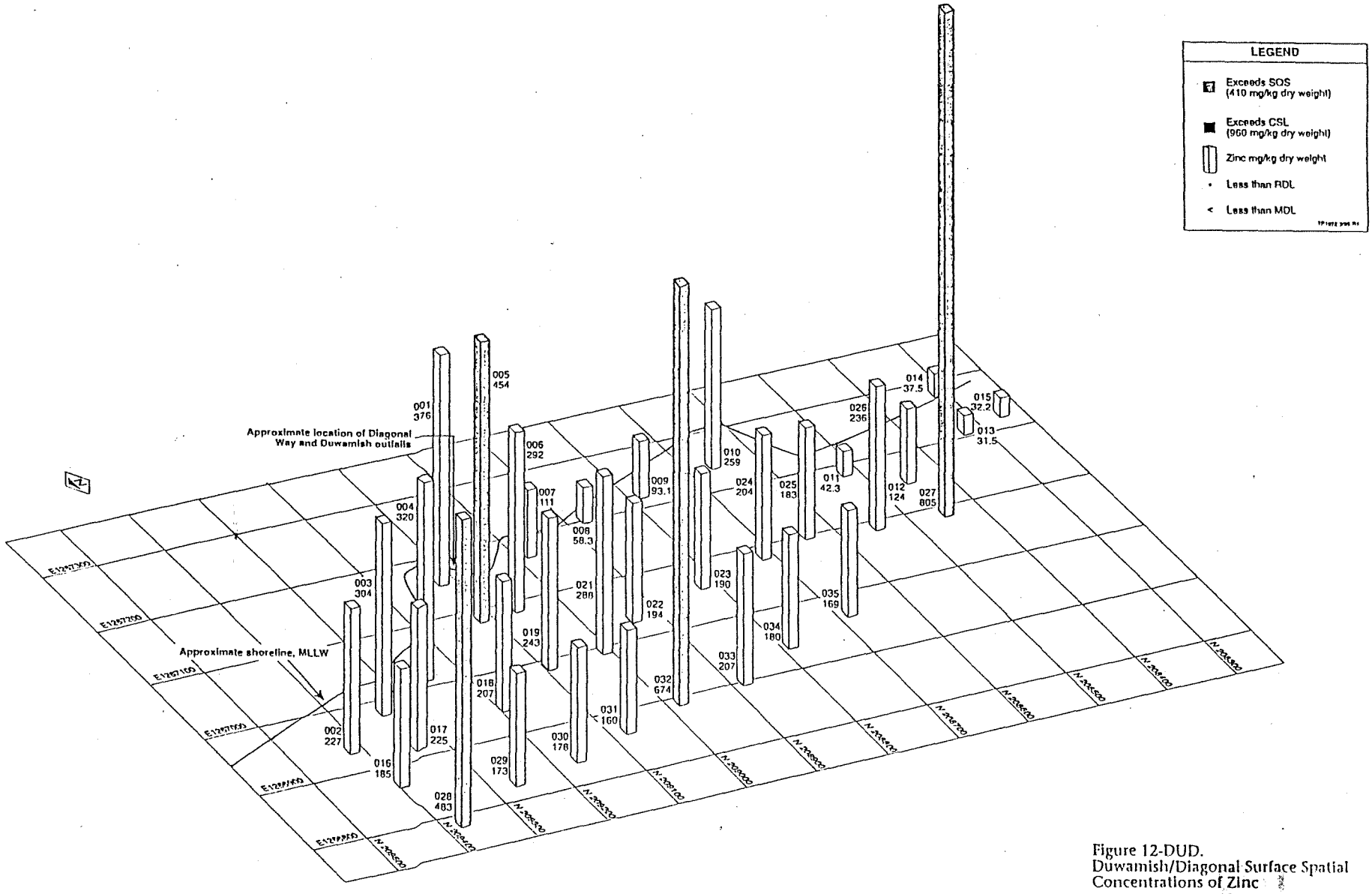


Figure 12-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Zinc

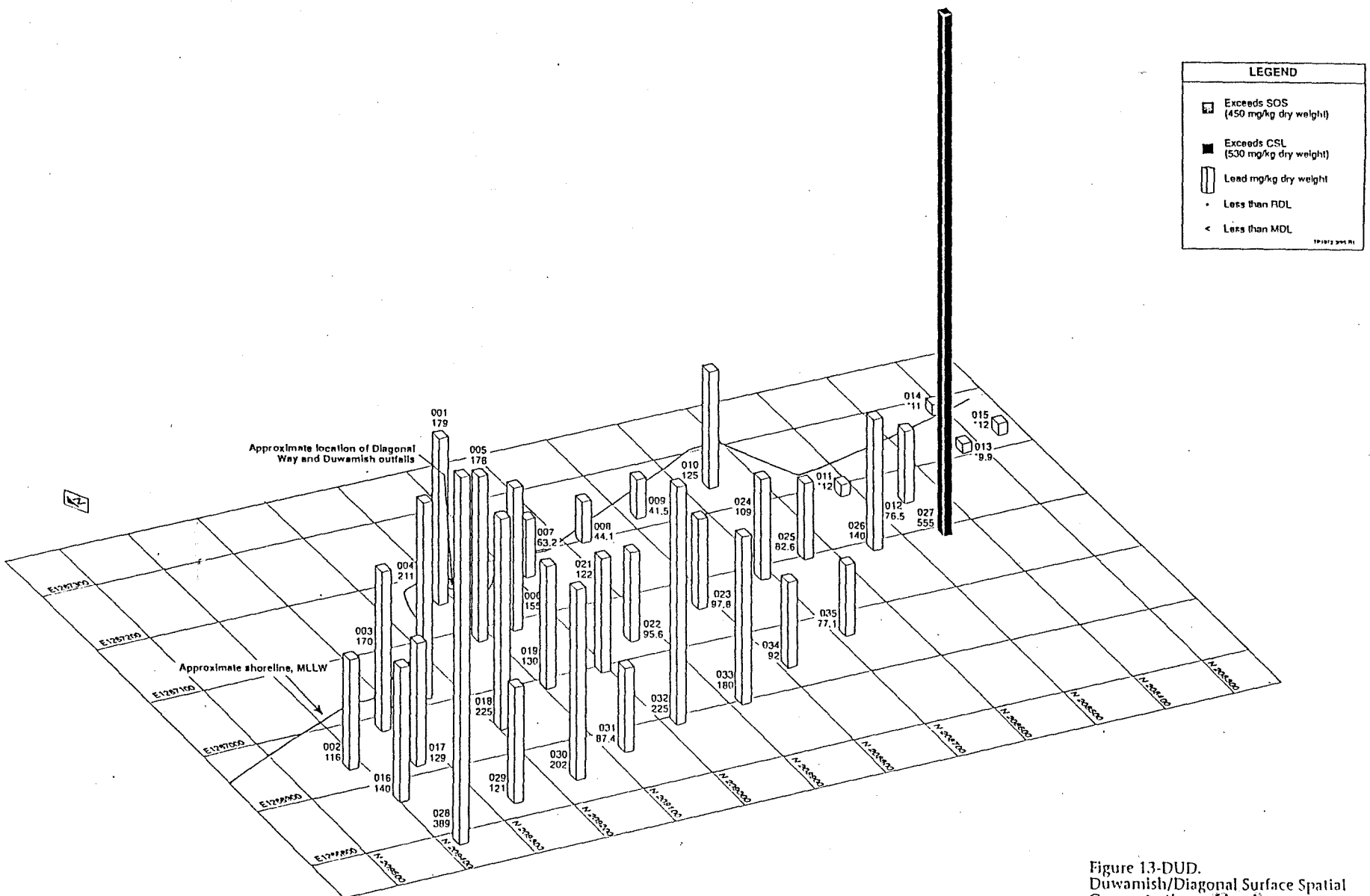
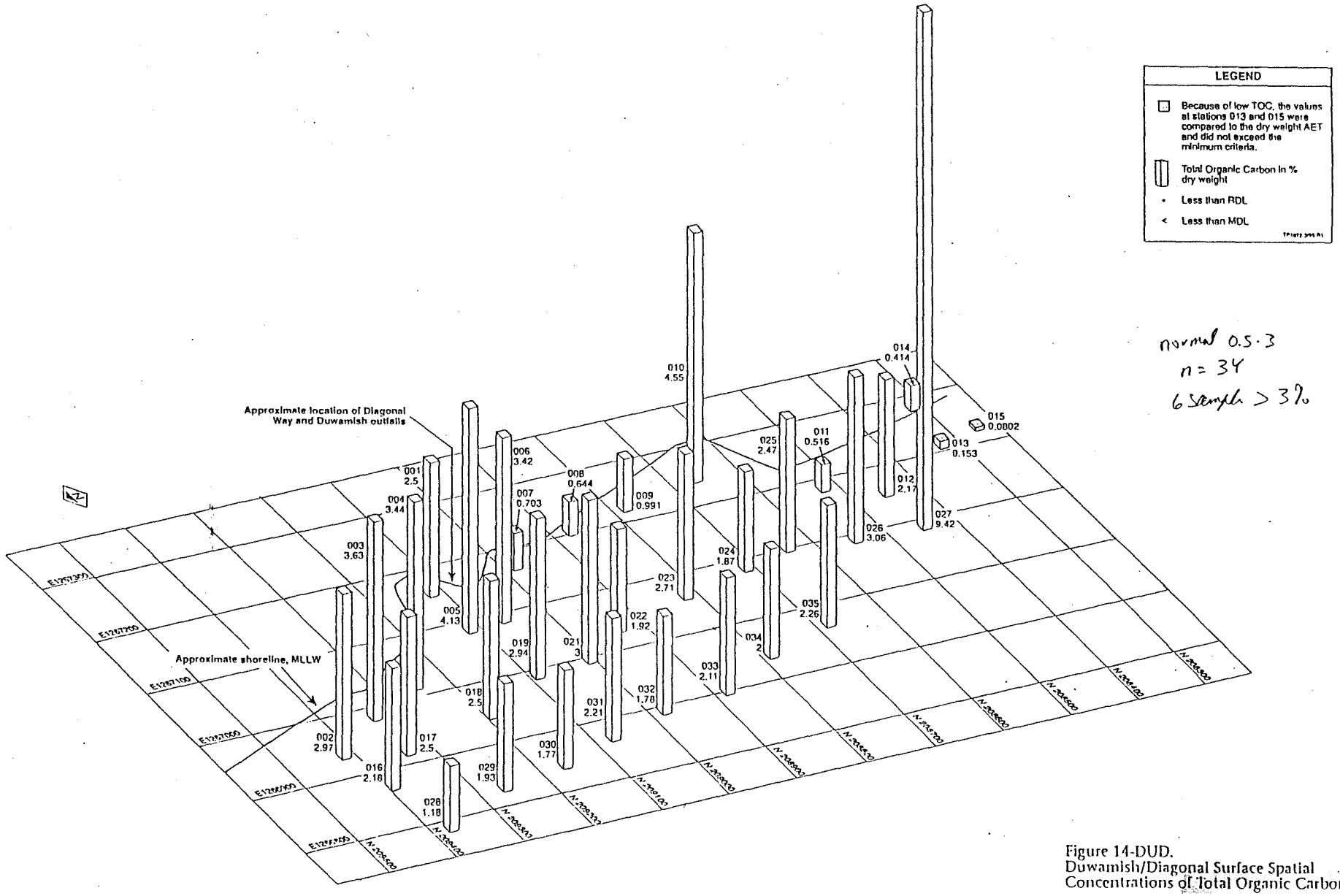


Figure 13-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Lead



normal 0.5-3
n = 34
6 samples > 3%

Figure 14-DUD.
Duwamish/Diagonal Surface Spatial Concentrations of Total Organic Carbon

Table N-1
SEDIMENT CORE EXCEEDANCES OF SMS CRITERIA OR AET VALUES
NORTHERN STUDY AREA (PHASE 1 CORES)[a]

Chemical	Station Cores Exceeding SQS Only[b]	Station Cores Exceeding CSL[b]
Mercury	DUD006 (30-45 cm)	DUD006 (45-60 cm) DUD006 (135-150 cm) DUD006 (60-75 cm) DUD020 (15-30 cm) DUD006 (75-90cm) DUD020 (30-45 cm) DUD006 (105-120 cm)
Cadmium	DUD020 (75-90cm)	DUD006 (45-60cm) DUD006 (105-120cm) DUD006 (60-75cm) DUD006(135-150cm) DUD006(75-90cm)
Copper		DUD006 (15-30cm)
Lead	DUD020 (30-45cm)	DUD006 (45-60cm) DUD006 (105-120cm) DUD006 (60-75cm) DUD006 (135-150cm) DUD006 (75-90cm) DUD020 (75-90cm)
Zinc	DUD006 (15-30cm) DUD020 (75-90cm)	
Total PCBs	DUD006 (15-30cm) DUD020 (0-15cm) DUD006 (45-60cm) DUD020 (15-30cm) DUD006 (60-75cm) DUD020 (45-60cm)	DUD006 (30-45cm) DUD006 (135-150cm) DUD006 (75-90cm) DUD020 (60-75cm) DUD006 (105-120cm) DUD020 (75-90cm)
1,2-Dichlorobenzene		DUD006 (105-120cm)
1,4-Dichlorobenzene	DUD006 (60-75cm) DUD006 (135-150cm)	DUD006 (15-30cm) DUD006 (45-60cm) DUD006 (30-45cm)
Bis (2-ethylhexyl) phthalate		DUD006 (0-15cm) DUD006 (75-90cm) DUD006 (15-30cm) DUD006 (105-120cm) DUD006 (30-45cm) DUD006 (135-150cm) DUD006 (45-60cm) DUD006 (60-75cm)
Benzyl butyl phthalate	DUD006 (15-30cm) DUD006 (105-120cm) DUD006 (30-45cm) DUD020 (0-15cm) DUD006 (45-60cm) DUD020 (15-30cm)	DUD006 (60-75cm)
Acenaphthene	DUD006(75-90cm) DUD006 (105-120cm)	
Dibenzofuran	DUD006 (75-90cm)	
Phenanthrene	DUD006 (75-90cm)	DUD006 (105-120cm)
Fluorene	DUD006 (75-90cm)	DUD006 (105-120cm)
Total LPAHs	DUD006 (75-90cm)	DUD006 (105-120cm)
Benzo(a)anthracene	DUD006 (75-90cm)	DUD006 (105-120cm)
Chrysene	DUD006 (75-90cm) DUD006 (105-120cm)	
Total Benzofluoranthenes	DUD006(75-90cm) DUD006(135-150cm)	DUD006(105-120cm)
Benzo(a)pyrene	DUD006(75-90cm) DUD006(135-150cm)	DUD006(135-120cm)
Fluoranthene	DUD006 (75-90cm) DUD006 (105-120cm)	
Indeno (1,2,3-cd) pyrene	DUD006(75-90cm) DUD006(135-150cm) DUD006(105-120cm)	

Table D-1 (Continued)
SEDIMENT CORE EXCEEDANCES OF SMS CRITERIA OR AET VALUES
NORTHERN STUDY AREA (PHASE 1 CORES)[a]

Chemical	Station Cores Exceeding SQS Only[b]	Station Cores Exceeding CSL[b]
Dibenzo (a,h) anthracene	DUD006(105-120cm) DUD006(135-150cm)	
Benzo (g,h,i) perylene	DUD006(75-90cm) DUD006(135-150cm)	
Total HPAHs	DUD006(75-90cm) DUD006(105-120cm)	
N-Nitrosodiphenylamine	DUD006 (60-75cm) DUD006 (75-90cm) DUD006 (105-120cm)	

Footnotes:

[a] Exceedances based on detected chemicals only for Phase 1 cores (DUD006 and DUD020)

[b]SQS/CSL Exceedances are reported for stations with TOC concentrations >0.2 percent.

[c]LAET/2LAET Exceedances are reported for stations with TOC concentrations <0.2 percent.

Other Notes:

(0 to 30) Core section in centimeters.
SMS: Sediment Management Standards, WAC 173-204
SQS: Sediment Quality Standards, WAC 173-204-320
CSL: Cleanup Screening Levels, WAC 173-204-520
LAET: Lowest Apparent Effects Threshold, PSEP 1988
2LAET Second Lowest AET value

Appendix N
Sediment Bioassay Results

Final Report
Seattle Metro Sampling Event One

Marine Sediment Bioassays

Submitted To

King County Department of Natural Resources
Water Resources Division
Environmental Lab
322 West Ewing Street
Seattle, WA 98119

Submitted By

MEC Analytical Systems, Inc.
6060 Corte del Cedro
Carlsbad, CA 92009

December 6, 1996

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

CASE SUMMARY

1. Project/Sample Identification

Bioassay testing on marine sediments was conducted in support of the Elliott Bay/Duwamish River Sediment Remediation Project, Seattle Waterfront Project, the Connecticut Hanford and Chelan Street, and other Combined Sewer Overflow (CSO) Projects. Toxicity tests were conducted on a total of 21 samples. Seven sediment samples were received by the laboratory on 11 September 1996, and 12 sediment samples plus 2 reference sediment samples were received on 13 September 1996 (see Table below). The control sediment was received and logged in on 13 September, 1996.

Sample ID	Collection Date	Date Received	Sample ID	Collection Date	Date Received
L9443-1	9/9/96	9/11/96	L9444-5	9/10/96	9/13/96
L9443-2	9/9/96	9/11/96	L9444-6	9/11/96	9/13/96
L9443-3	9/9/96	9/11/96	L9444-7	9/11/96	9/13/96
L9443-4	9/9/96	9/11/96	L9444-8	9/11/96	9/13/96
L9443-5	9/9/96	9/11/96	L9444-9	9/10/96	9/13/96
L9443-6	9/9/96	9/11/96	L9444-10	9/11/96	9/13/96
L9443-7	9/10/96	9/11/96	L9446-1 (Ref)	9/11/96	9/13/96
L9444-1	9/10/96	9/13/96	L9446-2 (Ref)	9/11/96	9/13/96
L9444-2	9/10/96	9/13/96	L9445-1	9/10/96	9/13/96
L9444-3	9/11/96	9/13/96	L9445-2	9/10/96	9/13/96
L9444-4	9/11/96	9/13/96			

QA Officer	6 Dec 96 Date	Laboratory Manager	6 Dec 96 Date

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

2. Test Method

Toxicity tests were conducted on juvenile polychaetes (*Neanthes arenaceodentata*) using MEC Protocol #P014.1. All methods and protocols employed in this program followed general procedures established by the EPA and the State of Washington in Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments (PSEP, July 1995). Testing was performed at the MEC Analytical Systems, Inc. Bioassay Laboratory located in Carlsbad, California.

3. Case Narrative

Testing was initiated on 19 September 1996, and completed on 9 October 1996. Testing was performed concurrently on sample, reference, and control sediments.

Negative control and reference sediments were collected and tested in compliance with SMS performance standards for test validation.

Dissolved oxygen and pH meters used in the conduct of these bioassays were calibrated each day prior to use. The conductivity/salinity meter calibration is verified monthly. No irregularities were encountered in the calibration or operation of the instruments.

Water quality measurements were taken for all replicates of all samples on day 0 and then from one replicate test container for each sample every third day. Data on mean, minimum and maximum values are presented in the report following the case narrative.

Data were recorded on pre-printed data sheets in ink. All corrections were initialed by the person making the correction and the mistake was coded. A table of correction codes for the laboratory and a table with the names and initials of the laboratory staff are presented in the appendix of this report.

Data for water quality and mortality were double entered and cross compared for accuracy. In the event of a discrepancy, the correct information was confirmed from the original data sheets. The test acceptance criterion for the polychaete test is ≥90% survival and 0.72 mg/individual/day growth rate. The negative control had a mean survival of 100% and a weight gain range of 0.77 to 0.83 mg/individual/day. Reference site daily growth data was 0.48 mg/individual/day (9446-1) and 0.60 mg/individual/day (9446-2). These values are less than the SMS growth criterion of 80% of control growth. All data generated from this were accepted without qualification.

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
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Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Communications between the laboratory (MEC) and King County Environmental Laboratory (KCEL) were logged and kept as part of the permanent project file.

1. Sediment interstitial salinity for sample C960911.0937 was 20.2 ppt. Sediment interstitial salinity adjustment to test specifications (28 $\pm$ 2 ppt) was necessary before the test was started.

2. Sediment interstitial salinity for sample C960911.1137 was 5.0 ppt. Sediment interstitials salinity adjustment to test specifications was necessary before the test was started.

3. Salinity reading for sample C960913.1137, Rep 2, day 20 was not recorded. All previous salinity measurements were within protocol specifications (28 $\pm$ 2 ppt). This oversight does not limit the usefulness of the data.

4. Salinity reading for sample C960913.1237, Rep 2, day 20 was not recorded. All previous salinity measurements were within protocol specifications (28 $\pm$ 2 ppt). This oversight does not limit the usefulness of the data.

5. pH reading for sample C960913.0937, Rep 1, day 3 was not recorded. pH data for this sample and all other samples were within protocols specifications throughout the test. This oversight does not limit the usefulness of the data.

4. Summary of Test Response

The following tables show test response by replicate, mean, and standard deviation for negative control, reference, and test sediments. Analyses include survival, total biomass, individual biomass, and individual growth rate. Results marked with an asterisk (*) are statistically significant relative to reference sediment response (Student's t-test, p = 0.05).

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Survival (%)			Total Biomass (Dry weight, mg)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
Control A	C960913.1737A	1	100%	100%	0.00	104.75	85.20	17.23
		2	100%			66.31		
		3	100%			67.94		
		4	100%			96.08		
		5	100%			90.90		
Control B	C960913.1737B	1	100%	100%	0.00	94.91	80.33	20.06
		2	100%			102.59		
		3	100%			83.84		
		4	100%			66.27		
		5	100%			54.02		
P9443-1	C960911.0537	1	100%	100%	0.00	39.76	63.28	15.35
		2	100%			66.25		
		3	100%			58.26		
		4	100%			72.32		
		5	100%			79.83		
P9443-2	C960911.0637	1	100%	100%	0.00	44.12	58.50	8.97
		2	100%			62.20		
		3	100%			68.28		
		4	100%			57.29		
		5	100%			60.62		
P9443-3	C960911.0737	1	100%	100%	0.00	50.41	65.34	14.63
		2	100%			57.66		
		3	100%			73.24		
		4	100%			58.49		
		5	100%			86.90		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Survival (%)			Total Biomass (Dry weight, mg)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9443-4	C960911.0837	1	100%	100%	0.00	59.81	63.17	9.35
		2	100%			70.06		
		3	100%			74.54		
		4	100%			60.75		
		5	100%			50.68		
P9443-5	C960911.0937	1	100%	100%	0.00	61.29	54.74	10.45
		2	100%			48.80		
		3	100%			40.03		
		4	100%			66.42		
		5	100%			57.14		
P9443-6	C960911.1037	1	100%	100%	0.00	53.89	58.00	15.50
		2	100%			58.54		
		3	100%			38.74		
		4	100%			56.91		
		5	100%			81.91		
P9443-7	C960911.1137	1	100%	100%	0.00	53.85	55.59	5.48
		2	100%			50.68		
		3	100%			62.60		
		4	100%			50.72		
		5	100%			60.08		
P9444-1	C960913.0237	1	100%	100%	0.00	51.33	61.14	9.30
		2	100%			54.74		
		3	100%			75.28		
		4	100%			63.95		
		5	100%			60.39		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client: KCEL
Project: Metro Set I
Sample Matrix: Sediment
MEC Project ID 0906

Date Received: 11&13Sep96
Date Test Started: 19Sep96
Date Test Ended: 9Oct96

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Survival (%)			Total Biomass (Dry weight, mg)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-2	C960913.0337	1	100%	100%	0.00	49.93	55.73	11.28
		2	100%			49.27		
		3	100%			44.29		
		4	100%			70.87		
		5	100%			64.31		
P9444-3	C960913.0437	1	100%	100%	0.00	61.21	64.04	10.35
		2	100%			62.87		
		3	100%			68.94		
		4	100%			77.64		
		5	100%			49.55		
P9444-4	C960913.0537	1	100%	100%	0.00	77.68	68.31	6.90
		2	100%			62.81		
		3	100%			73.41		
		4	100%			62.05		
		5	100%			65.58		
P9444-5	C960913.0637	1	100%	100%	0.00	45.50	67.99	15.74
		2	100%			89.66		
		3	100%			66.76		
		4	100%			71.43		
		5	100%			66.61		
P9444-6	C960913.0737	1	100%	100%	0.00	51.57	62.63	11.56
		2	100%			63.62		
		3	100%			58.17		
		4	100%			57.94		
		5	100%			81.86		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Survival (%)			Total Biomass (Dry weight, mg)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-7	C960913.0837	1	100%	100%	0.00	53.90	46.92	12.08
		2	100%			39.99		
		3	100%			48.81		
		4	100%			30.43		
		5	100%			61.46		
P9444-8	C960913.0937	1	100%	100%	0.00	45.47	58.19	22.44
		2	100%			90.23		
		3	100%			55.51		
		4	100%			31.44		
		5	100%			68.32		
P9444-9	C960913.1037	1	100%	100%	0.00	67.95	69.27	5.77
		2	100%			63.77		
		3	100%			64.01		
		4	100%			75.82		
		5	100%			74.79		
P9444-10	C960913.1137	1	100%	100%	0.00	58.39	59.35	10.77
		2	100%			73.19		
		3	100%			47.54		
		4	100%			50.69		
		5	100%			66.92		
P9446-1 Reference	C960913.1237	1	100%	100%	0.00	50.14	51.75	9.19
		2	100%			58.76		
		3	100%			40.96		
		4	100%			45.64		
		5	100%			63.26		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Survival (%)			Total Biomass (Dry weight, mg)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9446-2 Reference	C960913.1337	1	100%	100%	0.00	63.37	63.80	18.28
		2	100%			82.01		
		3	100%			54.32		
		4	100%			38.68		
		5	100%			80.63		
P9445-1	C960913.1437	1	100%	100%	0.00	52.15	69.78	15.44
		2	100%			84.22		
		3	100%			59.27		
		4	100%			65.93		
		5	100%			87.35		
P9445-2	C960913.1537	1	100%	100%	0.00	59.46	60.82	10.72
		2	100%			64.20		
		3	100%			51.20		
		4	100%			51.86		
		5	100%			77.36		

Initial Biomass

Number of Worms	Total Biomass (mg)	Average	Individual Biomass (mg)	Average
5	3.24	3.71	0.65	0.74
5	4.07		0.81	
5	3.82		0.76	

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Individual Biomass (Dry weight, mg)			Individual Growth Rate (mg/Day)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
Control A	C960913.1737A	1	20.95	17.04	3.45	1.01	0.81	0.17
		2	13.26			0.63		
		3	13.59			0.64		
		4	19.22			0.92		
		5	18.18			0.87		
Control B	C960913.1737B	1	18.98	16.07	4.01	0.91	0.77	0.20
		2	20.52			0.99		
		3	16.77			0.80		
		4	13.25			0.63		
		5	10.80			0.50		
P9443-1	C960911.0537	1	7.95	12.66	3.07	0.36	0.60	0.15
		2	13.25			0.63		
		3	11.65			0.55		
		4	14.46			0.69		
		5	15.97			0.76		
P9443-2	C960911.0637	1	8.82	11.70	1.79	0.40	0.55	0.09
		2	12.44			0.58		
		3	13.66			0.65		
		4	11.46			0.54		
		5	12.12			0.57		
P9443-3	C960911.0737	1	10.08	13.07	2.93	0.47	0.62	0.15
		2	11.53			0.54		
		3	14.65			0.70		
		4	11.70			0.55		
		5	17.38			0.83		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Individual Biomass (Dry weight, mg)			Individual Growth Rate (mg/Day)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9443-4	C960911.0837	1	11.96	12.63	1.87	0.56	0.59	0.09
		2	14.01			0.66		
		3	14.91			0.71		
		4	12.15			0.57		
		5	10.14			0.47		
P9443-5	C960911.0937	1	12.26	10.95	2.09	0.58	0.51	0.10
		2	9.76			0.45		
		3	8.01			0.36		
		4	13.28			0.63		
		5	11.43			0.53		
P9443-6	C960911.1037	1	10.78	11.60	3.10	0.50	0.54	0.16
		2	11.71			0.55		
		3	7.75			0.35		
		4	11.38			0.53		
		5	16.38			0.78		
P9443-7	C960911.1137	1	10.77	11.12	1.10	0.50	0.52	0.05
		2	10.14			0.47		
		3	12.52			0.59		
		4	10.14			0.47		
		5	12.02			0.56		
P9444-1	C960913.0237	1	10.27	12.23	1.86	0.48	0.57	0.09
		2	10.95			0.51		
		3	15.06			0.72		
		4	12.79			0.60		
		5	12.08			0.57		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Individual Biomass (Dry weight, mg)			Individual Growth Rate (mg/Day)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-2	C960913.0337	1	9.99	11.15	2.26	0.46	0.52	0.11
		2	9.85			0.46		
		3	8.86			0.41		
		4	14.17			0.67		
		5	12.86			0.61		
P9444-3	C960913.0437	1	12.24	12.81	2.07	0.58	0.60	0.10
		2	12.57			0.59		
		3	13.79			0.65		
		4	15.53			0.74		
		5	9.91			0.46		
P9444-4	C960913.0537	1	15.54	13.66	1.38	0.74	0.65	0.07
		2	12.56			0.59		
		3	14.68			0.70		
		4	12.41			0.58		
		5	13.12			0.62		
P9444-5	C960913.0637	1	9.10	13.60	3.15	0.42	0.64	0.16
		2	17.93			0.86		
		3	13.35			0.63		
		4	14.29			0.68		
		5	13.32			0.63		
P9444-6	C960913.0737	1	10.31	12.53	2.31	0.48	0.59	0.12
		2	12.72			0.60		
		3	11.63			0.54		
		4	11.59			0.54		
		5	16.37			0.78		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Individual Biomass (Dry weight, mg)			Individual Growth Rate (mg/Day)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-7	C960913.0837	1	10.78	9.38	2.42	0.50	0.43	0.12
		2	8.00			0.36		
		3	9.76			0.45		
		4	6.09			0.27		
		5	12.29			0.58		
P9444-8	C960913.0937	1	9.09	11.64	4.49	0.42	0.54	0.22
		2	18.05			0.87		
		3	11.10			0.52		
		4	6.29			0.28		
		5	13.66			0.65		
P9444-9	C960913.1037	1	13.59	13.85	1.15	0.64	0.66	0.06
		2	12.75			0.60		
		3	12.80			0.60		
		4	15.16			0.72		
		5	14.96			0.71		
P9444-10	C960913.1137	1	11.68	11.87	2.15	0.55	0.56	0.11
		2	14.64			0.69		
		3	9.51			0.44		
		4	10.14			0.47		
		5	13.38			0.63		
P9446-1 Reference	C960913.1237	1	10.03	10.35	1.84	0.46	0.48	0.09
		2	11.75			0.55		
		3	8.19			0.37		
		4	9.13			0.42		
		5	12.65			0.60		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Client Sample ID	MEC Sample ID	Rep	Individual Biomass (Dry weight, mg)			Individual Growth Rate (mg/Day)		
			By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9446-2 Reference	C960913.1337	1	12.67	12.76	3.66	0.60	0.60	0.18
		2	16.40			0.78		
		3	10.86			0.51		
		4	7.74			0.35		
		5	16.13			0.77		
P9445-1	C960913.1437	1	10.43	13.96	3.09	0.48	0.66	0.15
		2	16.84			0.81		
		3	11.85			0.56		
		4	13.19			0.62		
		5	17.47			0.84		
P9445-2	C960913.1537	1	11.89	12.16	2.14	0.56	0.57	0.11
		2	12.84			0.60		
		3	10.24			0.47		
		4	10.37			0.48		
		5	15.47			0.74		

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Test Water Quality Data

Analyte:	**Salinity**	**Dissolved Oxygen**	**pH**
Method (ISP: Ion Specific Probe)	ISP	ISP	ISP
Method Reporting Limit:	0.1 ‰	1% sat	0.1 unit

Sample ID *Client (MEC)*	**Statistic**	**pH**	**D.O. (% Sat.)**	**Temp (°C)**	**Salinity (ppt)**
Control A (C960913.1737A)	Mean Minimum Maximum	8.0 7.9 8.1	93.5 81.0 100.0	20.4 19.8 21.0	28.1 27.8 28.5
Control B (C960913.1737B)	Mean Minimum Maximum	8.0 7.1 8.3	94.3 77.0 99.0	20.3 19.8 21.0	28.1 27.7 28.8
P9443-1 (C960911.0537)	Mean Minimum Maximum	8.1 8.0 8.5	93.3 86.0 97.0	20.3 19.8 21.2	28.3 28.0 28.8
P9443-2 (C960911.0637)	Mean Minimum Maximum	8.0 7.1 8.3	92.3 81.0 97.0	20.2 19.9 20.9	28.2 27.9 28.6
P9443-3 (C960911.0737)	Mean Minimum Maximum	8.2 7.9 8.5	92.4 79.0 97.0	20.2 19.9 20.7	28.2 27.9 28.7

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client: KCEL
Project: Metro Set I
Sample Matrix: Sediment
MEC Project ID 0906

Date Received: 11&13Sep96
Date Test Started: 19Sep96
Date Test Ended: 9Oct96

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Sample ID *Client (MEC)*	Statistic	pH	D.O. (% Sat.)	Temp (°C)	Salinity (ppt)
P9443-4 (C960911.0837)	Mean	8.0	92.0	20.2	28.2
	Minimum	7.9	80.0	19.8	28.0
	Maximum	8.1	97.0	21.8	28.5
P9443-5 (C960911.0937)	Mean	8.1	92.3	20.3	28.3
	Minimum	7.8	80.0	19.3	28.0
	Maximum	8.4	96.0	21.2	28.7
P9443-6 (C960911.1037)	Mean	8.1	92.6	20.2	28.2
	Minimum	7.9	80.0	19.6	28.0
	Maximum	8.3	101.0	21.0	28.6
P9443-7 (C960911.1137)	Mean	8.0	94.4	20.1	27.4
	Minimum	7.9	83.0	19.5	26.5
	Maximum	8.1	99.0	20.8	28.3
P9444-1 (C960913.0237)	Mean	8.1	92.3	20.2	28.3
	Minimum	8.0	80.0	19.8	28.1
	Maximum	8.3	97.0	20.8	28.8
P9444-2 (C960913.0337)	Mean	8.1	93.7	20.1	28.2
	Minimum	8.0	87.0	19.7	28.0
	Maximum	8.2	97.0	20.9	28.9
P9444-3 (C960913.0437)	Mean	8.2	91.1	20.2	28.3
	Minimum	8.0	77.0	19.8	28.0
	Maximum	8.5	96.0	21.2	28.9
P9444-4 (C960913.0537)	Mean	8.1	90.9	20.2	28.3
	Minimum	8.1	79.0	19.8	28.0
	Maximum	8.4	96.0	21.2	28.6
P9444-5 (C960913.0637)	Mean	8.0	90.5	20.3	28.2
	Minimum	7.8	77.0	19.9	28.0
	Maximum	8.2	97.0	20.9	28.6
P9444-6 (C960913.0737)	Mean	8.2	91.8	20.1	28.3
	Minimum	8.0	85.0	19.7	28.1
	Maximum	8.3	96.0	20.5	28.7

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Sample ID *Client (MEC)*	**Statistic**	**pH**	**D.O. (% Sat.)**	**Temp (°C)**	**Salinity (ppt)**
P9444-7 (C960913.0837)	Mean	8.2	91.9	20.3	28.4
	Minimum	8.1	87.0	19.8	27.9
	Maximum	8.3	97.0	20.9	29.0
P9444-8 (C960913.0937)	Mean	8.2	91.3	20.3	28.4
	Minimum	8.0	81.0	19.6	28.1
	Maximum	8.5	97.0	21.6	28.8
P9444-9 (C960913.1037)	Mean	8.1	91.9	20.3	28.3
	Minimum	7.9	85.0	19.5	27.9
	Maximum	8.2	97.0	20.9	28.8
P9444-10 (C960913.1137)	Mean	8.1	91.7	20.3	28.3
	Minimum	8.0	82.0	20.0	28.0
	Maximum	8.3	95.0	20.7	28.9
P9446-1 Reference (C960913.1237)	Mean	8.0	92.7	20.3	28.1
	Minimum	7.1	80.0	19.9	27.9
	Maximum	8.2	99.0	20.8	28.7
P9446-2 Reference (C960913.1337)	Mean	8.1	91.2	20.2	28.2
	Minimum	7.9	85.0	19.9	28.0
	Maximum	8.4	97.0	20.8	28.5
P9445-1 (C960913.1437)	Mean	8.1	91.3	20.3	28.1
	Minimum	7.9	80.0	19.9	27.9
	Maximum	8.4	98.0	21.0	28.6
P9445-2 (C960913.1537)	Mean	8.0	94.1	20.2	28.2
	Minimum	7.1	83.0	19.4	27.8
	Maximum	8.2	98.0	21.2	29.4

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Interstitial Salinity

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1737A)	32.0	28.0	P9444-4 (C960913.0537)	26.4	28.0
Control B (C960913.1737B)	32.0	28.0	P9444-5 (C960913.0637)	27.6	28.0
P9443-1 (C960911.0537)	27.6	28.0	P9444-6 (C960913.0737)	26.4	28.0
P9443-2 (C960911.0637)	27.0	28.0	P9444-7 (C960913.0837)	28.3	28.0
P9443-3 (C960911.0737)	27.7	28.0	P9444-8 (C960913.0937)	25.5	28.0
P9443-4 (C960911.0837)	27.7	28.0	P9444-9 (C960913.1037)	28.5	28.0
P9443-5 (C960911.0937)	28.0**	28.0	P9444-10 (C960913.1137)	27.9	29.0
P9443-6 (C960911.1037)	25.4	28.0	P9446-1 Reference (C960913.1237)	30.6	28.0
P9443-7 (C960911.1137)	28.0**	28.0	P9446-2 Reference (C960913.1337)	30.0	29.0
P9444-1 (C960913.0237)	25.2	28.0	P9445-1 (C960913.1437)	29.1	28.0
P9444-2 (C960913.0337)	27.5	28.0	P9445-2 (C960913.1537)	30.9	28.0
P9444-3 (C960913.0437)	25.6	30.0			

**Initial interstitial salinity below 25 ppt. Salinity adjustment of sediment done prior to testing.

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Ammonia

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1737A)	0.49	6.75	P9444-4 (C960913.0537)	1.05	0.95
Control B (C960913.1737B)	0.56	7.64	P9444-5 (C960913.0637)	0.57	0.08
P9443-1 (C960911.0537)	1.27	0.14	P9444-6 (C960913.0737)	0.84	1.44
P9443-2 (C960911.0637)	1.75	0.14	P9444-7 (C960913.0837)	0.78	4.08
P9443-3 (C960911.0737)	1.47	6.37	P9444-8 (C960913.0937)	0.74	3.14
P9443-4 (C960911.0837)	1.02	0.14	P9444-9 (C960913.1037)	0.71	0.17
P9443-5 (C960911.0937)	2.05	3.39	P9444-10 (C960913.1137)	0.84	3.33
P9443-6 (C960911.1037)	1.55	0.09	P9446-1 Reference (C960913.1237)	0.34	0.16
P9443-7 (C960911.1137)	0.00	0.54	P9446-2 Reference (C960913.1337)	2.71	0.38
P9444-1 (C960913.0237)	0.37	2.42	P9445-1 (C960913.1437)	0.27	0.22
P9444-2 (C960913.0337)	0.00	0.33	P9445-2 (C960913.1537)	0.37	0.11
P9444-3 (C960913.0437)	1.81	0.08			

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

Sulfides (ppm)

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1737A)	<0.1	0.00	P9444-4 (C960913.0537)	<0.1	0.00
Control B (C960913.1737B)	<0.1	0.00	P9444-5 (C960913.0637)	<0.1	0.00
P9443-1 (C960911.0537)	<0.1	0.00	P9444-6 (C960913.0737)	<0.1	0.00
P9443-2 (C960911.0637)	<0.1	0.00	P9444-7 (C960913.0837)	<0.1	0.00
P9443-3 (C960911.0737)	0.00	0.00	P9444-8 (C960913.0937)	<0.1	0.00
P9443-4 (C960911.0837)	<0.1	0.00	P9444-9 (C960913.1037)	<0.1	0.00
P9443-5 (C960911.0937)	<0.1	0.00	P9444-10 (C960913.1137)	<0.1	0.00
P9443-6 (C960911.1037)	<0.1	0.00	P9446-1 Reference (C960913.1237)	<0.1	0.00
P9443-7 (C960911.1137)	<0.1	0.00	P9446-2 Reference (C960913.1337)	<0.1	0.00
P9444-1 (C960913.0237)	<0.1	0.00	P9445-1 (C960913.1437)	<0.1	0.00
P9444-2 (C960913.0337)	<0.1	0.00	P9445-2 (C960913.1537)	0.00	0.00
P9444-3 (C960913.0437)	<0.1	0.00			

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

5. Statistical Analyses

Tests of normal distribution were done using SAS® Proc Univariate. T-tests were done to compare each sample endpoint to the corresponding reference sample endpoint. Proc TTEST was used for these tests, are based on a one-tail test.

6. Positive Control Response

A reference toxicity test with cadmium chloride was performed on 18 September 1996. Concentrations tested were 3.8, 7.5, 15, 30 and 60 ppm cadmium. The estimate of the 96-hour EC_{50} was within PSEP guidelines (8.44 ppm). A laboratory control chart (attached) shows a laboratory mean of 9.55, with upper and lower 95% confidence limits of 14.45 and 4.64 ppm, respectively.

Verification of laboratory cadmium (10,000 ppm) stock solution gave a value of 10,400 ppm. Analysis of the highest reference concentration (60 ppm) gave a value of 57.8 ppm. The laboratory analysis results are included in the supporting documentation to this report

7. Dilution Water

Dilution water was collected by MEC personnel from Scripps Institute of Oceanography (SIO), La Jolla, CA on September 16 and 25 and October 7, 1996. The 3 batches of seawater were given the identification numbers SIO 091696, SIO 092596, and SIO 100796, respectively.

Priority pollutant analysis results SIO 091696, SIO 092596, and SIO 100796 indicated that all analytes were below detection limits except for cadmium. Cadmium at 8 ppb and 6 ppb appeared in SIO 092596 and SIO 100796, respectively. The laboratory analysis results are included in the supporting documentation to this report

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11&13Sep96
Project:	Metro Set I	**Date Test Started:**	19Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	9Oct96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
20-Day Solid Phase Polychaete

Test Organism: *Neanthes arenaceodentata*
MEC Protocol: P014.1

APPENDIX
Pertinent Test Data

DILUTION WATER: Scripps Institute of Oceanography filtered seawater

Target Values:	Salinity	28 ± 2 ppt
	pH	ambient, ± 0.5 units
	D.O.	> 60% saturation
	Temperature	20.0° C, ± 1° C

TEST ORGANISM: 2-3 week-old *Neanthes arenaceodentata*, 0.5 - 1.0 mg each, from California State University, Long Beach, cultured by Dr. Don Reish.

TEST CHAMBER: 1 L glass beakers, 5 replicates, brought to a 950 mL final volume.

EXPERIMENTAL DESIGN:

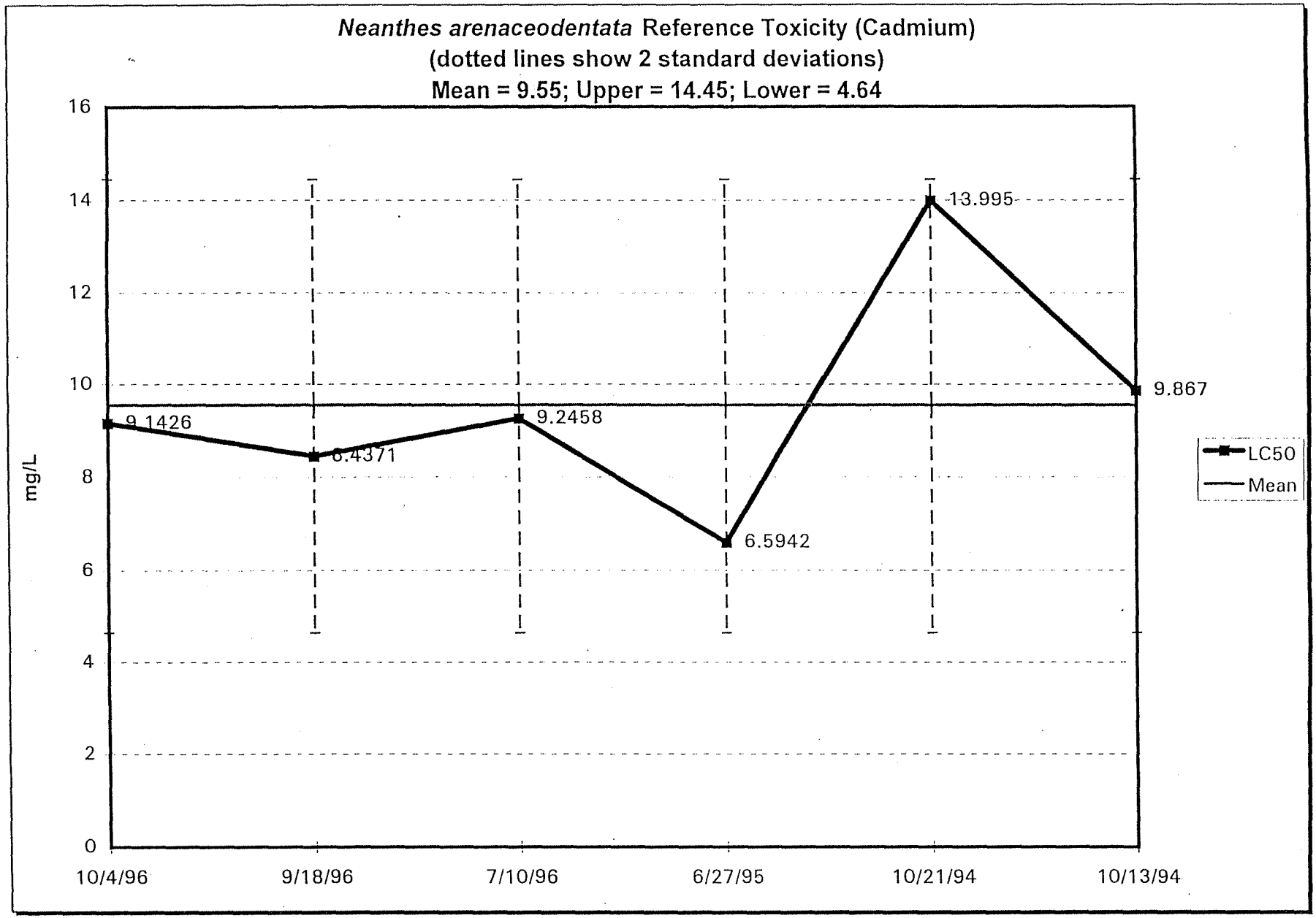
1. Two cm of sediment were placed into each beaker, seawater was added, the temperature of the seawater was adjusted to 20±1°C.
2. 5 test organisms were placed into each chamber.
3. Samples were aerated.
4. Test chambers were held at 20°C ±1° for 20 days with a photo period of 16 hours light, 8 hours darkness.
5. One-third of seawater from each chamber was renewed every third day.
6. Test organisms were fed every other day.
7. Test room temperature was monitored with a thermistor and continuously recorded with a data logger.

MORTALITY DEFINITION: Lack of respiratory movement and lack of reaction to gentle prodding.

CONTROL CRITERION: ≥90% Survival in controls, 0.72 mg/individual/day weight gain

STUDY DIRECTOR: A. Monji

INVESTIGATORS: A. Monji, E. McCoy, K. Bothner, T. Fitzsimmons, M. Woo


Neanthes arenaceodentata Reference Toxicity (Cadmium)
(dotted lines show 2 standard deviations)
Mean = 9.55; Upper = 14.45; Lower = 4.64
mg/L
16
14
12
10
8
6
4
2
0
9.1426
8.4371
9.2458
6.5942
13.995
9.867
LC50
Mean
10/4/96
9/18/96
7/10/96
6/27/95
10/21/94
10/13/94

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

CASE SUMMARY

1. Project/Sample Identification

Bioassay testing on marine sediments was conducted in support of the Elliott Bay/Duwamish River Sediment Remediation Project, Seattle Waterfront Project, the Connecticut Hanford and Chelan Street, and other Combined Sewer Overflow (CSO) Projects. Toxicity tests were conducted on a total of 21 samples. Seven sediment samples were received by the laboratory on 11 September 1996, and 12 sediment samples plus 2 reference samples were received on 13 September 1996 (see Table below). The control sediment was received and logged in on 13 September, 1996.

Sample ID	Collection Date	Date Received	Sample ID	Collection Date	Date Received
L9443-1	9/9/96	9/11/96	L9444-5	9/10/96	9/13/96
L9443-2	9/9/96	9/11/96	L9444-6	9/11/96	9/13/96
L9443-3	9/9/96	9/11/96	L9444-7	9/11/96	9/13/96
L9443-4	9/9/96	9/11/96	L9444-8	9/11/96	9/13/96
L9443-5	9/9/96	9/11/96	L9444-9	9/10/96	9/13/96
L9443-6	9/9/96	9/11/96	L9444-10	9/11/96	9/13/96
L9443-7	9/10/96	9/11/96	L9446-1 (Ref)	9/11/96	9/13/96
L9444-1	9/10/96	9/13/96	L9446-2 (Ref)	9/11/96	9/13/96
L9444-2	9/10/96	9/13/96	L9445-1	9/10/96	9/13/96
L9444-3	9/11/96	9/13/96	L9445-2	9/10/96	9/13/96
L9444-4	9/11/96	9/13/96			

QA Officer — 6 Dec 96 — Date — Laboratory Manager — 6DEC96 — Date

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

2. Test Method

Toxicity tests were conducted on amphipods (*Rhepoxynius abronius*) using MEC Protocol #P024.1. All methods and protocols employed in this program followed general procedures established by the EPA and the State of Washington in Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments (PSEP, July 1995). Testing was performed at the MEC Analytical Systems, Inc. Bioassay Laboratory located in Carlsbad, California.

3. Case Narrative

Testing was initiated on 17 September 1996, and completed on 27 September 1996. Bioassays were performed concurrently on control, reference and test sediments.

Negative control and reference sediments were collected and tested in compliance with SMS performance standards for test validation.

Dissolved oxygen and pH meters used in the conduct of these bioassays were calibrated each day prior to use. The conductivity/salinity meter calibration is verified monthly. No irregularities were encountered in the calibration or operation of the instruments.

Water quality measurements were performed on all replicates on the day of test initiation (day 0) and day 10. Water quality from one replicate from each sample was measured on days 1 through 9. Data on mean, minimum and maximum values are presented in the report following the case narrative.

Data were recorded on pre-printed data sheets in ink. All corrections were initialed by the person making the correction and the mistake was coded. A table of correction codes for the laboratory and a table with the names and initials of the laboratory staff are presented in the appendix of this report.

Data for water quality and mortality were double entered and cross compared for accuracy. In the event of a discrepancy, the correct information was confirmed from the original data sheets. The test acceptance criterion for the Rhepox test is ≥90% survival in the controls. All controls exceeded this criterion, the percent survival ranged from 97 to 99% in the two controls. All data generated from this were accepted without qualification.

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Communications between the laboratory (MEC) and King County Environmental Laboratory (KCEL) were logged and kept as part of the permanent project file.

3.1 Protocol Deviations

1. pH measurements on day 0 in sample C960913.0833, replicates 2-5 were recorded as 8.6. This is very close to the protocol limit of ambient, $\pm$ 0.5 units, and was only a temporary occurence. Slightly different sediment settling rates are the likely cause of the pH differences. This increase in pH over the protocol specification does not limit the usefulness of the data.

2. pH measurements on day 10 in sample C960913.0833, replicates 1 and 5, were recorded as 8.8. This is very close to the protocol limit. A gradual increase in pH readings were noted over the 10 day duration of the test. This increase over time does not limit the usefulness of the data.

3. pH measurements on day 9, replicate 4 and all replicates on day 10 in sample C960911.1033 were recorded as 8.6-8.7. This is very close to the protocol limit. A gradual increase in pH readings were noted over the 10 day duration of the test. This increase over time does not limit the usefulness of the data.

4. pH measurements on day 10 in sample C960913.0433, replicate 4, was recorded as 8.6. This is very close to the protocol limit. A gradual increase in pH reading were noted over the 10 day duration of the test. This increase over time does not limit the usefulness of the data.

5. pH measurements on day 10 in sample C960913.0933 replicates 1-5, were recorded as 8.6-8.9. This is close to the protocol limit. A gradual increase in reading were noted over the 10 day duration of the test. This increase over time does not limit the usefulness of the data.

6. pH measurements on day 10 in sample C960913.1433, replicate 2, was recorded as 8.6. This is very close to the protocol limit. A gradual increase in reading was noted over the 10 day duration of the test. This increase over time does not limit the usefulness of the data.

7. Temperature measurement on day 5, replicate 5, for sample C960911.1133 exceeded the protocol limit of 15 °C $\pm$ 1 by 0.9 °C. Subsequent readings and the continuous temperature monitoring device show test withing test specifications. This temporary excursion above the test protocol limit does not limit the usefulness of the data.

8. Temperature measurement on day 5, replicate 5, for sample C960913.1533 exceeded theprotocol limit of 15 °C $\pm$ 1 by 0.9 °C. Subsequent readings and the continuous temperature monitoring

device show test within test specifications. This temporary excursion above the test protocol limit does not limit the usefulness of the data.

9. Temperature measurements on one or more replicates from samples C960913.1733A and B, C960911.0533, C960911.0733, C960911.0833, C960911.0933, C960911.1133, C960913.0333, C960913.0433, and C960913.0633 on day 10 exceeded the protocol limit of 15 °C ± 1 by 0.1 °C to 2.3 °C. Test containers were removed from their temperature controlled environment as they were processed for final water quality and animal counts. This short excursion above the test protocol limit does not limit the usefulness of the data.

10. Temperature measurement on day 5, replicate 5, for sample C960913.0433 exceeded the protocol limit. Subsequent readings and the continuous temperature monitoring device show temperatures withing test specifications. This temporary excursion above the test protocol limit does not limit the usefulness of the data.

11. Salinity in sample C960913.1133 replicate 1 was recorded as 26.4 ppt on day 1. This reading was probably due to an unknown error, such as sediment particles on the probe. Day 0 and all other subsequent readings are within protocol limits (28 ppt ± 1). This short excursion below the test protocol limit does not limit the usefulness of the data.

12. Sediment interstitial salinity for sample C960911.0933 was 20.2 ppt. Sediment interstitial salinity was adjusted to test specifications before the test was started.

13. Sediment interstitial salinity for sample C960911.1133 was 5.0 ppt. Sediment interstitial salinity was adjusted to test specifications before the test was started.

4. Summary of Test Response

The following tables show test response replicate mean and standard deviation for negative control, reference, and test sediments. Results marked with an asterisk (*) are statistically significant relative to reference sediment response (Student's t-test, p = 0.05).

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Client Sample ID	MEC Sample ID	Mortality (%)			Failure to Rebury (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
Control A	C960913.1733A	0%	3%	4%	45%	9%	2%
		0%			0%		
		0%			0%		
		5%			0%		
		10%			0%		
Control B	C960913.1733B	0%	1%	2%	0%	1%	2%
		5%			0%		
		0%			0%		
		0%			5%		
		0%			0%		
P9443-1	C960911.0533	0%	13%	8%	0%	2%	5%
		10%			0%		
		15%			12%		
		20%			0%		
		20%			0%		
P9443-2	C960911.0633	35%	21%*	9%	0%	0%	0%
		20%			0%		
		20%			0%		
		20%			0%		
		10%			0%		
P9443-3	C960911.0733	20%	18%*	3%	0%	0%	0%
		20%			0%		
		15%			0%		
		20%			0%		
		15%			0%		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client: KCEL
Project: Metro Set I
Sample Matrix: Sediment
MEC Project ID 0906

Date Received: 11 & 13Sep96
Date Test Started: 17Sep96
Date Test Ended: 27Sep96

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Client Sample ID	MEC Sample ID	Mortality (%)			Failure to Rebury (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9443-4	C960911.0833	50%	22%*	17%	0%	1%	3%
		10%			0%		
		10%			0%		
		25%			7%		
		15%			0%		
P9443-5	C960911.0933	20%	26%*	12%	0%	2%	4%
		45%			9%		
		30%			0%		
		15%			0%		
		20%			0%		
P9443-6	C960911.1033	30%	19%	11%	0%	4%	6%
		20%			0%		
		0%			5%		
		25%			13%		
		20%			0%		
P9443-7	C960911.1133	0%	4%	4%	0%	1%	2%
		5%			0%		
		5%			0%		
		10%			6%		
		0%			0%		
P9444-1	C960913.0233	10%	22%*	13%	11%	2%	5%
		30%			0%		
		15%			0%		
		15%			0%		
		40%			0%		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Client Sample ID	MEC Sample ID	Mortality (%)			Failure to Rebury (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-2	C960913.0333	0%	15%	19%	0%	2%	4%
		0%			0%		
		20%			0%		
		45%			9%		
		10%			0%		
P9444-3	C960913.0433	40%	20%	17%	0%	2%	3%
		0%			0%		
		5%			5%		
		25%			0%		
		30%			7%		
P9444-4	C960913.0533	45%	28%*	20%	0%	3%	5%
		15%			6%		
		55%			11%		
		15%			0%		
		10%			0%		
P9444-5	C960913.0633	5%	11%	11%	0%	2%	4%
		10%			0%		
		10%			0%		
		30%			0%		
		0%			10%		
P9444-6	C960913.0733	45%	50%*	30%	0%	0%	0%
		40%			0%		
		20%			0%		
		45%			0%		
		100%			–		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Client Sample ID	MEC Sample ID	Mortality (%)			Failure to Rebury (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-7	C960913.0833	45%	53%*	13%	0%	7%	10%
		65%			0%		
		60%			0%		
		60%			12%		
		35%			23%		
P9444-8	C960913.0933	45%	45%*	38%	0%	0%	0%
		60%			0%		
		0%			0%		
		20%			0%		
		100%			--		
P9444-9	C960913.1033	30%	19%	13%	0%	3%	4%
		15%			6%		
		35%			8%		
		5%			0%		
		10%			0%		
P9444-10	C960913.1133	15%	15%	14%	0%	3%	4%
		20%			6%		
		35%			8%		
		0%			0%		
		5%			0%		
P9446-1 Reference	C960913.1233	0%	6%	9%	0%	0%	0%
		20%			0%		
		0%			0%		
		10%			0%		
		0%			0%		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Client Sample ID	MEC Sample ID	Mortality (%)			Failure to Rebury (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9446-2 Reference	C960913.1333	5%	8%	4%	0%	0%	0%
		10%			0%		
		5%			0%		
		5%			0%		
		15%			0%		
P9445-1	C960913.1433	0%	6%	8%	0%	0%	0%
		0%			0%		
		5%			0%		
		5%			0%		
		20%			0%		
P9445-2	C960913.1533	5%	10%	7%	0%	0%	0%
		15%			0%		
		15%			0%		
		0%			0%		
		15%			0%		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Test Water Quality Data

Analyte:	**Salinity**	**Dissolved Oxygen**	**pH**
Method (ISP: Ion Specific Probe)	ISP	ISP	ISP
Method Reporting Limit:	0.1 ‰	1% sat	0.1 unit

Sample ID *Client (MEC)*	**Statistic**	**pH**	**D.O. (% Sat.)**	**Temp (°C)**	**Salinity (ppt)**
Control A (C960913.1733A)	Mean	8.1	95.9	15.8	27.6
	Minimum	7.8	75.0	15.1	27.4
	Maximum	8.3	104.0	17.2	27.9
Control B (C960913.1733B)	Mean	8.1	96.4	15.6	27.6
	Minimum	7.8	87.0	14.6	27.4
	Maximum	8.3	101.0	17.2	27.8
P9443-1 (C960911.0533)	Mean	8.2	95.3	15.6	27.9
	Minimum	7.9	90.0	15.0	27.8
	Maximum	8.6	102.0	17.0	28.1
P9443-2 (C960911.0633)	Mean	8.2	94.1	15.7	27.8
	Minimum	7.7	84.0	14.8	27.6
	Maximum	8.6	103.0	16.4	28.3
P9443-3 (C960911.0733)	Mean	8.3	94.5	16.1	27.9
	Minimum	7.8	88.0	14.9	27.6
	Maximum	8.7	101.0	18.8	28.2
P9443-4 (C960911.0833)	Mean	8.1	93.4	16.0	27.9
	Minimum	7.8	82.0	15.0	27.8
	Maximum	8.3	101.0	18.7	28.1

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Sample ID *Client (MEC)*	**Statistic**	**pH**	**D.O. (% Sat.)**	**Temp (°C)**	**Salinity (ppt)**
P9443-5 (C960911.0933)	Mean	8.2	93.5	15.7	28.4
	Minimum	7.9	73.0	14.9	28.1
	Maximum	8.8	101.0	17.1	28.5
P9443-6 (C960911.1033)	Mean	8.2	93.9	15.3	27.9
	Minimum	7.7	83.0	14.6	27.5
	Maximum	8.7	99.0	16.5	28.1
P9443-7 (C960911.1133)	Mean	8.1	98.8	15.7	27.6
	Minimum	8.0	92.0	14.9	27.0
	Maximum	8.2	104.0	17.0	27.9
P9444-1 (C960913.0233)	Mean	8.1	95.5	15.4	28.0
	Minimum	7.9	88.0	14.5	26.6
	Maximum	8.3	101.0	16.5	28.3
P9444-2 (C960913.0333)	Mean	8.1	96.5	15.4	28.3
	Minimum	8.0	91.0	14.9	28.2
	Maximum	8.3	102.0	16.7	28.5
P9444-3 (C960913.0433)	Mean	8.3	94.7	16.1	28.0
	Minimum	8.0	83.0	15.0	27.9
	Maximum	8.6	100.0	18.3	28.3
P9444-4 (C960913.0533)	Mean	8.2	94.7	15.4	28.0
	Minimum	8.0	86.0	14.8	27.8
	Maximum	8.5	99.0	16.2	28.4
P9444-5 (C960913.0633)	Mean	8.1	96.4	15.5	27.9
	Minimum	7.9	88.0	14.5	27.6
	Maximum	8.3	103.0	16.9	28.1
P9444-6 (C960913.0733)	Mean	8.3	95.8	15.4	28.6
	Minimum	8.0	89.0	15.0	28.4
	Maximum	8.9	102.0	16.4	29.1
P9444-7 (C960913.0833)	Mean	8.3	94.4	15.3	28.5
	Minimum	7.8	83.0	14.4	27.2
	Maximum	8.6	101.0	16.1	28.8

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Sample ID *Client (MEC)*	Statistic	pH	D.O. (% Sat.)	Temp (°C)	Salinity (ppt)
P9444-8	Mean	8.3	95.7	15.4	28.6
(C960913.0933)	Minimum	7.9	88.0	14.3	28.3
	Maximum	8.9	105.0	16.2	28.8
P9444-9	Mean	8.2	95.5	15.3	28.4
(C960913.1033)	Minimum	8.0	88.0	14.7	28.2
	Maximum	8.3	101.0	16.3	28.6
P9444-10	Mean	8.2	95.1	15.3	28.3
(C960913.1133)	Minimum	8.0	89.0	14.7	26.4
	Maximum	8.5	101.0	16.5	28.8
P9446-1	Mean	8.2	96.5	15.4	28.2
Reference	Minimum	7.8	92.0	14.5	28.0
(C960913.1233)	Maximum	8.5	101.0	16.2	28.4
P9446-2	Mean	8.2	96.5	15.2	28.3
Reference	Minimum	8.0	92.0	14.9	28.1
(C960913.1333)	Maximum	8.5	100.0	15.8	28.4
P9445-1	Mean	8.2	92.9	15.4	28.3
(C960913.1433)	Minimum	7.9	66.0	14.1	28.1
	Maximum	8.6	104.0	16.4	28.6
P9445-2	Mean	8.1	97.2	15.4	28.2
(C960913.1533)	Minimum	7.9	93.0	14.5	27.8
	Maximum	8.3	104.0	16.9	28.4

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Interstitial Salinity

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1733A)	32.0	30.0	P9444-4 (C960913.0533)	26.4	27.0
Control B (C960913.1733B)	32.0	32.0	P9444-5 (C960913.0633)	27.6	28.0
P9443-1 (C960911.0533)	27.6	28.0	P9444-6 (C960913.0733)	26.4	30.0
P9443-2 (C960911.0633)	27.0	28.0	P9444-7 (C960913.0833)	28.3	30.0
P9443-3 (C960911.0733)	27.7	30.0	P9444-8 (C960913.0933)	25.5	30.0
P9443-4 (C960911.0833)	27.7	28.0	P9444-9 (C960913.1033)	28.5	30.0
P9443-5 (C960911.0933)	28.0**	29.0	P9444-10 (C960913.1133)	27.9	30.0
P9443-6 (C960911.1033)	25.4	30.0	P9446-1 Reference (C960913.1233)	30.6	29.0
P9443-7 (C960911.1133)	28.0**	27.0	P9446-2 Reference (C960913.1333)	30.0	29.0
P9444-1 (C960913.0233)	25.2	29.0	P9445-1 (C960913.1433)	29.1	30.0
P9444-2 (C960913.0333)	27.5	29.0	P9445-2 (C960913.1533)	30.90	28.0
P9444-3 (C960913.0433)	25.6	29.0			

** Initial interstitial salinity below 25 ppt. Salinity adjustment of sediment done prior to testing.

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Total Ammonia (mg/L)

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1733A)	0.12	0.63	P9444-4 (C960913.0533)	0.89	0.76
Control B (C960913.1733B)	0.11	0.69	P9444-5 (C960913.0633)	0.30	1.18
P9443-1 (C960911.0533)	0.43	0.43	P9444-6 (C960913.0733)	0.71	1.67
P9443-2 (C960911.0633)	1.99	13.20	P9444-7 (C960913.0833)	0.92	4.17
P9443-3 (C960911.0733)	0.43	0.12	P9444-8 (C960913.0933)	0.41	2.03
P9443-4 (C960911.0833)	0.57	0.12	P9444-9 (C960913.1033)	0.62	0.29
P9443-5 (C960911.0933)	1.23	0.69	P9444-10 (C960913.1133)	0.59	0.89
P9443-6 (C960911.1033)	1.00	1.59	P9446-1 Reference (C960913.1233)	0.12	0.20
P9443-7 (C960911.1133)	0.00	0.04	P9446-2 Reference (C960913.1333)	1.44	3.22
P9444-1 (C960913.0233)	0.14	0.52	P9445-1 (C960913.1433)	0.55	0.03
P9444-2 (C960913.0333)	0.00	0.06	P9445-2 (C960913.1533)	0.83	0.03
P9444-3 (C960913.0433)	1.37	0.67			

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

Sulfides (ppm)

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1733A)	0.0043	0.0000	P9444-4 (C960913.0533)	0.0034	0.0000
Control B (C960913.1733B)	0.0031	0.0000	P9444-5 (C960913.0633)	0.0034	0.0000
P9443-1 (C960911.0533)	0.0012	0.0000	P9444-6 (C960913.0733)	0.0041	0.0000
P9443-2 (C960911.0633)	0.0026	0.0000	P9444-7 (C960913.0833)	0.0029	0.0000
P9443-3 (C960911.0733)	0.0041	0.0000	P9444-8 (C960913.0933)	0.0024	0.0000
P9443-4 (C960911.0833)	0.0029	0.0000	P9444-9 (C960913.1033)	0.0024	0.0000
P9443-5 (C960911.0933)	0.0019	0.0000	P9444-10 (C960913.1133)	0.0016	0.0000
P9443-6 (C960911.1033)	0.0034	0.0000	P9446-1 Reference (C960913.1233)	0.0010	0.0000
P9443-7 (C960911.1133)	0.0019	0.0000	P9446-2 Reference (C960913.1333)	0.0022	0.0000
P9444-1 (C960913.0233)	0.0050	0.0000	P9445-1 (C960913.1433)	0.0023	0.0000
P9444-2 (C960913.0333)	0.0021	0.0000	P9445-2 (C960913.1533)	0.0012	0.0000
P9444-3 (C960913.0433)	0.0025	0.0000			

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	17Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

5. Statistical Analyses

Tests of normal distribution were done using SAS® Proc Univariate. T-tests were done to compare each sample endpoint to the corresponding reference sample endpoint. Proc TTEST was used for these tests, and results adjusted for a one-tail test.

6. Positive Control Response

A reference toxicity test with cadmium chloride was performed on 25 September 1996. Concentrations tested were 0.12, 0.25, 0.5, 1 and 2 ppm cadmium. The estimate of the 96-hour EC_{50} was 0.68 ppm. A laboratory control chart (attached) shows a laboratory mean of 0.72, with upper and lower 95% confidence limits of 1.21 and 0.23 ppm, respectively.

Verification analysis of the laboratory cadmium stock solution (10,000 ppm) was recorded at 10,400 ppm cadmium. Analysis of the highest test concentration (2.0 ppm) was measured at 30.8 ppm by the chemistry laboratory. Improper sample storage, identification, and/or handling is suspected for the differences in expected and analyzed values in this test. The laboratory analysis results are included in the supporting documentation.

7. Dilution Water

Dilution water was collected by MEC personnel from Scrippps Institute of Oceanography (SIO) in La Jolla, CA on September 16, 1996. The seawater was assigned the identifcation number SIO 091696.

Priority pollutant analysis of SIO 091696 showed all analytes below laboratory detection limits. The results of this analysis are included in the supporting documentation.

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
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Sample Matrix:	Sediment	**Date Test Ended:**	27Sep96
MEC Project ID	0906		

Acute/Chronic Toxicity Bioassay
10-Day Solid Phase Amphipod

Test Organism: *Rhepoxynius abronius*
MEC Protocol: P024.1

APPENDIX
Pertinent Test Data

DILUTION WATER: Scripps Institute of Oceanography filtered seawater

Target Values:		
	Salinity	28 ‰, ± 1‰
	pH	ambient, ± 0.5 units
	D.O.	> 60% saturation
	Temperature	15.0° C, ± 1° C

TEST ORGANISM: 3 to 5 mm *Rhepoxynius abronius*, from Puget Sound, collected by Dr. Ken Brooks. Held for 4 days and acclimated to 28 ppt with daily water changes.

TEST CHAMBER: 1 L glass beakers, 5 replicates, brought to a 950 mL final volume.

EXPERIMENTAL DESIGN:

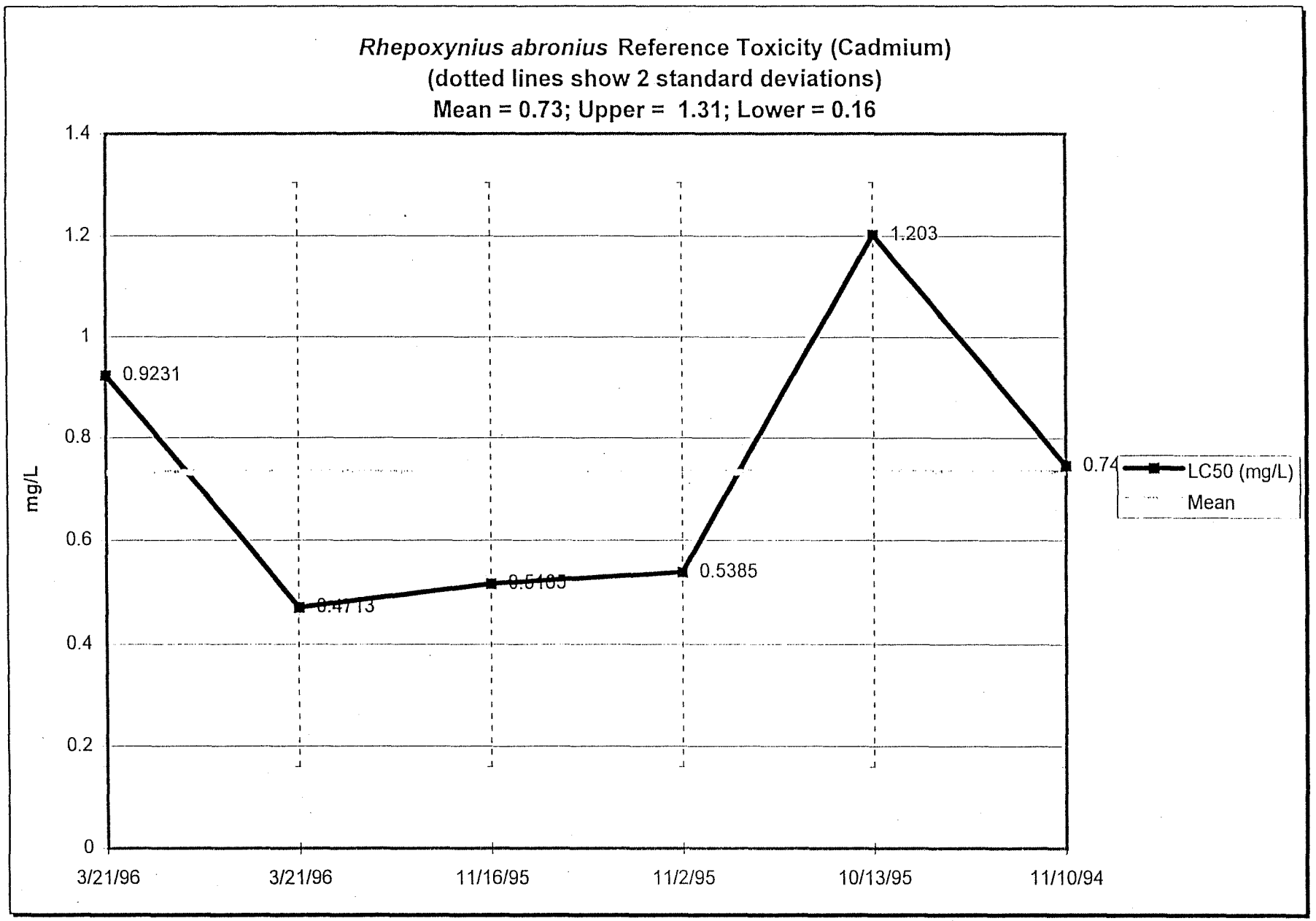
1. Two cm of sediment were placed into each beaker, seawater was added, the temperature of the seawater was adjusted to 15 ± 1°C.
2. 20 test organisms were placed into each chamber.
3. Samples were aerated.
4. Test chambers were held at 15°C ±1° for 10 days with continuous light.
5. Test room temperature was monitored with a thermistor and continuously recorded with a data logger.

MORTALITY DEFINITION: Lack of respiratory movement and lack of reaction to gentle prodding.

CONTROL CRITERION: ≥90% Survival in controls

STUDY DIRECTOR: A. Monji

INVESTIGATORS: A. Monji, M. Woo, E. McCoy, K. Bothner, T. Fitzsimmons, E. Basmadjian


Rhepoxynius abronius Reference Toxicity (Cadmium)
(dotted lines show 2 standard deviations)
Mean = 0.73; Upper = 1.31; Lower = 0.16
mg/L
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.9231
0.4713
0.5185
0.5385
1.203
0.74
3/21/96
3/21/96
11/16/95
11/2/95
10/13/95
11/10/94
LC50 (mg/L)
Mean

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

CASE SUMMARY

1. Project/Sample Identification

Bioassay testing on marine sediments was conducted in support of the Elliott Bay/Duwamish River Sediment Remediation Project, Seattle Waterfront Project, and the Connecticut Hanford and Chelan Street, and other Combined Sewer Overflow (CSO) Projects. Toxicity tests were conducted on a total of 21 samples. Seven sediment samples were received by the laboratory on 11 September 1996, and 12 sediment samples plus 2 reference samples were received on 13 September 1996 (see Table below). The control sediment was received and logged in on 13 September, 1996.

Sample ID	Collection Date	Date Received	Sample ID	Collection Date	Date Received
L9443-1	9/9/96	9/11/96	L9444-5	9/10/96	9/13/96
L9443-2	9/9/96	9/11/96	L9444-6	9/11/96	9/13/96
L9443-3	9/9/96	9/11/96	L9444-7	9/11/96	9/13/96
L9443-4	9/9/96	9/11/96	L9444-8	9/11/96	9/13/96
L9443-5	9/9/96	9/11/96	L9444-9	9/10/96	9/13/96
L9443-6	9/9/96	9/11/96	L9444-10	9/11/96	9/13/96
L9443-7	9/10/96	9/11/96	L9446-1 (Ref)	9/11/96	9/13/96
L9444-1	9/10/96	9/13/96	L9446-2 (Ref)	9/11/96	9/13/96
L9444-2	9/10/96	9/13/96	L9445-1	9/10/96	9/13/96
L9444-3	9/11/96	9/13/96	L9445-2	9/10/96	9/13/96
L9444-4	9/11/96	9/13/96			

QA Unit — 6 Dec 96 Date — Approved — 6 Dec 96 Date

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

2. Test Method

Toxicity tests were conducted with the echinoderm (*Dendraster excentricus*), using MEC Protocol #P042.0. All methods and procedures employed in this program followed Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments (PSEP, July 1995). Testing was performed at the MEC Analytical Systems, Inc. Bioassay Laboratory located in Carlsbad, California.

3. Case Narrative

Testing was initiated on 27 September 1996, and completed on 30 September 1996. Bioassays were performed concurrently on control, reference and test sediments.

Testing with echinoderms was initially started on 20 September, 1996 and completed on 23 September 1996. Control development of 79-83% normal did not meet the protocol specification of greater than 90%. New animals were received and testing started over on 27 September 1996 and completed on 30 September 1996. Sediment samples were past the 14 day holding time at the start of the second test.

Negative control and reference sediments were collected and tested in compliance with SMS performance standards for test validation.

Control sediment was also tested concurrently with the test and reference sediments but was not required for this program. Results were not used in statistical comparisons.

Dissolved oxygen and pH meters used in the monitoring of these bioassays were calibrated each day prior to use. The conductivity and salinity meter calibration is verified monthly. No irregularities were encountered in the calibration or operation of the instruments.

Data were recorded on pre-printed data sheets in ink. All corrections were initialed by the person making the correction and the mistake was coded. A table of correction codes for the laboratory and a table with the names and initials of the laboratory staff are presented in the supporting documentation section of this report.

Data for water quality and mortality was double entered and cross compared for accuracy. In the event of a discrepancy, the correct information was confirmed from the original data sheets. Test acceptance criteria for the echinoderm test is ≥90% normal development and ≥70% survival in the seawater controls. The seawater control had a mean of 93.6% normal development and a mean of 93.3% survival. All data generated from this was accepted without qualification.

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Communications between the laboratory (MEC) and King County Environmental Laboratory (KCEL) were logged and kept as part of the permanent project file.

Water quality measurements were taken daily from a surrogate test container for each sample on day 0 through test termination. Data on mean, minimum and maximum values are presented in the report following the case narrative.

3.1 Protocol Deviations

1. Temperature measurements on day 0 (27 September) for all samples ranged from 16.0 to 17.5°C. This exceeded the temperature criterion (15 ± 1° C) by up to 1.5° C. It is thought that this was a short-term excursion during the time that the test chambers completely equilibrated to the water bath. Examination of the continuous temperature recording devices show the test chambers within acceptable limits. This brief exceedence of protocol temperature does not limit the usefulness of the data.

2. Test termination temperatures measurements on day 3 (30 September) for all samples ranged from 16.3 to 17.7°C. At the time of test termination, all test aeration (including the surrogate test containers) was discontinued. As test containers were removed from the water bath, the water level of the bath dropped, and the thermal capacity of the bath was reduced. These two factors are the probable cause of the slight temperature increase in surrogate test containers. Examination of the continuous temperature recording devices show the test chambers within acceptable limits. This brief exceedence of protocol temperature does not limit the usefulness of the data.

3. No water quality readings performed on sample C960913.0946, day 3. Water quality readings from the first 3 sets of measurements from this sample, and for the other samples, were within protocol specifications, with the exception of the temperature issues described in paragraphs 1 and 2 of this case narrative. The consistency of water quality throughout the tests supports the assumptions that this oversight does not limit the usefulness of the data

4. Summary of Test Response

The following tables show test response replicate mean and standard deviation for negative control, seawater control, reference, and test sediments. The first table shows combined larval mortality/abnormality and larval percent mortality plus abnormalities. The second table presents mortality

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
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Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

and abnormality endpoints. Results marked with an asterisk (*) are statistically significant relative to reference sediment response (Student's t-test, p = 0.05).

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Combined Larval Mortality/Abnormality (%)		
		By Replicate	Mean	Standard Deviation
Control A	C960913.1746A	41.98	30.96	12.49
		20.86		
		15.24		
		43.05		
		33.69		
Control B	C960913.1746B	5.88	15.24	7.34
		19.52		
		16.31		
		10.16		
		24.33		
Water Control	Water Control	15.78	11.82	6.98
		14.71		
		17.38		
		0.00		
		11.23		
P9443-1	C960911.0546	40.37	32.46	11.21
		44.92		
		30.75		
		15.78		
		30.48		
P9443-2	C960911.0646	35.83	34.55	4.50
		40.64		
		32.09		
		35.56		
		28.61		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Combined Larval Mortality/Abnormality (%)		
		By Replicate	Mean	Standard Deviation
P9443-3	C960911.0746	53.74 34.76 41.98 24.33 20.05	34.97	13.58
P9443-4	C960911.0846	20.05 29.41 22.19 54.01 38.50	32.83	13.86
P9443-5	C960911.0946	30.48 13.90 1.60 18.18 18.98	16.63	10.40
P9443-6	C960911.1046	27.27 7.22 18.18 1.07 25.67	15.88	11.46
P9443-7	C960911.1146	33.96 29.68 38.24 41.44 27.54	34.17	5.78

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Combined Larval Mortality/Abnormality (%)		
		By Replicate	Mean	Standard Deviation
P9444-1	C960913.0246	37.17 36.90 26.47 36.90 35.03	34.49	4.57
P9444-2	C960913.0346	8.56 13.10 31.55 21.93 30.75	21.18	10.30
P9444-3	C960913.0446	32.89 35.03 33.42 22.46 20.86	28.93	6.71
P9444-4	C960913.0546	44.39 51.87 46.52 69.79 46.52	*51.82	10.42
P9444-5	C960913.0646	1.07 55.88 20.86 28.88 26.47	26.63	19.67

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Combined Larval Mortality/Abnormality (%)		
		By Replicate	Mean	Standard Deviation
P9444-6	C960913.0746	35.56	*40.11	7.94
		44.92		
		36.10		
		32.35		
		51.60		
P9444-7	C960913.0846	14.97	32.14	11.82
		30.48		
		29.14		
		45.72		
		40.37		
P9444-8	C960913.0946	44.39	*39.41	3.20
		40.64		
		36.36		
		37.43		
		38.24		
P9444-9	C960913.1046	29.14	29.14	6.45
		38.24		
		29.95		
		28.34		
		20.05		
P9444-10	C960913.1146	54.01	40.32	18.23
		43.58		
		58.02		
		12.57		
		33.42		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Combined Larval Mortality/Abnormality (%)		
		By Replicate	Mean	Standard Deviation
P9446-1 Reference	C960913.1246	67.91 12.03 9.09 12.83 33.42	27.06	24.80
P9446-2 Reference	C960913.1346	36.90 26.74 38.77 18.72 24.06	29.04	8.56
P9445-1	C960913.1446	16.84 22.73 15.51 29.95 16.31	20.27	6.12
P9445-2	C960913.1546	45.72 38.50 40.64 49.20 39.57	42.73	4.55

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Mortality (%)			Abnormality (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
Control A	C960913.1746A	32.64	19.64	13.40	4.41	4.79	2.37
		8.90			3.58		
		3.86			2.16		
		33.23			5.33		
		19.58			8.49		
Control B	C960913.1746B	0.00	3.98	4.55	2.22	4.46	1.40
		6.23			4.75		
		2.97			4.28		
		0.00			5.08		
		10.68			5.98		
Water Control	Water Control	9.36	6.68	4.20	7.08	6.36	3.60
		5.08			10.14		
		9.09			9.12		
		0.00			3.98		
		9.89			1.48		
P9443-1	C960911.0546	32.34	23.09	12.37	2.19	2.61	1.05
		36.50			3.74		
		20.18			3.72		
		4.75			1.87		
		21.66			1.52		
P9443-2	C960911.0646	24.63	24.51	5.25	5.51	3.76	1.07
		31.75			3.48		
		22.26			3.05		
		26.41			2.82		
		17.51			3.96		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Mortality (%)			Abnormality (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9443-3	C960911.0746	46.88	25.58	15.26	3.35	3.09	0.61
		24.63			3.94		
		33.53			3.13		
		13.95			2.41		
		8.90			2.61		
P9443-4	C960911.0846	9.20	23.26	14.90	2.29	3.07	1.57
		20.18			1.86		
		12.17			1.69		
		46.29			4.97		
		28.49			4.56		
P9443-5	C960911.0946	19.88	6.77	7.78	3.70	3.38	1.02
		2.08			2.42		
		0.00			2.90		
		6.53			2.86		
		5.34			5.02		
P9443-6	C960911.1046	14.24	6.71	7.00	5.88	3.81	1.57
		0.00			3.34		
		5.64			3.77		
		0.00			1.60		
		13.65			4.47		
P9443-7	C960911.1146	24.93	24.33	6.59	2.37	3.45	1.33
		19.88			2.59		
		29.67			2.53		
		31.45			5.19		
		15.73			4.58		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Mortality (%)			Abnormality (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-1	C960913.0246	24.04	22.49	4.15	8.20	6.26	1.76
		25.22			6.35		
		15.43			3.51		
		25.52			5.98		
		22.26			7.25		
P9444-2	C960913.0346	0.00	10.33	9.54	3.39	3.61	1.74
		1.78			1.81		
		21.66			3.03		
		10.39			3.31		
		17.80			6.50		
P9444-3	C960913.0446	23.15	17.69	8.00	3.09	4.15	1.70
		25.22			3.57		
		21.96			5.32		
		8.01			6.45		
		10.09			2.31		
P9444-4	C960913.0546	34.72	42.61*	11.33	5.45	*7.20	2.91
		43.03			6.25		
		37.98			4.31		
		62.02			11.72		
		35.31			8.26		
P9444-5	C960913.0646	0.00	18.04	17.40	2.63	4.08	2.55
		46.59			8.33		
		10.39			1.99		
		18.69			2.92		
		14.54			4.51		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Mortality (%)			Abnormality (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9444-6	C960913.0746	27.60	30.74*	8.13	1.23	4.06	4.80
		30.27			12.34		
		26.41			3.63		
		24.63			0.39		
		44.81			2.69		
P9444-7	C960913.0846	2.08	21.66	13.70	3.64	3.85	0.50
		19.88			3.70		
		17.51			4.68		
		37.69			3.33		
		31.16			3.88		
P9444-8	C960913.0946	35.61	30.33*	3.48	4.15	3.50	0.53
		32.05			3.06		
		27.30			2.86		
		27.89			3.70		
		28.78			3.75		
P9444-9	C960913.1046	19.29	18.81	7.29	2.57	3.15	0.63
		29.38			2.94		
		19.29			3.68		
		17.21			3.94		
		8.90			2.61		
P9444-10	C960913.1146	47.48	31.81	20.65	2.82	2.90	0.68
		35.31			3.21		
		52.23			2.48		
		0.89			2.10		
		23.15			3.86		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Client Sample ID	MEC Sample ID	Mortality (%)			Abnormality (%)		
		By Replicate	Mean	Standard Deviation	By Replicate	Mean	Standard Deviation
P9446-1 Reference	C960913.1246	63.20	17.45	27.43	3.23	3.17	1.11
		0.89			1.50		
		0.00			2.86		
		0.00			4.40		
		23.15			3.86		
P9446-2 Reference	C960913.1346	18.99	14.78	9.10	13.55	7.64	3.48
		11.57			8.05		
		28.19			5.37		
		4.45			5.59		
		10.68			5.65		
P9445-1	C960913.1446	0.89	5.99	6.09	6.89	*5.92	2.31
		9.79			4.93		
		0.30			5.95		
		14.54			9.03		
		4.45			2.80		
P9445-2	C960913.1546	37.39	34.24	5.50	3.79	3.30	1.87
		30.56			1.71		
		29.67			6.33		
		42.43			2.06		
		31.16			2.59		

* = statistically significant relative to reference sediment response (Student's t-test, p = 0.05)

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Test Water Quality Data

Analyte:	**Salinity**	**Dissolved Oxygen**	**pH**
EPA Method:	120.1	360.1	150.1
Method Reporting Limit:	0.1 ‰	1% sat	0.1 unit

Sample ID ***Client*** ***(MEC)***	**Statistic**	**Temp (°C)**	**D.O. (% Sat.)**	**Salinity (ppt)**	**pH**
Control A	Mean	16.3	96	28.8	8.0
(C960913.1746A)	Minimum	15.4	94	28.6	7.7
	Maximum	17.7	98	28.8	8.2
Control B	Mean	16.5	93	28.8	8.0
(C960913.1746B)	Minimum	16.0	87	28.7	7.8
	Maximum	17.0	96	29.0	8.3
Water Control	Mean	16.1	97	28.8	8.1
(Water Control)	Minimum	15.6	96	28.8	7.9
	Maximum	16.8	99	28.9	8.2
P9443-1	Mean	16.4	93	29.0	8.1
(C960911.0546)	Minimum	15.8	86	28.9	7.9
	Maximum	17.2	98	29.1	8.2
P9443-2	Mean	16.5	92	28.9	8.0
(C960911.0646)	Minimum	15.8	88	28.7	7.8
	Maximum	17.4	95	29.0	8.2
P9443-3	Mean	16.4	93	29.0	8.0
(C960911.0746)	Minimum	15.7	88	28.9	7.8
	Maximum	17.3	96	29.0	8.2
P9443-4	Mean	16.4	96	28.9	8.0
(C960911.0846)	Minimum	15.6	93	28.6	7.8
	Maximum	17.3	99	29.1	8.1

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Sample ID *Client (MEC)*	**Statistic**	**Temp (°C)**	**D.O. (% Sat.)**	**Salinity (ppt)**	**pH**
P9443-5 (C960911.0946)	Mean	16.3	95	29.0	8.0
	Minimum	15.6	88	29.0	7.8
	Maximum	17.1	100	29.1	8.2
P9443-6 (C960911.1046)	Mean	16.4	97	28.8	8.0
	Minimum	16.1	94	28.7	7.9
	Maximum	16.9	99	28.9	8.2
P9443-7 (C960911.1146)	Mean	16.6	96	28.9	8.1
	Minimum	15.8	94	28.8	7.9
	Maximum	17.3	101	28.9	8.2
P9444-1 (C960913.0246)	Mean	16.3	93	29.0	8.0
	Minimum	15.6	86	29.0	7.9
	Maximum	17.3	99	29.0	8.1
P9444-2 (C960913.0346)	Mean	16.5	97	28.8	8.1
	Minimum	16.2	95	28.6	8.0
	Maximum	17.0	99	28.9	8.2
P9444-3 (C960913.0446)	Mean	16.3	93	29.0	8.0
	Minimum	15.6	90	28.7	7.9
	Maximum	17.5	95	29.1	8.1
P9444-4 (C960913.0546)	Mean	16.2	94	29.0	8.0
	Minimum	15.7	88	28.9	7.9
	Maximum	17.3	99	29.1	8.2
P9444-5 (C960913.0646)	Mean	16.3	95	28.9	8.0
	Minimum	15.6	88	28.8	7.8
	Maximum	17.0	100	28.9	8.1
P9444-6 (C960913.0746)	Mean	16.3	96	28.8	8.1
	Minimum	15.8	91	28.5	7.9
	Maximum	16.8	98	28.9	8.2
P9444-7 (C960913.0846)	Mean	16.3	93	29.0	8.2
	Minimum	15.6	85	28.8	7.9
	Maximum	17.0	98	29.0	8.3

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Sample ID *Client* *(MEC)*	**Statistic**	**Temp (°C)**	**D.O. (% Sat.)**	**Salinity (ppt)**	**pH**
P9444-8 (C960913.0946)	Mean	15.8	93	29.1	8.0
	Minimum	15.1	89	29.0	7.9
	Maximum	16.9	98	29.1	8.1
P9444-9 (C960913.1046)	Mean	16.5	94	28.8	8.0
	Minimum	15.8	87	28.7	7.9
	Maximum	17.3	100	28.9	8.1
P9444-10 (C960913.1146)	Mean	16.4	94	29.0	8.0
	Minimum	15.7	90	28.9	7.9
	Maximum	17.3	96	29.1	8.1
P9446-1 Reference (C960913.1246)	Mean	16.6	95	28.9	8.1
	Minimum	15.7	88	28.8	8.0
	Maximum	17.6	99	29.0	8.1
P9446-2 Reference (C960913.1346)	Mean	16.5	93	29.0	8.0
	Minimum	15.7	89	28.8	7.9
	Maximum	17.3	98	29.0	8.1
P9445-1 (C960913.1446)	Mean	16.1	93	28.8	8.1
	Minimum	15.4	89	28.7	8.0
	Maximum	17.0	98	28.9	8.2
P9445-2 (C960913.1546)	Mean	16.5	96	28.8	8.0
	Minimum	15.6	93	28.6	7.8
	Maximum	17.5	102	28.9	8.1

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Total Ammonia (mg/L)

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1746A)	0.11	0.00	P9444-4 (C960913.0546)	0.26	0.02
Control B (C960913.1746B)	0.06	0.00	P9444-5 (C960913.0646)	0.07	0.03
P9443-1 (C960911.0546)	0.14	0.00	P9444-6 (C960913.0746)	0.14	0.00
P9443-2 (C960911.0646)	0.09	0.00	P9444-7 (C960913.0846)	0.18	0.08
P9443-3 (C960911.0746)	0.06	0.00	P9444-8 (C960913.0946)	0.20	0.00
P9443-4 (C960911.0846)	0.12	0.00	P9444-9 (C960913.1046)	0.20	0.07
P9443-5 (C960911.0946)	0.34	0.00	P9444-10 (C960913.1146)	0.20	0.71
P9443-6 (C960911.1046)	0.27	0.00	P9446-1 Reference (C960913.1246)	0.13	0.68
P9443-7 (C960911.1146)	0.01	0.00	P9446-2 Reference (C960913.1346)	0.36	0.69
P9444-1 (C960913.0246)	0.16	0.12	P9445-1 (C960913.1446)	0.13	0.38
P9444-2 (C960913.0346)	0.12	0.00	P9445-2 (C960913.1546)	0.12	0.02
P9444-3 (C960913.0446)	0.30	0.08	Seawater Control	0.00	0.00

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

Sulfides (ppm)

Sample ID	Initial	Final	Sample ID	Initial	Final
Control A (C960913.1746A)	<0.1	0.00	P9444-4 (C960913.0546)	<0.1	0.00
Control B (C960913.1746B)	<0.1	0.00	P9444-5 (C960913.0646)	<0.1	0.00
P9443-1 (C960911.0546)	<0.1	0.00	P9444-6 (C960913.0746)	<0.1	0.00
P9443-2 (C960911.0646)	<0.1	0.00	P9444-7 (C960913.0846)	<0.1	0.00
P9443-3 (C960911.0746)	<0.1	0.00	P9444-8 (C960913.0946)	0.005	0.00
P9443-4 (C960911.0846)	<0.1	0.00	P9444-9 (C960913.1046)	0.226	0.00
P9443-5 (C960911.0946)	<0.1	0.00	P9444-10 (C960913.1146)	<0.1	0.00
P9443-6 (C960911.1046)	<0.1	0.00	P9446-1 Reference (C960913.1246)	<0.1	0.00
P9443-7 (C960911.1146)	0.00	0.00	P9446-2 Reference (C960913.1346)	<0.1	0.00
P9444-1 (C960913.0246)	<0.1	0.00	P9445-1 (C960913.1446)	<0.1	0.00
P9444-2 (C960913.0346)	<0.1	0.00	P9445-2 (C960913.1546)	<0.1	0.00
P9444-3 (C960913.0446)	<0.1	0.00			

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

5. Statistical Analyses

Tests of normal distribution were done using SAS® Proc Univariate. T-tests were done to compare each sample endpoint to the corresponding reference sample endpoint. Proc TTEST was used for these tests, and results adjusted for a one-tail test.

6. Positive Control Response

A reference toxicity test with cadmium chloride was performed on 27 September 1996. Concentrations tested were 1.6, 3.2, 7.5, 15 and 30 cadmium ppm. The estimate of the 48-96 hour EC_{50} was 6.20 ppm. A laboratory control chart could not be generated due to lack of data points.

Verification analysis of the laboratory cadmium stock solution (10,000 ppm) was recorded at 10,400 ppm cadmium. Analysis of the highest test concentration (30 ppm) was at 10.4 ppm. Improper sample storage and handling is suspected for the differences in expected and analyzed values in this test. The laboratory analysis results are included in the supporting documentation section.

7. Dilution Water

Dilution water was collected by MEC personnel from Scripps Institute of Oceanography (SIO) in La Jolla, CA on September 16, 1996. The seawater was assigned the identifcation number SIO 091696.

Priority pollutant analysis of SIO 091696 showed all analytes below laboratory detection limits. The laboratory analysis results are included in the supporting documentation section.

MEC ANALYTICAL SYSTEMS, INC.

Analytical Report

Client:	KCEL	**Date Received:**	11 & 13Sep96
Project:	Metro Set I	**Date Test Started:**	27Sep96
Sample Matrix:	Sediment	**Date Test Ended:**	30Sep96
MEC Project ID	0906		

Echinoderm Embryo Sediment Bioassay

Test Organism: *Dendraster excentricus*
MEC Protocol: P042.0

APPENDIX
Pertinent Test Data

TEST: Echinoderm Embryo Sediment Bioassay (PSEP)
MEC Protocol P042.0

DILUTION WATER: Scripps Institute of Oceanography filtered seawater

Target Values:		
	Salinity	28 ± 1 ppt
	D.O.	> 60% saturation
	Temperature	15.0° C, ± 1° C

TEST ORGANISM: Sand Dollar (*Dendraster excentricus*), from Aquatic Environmental Science, Port Townsend, Washington. Collected by Ken Brooks, received 27 September 1996, holding time <1 day.
Stocking Density: 32.9 eggs/mL
Stocking Aliquot Size: 2.8 mL
Initial Count Data: 374 eggs/10 mL

TEST CHAMBER: 1L glass jars, sediment volume 18 grams

EXPERIMENTAL DESIGN:

1. 18 grams of sediment were placed into each jar, 900 mL of seawater was added, the temperature of the seawater was adjusted to 15 ± 1°C.
2. ~20,000 to 30,000 embryos were placed into each chamber.
3. Samples were aerated.
4. Test chambers were held at 15°C ±1° for 48 to 96 hours with a photoperiod of 14 hours light, 10 hours dark.
5. Test bath temperature was monitored with a thermistor, continuously recorded with a data logger.

CONTROL CRITERIA: ≥90% Normal Development; ≥70% survival in seawater controls

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