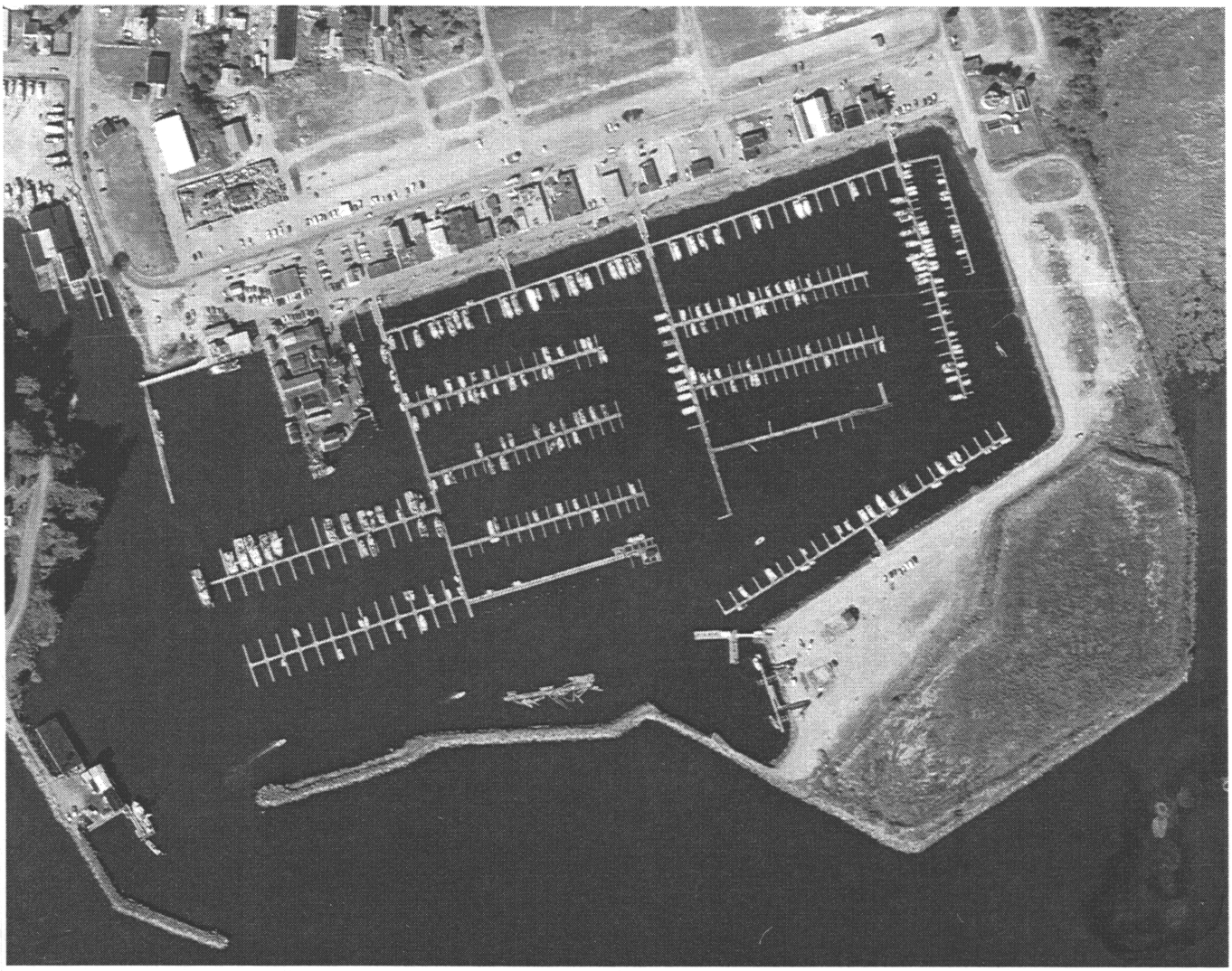
US Army Corps
of Engineers
Portland District

EPA
Region 10

Characteristics of Ilwaco Boat Basin Sediment in Baker Bay, Washington



Final Report
December 1992

Characteristics of Ilwaco Boat Basin Sediment in Baker Bay, Washington

Prepared For:
Sediment Management Program
U. S. Environmental Protection Agency
Region 10
Seattle, Washington

Prepared By:
U. S. Army Corps of Engineers
Portland District
Portland, Oregon

December 1992

Report Preparers

Jim Britton	Biologist	CENPP-PE-HR
Mark Siipola	Civil Engineer	CENPP-PE-HR
John Malek	Dredging and Contaminated Sediments Specialist, Ocean Dumping Coordinator	Region 10, EPA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Characteristics of Ilwaco Boat Basin Sediment
in Baker Bay, Washington

Abstract

Sediments from the Ilwaco Boat Basin were characterized in Spring 1992. The sediment is predominantly sandy, clayey silt, relatively free of contaminants. Cadmium exceeded EPA, Region 10 screening levels in two samples. These samples also had the highest levels of the other metals tested. The AVS concentrations are typical of marina samples in the area. PCBs were undetected at detection limits less than 10 ppb. A small amount of the pesticide endosulfan II (6.0 ppb) was found in one sample. No DDT, DDD or DDE was detected in the samples. PAHs and TBT were below screening levels. Phenol was detected in some samples, but its detection is suspect because the method blank was contaminated with phenol. Dioxin and furan congeners were detected at low concentrations. Results regarding the concentration of the highly toxic 2378-TCDD congener are ambiguous due to chemical interference and co-eluting compounds. Besides stormwater and sewage treatment runoff, there are few local sources of contaminants. Boat repair facilities, a cannery, and refueling docks are located near or in the basin. Activities associated with the marina such as boat refueling and boat traffic may be sources of contaminants.

Introduction

1. The purpose of the present study is to collect background information regarding sediment characteristics of the Ilwaco Boat Basin. Many smaller boat basins are outside of Federally authorized dredging channels and are infrequently studied. In recent years the Corps of Engineers, Portland District, and EPA, Region 10, have been cooperatively and routinely evaluating selected locations and sediment quality parameters. This has allowed for efficient use of Federal monies while providing quality, scientific information useful to both agencies. Characteristics such as grain size distribution and levels of contaminants, if any, in small boat basin sediments are used to provide a basis for decision making regarding disposal of sediments from maintenance dredging. The information also provides a 'snap shot' of the environmental conditions in the boat basins. These conditions are important because of the importance of Baker Bay as a nursery and feeding area for aquatic life and because it is a depositional area for fine grained sediments. A similar sediment evaluation of nearby Chinook Marina has been prepared.

2. The Ilwaco Boat Basin lies on the northern edge of Baker Bay next to the town of Ilwaco, Washington (see area map). The boat basin connects to the main channel of the Columbia River by a Federally authorized side channel called the West Channel. The West Channel branches off the main Columbia River Channel at River Mile (RM) 2.5. It passes northeast of Sand Island and proceeds 3.2 miles to the entrance of Ilwaco Boat Basin (1). The boat basin is maintained by local interests at a depth of -12 to -14 feet. It was last dredged in 1987. The dredge material was placed upland at a site adjacent to and due east of the boat basin.

3. Ilwaco Boat Basin is subject to typical local sources of contaminants. Recreational, commercial and sports fishery water craft provide some input. As many as 1,000 boats use the facility in the height of the fishing season in August and September. The marina has around 1,000 boat slips and a fuel dock. During the off season around 150-200 boats use the facility

(2). There are two fuel docks and three canneries in the boat basin. Five or six nearby outfalls deliver storm water from the City of Ilwaco to the boat basin. Another outfall comes from the local sewage treatment plant, which has been condemned by Department of Ecology (2). It drains into Baker Bay near the boat basin. Stormwater runoff from urban areas and highways may contain heavy metals and organics that could contaminate the sediment. The boat basin is a depositional area for fine grained material. Fine grained sedimentary and organic material may adsorb metals and hydrophobic, organic compounds in concentrations that are harmful to the environment. The results of this study will provide information regarding the levels of contaminants of concern in the boat basin sediment.

4. Baker Bay is "a shallow mudflat area that supports an important nursery and feeding area for many species of juvenile anadromous fish, adult and juvenile marine fishes, shellfish and birds" (3). Historically, Baker Bay was an exposed, sandy bottom habitat until the north, south and A jetties were constructed at the mouth of the Columbia River (see area map). Since then, the bay has become a more protected and shallow area containing sand and mud sediments. Several studies of sediment from Baker Bay have been conducted by the Corps and U. S. G. S. over the years (4-14). Results of analyses for contaminants show that the bay is relatively free of contaminants.

Methods

5. On March 19, 1992 thirteen samples were taken by U. S. Army Corps of Engineers (USACE) and National Marine Fisheries Service (NMFS) personnel, using a modified 0.96 m^2 Gray O'Hara box corer, at the locations shown on the enclosed map (Figure 1). Sample locations within Ilwaco Boat Basin were determined jointly by USACE and EPA personnel. Three of the samples (BB-BC-1 to 3) were taken in the Federal West Channel leading up to the boat basin and ten samples (IL-BC-1 to 6, 8 to 11) were taken from within the boat basin. Three of the samples (IL-BC-1 to 3), from within the boat basin, were archived in case further tests were needed. The box corer obtains a sample that is roughly 2 feet in depth when used in soft, fine grained sediment typical of marina bottoms. At each sampling station subsamples of sediment in the box corer were composited for physical and chemical analyses. Physical subsamples were cold stored in plastic baggies and were analyzed for grain size distribution and volatile solids content. Physical tests were conducted by the U. S. Army Corps of Engineers Materials Lab, Troutdale, Oregon. Chemical subsamples were cold stored in EPA approved, glass containers. These were acid and hexane rinsed by the supplier according to EPA/USACE protocols and topped with teflon lined lids. Samples IL-BC-8 and 9 and 10 and 11 were composited into two samples for the chemical analyses. The chemical samples were tested for total organic carbon (TOC), heavy metals, polynuclear aromatic hydrocarbons (PAHs), pesticides, polychlorobiphenyls (PCBs), acid volatile sulfides (AVS), phenols, tributyltin (TBT) and dioxin/furans. Chemical analyses were performed by Columbia Analytical Associates, Kelso, Washington, Battelle Laboratories, Squim, Washington and Keystone/NEA Environmental Resources, Portland, Oregon. All sampling procedures and analyses were performed according to EPA/USACE approved methods (15). A quality control (QC) and quality assurance (QA) report of the results was prepared by the USACE, Portland District Materials Lab in Troutdale, Oregon (see appendix).

Results/Discussion

Physical Results

6. The results of physical analyses of Ilwaco Boat Basin sediment are shown in Table 1. Sediment in the boat basin is a sandy, clayey silt. The mean percent of each fraction is: sand - 2.1 %, silt - 81.5 %, and clay - 16.4 %. The mean, median grain size is that of a fine silt (0.011 mm). A comparison of sample locations to median grain size indicates that the grain size decreases further away from the entrance to the boat basin (IL-BC-1, 0.015 mm vs. IL-BC-11, 0.009 mm). This is to be expected as finer grained material would settle out in the more quiescent parts of the basin. This is reflected in the percent sand, silt and clay in the samples furthest away from the entrance. The percent sand and silt decreases while the clay content increases. Results from the samples taken in the Federal channel leading up to the boat basin are different except sample BB-BC-3 taken near the entrance to the boat basin. This sample is similar to boat basin samples in its physical characteristics while the samples further away from the basin are mostly sand. In the boat basin the volatile solids content, which is a rough measure of organic content, averaged 7.0 %. This level is typical of quiescent marina areas where volatile solids often exceed 5.0 %. The Volatile solids also tended to increase in samples furthest away from the entrance and toward the back end of the boat basin. Many solids that make up this fraction are fine grained organic material and these help contribute to the decreased grain size reflected in the samples.

7. The physical parameters of Ilwaco Boat Basin sediment are similar to those of Chinook Marina, another boat basin in Baker Bay studied by USACE, Portland District for EPA (9). The median grain sizes are the same in the two boat basins. The percent sand is similar. There is less silt and more clay in the Ilwaco Boat Basin sediment than in Chinook Marina. The silt content is about 10 % less and the clay content is 50 % greater than in Chinook Marina sediment. The Ilwaco Boat Basin is the larger of the two and provides more surface area and holding time for fines to settle out.

8. The small grain size, high silt, clay and volatile solids content suggest a potential for enrichment of chemicals of concern in the sediment. Experience has shown that these conditions can lead to accumulation of metals and hydrophobic organic contaminants in sediment. Metals can adsorb to, or chemically combine with, both the fine grained and organic fraction. Hydrophobic organic contaminants associate with organics in sediment. However, the following results of chemical analyses support the conclusion that the sediment in Ilwaco Boat basin is relatively uncontaminated.

Chemical Results

Metals

9. Metals concentrations in the sediment samples are presented in Table 2. Exceptcadmium, all metals in all samples were below EPA, Region 10 screening levels for marine sediment. In samples IL-BC-8/9 and 10/11 cadmium (1.1 and 1.2 ppm respectively) exceeded the screening level (0.96 ppm). These two samples were also highest in concentrations for all the other metals. They are furthest from the entrance to the boat basin in

a quiescent area and are greatest in fines and organic content. There is a close correlation between metals levels in sediment and fines/organic content (28). The concentrations found in Ilwaco Boat Basin sediment closely match those of another location in Baker Bay at Chinook Marina about 9 miles distant.

AVS

10. Sulfides in sediment are solid-phase iron sulfides (and possibly manganese sulfides) and organic sulfides associated with organic matter (29). AVS are primarily iron monosulfides, which are extracted with cold hydrochloric acid. AVS is a measure of the fraction of sulfur available in the sediment that can readily form metal sulfides. Metals, loosely bound to sediment or dissolved in the interstitial water between sediment grains or dissolved in the water column, compete with iron for sulfur to form insoluble metal sulfides that precipitate out of solution (29). These metal sulfides render metals less bioavailable to aquatic organisms thereby lowering toxic effects (30). For instance, LC50 bioassays, conducted on cadmium spiked sediment versus cadmium spiked water only, show that the LC50 concentration for sediment is much higher than for water only. only when the interstial water cadmium concentration becomes equal to the water only LC50 concentration does toxicity occur (30). Somehow, a factor in the sediment is rendering the cadmium less bioavailable and less toxic by removing it from solution. The presumed mechanism is the formation of insoluble cadmium sulphide from the AVS reactive pool. This protective mechanism probably extends to other metals as well.

11. In Ilwaco Boat Basin samples, the AVS concentration ranged from 0.55 - 52 µm/g and the mean for all samples was 26.71 µm/g (Table 2). The amounts in Ilwaco Boat Basin are typical of marinas with fine grained sediment in the lower Columbia River and elswhere along the Oregon coast (9,10,23,24). Sandy sediment often contains less than 1 µm/g while, in silty sediments, as much as 300 µm/g can be found.

12. Research shows that sediments with half the average AVS of Ilwaco Boat Basin sediment can bind from 4 to 9 micromoles/gram (µm/g) of cadmium (30). This is more than enough to handle the 0.01 µm/g average cadmium concentration found in the bulk sediment of Ilwaco Boat Basin. Research results described above provide evidence that the marginally high cadmium levels found in Ilwaco Boat Basin are probably not of toxic concern.

TOC

13. The total organic carbon (TOC) content of sediment is also an indicator of the relative ability of sediment to concentrate metals and organic contaminants from the water column. This ability may help render contaminants less bioavailable and therefore less toxic to aquatic organisms residing in the water column. The highest TOC was measured in the sample furthest from the entrance to the boat basin (IL-BC-10/11). This sample, as mentioned, contained the most metals.

Pesticides/PCBs

14. Tests for seven PCB aroclors and seventeen pesticides were conducted on the samples. No PCBs were detected in the sediment (Table 2). The detection limits for PCBs were well below concern levels. Only the pesticide endosulfan II (6.0 ppb) was observed in one sample (IL-BC-8/9). These results are similar to Chinook Marina values except that the degradation products of DDT, DDD and DDE were detected in small amounts in Chinook Marina.

PAHs

15. Two to seven PAHs were detected in the samples (Table 3). These were phenanthrene (72-84 ppb), fluoranthene (120-370 ppb), pyrene (130-310 ppb), benzo (a) anthracene (94 ppb), chrysene (74-110 ppb), benzo (b+k) fluoranthenes (160 ppb) and benzo (a) pyrene (81 ppb). None of the PAHs found exceeded EPA, Region 10 screening levels. Total PAHs were also below concern levels. Four of the PAHs are noncarcinogenic - phenanthrene, fluoranthene, pyrene and benzo (k) fluoranthene. Benzo (a) anthracene, chrysene, benzo (b) fluoranthene and benzo (a) pyrene are weakly carcinogenic, cocarcinogenic or tumorogenic (16).

16. PAHs are ubiquitous in the environment. Around 43,000 metric tons are discharged into the atmosphere every year. Another 230,000 tons enter the aquatic environment (16). Natural sources are synthesis in terrestrial vegetation and microbes, volcanic activity, forest and prairie fires - the latter two producing by far the greater natural quantities (16). Anthropogenic sources are: coke production in the iron and steel industry; catalytic cracking in the petroleum industry; the manufacture of carbon black, coal tar pitch, and asphalt; heating and power generation; refuse incineration and open burning; and emissions from internal combustion engines (16). Most of the PAHs that enter the aquatic environment come from petroleum spillage (74 %). Other inputs to the aquatic environment are atmospheric (22 %), wastewaters (2 %), surface land runoff (1 %) and biosynthesis (1 %).

17. The sources of PAHs to Ilwaco Boat Basin cannot be determined from the results of this study because the types of inputs were not measured. The levels detected in Ilwaco Boat Basin sediment are typical of other boat basins in the lower Columbia River (9,10,17,18). The fate of PAHs in the aquatic environment is poorly understood. It is known that PAHs in anoxic sediments degrade very slowly and may persist indefinitely (11). It would seem prudent to monitor the PAHs in boat basins in the lower Columbia River estuary since these areas tend to concentrate fine grained material under anoxic conditions.

TBT

18. TBT concentrations ranged from 2.6 - 7.7 ppb and are 4 to 12 times lower than the screening level (30 ppb). TBT has been used as an antifouling additive in marine paints but that use is currently prohibited. Other sources of TBT persist. The concentrations of TBT in Ilwaco Boat Basin sediment samples are average for other boat basins sampled by the Corps in Oregon coastal areas. These other areas have ranged from less than 1.0 to 300 ppb TBT(14, 22-25). In other areas such as the Portland Harbor and certain sites in Coos Bay, TBT concentrations well over 1,000 ppb have been reported (26,27).

Phenols

19. Phenol was detected in 3 samples ranging from 72-110 ppb. But, the concentration is probably lower than reported because phenol was also observed in the method blank (72 ppb). The other types of phenols were not detected (Table 4). The detection limits were elevated in the procedure for 3 out of the 5 phenols tested because of matrix interferences. Thus, detection limits for 2-methylphenol, 2,4-dimethylphenol and pentachlorophenol were greater than the EPA, Region 10 screening level. Phenols are highly soluble in water. Even if concentrations were at the method reporting limits for these three phenols, it is likely that incoming water in the boat basin would dilute phenols released from sediment to acceptable concentrations.

Dioxins/Furans

20. Dioxins and furans are ubiquitous in the environment and contain a complex array of congeners. The congeners are present in chlorophenols, certain phenoxypesticides, and combustion products of municipal and industrial incinerators. Other possible anthropogenic sources are the combustion of bitumous coal, fossil fuel power plants and internal combustion engines. They are also produced naturally by forest and prairie fires. Major sources to the Columbia River are effluents from paper mills. These compounds are hydrophobic, partition out into fine grained sediment, and persist for a long time.

21. One sample, IL-BC-8/9, was tested for dioxins/furans congeners. A summary of the results is shown in Table 5. Each dioxin or furan congener class is defined by the number of chlorine atoms attached to the molecule. For instance, the tetra class has 4 chlorine atoms in various positions on the molecule. The total concentrations of each tetra, penta, hexa, hepta and octa congener class are shown.

22. The concentration of each dioxin congener class increased as the number of chlorine atoms in the congeners increased. By far the largest contributor to the dioxins are the OCDDs (2,700 ppt). They contribute 73 % of the total concentration of dioxins. The OCDD class, with 8 chlorine atoms, is the least toxic of dioxin classes. The most toxic dioxin or furan congener is the tetra congener 2,3,7,8-TCDD. Its detection in sample IL-BC-8/9 was ambiguous. It was reported by Keystone/NEA Environmental Resources as EMPC=1.68 ppt. EMPC stands for estimated maximum possible concentration. This tag is applied to a concentration when the signal passes all QA criteria except for the analyte isotope ratios and when the concentration falls below the lower method calibration limit (LMCL). "In cases where the reported concentration falls below the LMCL, it should be considered an estimate only" (from the attached case narrative in the appendix). Sample IL-BC-8/9 produced the two eluting peaks for 2378-TCDD, but the ratio of two naturally occurring chlorine isotopes in the two peaks did not meet QA criteria. This situation is an indication of co-eluting contaminants of similar molecular weight or of chemical interferences. The result is that the reported concentration is at best an estimate and it is at or below the detection limit of the method. To obtain a clearer picture of the concentration of 2378-TCDD would require another analysis of sediment from the boat basin. It should be noted that no 2378-TCDD was detected in Chinook Marina sediment, which is on the northeast side Baker Bay about 9 miles away. Considering that only one sample was tested and that low concentrations were reported for the other dioxin/furan congeners in

Chinook Marina and Ilwaco Boat Basin, a reanalysis for 2378-TCDD does not appear warrented at this time.

23. In the furans, the OCDF concentration was not very high relative to the other furan congener classes. The OCDFs contribute only 29 % of the total for furans compared to the contribution of OCDDs to dioxins (73 %). In comparing the dioxins to the furans, there were thirty times more OCDD (1,320 ppt) than OCDF (41.3 ppt). The tetra through hepta congener classes were fairly similar in concentration between dioxins and furans. The distribution pattern of dioxins and furans in the Ilwaco Boat Basin sample is similar to that observed in other lower Columbia River samples, including samples offshore from the mouth, and samples from Yaquina Bay (19-21).

Conclusions

24. The sediment in Ilwaco Boat Basin is relatively free of contaminants. Cadmium exceeded EPA, Region 10 screening levels in two samples. These samples also had the highest levels of the other metals tested. The AVS concentrations are typical of marina samples in the area and probably will help ameliorate any toxic effects from cadmium in the sediment. PCBs were undetected and are probably less than 10 ppb. A small amount of the pesticide endosulfan II was found in one sample. Unlike nearby Chinook Marina, no DDD or DDE was detected in the samples. PAHs were below screening levels and are typical of other small marinas in the area. TBT concentrations were well below the screening level. Phenol was detected in some samples, but its detection is suspect because the method blank was contaminated with phenol. Also, the detection limits for phenols were not acceptable as they were above EPA screening levels. Dioxins and furans were detected at low concentrations. The pattern of concentrations of the congener classes was similar to the pattern observed in other samples taken from the Columbia River (between Wauna and Bonneville) and Yaquina Bay. Results regarding the concentration of the highly toxic 2378-TCDD congener are ambiguous due to chemical interference and co--eluting compounds. It is unlikely that there is a concentration of any significance since none was detected in the nearby Chinook Marina samples. There are few local sources of contaminants to Ilwaco Boat Basin. Possible sources are stormwater runoff, sewage treatment runof and effluent from canneries. Activities associated with the marina such as boat traffic, boat repair and boat refueling may also be sources.

25. Based on the above, more complete characterization of the Ilwaco Boat Basin sediments prior to dredging or disposal is warrented.

REFERENCES

1. Navigation Branch, Operations Division, U. S. Army Corps of Engineers, Portland District. September 1991. Federal Navigation Projects: Columbia River Maintenance Disposal Plan. (Prepared by Mandaville Associates, 600 S. W. Tenth #418, Portland, Oregon 92205)

2. Mik Hendrickson. Port of Chinook. Personal communication.

3. U. S. Army Corps of Engineers, Portland District. August 1983. Baker Bay (Ilwaco) West Channel Improvements. Detailed Project Report and Environmental Assessment.

4. CENPP, Portland District. 1980. Findings of Compliance Dredged Material Disposal Operations Chinook Federal Navigation Project July - August 1980.

5. U. S. Army Corps of Engineers, Portland District. December 1986. (Data taken from Corps sediment quality database showing samples taken in 1986 in Chinook Channel).

6. U. S. Army Corps of Engineers, Portland District. July 1987. (Data taken from Corps sediment quality database showing samples taken in 1987 in Chinook Channel).

7. U. S. Geological Survey. 1984. Chemical analyses of elutriates, native water, and bottom material from the Chetco, Rogue, and Columbia Rivers in western Oregon (Open-File Report 84-133).

8. U. S. Geological Survey. 1986. Extractable cadmium, mercury, copper, lead, and zinc in the lower Columbia River estuary, Oregon and Washington (Water Resources Investigations Report 86-4088).

9. Britton J. U. S. Army Corps of Engineers, Portland District. March 1993. Characteristics of Chinook Marina sediment in Baker Bay, Washington. Prepared for EPA, Region 10, Seattle, Washington.

10. Britton J. U. S. Army Corps of Engineers, Portland District. 20 July 1992. Evaluation of Sediment at U. S. Coast Guard Station Ilwaco, Washington.

11. Turner R. and Babcock S. CENPP, Portland District. 1988. Results of 1987 Baker Bay at Ilwaco, WA Sediment Quality Testing.

12. U. S. Army Corps of Engineers, Portland District. July-August 1980. Findings of Compliance Dredged Material Disposal Operations Baker Bay Navigation Project.

13. Britton J. U. S. Army Corps of Engineers, Portland District. August 1992. Baker Bay West Channel Sediment Evaluation.

14. Britton J. U. S. Army Corps of Engineers, Portland District. October 1992. Evaluation of Sediment From Chinook Channel in Baker Bay.

15. U. S. Environmental Protection Agency and U. S. Army Corps of Engineers. February 1991. Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).

16. Eisler, R. 1987. Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service.

17. Britton J. U. S. Army Corps of Engineers, Portland District. 21 August 1991. Skipanon River Sediment Evaluation.

18. Young, J. S. et al. December 1988. Confirmatory chemical analyses and solid phase bioassays on sediment from the Columbia River estuary at Tongue Point, Oregon. Prepared for the U. S. Army Corps of Engineers, Portland District by Battelle, Pacific Northwest laboratory, Richland, Washington.

19. Britton J. U. S. Army Corps of Engineers, Portland District. December 1990. Results of Studies Correlating Total Organic Chlorine and Dioxin/furans in Selected Oregon Sediments. Prepared for U. S. Environmental Protection Agency, Region 10.

20. Britton J. U. S. Army Corps of Engineers, Portland District. October 1990. Characterization of Sediments at yaquina Bay & Harbor. Prepared for U. S. Environmental Protection Agency, Region 10.

21. U. S. Army Corps of Engineers, Portland District. Dioxins and furans data, on file in the District Office, obtained from offshore sediment samples collected near the mouth of the Columbia River in 1992.

22. Britton J. U. S. Army Corps of Engineers, Portland District. March 1993. U. S. Coast Guard Station at Winchester Bay Sediment Evaluation.

23. Britton J. U. S. Army Corps of Engineers, Portland District. October 1992. Physical and Chemical Characteristics of Sediment From the Gold Beach Boat Basin on the Rogue River. Prepared for EPA, Region 10, Seattle, Washington.

24. Britton J. U. S. Army Corps of Engineers, Portland District. December 1992. Lower Willamette River Sediment Evaluation - Portland Harbor.

25. Britton J. U. S. Army Corps of Engineers, Portland District. 30 April 1992. Update on Suitability of Winchester Bay Sediment for Development of Wetlands Habitat in Constructed Dunal Ponds on the North Spit of the Umpqua River.

26. Mark Siipola, USACE, Portland District, personnel communication.

27. Pam Blake, DEQ, Coos Bay,personnel communication.

28. Horowitz, A. J. U. S. Geological Survey. 1984. A primer on trace metal-sediment chemistry. Open-file report 84-709.

29. DiToro et al. Acid Volatile Sulfide Predicts the Acute Toxicity of Cadmium and Nickel in Sediments. Environ. Sci. Technol. 1992, 26, 96-101.

30. DiToro D.M., Mahony, J.D., Scott, K.J., Hicks, M.R., Mayr, S.M., and Redmond, M.S. Feb. 1990. Toxicity of Cadmium in sediments: the Role of Acid Volatile Sulfide. Environmental Toxicology and Chemistry, in press.

Table 1. Results of physical analyses of Ilwaco Boat Basin sediment.

sample	median grain size mm	sand	silt	clay	volatile solids
		%			
IL-BC-1	0.015	3.7	83.4	12.9	6.3
IL-BC-2	0.013	2.7	84.4	12.9	6.0
IL-BC-3	0.013	3.5	81.9	14.6	6.9
IL-BC-4	0.011	3.6	78.9	17.5	7.1
IL-BC-5	0.011	1.5	83.0	15.5	6.9
IL-BC-6	0.010	1.0	82.4	16.6	5.5
IL-BC-8	0.008	0.7	80.8	18.5	7.3
IL-BC-9	0.008	1.2	77.5	21.3	7.1
IL-BC-10	0.008	2.1	76.6	21.3	8.3
IL-BC-11	0.009	1.3	86.3	12.4	8.9
mean	0.011	2.1	81.5	16.4	7.0
BB-BC-1	0.240	100.0	0.0	0.0	0.4
BB-BC-2	0.290	99.9	0.1	0.0	0.4
BB-BC-3	0.027	13.3	79.6	7.1	4.7

Table 2. Metals, acid volatile sulfides (AVS) and total organic carbon (TOC) in Ilwaco Boat Basin sediment.

sample	metals								AVS	TOC
	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	um/g	%
	ppm									
IL-BC-4/5	8	0.8	21	43	21	0.10	18	118	16.00	1.80
IL-BC-6	6	0.6	17	40	18	0.09	15	98	30.00	1.60
IL-BC-8/9	10	1.1	30	56	30	0.18	22	152	35.00	1.81
IL-BC-10/11	10	1.2	28	48	28	0.19	20	142	52.00	2.10
BB-BC-3	7	0.7	19	26	17	0.08	16	96	0.55	1.38
mean	8	0.9	23	43	23	0.13	18	121	26.71	1.74

Table 3. Concentrations PCBs, pesticides, PAHs and TBT in Chinook Marina sediment*.

sample	PCBs	Endosulfan II	PAHs							TBT
			Phenanthrene	Fluoranthene	Pyrene	Benzo (a) anthracene	Chrysene	Benzo (b+k) Fluoranthenes	Benzo (a) Pyrene	
	ppb		ppb							ppb
IL-BC-4/5	<10	<5	84	340	270	94	110	160	81	2.6
IL-BC-6	<10	<5	<72	200	170	<72	74	<140	<72	3.2
IL-BC-8/9	<10	6	<92	270	240	<92	<92	<180	<92	2.4
IL-BC-10/11	<10	<5	<90	370	310	<90	<90	<180	<90	7.7
BB-BC-3	<10	<2	72	120	130	<62	<62	<120	<62	-
SL*	130	NA	320	630	430	450	670	800	680	30

* EPA, Region 10 screening levels for marine waters.

Table 4. Concentrations of phenols in Ilwaco Boat Basin sediment.

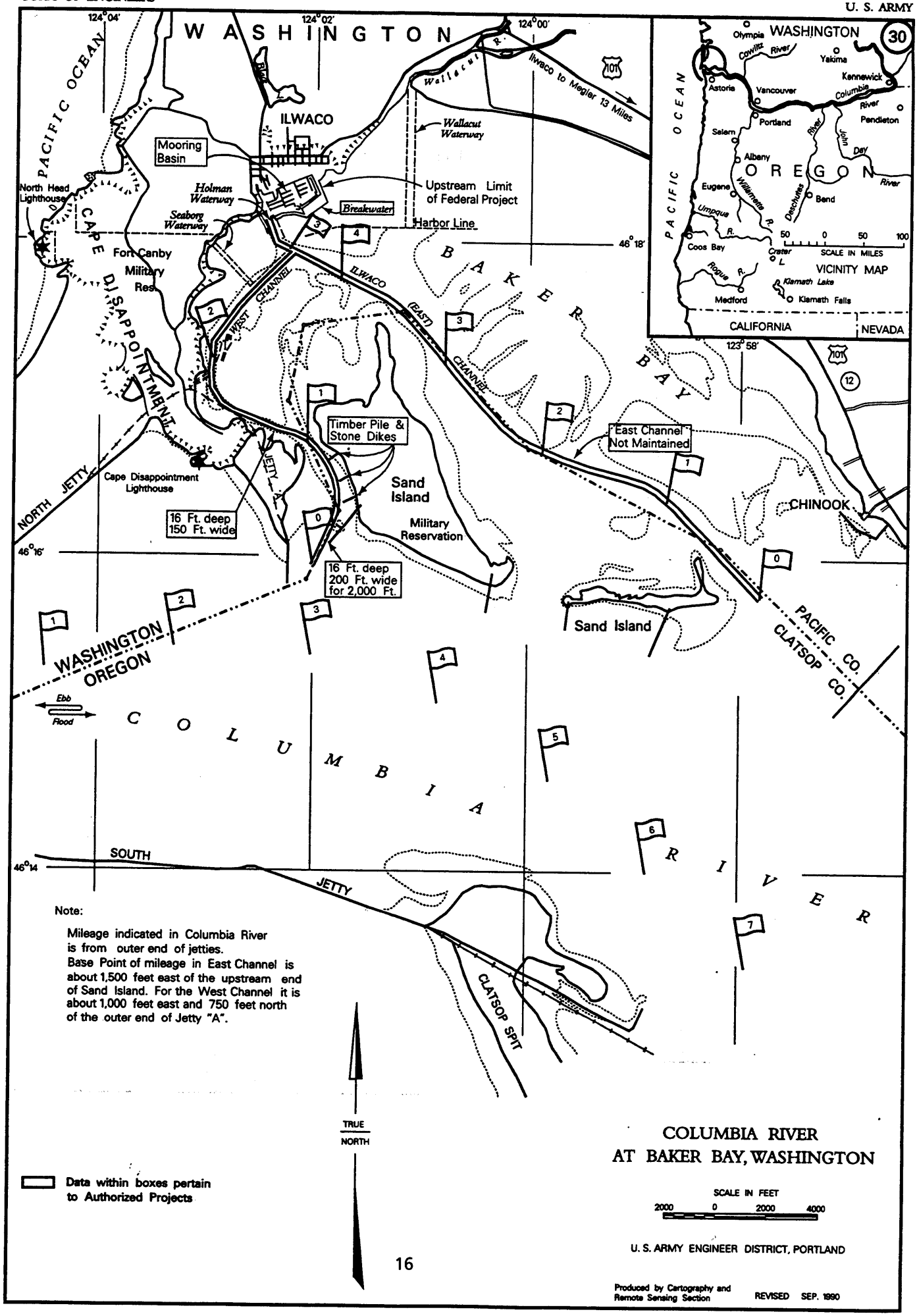
sample	phenol	2-methyl phenol	4-methyl phenol	2,4-dimethyl phenol	pentachloro phenol
			ppb		
IL-BC-4/5	97*	<73	<73	<73	<180
IL-BC-6	72*	<72	<72	<72	<180
IL-BC-8/9	<92	<92	<92	<92	<230
IL-BC-10/11	<90	<90	<90	<90	<230
BB-BC-3	110*	<62	<62	<62	160
method blank	72	<33	<33	<33	<67

* Suspect because phenol was also found in the method blank.

Table 5. Concentrations of dioxins and furans in Chinook Marina sediment.

units	IL-BC-8/9	Method Blank
	ppt	
2378 TCDD	1.68(EMPC)	<0.78
total TCDD	5.37	<0.78
total PeCDD	9.34	<0.72
total HxCDD	126	<1.30
total HpCDD	782	<2.83
OCDD	2,700	<4.70
2378-TCDF	10.9	<1.08
total TCDF	21.9	<1.08
total PeCDF	32	<1.65
total HxCDF	73	<0.84
total HpCDF	150	<0.81
OCDF	144	<3.13

EMPC = Estimated maximum possible concentration. Where a peak has passed all QA criteria except for the analyte isotope ratios, there may co-eluting contaminants or other chemical interferences. In such cases, a concentration has been calculated in the usual manner but reported as an Estimated Maximum Possible Concentration (EMPC).



Note:

Mileage indicated in Columbia River is from outer end of jetties.
Base Point of mileage in East Channel is about 1,500 feet east of the upstream end of Sand Island. For the West Channel it is about 1,000 feet east and 750 feet north of the outer end of Jetty "A".

TRUE NORTH

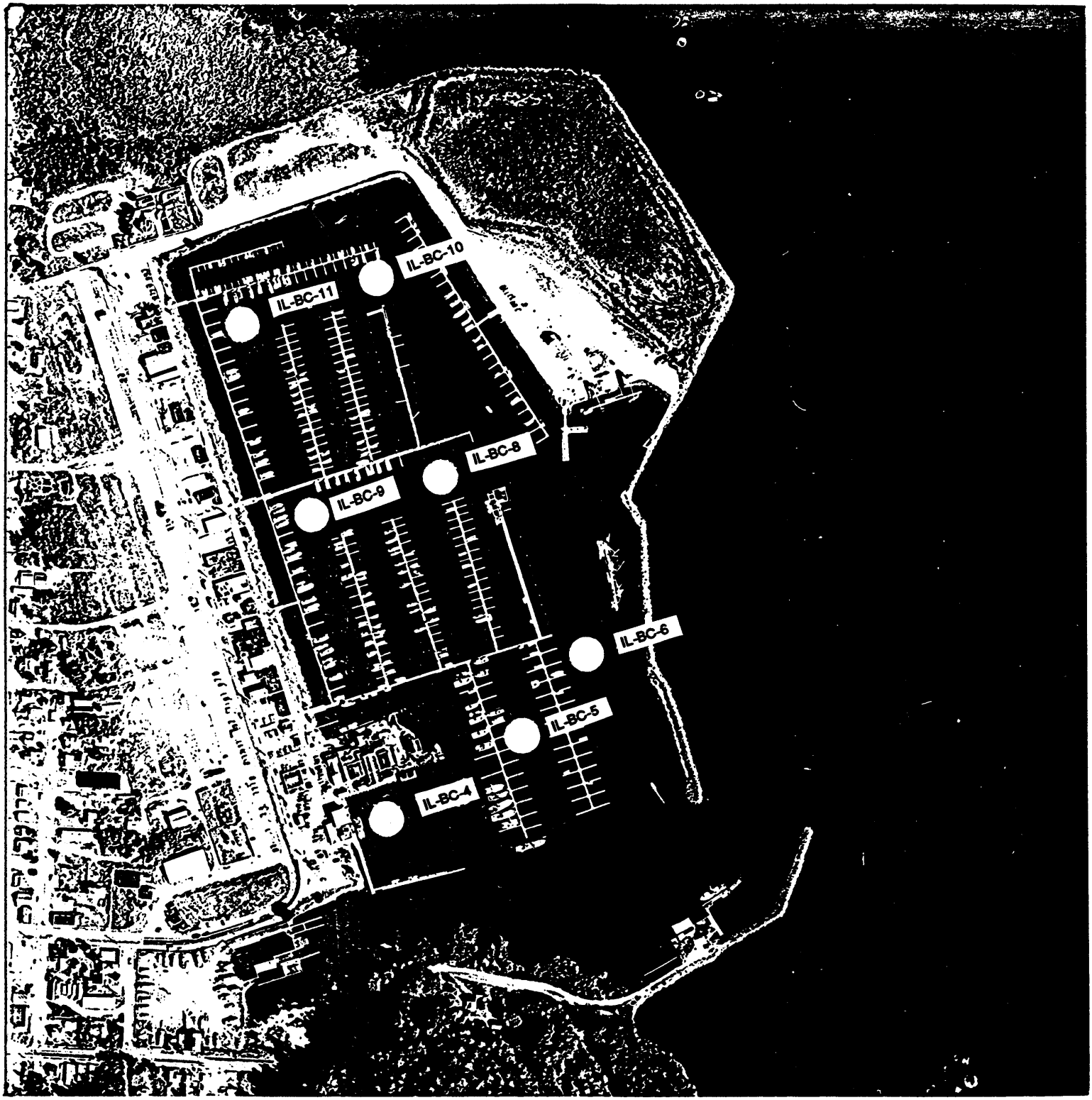
Data within boxes pertain to Authorized Projects

COLUMBIA RIVER AT BAKER BAY, WASHINGTON

SCALE IN FEET
2000 0 2000 4000

U. S. ARMY ENGINEER DISTRICT, PORTLAND

Produced by Cartography and Remote Sensing Section REVISED SEP. 1990


IL-BC-11
IL-BC-10
IL-BC-8
IL-BC-9
IL-BC-6
IL-BC-5
IL-BC-4

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION LABORATORY
CORPS OF ENGINEERS
1491 N.W. GRAHAM AVENUE
TROUTDALE, OREGON 97060-9503

CENPD-PE-GT-L (1110-1-8100c) 27 Aug 92

MEMORANDUM FOR Commander, Portland District, ATTN: CENPP-PE-HR (Britton)

SUBJECT: W.O. 92-SHM-183, Report of Soil Analysis

Project: PORTLAND DISTRICT DREDGING PROJECT
Intended Use: Evaluate site
Source of Material: Reference Chain of Custody Records
Submitted by: CENPP-PE-HR (Britton)
Date Sampled: 19 May 92 Date Received: 23 May 92
Methods of Tests: Reference Enclosure 1
Reference: a) DD Form 448, MIPR Nos. E86-92-0074, dated 12 Mar 92 and E86-92-0040, dated 31 Mar 92
b) Our report, this subject, dated 29 Jul 92

1. Enclosed are results of total organic carbon (TOC) analysis for environmental samples collected from the above site. Included is report number K924822 from Columbia Analytical Services, Inc.

2. TOC levels ranged from 1.38 to 2.75-percent in all seventeen samples tested. The relative percent differences in the three laboratory duplicates ranged from <1 to 16-percent. Samples were analyzed for TOC after expiration of holding times, per request on 27 Jul 92 from Jim Britton.

3. Please contact Dr. Ajmal M. Ilias at (503) 665-4166 if you have any questions.

4. This completes all work requested to date.

Timothy J. Seeman

Enclosures

TIMOTHY J. SEEMAN
Director

Copy Furnished: CENPD-PE-GT

Columbia Analytical Services inc.

May 5, 1992

Tim Seeman
U.S. Army Corps of Engineers
CENPD Materials Laboratory
1491 N.W. Graham Avenue
Troutdale, OR 97060-9503

Re: **Portland District Dredging/Project #92-SHM-183**

Dear Tim:

Enclosed are the results of the samples submitted to our lab on March 23, 1992. For your reference, these analyses have been assigned our work order number K921793.

Please note that the data for the dioxin/furan analyses is located in Appendix C.

Also note that the tributyltin analyses will follow under separate cover, as we have not received results from Battelle at this time.

All analyses were performed in accordance with our laboratory's quality assurance program.

Please call if you have any questions.

Respectfully submitted,

Columbia Analytical Services, Inc.

Kevin DeWhitt
Project Chemist

KD/krh

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging	**Work Order No.:**	K924822
Sample Matrix:	Soil		

Inorganic Parameters
Percent (%)
Dry Weight Basis

Analyte:		Total Organic Carbon (TOC)	Total Solids
Method:		ASTM D 4129-28M	EPA 160.3M
Method Reporting Limit:		0.05	--
Date Analyzed:		08/12/92	08/13/93
Sample Name	**Lab Code**		
BB-BC-3	K1793-1	1.38	60.8
CH-BC-1	K1793-2	2.72	37.7
CH-BC-2	K1793-3	1.62	60.3
IL-BC-4	K1793-4	1.92	49.1
IL-BC-5	K1793-5	1.68	43.9
IL-BC-6	K1793-6	1.60	47.3
IL-BC-8	K1793-7	1.73	43.6
IL-BC-9	K1793-8	1.88	40.0
IL-BC-10	K1793-9	2.04	39.3
IL-BC-11	K1793-10	2.16	34.0

M Modified

Approved by _____ Date 8-26

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging	**Work Order No.:**	K924822
Sample Matrix:	Soil		

Inorganic Parameters
Percent (%)
Dry Weight Basis

Analyte:		Total Organic Carbon (TOC)	Total Solids
Method:		ASTM D 4129-28M	EPA 160.3M
Method Reporting Limit:		0.05	--
Date Analyzed:		08/12/92	08/13/92
Sample Name	**Lab Code**		
CB-BC-1	K1793-11	2.65	36.9
CB-BC-2	K1793-12	1.92	44.5
CB-BC-3	K1793-13	2.75	34.7
CB-BC-4	K1793-14	2.68	40.3
IL-BC-1	K1793-15	2.22	43.0
IL-BC-2	K1793-16	1.96	46.1
IL-BC-3	K1793-17	2.23	46.9
Method Blank	K4822-MB	ND	--

M Modified
ND None Detected at or above the method reporting limit

Approved by [signature] Date 8-26

0002

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

APPENDIX A

LABORATORY QC RESULTS

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U. S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging	**Date Analyzed:**	08/12/92
Sample Matrix:	Soil	**Work Order No.:**	K924822

Duplicate Summary
Total Organic Carbon (TOC)
ASTM Method D 4129-28M
Percent (%)
Dry Weight Basis

Sample Name	Lab Code	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference
BB-BC-3	K1793-1	0.05	1.38	1.38	1.38	<1
CH-BC-1	K1793-2	0.05	2.72	2.92	2.82	4
CH-BC-2	K1793-3	0.05	1.62	1.91	1.76	16

M Modified
MRL Method Reporting Limit

Approved by [signature] Date 8-26

00004

COLUMBIA ANALYTICAL SERVICES (CF #437)
ORGANOTINS ANALYSIS OF SEDIMENT SAMPLES

5/7/92

(concentrations in ng/g)

MSL Code	Sponsor Code	Tripentyl % Surrogate	Tetra Tin	Tributyl Tin	Dibutyl Tin	Monobutyl Tin
437CAS-1-R	CG-BC-1	53.36	2.3 U	2.4 U	2.3 U	5.0 U
437CAS-2-R	CG-BC-2	45.49	2.4 U	2.5 U	2.4 U	5.1 U
437CAS-3	IL-BC-4,5 (COMP)	48.33	2.4 U	2.6	3.8	2.3 J
437CAS-4-R	IL-BC-6	44.83	2.1 U	3.2	1.4 J	4.4 U
437CAS-5-R	IL-BC-8,9 (COMP)	42.38	2.0 U	2.4	4.3	4.2 U
437CAS-6-R	IL-BC-10,11 (COMP)	43.13	2.3 U	7.7	2.3 U	4.9 U
437CAS-7-R	CB-BC-1	24.11	2.0 U	3.9	2.0 U	1.8 J
437CAS-8	CB-BC-2	86.88	2.2 U	5.7	6.5	34.7
437CAS-9-R	CB-BC-3	43.75	2.2 U	5.0	2.2 U	4.6 U
437CAS-10-R	CB-BC-4	32.54	2.1 U	5.0	2.1 U	4.4 U
437CAS-Blank		42.18	2.3 U	2.4 U	2.3 U	4.9 U
437CAS-Blank-R		40.50	2.2 U	2.2 U	2.2 U	4.6 U
MATRIX SPIKE RESULTS						
Amount Spiked			126.9	126.9	126.9	126.9
437CAS-2-R	CG-BC-2	45.49	2.4 U	2.5 U	2.4 U	5.1 U
437CAS-2-R + Spike		40.91	89.4	49.8	37.4	4.2 J
Amount Recovered			89.4	49.8	37.4	4.2 J
Percent Recovery			70%	39%	29%	3%

U = Indicates analyte not detected above detection limits.
J = Indicates value detected below the detection limits.

Columbia Analytical Services inc.

August 26, 1992

Tim Seeman
U.S. Army Corps of Engineers
CENPD Materials Laboratory
1491 N.W. Graham Avenue
Troutdale, OR 97060-9503

Re: **Portland District Dredging/Project #92-SHM-183**

Dear Tim:

Enclosed are the results of the samples requested for analysis on July 27, 1992, from previous work order number K921793. For your reference, these analyses have been assigned our work order number K924822.

All analyses were performed in accordance with our laboratory's quality assurance program. Reproduction of reports is allowed only in whole, not in part. Results apply only to the samples analyzed.

Please call if you have any questions.

Respectfully submitted,

Columbia Analytical Services, Inc.

Kevin DeWhitt
Project Chemist

KD/do

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	03/28/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Acid Volatile Sulfides in Sediment
EPA Draft Method for Acid Volatile Sulfides in Sediment August 1991
µmoles/g
Dry Weight Basis

Sample Name	Lab Code	MRL	Result
BB-BC-3	K1793-1	0.01	0.55
CH-BC-1	K1793-2	0.01	46
CH-BC-2	K1793-3	0.01	7.31
IL-BC-4,5 Comp	K1793-6	0.01	16
IL-BC-6	K1793-7	0.01	30
IL-BC-8,9 Comp	K1793-10	0.01	35
IL-BC-10,11 Comp	K1793-13	0.01	52
CB-BC-1	K1793-14	0.01	45
CB-BC-2	K1793-15	0.01	38
CB-BC-3	K1793-16	0.01	74

MRL Method Reporting Limit

Approved by Kevin Tennant[26] Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Work Order No.:**	K921793
Sample Matrix:	Sediment		

Total Metals
mg/Kg (ppm)
Dry Weight Basis

	Sample Name:		IL-BC-4,5 Comp	IL-BC-6	IL-BC-8,9 Comp
	Lab Code:		K1793-6	K1793-7	K1793-10
Analyte	**EPA Method**	**MRL**			
Arsenic	7060	1	8	6	10
Cadmium	7131	0.1	0.8	0.6	1.1
Chromium	6010	1	21	17	30
Copper	6010	1	43	40	56
Lead	7421	1	21	18	30
Mercury	7471	0.02	0.10	0.09	0.18
Nickel	249.2	1	18	15	22
Zinc	6010	1	118	98	152
Solids, Total (%)	160.3	--	43.4	45.8	34.3

MRL Method Reporting Limit

Approved by KEVIN DEWITT Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client: U.S. Army Corps of Engineers
Project: Portland District Dredging/#92-SHM-183
Sample Matrix: Sediment

Date Received: 03/23/92
Work Order No.: K921793

Total Metals
mg/Kg (ppm)
Dry Weight Basis

	Sample Name:	IL-BC-10,11 Comp	CB-BC-1	CB-BC-2
	Lab Code:	K1793-13	K1793-14	K1793-15
Analyte	**EPA Method**	**MRL**		
Arsenic	7060	1	10	9	6
Cadmium	7131	0.1	1.2	1.6	0.9
Chromium	6010	1	28	26	16
Copper	6010	1	48	50	52
Lead	7421	1	28	41	15
Mercury	7471	0.02	0.19	0.14	0.09
Nickel	249.2	1	20	23	16
Zinc	6010	1	142	164	108
Solids, Total (%)	160.3	--	36.1	34.6	40.7

MRL Method Reporting Limit

Approved by Kevin Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Work Order No.:**	K921793
Sample Matrix:	Sediment		

Total Metals
mg/Kg (ppm)
Dry Weight Basis

	Sample Name:		CB-BC-3	CB-BC-4	Method Blank
	Lab Code:		K1793-16	K1793-17	K1793-MB
Analyte	**EPA Method**	**MRL**			
Arsenic	7060	1	8	8	ND
Cadmium	7131	0.1	1.6	1.2	ND
Chromium	6010	1	26	23	ND
Copper	6010	1	47	46	ND
Lead	7421	1	30	20	ND
Mercury	7471	0.02	0.15	0.12	ND
Nickel	249.2	1	22	21	ND
Zinc	6010	1	165	122	ND
Solids, Total (%)	160.3	--	33.8	38.0	--

MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Kevin Dewitt Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)
EPA Methods 3540/8080
mg/Kg (ppm)
Dry Weight Basis

Sample Name:		IL-BC-4,5 Comp	IL-BC-6	IL-BC-8,9 Comp
Lab Code:		K1793-6	K1793-7	K1793-10
Date Analyzed:		04/08/92	04/08/92	04/13/92
Analyte	**MRL**			
Alpha-BHC	0.005	ND	ND	ND
Gamma-BHC (Lindane)	0.005	ND	ND	ND
Beta-BHC	0.010	ND	ND	ND
Heptachlor	0.005	ND	ND	ND
Delta-BHC	0.005	ND	ND	ND
Aldrin	0.005	ND	ND	ND
Heptachlor Epoxide	0.005	ND	ND	ND
Endosulfan I	0.005	ND	ND	ND
4,4'-DDE	0.005	ND	ND	ND
Dieldrin	0.005	ND	ND	ND
Endrin	0.005	ND	ND	ND
4,4'-DDD	0.005	ND	ND	ND
Endosulfan II	0.005	ND	ND	0.006
4,4'-DDT	0.005	ND	ND	ND
Endrin Aldehyde	0.005	ND	ND	ND
Endosulfan Sulfate	0.005	ND	ND	ND
Methoxychlor	0.010	ND	ND	ND
Toxaphene	0.03	ND	ND	ND
Chlordane	0.01	ND	ND	ND
PCBs: Aroclor 1016	0.01	ND	ND	ND
Aroclor 1221	0.01	ND	ND	ND
Aroclor 1232	0.01	ND	ND	ND
Aroclor 1242	0.01	ND	ND	ND
Aroclor 1248	0.01	ND	ND	ND
Aroclor 1254	0.01	ND	ND	ND
Aroclor 1260	0.01	ND	ND	ND

MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Kevin Bennett Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)
EPA Methods 3540/8080
mg/Kg (ppm)
Dry Weight Basis

Sample Name:		IL-BC-10,11 Comp	CB-BC-4
Lab Code:		K1793-13	K1793-17
Date Analyzed:		04/10/92	04/14/92
Analyte	**MRL**		
Alpha-BHC	0.005	ND	ND
Gamma-BHC (Lindane)	0.005	ND	ND
Beta-BHC	0.010	ND	ND
Heptachlor	0.005	ND	ND
Delta-BHC	0.005	ND	ND
Aldrin	0.005	ND	ND
Heptachlor Epoxide	0.005	ND	ND
Endosulfan I	0.005	ND	ND
4,4'-DDE	0.005	ND	ND
Dieldrin	0.005	ND	ND
Endrin	0.005	ND	ND
4,4'-DDD	0.005	ND	ND
Endosulfan II	0.005	ND	ND
4,4'-DDT	0.005	ND	ND
Endrin Aldehyde	0.005	ND	ND
Endosulfan Sulfate	0.005	ND	ND
Methoxychlor	0.010	ND	ND
Toxaphene	0.03	ND	ND
Chlordane	0.01	ND	ND
PCBs: Aroclor 1016	0.01	ND	ND
Aroclor 1221	0.01	ND	ND
Aroclor 1232	0.01	ND	ND
Aroclor 1242	0.01	ND	ND
Aroclor 1248	0.01	ND	ND
Aroclor 1254	0.01	ND	ND
Aroclor 1260	0.01	ND	ND

MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Kevin Rewitt Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24,25/92
Project:	Portland District Dredging/#92-SHM-183	**Work Order No.:**	K921793
Sample Matrix:	Sediment		

Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)
EPA Methods 3540/8080
mg/Kg (ppm)
Dry Weight Basis

Sample Name:		**Method Blank**	**Method Blank**
Lab Code:		**K1793-MB1**	**K1793-MB2**
Date Analyzed:		**04/07/92**	**04/07/92**
Analyte	**MRL**		
Alpha-BHC	0.001	ND	ND
Gamma-BHC (Lindane)	0.001	ND	ND
Beta-BHC	0.003	ND	ND
Heptachlor	0.001	ND	ND
Delta-BHC	0.001	ND	ND
Aldrin	0.001	ND	ND
Heptachlor Epoxide	0.001	ND	ND
Endosulfan I	0.001	ND	ND
4,4'-DDE	0.001	ND	ND
Dieldrin	0.001	ND	ND
Endrin	0.001	ND	ND
4,4'-DDD	0.001	ND	ND
Endosulfan II	0.001	ND	ND
4,4'-DDT	0.001	ND	ND
Endrin Aldehyde	0.001	ND	ND
Endosulfan Sulfate	0.001	ND	ND
Methoxychlor	0.002	ND	ND
Toxaphene	0.03	ND	ND
Chlordane	0.01	ND	ND
PCBs: Aroclor 1016	0.01	ND	ND
Aroclor 1221	0.01	ND	ND
Aroclor 1232	0.01	ND	ND
Aroclor 1242	0.01	ND	ND
Aroclor 1248	0.01	ND	ND
Aroclor 1254	0.01	ND	ND
Aroclor 1260	0.01	ND	ND

MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Kevin Dennett Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/14/92
		Work Order No.:	K921793

Polynuclear Aromatic Hydrocarbons
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		**IL-BC-4,5 Comp**
Lab Code:		**K1793-6**
Analyte	**MRL***	
Naphthalene	73	ND
2-Methylnaphthalene	73	ND
Acenaphthylene	73	ND
Dibenzofuran	73	ND
Acenaphthene	73	ND
Fluorene	73	ND
Phenanthrene	73	84
Anthracene	73	ND
Fluoranthene	73	340
Pyrene	73	270
Benz(a)anthracene	73	94
Chrysene	73	110
Benzo(b+k)fluoranthene◆	150	160
Benzo(a)pyrene	73	81
Indeno(1,2,3-cd)pyrene	73	ND
Dibenz(a,h)anthracene	73	ND
Benzo(g,h,i)perylene	73	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
ND None Detected at or above the method reporting limit
◆ These compounds coelute; therefore, the results are reported as the combined concentration.

Approved by Kevin Dennett 33 Date 5-5

U0015

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/14/92
		Work Order No.:	K921793

Polynuclear Aromatic Hydrocarbons
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:	**IL-BC-6**
Lab Code:	**K1793-7**

Analyte	**MRL***	
Naphthalene	72	ND
2-Methylnaphthalene	72	ND
Acenaphthylene	72	ND
Dibenzofuran	72	ND
Acenaphthene	72	ND
Fluorene	72	ND
Phenanthrene	72	ND
Anthracene	72	ND
Fluoranthene	72	200
Pyrene	72	170
Benz(a)anthracene	72	ND
Chrysene	72	74
Benzo(b + k)fluoranthene◆	140	ND
Benzo(a)pyrene	72	ND
Indeno(1,2,3-cd)pyrene	72	ND
Dibenz(a,h)anthracene	72	ND
Benzo(g,h,i)perylene	72	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
ND None Detected at or above the method reporting limit
◆ These compounds coelute; therefore, the results are reported as the combined concentration.

Approved by Kevin Dennis 34 Date 5-5

U0016

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/14/92
		Work Order No.:	K921793

Polynuclear Aromatic Hydrocarbons
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		IL-BC-8,9 Comp
Lab Code:		K1793-10
Analyte	**MRL***	
Naphthalene	92	ND
2-Methylnaphthalene	92	ND
Acenaphthylene	92	ND
Dibenzofuran	92	ND
Acenaphthene	92	ND
Fluorene	92	ND
Phenanthrene	92	ND
Anthracene	92	ND
Fluoranthene	92	270
Pyrene	92	240
Benz(a)anthracene	92	ND
Chrysene	92	ND
Benzo(b + k)fluoranthene◆	180	ND
Benzo(a)pyrene	92	ND
Indeno(1,2,3-cd)pyrene	92	ND
Dibenz(a,h)anthracene	92	ND
Benzo(g,h,i)perylene	92	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
ND None Detected at or above the method reporting limit
◆ These compounds coelute; therefore, the results are reported as the combined concentration.

Approved by KEVIN DEWITT Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/14/92
		Work Order No.:	K921793

Polynuclear Aromatic Hydrocarbons
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		IL-BC-10,11 Comp
Lab Code:		K1793-13
Analyte	**MRL***	
Naphthalene	90	ND
2-Methylnaphthalene	90	ND
Acenaphthylene	90	ND
Dibenzofuran	90	ND
Acenaphthene	90	ND
Fluorene	90	ND
Phenanthrene	90	ND
Anthracene	90	ND
Fluoranthene	90	370
Pyrene	90	310
Benz(a)anthracene	90	ND
Chrysene	90	ND
Benzo(b+k)fluoranthene♦	180	ND
Benzo(a)pyrene	90	ND
Indeno(1,2,3-cd)pyrene	90	ND
Dibenz(a,h)anthracene	90	ND
Benzo(g,h,i)perylene	90	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
ND None Detected at or above the method reporting limit
♦ These compounds coelute; therefore, the results are reported as the combined concentration.

Approved by KEVIN DENNIS Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/10/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Polynuclear Aromatic Hydrocarbons
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		**Method Blank**
Lab Code:		**K1793-MB**
Analyte	**MRL**	
Naphthalene	33	ND
2-Methylnaphthalene	33	ND
Acenaphthylene	33	ND
Dibenzofuran	33	ND
Acenaphthene	33	ND
Fluorene	33	ND
Phenanthrene	33	ND
Anthracene	33	ND
Fluoranthene	33	ND
Pyrene	33	ND
Benz(a)anthracene	33	ND
Chrysene	33	ND
Benzo(b + k)fluoranthene♦	67	ND
Benzo(a)pyrene	33	ND
Indeno(1,2,3-cd)pyrene	33	ND
Dibenz(a,h)anthracene	33	ND
Benzo(g,h,i)perylene	33	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
ND None Detected at or above the method reporting limit
♦ These compounds coelute; therefore, the results are reported as the combined concentration.

Approved by KEVIN DEWITT Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/19/92
		Work Order No.:	K921793

Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		IL-BC-4,5 Comp
Lab Code:		K1793-6
Analyte	**MRL***	
Phenol	73	**97
2-Methylphenol	73	ND
4-Methylphenol	73	ND
2,4-Dimethylphenol	73	ND
Pentachlorophenol	180	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
** Analyte concentration is an estimate because this analyte was also found in the method blank.
ND None Detected at or above the method reporting limit

Approved by Kevin Dermitt Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/19/92
		Work Order No.:	K921793

Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		IL-BC-6
Lab Code:		K1793-7
Analyte	**MRL***	
Phenol	72	**72
2-Methylphenol	72	ND
4-Methylphenol	72	ND
2,4-Dimethylphenol	72	ND
Pentachlorophenol	180	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
** Analyte concentration is an estimate because this analyte was also found in the method blank.
ND None Detected at or above the method reporting limit

Approved by Kevin Dennett Date 5-5

U0028

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-106

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/19/92
		Work Order No.:	K921793

Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		IL-BC-8,9 Comp
Lab Code:		K1793-10
Analyte	**MRL***	
Phenol	92	ND
2-Methylphenol	92	ND
4-Methylphenol	92	ND
2,4-Dimethylphenol	92	ND
Pentachlorophenol	230	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
ND None Detected at or above the method reporting limit

Approved by Kevin Dennis Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/19/92
		Work Order No.:	K921793

Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		**IL-BC-10,11 Comp**
Lab Code:		**K1793-13**
Analyte	**MRL***	
Phenol	90	ND
2-Methylphenol	90	ND
4-Methylphenol	90	ND
2,4-Dimethylphenol	90	ND
Pentachlorophenol	230	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
* MRLs are elevated because of matrix interferences, because the sample(s) required diluting, and because of the low percent solids in the sample as received.
ND None Detected at or above the method reporting limit

Approved by Kevin Demmitt Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/18/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name:		**Method Blank**
Lab Code:		**K1793-MB**
Analyte	**MRL**	
Phenol	33	72
2-Methylphenol	33	ND
4-Methylphenol	33	ND
2,4-Dimethylphenol	33	ND
Pentachlorophenol	67	ND

SIM Selected Ion Monitoring
MRL Method Reporting Limit
ND None Detected at or above the method reporting limit

Approved by Kevin Dennis Date 5-5

U0035

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

APPENDIX A

LABORATORY QC RESULTS

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	03/28/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Matrix Spike Summary
Acid Volatile Sulfides in Sediment
EPA Draft Method for Acid Volatile Sulfides in Sediment August 1991
µmoles/g
Dry Weight Basis

Sample Name	Lab Code	MRL	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery
Batch QC	K1786-1MS	0.01	0.13	0.04	0.14	78
Batch QC	K1786-1DMS	0.01	0.13	0.04	0.11	54

MRL Method Reporting Limit

Approved by Kevin Downum Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Work Order No.:**	K921793
Sample Matrix:	Sediment		

Matrix Spike Summary
Total Metals
mg/Kg (ppm)
Dry Weight Basis

Sample Name: BB-BC-3
Lab Code: K1793-1

Analyte	MRL	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery	CAS Percent Recovery Acceptance Criteria
Arsenic	1	15	7	20	87	60-130
Cadmium	0.1	1.9	0.7	2.7	105	60-130
Chromium	1	76	19	92	96	60-130
Copper	1	96	26	112	90	60-130
Lead	1	8	17	24	88	60-130
Mercury	0.02	0.05	0.08	0.14	120	60-130
Nickel	1	10	16	26	100	60-130
Zinc	1	192	96	263	97	60-130

MRL Method Reporting Limit

Approved by Kevin Dennett 45 Date 5-5

U0038

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Work Order No.:**	K921793
Sample Matrix:	Sediment		

Duplicate Summary
Total Metals
mg/Kg (ppm)
Dry Weight Basis

Sample Name: BB-BC-3
Lab Code: K1793-1

Analyte	EPA Method	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference
Arsenic	7060	1	7	7	7	<1
Cadmium	7131	0.1	0.7	0.7	0.7	<1
Chromium	6010	1	19	19	19	<1
Copper	6010	1	26	28	27	7
Lead	7421	1	17	16	17	6
Mercury	7471	0.02	0.08	0.09	0.08	12
Nickel	249.2	1	16	16	16	<1
Zinc	6010	1	96	98	97	2

MRL Method Reporting Limit

Approved by Kevin Dennett 46 Date 5-5

U0039

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/07-14/92
		Work Order No.:	K921793

Surrogate Recovery Summary
Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)
EPA Methods 3540/8080

Sample Name	Lab Code	Percent Recovery	
		Tetrachloro-*m*-xylene	Decachlorobiphenyl
BB-BC-3	K1793-1	54	82
CH-BC-1	K1793-2	69	81
CH-BC-2	K1793-3	61	76
IL-BC-4,5 Comp	K1793-6	52	70
IL-BC-6	K1793-7	70	*52
IL-BC-8,9 Comp	K1793-10	74	108
IL-BC-10,11 Comp	K1793-13	66	96
CB-BC-1	K1793-14	68	98
CB-BC-2	K1793-15	62	94
CB-BC-3	K1793-16	67	88
	CAS Acceptance Criteria	45-112	53-120

* Outside of acceptance limits because of matrix interferences. The chromatogram showed nontarget components that interfered with the analysis.

Approved by Kevin Dennis Date 5-5

U0041

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/07/92
LCS Matrix:	Sediment	**Work Order No.:**	K921793

Laboratory Control Sample Summary
Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)
EPA Methods 3540/8080
mg/Kg (ppm)

Analyte	True Value	Result	Percent Recovery	CAS Percent Recovery Acceptance Criteria
Gamma-BHC (Lindane)	0.020	0.011	55	52-125
Heptachlor	0.020	0.014	70	38-147
Aldrin	0.020	0.014	70	51-124
Dieldrin	0.020	0.015	75	57-130
Endrin	0.020	0.016	80	54-143
4,4'-DDT	0.020	0.016	80	40-157

Approved by Kevin DeWitt 48 Date 5-5

U0043

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/10/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Surrogate Recovery Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method

Sample Name	Lab Code	Percent Recovery		
		NAP	FLR	CRY
Method Blank	K1793-MB	*61	*86	*91

SIM Selected Ion Monitoring
NAP Naphthalene-D_8
FLR Fluorene-D_{10}
CRY Chrysene-D_{12}

* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.

Approved by Kevin Dennett Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/18,19/92
		Work Order No.:	K921793

Surrogate Recovery Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method

Sample Name	Lab Code	Percent Recovery *2FP	*PHL	*TBP
BB-BC-3	K1793-1	76	91	143
CH-BC-1	K1793-2	66	85	139
CH-BC-2	K1793-3	56	65	121
IL-BC-4,5 Comp	K1793-6	54	67	133
IL-BC-6	K1793-7	28	54	122
IL-BC-8,9 Comp	K1793-10	36	50	123
IL-BC-10,11 Comp	K1793-13	27	36	124
CB-BC-1	K1793-14	32	26	114
Method Blank	K1793-MB	139	144	113
Laboratory Control Sample	K1793-LCS	131	147	86

SIM Selected Ion Monitoring
2FP 2-Fluorophenol
PHL Phenol-D_6
TBP 2,4,6-Tribromophenol

* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.

Approved by [signature] Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client: U.S. Army Corps of Engineers
Project: Portland District Dredging/#92-SHM-183
Sample Matrix: Sediment

Date Received: 03/23/92
Date Extracted: 03/24/92
Date Analyzed: 04/14/92
Work Order No.: K921793

Surrogate Recovery Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method

Sample Name	Lab Code	Percent Recovery *NAP	*FLR	*CRY
CH-BC-2	K1793-3	64	96	99
IL-BC-4,5 Comp	K1793-6	48	94	108
IL-BC-6	K1793-7	32	93	95
IL-BC-8,9 Comp	K1793-10	56	99	87
IL-BC-10,11 Comp	K1793-13	53	95	48
CB-BC-1	K1793-14	43	91	82
CB-BC-2	K1793-15	44	87	55
CB-BC-3	K1793-16	50	66	88
CB-BC-4	K1793-17	58	101	95

SIM Selected Ion Monitoring
NAP Naphthalene-D_8
FLR Fluorene-D_{10}
CRY Chrysene-D_{12}

* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.

Approved by Kevin Denman Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/18,19/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Surrogate Recovery Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method

Sample Name	Lab Code	Percent Recovery *2FP	*PHL	*TBP
Batch QC**	K1786-2	143	156	164
Batch QC**	K1786-2MS	116	140	161
Batch QC**	K1786-2DMS	86	119	152

SIM Selected Ion Monitoring
2FP 2-Fluorophenol
PHL Phenol-D_6
TBP 2,4,6-Tribromophenol

* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.
** Batch QA/QC data from another ACOE project.

Approved by KEVIN DEWATA Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/19,20/92
		Work Order No.:	K921793

Surrogate Recovery Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method

Sample Name	Lab Code	Percent Recovery *NAP	*FLR	*CRY
BB-BC-3	K1793-1	62	97	82
CH-BC-1	K1793-2	54	99	87
Laboratory Control Sample	K1793-LCS	74	74	109

SIM Selected Ion Monitoring
NAP Naphthalene-D_8
FLR Fluorene-D_{10}
CRY Chrysene-D_{12}

* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.

Approved by Kevin Dewitt Date 5-5

U0048

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Received:**	03/23/92
Project:	Portland District Dredging/#92-SHM-183	**Date Extracted:**	03/24/92
Sample Matrix:	Sediment	**Date Analyzed:**	04/20/92
		Work Order No.:	K921793

Surrogate Recovery Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method

Sample Name	Lab Code	Percent Recovery		
		*NAP	*FLR	*CRY
Batch QC**	K1786-2	65	98	82
Batch QC**	K1786-2MS	61	102	78
Batch QC**	K1786-2DMS	72	108	85

SIM Selected Ion Monitoring
NAP Naphthalene-D_8
FLR Fluorene-D_{10}
CRY Chrysene-D_{12}

* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.
** Batch QA/QC data from another ACOE project.

Approved by Kevin Denton Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/18,19/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Matrix Spike/Duplicate Matrix Spike Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name: Batch QC*
Lab Code: K1786-2

	Spike Level			Spike Result		Percent Recovery			
Analyte	MS	DMS	**Sample Result**	MS	DMS	MS	DMS	CAS Acceptance Criteria	**Relative Percent Difference**
Pentachlorophenol	21	23	ND	**40	**39	‡190	‡170	10-120	11

SIM Selected Ion Monitoring
* Batch QA/QC data from another ACOE project.
ND None Detected at or above the method reporting limit
** Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.
‡ Outside of acceptance limits. Accuracy of spike recovery value is reduced, since analysis of the sample required a dilution such that the target compound concentration was diluted below both the MRL and the quantitative calibration range of the instrument.

Approved by Kevin Devlin Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/20/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Matrix Spike/Duplicate Matrix Spike Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in Combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name: Batch QC*
Lab Code: K1786-2

	Spike Level		Sample	Spike Result		Percent Recovery		CAS Acceptance	Relative Percent
Analyte	MS	DMS	**Result**	MS	DMS	MS	DMS	Criteria	**Difference**
Acenaphthene	21	23	ND	**20	**20	95	87	40-130	9
Pyrene	21	23	**31	**60	56	‡138	109	40-130	23

SIM Selected Ion Monitoring
* Batch QA/QC data from another ACOE project.
ND None Detected at or above the method reporting limit
** Analyte concentration is an estimate because the result was below the instrument calibration range and below the sample MRL.
‡ Outside of acceptance limits. Accuracy of spike recovery value is reduced, since analysis of the sample required a dilution such that the target compound concentration was diluted below both the MRL and the quantitative calibration range of the instrument.

Approved by KEVIN DENNETT Date 5-5

00052

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/18/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Laboratory Control Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name: Laboratory Control Sample
Lab Code: K1793-LCS

Analyte	Spike Level	Blank Result	Spiked Sample Result	Percent Recovery	CAS Percent Recovery Acceptance Criteria
Pentachlorophenol	17	ND	*19	112	10-20

SIM Selected Ion Monitoring
ND None Detected at or above the method reporting limit
* Analyte concentration is an estimate because extract dilutions resulted in values below the instrument calibration range.

Approved by KEVIN DENNIM Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client:	U.S. Army Corps of Engineers	**Date Extracted:**	03/24/92
Project:	Portland District Dredging/#92-SHM-183	**Date Analyzed:**	04/19/92
Sample Matrix:	Sediment	**Work Order No.:**	K921793

Laboratory Control Summary
Polynuclear Aromatic Hydrocarbons and Phenols
EPA Method 3550 in combination with GC/MS SIM Method
µg/Kg (ppb)
Dry Weight Basis

Sample Name: Laboratory Control Sample
Lab Code: K1793-LCS

Analyte	Spike Level	Blank Result	Spiked Sample Result	Percent Recovery	CAS Percent Recovery Acceptance Criteria
Acenaphthene	17	ND	*15	88	40-130
Pyrene	17	ND	*14	82	40-130

SIM Selected Ion Monitoring
ND None Detected at or above the method reporting limit
***** Analyte concentration is an estimate because the result was below the instrument calibration range.

Approved by Kevin Rettmann Date 5-5

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

APPENDIX B

CHAIN OF CUSTODY INFORMATION

1317 South 13th Avenue • P.O. Box 479 • Kelso, Washington 98626 • Telephone 206/577-7222 • Fax 206/636-1068

CHAIN OF CUSTODY RECORD

PROJECT Baker Bay Channels, Ilwaco & Chinook Boat Basins

SAMPLERS: (Signature) Jim Britton

92-SHM-183

92-SHM-181

SAMPLE NUMBER	DATE	TIME	COMP.	GRAB	NO. CONTAINERS	Metals * (see list)	Pesticides/PCBs	PAHs (Sims)	Phenols (Sims)	TBT	AVS	Dioxins				REMARKS OR SAMPLE LOCATION	ICED	SPECIFY CHEMICALS ADDED AND FINAL pH IF KNOWN
BB-BC-3	3/19				1	X	X	X	X		X							
CH-BC-1	"				1	X	X	X	X		X							
CH-BC-2	"				1	X	X	X	X		X							
IL-BC-4	"				1	X	X	X	X	X	X					composite		
IL-BC-5	"				1	X	X	X	X	X	X							
IL-BC-6	"				1	X	X	X	X	X	X							
IL-BC-8	"				1	X	X	X	X	X	X	X				composite		
IL-BC-9	"				1	X	X	X	X	X	X	X						
IL-BC-10	"				1	X	X	X	X	X	X					composite		
IL-BC-11	"				1	X	X	X	X	X	X							
CB-BC-1	"				1	X	X	X	X	X	X							
CB-BC-2	"				1	X	X	X	X	X	X	X						
CB-BC-3	"				1	X	X	X	X	X	X							
TB-BC-4	"				1	X	X	X	X	X	X							
IL-BC-1,2&3	"				3											Hold		

Relinquished by: (Signature) ①	Date / Time	Received by: (Signature)	Relinquished by: (Signature) ④	Date / Time	Shipped via:
Jim Britton	3/20/92 1:57	Pamela Swan			
Relinquished by: (Signature) ②	**Date / Time**	**Received by: (Signature)**	**Received for Laboratory by: (Signature)**	**Date / Time**	**Shipping Ticket No.**
Pamela Swan	3/20/92 1700		[signature]	3-23-92 0800	
Relinquished by: (Signature) ③	**Date / Time**	**Received by: (Signature)**	**Remarks** * metals - As, Cd, Cr, Cu, Hg, Ni, Pb, Zn		

TBT = Tributyl Tin
AVS = acid volatile sulfide

09

00056

cc: Central File
Login File

SAMPLE LOGIN

PROJECT: COLUMBIA ANALYTICAL - TBT 04/01/92

SPONSOR CODE	BATTELLE CODE	SAMPLE TYPE	UNIT	SHELF/FR#	TRAY/RM#	PARAMETERS REQUESTED	DATE	INITIALS
CG-BC-1	437CAS*1	SED	C	4	2	TBT	04/01/92	MPG
CG-BC-2	437CAS*2	SED	C	4	2	TBT	04/01/92	MPG
IL-BC-4,5(COMP)	437CAS*3	SED	C	4	2	TBT	04/01/92	MPG
IL-BC-6	437CAS*4	SED	C	4	2	TBT	04/01/92	MPG
IL-BC-8,9-COMP	437CAS*5	SED	C	4	2	TBT	04/01/92	MPG
IL-BC-10,11COMP	437CAS*6	SED	C	4	2	TBT	04/01/92	MPG
CB-BC-1	437CAS*7	SED	C	4	2	TBT	04/01/92	MPG
CB-BC-2	437CAS*8	SED	C	4	2	TBT	04/01/92	MPG
CB-BC-3	437CAS*9	SED	C	4	2	TBT	04/01/92	MPG
CB-BC-4	437CAS*10	SED	C	4	2	TBT	04/01/92	MPG

61

COMMENTS:

COOLER RECEIPT FORM

Project: Portland District Dredging

Cooler received on 3 /21 /92 and opened on 3 /21 /92 by R. Allison

1)	Were custody seals on outside of cooler ----------	(YES) NO
	If yes, how many and where? 2 - Front	
	Were signature and date correct? ----------	(YES) NO
2)	Were custody papers taped to lid inside cooler? ----------	(YES) NO
3)	Were custody papers properly filled out (ink, signed, etc.)? ---------	(YES) NO
4)	Did you sign custody papers in the appropriate place? ----------	(YES) NO
5)	Did you attach shipper's packing slip to this form? ----------	(YES) NO
6)	What kind of packing material was used? vermiculite	
7)	Was sufficient ice used (if appropriate)? ----------	(YES) NO
8)	Were all bottles sealed in separate plastic bags? ----------	(YES) NO
9)	Did all bottles arrive in good condition (unbroken)? ----------	(YES) NO
10)	Were all bottle labels complete (No., date, signed, anal. pres, etc.)	(YES) NO
11)	Did all bottle labels and tags agree with custody papers? ----------	(YES) NO
12)	Were correct bottles used for the tests indicated? ----------	(YES) NO
13)	Were VOA vials checked for absence of air bubbles, & noted if so?	YES NO
14)	Was sufficient amount of sample sent in each bottle? ----------	(YES) NO

Explain any discrepancies ----->

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION MATERIALS LABORATORY
CORPS OF ENGINEERS
1491 N.W. GRAHAM AVENUE
TROUTDALE, OREGON 97060-9503

CENPD-PE-GT-L (1110-1-8100c) 29 Jul 92

MEMORANDUM FOR: Commander, Portland District, ATTN: CENPP-PE-HR (Britton)

SUBJECT: W.O. 92-SHM-183, Results of Chemical Analyses

Project: PORTLAND DISTRICT DREDGING PROJECT
Intended Use: Evaluate site
Source of Material: Reference Chain of Custody Records
Submitted by: CENPP-PE-HR (Britton)
Date Sampled: 19 May 92 Date Received: 23 Mar 92
Methods of Test: Reference Enclosure 1
Reference: DD Forms 448, MIPR Nos. E86-92-0074 dated 4 Mar 92 and E86-92-0040, dated 31 Mar 92

1. Enclosed are results of analyses and quality assurance data for environmental samples collected from the above site. Included are:

a. Enclosure 1, Chemical Quality Assurance Report.

b. Enclosure 2, Report number K921793 from Columbia Analytical Services, Inc.

c. Enclosure 3, Report dated 27 May 92 from Battelle.

d. Enclosure 4, Chain of Custody and Cooler Receipt forms.

2. If you have any questions or comments regarding the Chemical Quality Assurance Report, please contact Dr. Ajmal Ilias at (503) 665-4166.

3. This completes all work requested to date.

Timothy J. Seeman

Enclosures

TIMOTHY J. SEEMAN
Director

Copy Furnished: CENPD-PE-GT

CHEMICAL QUALITY ASSURANCE REPORT

PORTLAND DISTRICT DREDGING PROJECT

1. **SUMMARY:**

a. Up to 74 u moles/g of acid volatile sulfides (AVS), 0.08 through 165 ppm of metals, 8 ppb of pesticides, 370 ppb of polynuclear aromatics (PNA), 34.7 ppb of organotin compounds, and 782/150 ppt of dioxin/furans were detected in this tier of analysis.

b. The project and quality assurance (QA) data comparisons are shown in Table I. All data agree.

2. **BACKGROUND:** The samples were collected on March 19, 1992 and were received by the analytical laboratories on March 23, 1992.

3. **OBJECTIVES:**

a. Seventeen sediment samples were collected to determine the extent of chemical contamination on the site.

b. One QA sample was submitted to evaluate the project laboratory's data.

4. **PROJECT ORGANIZATION:**

a. The samples were collected by North Pacific Division/Portland District staff.

b. The project samples were analyzed by Columbia Analytical Services, Inc. (CAS), Kelso, Washington, Keystone/NEA, Environmental Resources, Tigard, Oregon, and Battelle, Sequim, Washington.

c. The QA samples were analyzed by Battelle, Sequim, Washington and Analytical Resources, Inc., Seattle, Washington.

5. **ANALYTICAL REFERENCES:**

Number	Title	Date
a. SW-846, Third Edition	Test Methods for Evaluating Solid Waste	11/86
b. Battelle	In-house Modified Methods	91/92

6. **PROJECT LABORATORIES' DATA:** Up to 74 u moles/g of acid volatile sulfides (AVS), 0.08 through 165 ppm of metals, 8 ppb of pesticides, 370 ppb of polynuclear aromatics (PNA), 34.7 ppb of organotin compounds, and 782/150 ppt of dioxin/furans were detected in this tier of analysis.

7. **EVALUATION OF THE PROJECT LABORATORIES' DATA:** All method blanks were free from targeted analytes except for phenol blanks, which were contaminated with 72 ppb of phenol. Phenol data reported in CAS report K921793 is due to laboratory contamination. The detection limits and holding times met method requirements and are acceptable. Surrogate recoveries of all methods were within quality control (QC) limits and are acceptable. The matrix spike (MS) and matrix spike duplicates (MSD) of all organics were within QC limits except for the following: MSD of gamma-BHC was marginally below QC limits and MS and MSD of 4,4'-DDT were below lower QC limits, data were accepted based on acceptable surrogate and laboratory control (LC) recoveries. MS and MSD of PNA were within QC limits except for MS of pyrene, which was above advisory limits. Data of PNA were accepted based on surrogate and other acceptable MS and MSD recoveries. The MS and MSD of pentachlorophenols were above upper QC advisory limits. Phenol data were not affected as no targeted analytes except for laboratory contaminated phenols were found. MS and MSD of dioxin/furans and AVS were within QC limits and are acceptable. The recoveries of monobutyl through tributyl tins were 3 through 39-percent, which are considered poor since no EPA guidelines are available, and data should be considered acceptable as low estimates. The MS recoveries of metals were within QC limits and are acceptable. The relative percent differences (RPDs) of all methods were within QC limits except for the following: The RPD of 123478HXCDD, 1234678XPCDD and OCDD were above QC limits, probably due to non-homogeneous samples. The data of these analytes should be considered estimates. Overall, data are acceptable except for phenol, which is due to laboratory contamination.

8. **EVALUATION OF THE QA LABORATORIES' DATA:** All surrogate, MS and MSD recoveries were within QC limits. All method blanks were free of targeted analytes except for the metals blank, where cadmium and mercury were detected. All holding times and detection limits met method requirements. Overall, all QA data are acceptable.

9. **QA/QC COMPARISONS:** The project and QA data comparisons are shown in Table I. All data agree.

10. **PROBLEMS ENCOUNTERED/LESSONS LEARNED:** The project laboratory (CAS), subcontracted tributyl-tin analysis to Battelle Laboratories. Battelle was also the QA laboratory for this analysis and inadvertently conducted both the project and QA analyses for tributyl tin.

COMPARISON OF PROJECT AND QA RESULTS

TABLE I

Project: PORTLAND DISTRICT DREDGING PROJECT Matrix: sediment
Project Laboratory: CAS QA Laboratory: Battelle

1. Method: Pesticides/PCBs (EPA 8080) Units: ug/Kg (ppb)

Analytes Detected	Project Lab CB-BC-4	Detection Limits	QA Lab CB-BC-4-QA	Detection Limits
4,4'-DDE	ND	5	2.1	2.0
Endrin	ND	5	0.96J	2.0
Percent Solids	38.0		--	

ND = None detected
-- = Not reported
J = Estimated value found at less than instrument detection limits

SUMMARY: The project and QA data agree within a factor of three to each other or their detection limits and are acceptable.

2. Method: Acid Volatile Sulfides in Sediment Units: u moles/g (ppt)

Analytes Detected	Project Lab CB-BC-4	Detection Limits	QA Lab CB-BC-4-QA	Detection Limits
	50	0.01	58.84	--

SUMMARY: The project and QA data agree and are acceptable.

3. Method: Polynuclear Aromatics (GC/MS SIM) Units: ug/Kg (ppb)

Analytes Detected	Project Lab CB-BC-4	Detection Limits	QA Lab CB-BC-4-QA	Detection Limits
Fluoranthene	250	86	178.8	--
Pyrene	220	86	158.8	--
Chrysene	87	86	55	--
Naphthalene	ND	86	48.1	--
Phenanthrene	ND	86	63.6	--
Anthracene	ND	86	24.2	--
Benzo(a)anthracene	ND	86	56.3	--
Benzo(b)fluoranthene	ND	170	143.4	--
Indeno(1,2,3-c,d)pyrene	ND	86	40.2	--
Di-benzo(a,h)anthracene	ND	86	18.8	--
Benzo(g,h,i)perylene	ND	86	50.8	--

SUMMARY: The project and QA data agree within a factor of three to each other or their detection limits and are acceptable.

CENPD-PE-GT-L (92-SHM-183)
Table I

4. Method: Phenols (EPA 3550 GC/MS) Units: ug/Kg (ppb)

Analytes Detected	Project Lab CB-BC-4	Detection Limits	QA Lab CB-BC-4-QA	Detection Limits
Phenol	130B	86	ND	100
2-Methylphenol	ND	86	ND	66
4-Methylphenol	ND	86	ND	71
2,4-Dimethylphenol	ND	86	ND	75
Pentachlorophenol	ND	220	ND	5.8

B = Found in laboratory blank as well as sample

SUMMARY: The project and QA data agree and are acceptable. The phenol reported by the project laboratory is due to laboratory contamination.

5. Method: Butyl tins Units: ng/g

Analytes Detected	Project Lab CB-BC-4	Detection Limits	QA Lab CB-BC-4-QA	Detection Limits
Monobutyl tin	ND	4.4	ND	6.2
Dibutyl tin	ND	2.1	ND	2.9
Tributyl tin	5.0	2.1	13.0	--

SUMMARY: The project and QA data agree and are acceptable.

6. Method: Total Metals (EPA 6000/7000) Units: ug/Kg (ppb)

Analytes Detected	Project Lab CB-BC-4	Detection Limits	QA Lab CB-BC-4-QA	Detection Limits
Arsenic	8000	1000	10500	--
Cadmium	1200	100	940	--
Chromium	23000	1000	58300	--
Copper	46000	1000	58400	--
Lead	20000	1000	23900	--
Mercury	120	20	119	--
Nickel	21000	1000	30600	--
Zinc	122000	1000	174000	--

SUMMARY: The project and QA data agree within a factor of three and are acceptable.

ANALYSIS OF SOILS

For The Presence of

PCDD's AND PCDF's
By
HIGH RESOLUTION GAS CHROMATOGRAPHY
HIGH RESOLUTION MASS SPECTROMETRY

KEYSTONE/NEA
ENVIRONMENTAL RESOURCES

CASE NARRATIVE

CASE NARRATIVE

I. SAMPLE DESCRIPTION

Two soil samples were received under Chain-of-Custody on March 31, 1992. The samples were in good condition upon receipt, and were stored in a refrigerator maintained at 4°C until extraction.

One laboratory method blank, and one Matrix Spike and Matrix Spike Duplicate were also analyzed with this sample set.

II. ANALYSIS REQUEST

The analytical test requested for this sample set was as follows:

LAB ID NUMBER	ANALYSIS	LMCL
92CA31MR01	EPA Method 8290+	2 ppt (tetras) 10.0 (pentas ,hexas ,heptas) 20.0 (octas)

III. SAMPLE ANALYSIS SUMMARY

A. Background

Keystone/NEA's Center for Analytical Mass Spectrometry has analyzed this set of samples by High Resolution Gas Chromatography/High Resolution Mass Spectrometry (HRGC/HRMS) according to EPA Method 8290+. Deviations from the proposed Method 8290 are described under "Analytical Methodology", below.

The samples were extracted in one set on April 1, 1992. The extracts were analyzed on a DB-5.625 column on April 7, 1992. Confirmation analysis was done on a DB-225 column on April 7, 1992.

B. Results

General Soil results are based on the initial weight of the sample (approximately 5 grams). All of the reported results are rounded to three significant figures. Laboratory Method Blank results are also based on a theoretical sample size of 5 grams. Reported results for the 2378-TCDF are from a DB-225 column, and are highlighted with an asterisk (*). All other results are from a DB-5 column.

Sample Results The only significant differences between the two samples were in the concentrations of the two highest chlorinated dioxin isomers. The 1234678-HpCDD isomer was present in samples K1793-10 and K1793-15 at 358 ppt and 140 ppt, and OCDD was present at 2,700 ppt and 1,320 ppt, respectively. Otherwise the two soil samples contained similar concentrations of the seventeen target analytes. (See Table 1.)

Six of the seventeen 2378-substituted isomers were present in both samples at levels above the Lower Method Calibration Limit (LMCL). Sample K1793-10 contained 123678-HxCDD (18.0 ppt), 123789-HxCDD (10.5 ppt), 1234678-HpCDD (358 ppt), OCDD (2,700 ppt), 1234678-HpCDF (49.1 ppt), and OCDF (144 ppt).

Sample K1793-15 contained five of those isomers at concentrations above the LMCL: 123678-HxCDD (13.6 ppt), 1234678-HpCDD (140 ppt), OCDD (1,320 ppt), 1234678-HpCDF (20.1 ppt), and OCDF (41.3 ppt).

The remaining eleven isomers were detected in both samples at levels calculated to be below or near the individual LMCLs. Concentrations reported below the LMCL should be considered ESTIMATES ONLY.

C. Analytical Methodology

Modifications have been made to EPA Method 8290 to improve quantitation of the seventeen 2378-substituted isomers. Most of the modifications have been approved for other EPA methods (primarily EPA Method 1613). The significant modifications to EPA Method 8290 for PCDD and PCDF are outlined below.

Sample Preparation The extraction, sample clean-up, and instrumental analyses were done by EPA Method 8290. Solid samples are extracted with toluene in a soxhlet-Dean Stark apparatus. This procedure azeotropically removes the water from the sample, thus eliminating the time-consuming step of pre-drying the sample, or mixing with a drying agent. This adaptation has been approved for Method 1613 and Method 8290.

Calibration Standards This laboratory uses independently prepared and certified calibration standards, at concentrations specified in EPA Method 1613. The standards are traceable to EPA standards.

Internal Standard EPA Method 8290 calls for an Internal Standard solution containing nine of the seventeen 2378-substituted isomers for quantitation (section 2.3). The Internal Standard used for these analyses contains labeled analogues of sixteen of the 2378-substituted isomers. One compound, ^{13}C-123789-HxCDD, is used as a Recovery Standard; its native analyte is quantified against ^{13}C-123678-HxCDD.

Standard Preparation and Spiking To prevent changes in concentration due to solvent losses, the standards for these analyses have been prepared in tetradecane. Internal Standards and PAR solutions are dissolved in acetone immediately prior to spiking aqueous matrices.

Clean-Up Recovery Standard Spiking Levels EPA Method 8290 calls for spiking the sample extracts with 2,000 pg of ^{37}Cl-2378-TCDD immediately prior to the clean-up procedure. That level has been reduced to 200 pg, as suggested by NCASI. The purpose of this change is to reduce the occurrence of false positives due to native contamination in the 322 channel.

D. Calculations and Reporting

Positive Identification Where a peak has been positively identified as one of the 2378-substituted PCDD/PCDF isomers by passing all the QA criteria (retention times, analyte isotope ratios, and signal-to-noise), a concentration has been calculated in the usual manner and reported in the attached tables. In cases where the reported concentration falls below the LMCL, it should be considered an estimate only.

Estimated Maximum Possible Concentration Where a peak has passed all the QA criteria except for the analyte isotope ratios, there may be co-eluting contaminants or other chemical interferences. In such cases, a concentration has been calculated in the usual manner, but reported as an Estimated Maximum Possible Concentration (EMPC).

Analyte Not Detected Where the Chromatogram is characterized by the absence of peaks in both native channels (at the appropriate retention times), or where a peak is present in one or both channels, but does not pass the signal-to-noise criteria of 2.5:1, the analyte cannot be positively

identified and may be reported as Not Detected at or above the sample specific Estimated Detection Limit (ND/EDL). A data-review specialist has inspected each one individually and calculated an EDL based on the reporting requirements specified in EPA method 8290. Hard copies of the calculations are included in the sample data packet.

Calibration Limits A series of three Lower Method Calibration Limits (LMCLs) and three Upper Method Calibration Limits (UMCLs) can be calculated based on a sample size of 5 grams. The equations used are as follows:

(1) $$LMCL = \frac{(Lowest\ Instrument\ Calibration\ Pt) \times (Final\ Volume)}{(Sample\ Size)}$$

(2) $$UMCL = \frac{(Highest\ Instrument\ Calibration\ Pt) \times (Final\ Volume)}{(Sample\ Size)}$$

Note: pg/g = ppt

The Lowest and Highest Instrument Calibration Points (LICPs and HICPs) vary with each homologue group. For a sample size of 5 grams:

Homologue Group	LICP/HICP	LMCL	UMCL
Tetra	0.5/200 pg/µL	2.0 pg/g	800 pg/g
Penta, Hexa, Hepta	2.5/1,000 pg/µL	10.0 pg/g	4,000 pg/g
Octa	5.0/2,000 pg/µL	20.0 pg/g	8,000 pg/g

IV. QUALITY CONTROL

A. Project Quality Control

No special quality control measures were required or requested for this set of samples.

B. Instrument Quality Control

Conventional instrument quality control measures were applied for the analysis of these samples. The HRGC and HRMS systems' initial calibrations were verified immediately prior to and following analysis by injection of appropriate standards. One instrument blank was run prior to the laboratory Method Blank. All relevant instrument performance criteria were met. Documentation of initial and continuing calibrations, and GC and MS resolution checks can be found in the "QUALITY CONTROL DOCUMENTS" section of this report.

Continuing Calibration Because the samples were analyzed on a DB-5.625 column immediately following an initial calibration, only the continuing calibration following the sample analyses is included here.

C. Laboratory Quality Control

Laboratory Method Blank One laboratory Method Blank was analyzed with this set of samples to test for laboratory contamination. Its treatment in the laboratory was identical in all respects to that of the actual samples. The data are included in the "QUALITY CONTROL DOCUMENTS" section of this report.

The laboratory method blank was Non-Detect for all PCDD/PCDF isomers at the LMCL of 2.0 ppt (tetras), 10.0 ppt (pentas, hexas, heptas), and 20.0 ppt (octa). Many of these analytes, however, had sample specific EDL's significantly lower than the LMCL, ranging from 0.72 ppt to 3.17 ppt.

Matrix Spike and Matrix Spike Duplicate Fourteen of the seventeen 2378-substituted isomers in the Matrix Spike and Matrix Spike Duplicate samples had a Relative Percent Difference (RPD) below the method specified criteria of ±20%. The three remaining isomers had RPDs of 31%, 37% and 78%. The percent analyte recovery was lower in the MSd sample for each of the three isomers. One possible explanation may be inhomogeniety of the sample.

D. Quality Control Review

All of the data have been reviewed by the scientist performing the analysis, by the Director of the Center for Analytical Mass Spectrometry, and the Quality Assurance Officer. All of the quality control and sample-specific information in the package is complete and meets or exceeds the minimum requirements for acceptability.

Laura Chambers 4/10/92

Laura Chambers Date
Senior Scientist
Center for Analytical Mass Spectrometry

Peggy Meek 4/10/92

Peggy L. Meek Date
Wet Lab Supervisor
Center for Analytical Mass Spectrometry

4.10.92.

William H. Chambers Date
Director
Center for Analytical Mass Spectrometry

J. Sprenger 4/10/92

Jeff Sprenger Date
QA Officer
Keystone/NEA

KEYSTONE/NEA
ENVIRONMENTAL RESOURCES

SAMPLE ANALYSIS SUMMARY

SUMMARY OF ANALYTICAL RESULTS

2378-Substituted Isomers

Date received:	March 31, 1992
Client name:	Columbia Analytical
Laboratory Project Number:	92CA31MR01
Customer Project Number:	Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2071	07APR92LCB2091	07APR92LCB2101
Keystone/NEA Number:	92CA31MR01-MB	92CA31MR01-01	92CA31MR01-02
Customer Number:		K1793-10	K1793-15
Sample Description:	Method Blank	Soil	Soil
		1L-BC-84 comp.	CB-BC-2
Units	pg/g (ppt)	pg/g (ppt)	pg/g (ppt)
Dioxins			
2378-TCDD	ND/EDL=0.78	EMPC=1.68	1.06
12378-PeCDD	ND/EDL=0.72	EMPC=3.63	EMPC=1.67
123478-HxCDD	ND/EDL=2.30	7.85	2.54
123678-HxCDD	ND/EDL=1.30	18.0	13.6
123789-HxCDD	ND/EDL=1.28	10.5	6.43
1234678-HpCDD	ND/EDL=2.83	358	140
OCDD	EMPC=4.70	2,700	1,320
Furans			
2378-TCDF	ND/EDL=1.08	10.9*	7.12*
12378-PeCDF	ND/EDL=1.84	EMPC=3.36	2.03
23478-PeCDF	ND/EDL=1.65	4.37	2.25
123478-HxCDF	ND/EDL=0.90	7.25	EMPC=6.07
123678-HxCDF	ND/EDL=0.84	2.95	EMPC=2.22
234678-HxCDF	ND/EDL=1.26	6.99	EMPC=3.67
123789-HxCDF	ND/EDL=1.11	EMPC=2.54	EMPC=2.29
1234678-HpCDF	ND/EDL=0.81	49.1	20.1
1234789-HpCDF	ND/EDL=1.00	3.49	2.57
OCDF	ND/EDL=3.17	144	41.3

Notes:

1. ND/EDL = Analyte Not Detected at or above the sample specific Estimated Detection Limit.
2. EMPC = Estimated Maximum Possible Concentration.
3. Concentrations highlighted with an asterisk (*) are from a DB-225 column.
4. Concentrations below the LMCL or above the UMCL are ESTIMATES ONLY.

LMCL = Lowest method calibration limit

UMCL = Upper

Table 1

U0068

SUMMARY OF ANALYTICAL RESULTS

Homologue Group Totals

Date received:	March 31, 1992
Client name:	Columbia Analytical
Laboratory Project Number:	92CA31MR01
Customer Project Number:	Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2071	07APR92LCB2091	07APR92LCB2101
Keystone/NEA Number:	92CA31MR01-MB	92CA31MR01-01	92CA31MR01-02
Customer Number:		K1793-10	K1793-15
Sample Description:	Method Blank	Soil	Soil
		IL-BC-8/9 comp.	CB-B(-2
Units	pg/g (ppt)	pg/g (ppt)	pg/g (ppt)
Dioxins			
Total TCDD	ND/EDL=0.78	5.37	1.06 [2]
Total PeCDD	ND/EDL=0.72	9.34	9.13
Total HxCDD	ND/EDL=1.30	126	95.9
Total HpCDD	ND/EDL=2.83	782	388
Furans			
Total TCDF	ND/EDL=1.08	21.9	20.1
Total PeCDF	ND/EDL=1.65	32.0	12.5
Total HxCDF	ND/EDL=0.84	73.0	16.2
Total HpCDF	ND/EDL=0.81	150	54.7

Notes:

1. ND/EDL = Analyte Not Detected at or above the sample specific Estimated Detection Limit.
2. Concentrations below the LMCL or above the UMCL are ESTIMATES ONLY.

Table 2

00069

SUMMARY OF ANALYTICAL RESULTS

Internal Standard Recoveries

Date received:	March 31, 1992
Client name:	Columbia Analytical
Laboratory Project Number:	92CA31MR01
Customer Project Number:	Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2071	07APR92LCB2091	07APR92LCB2101
Keystone/NEA Number:	92CA31MR01-MB	92CA31MR01-01	92CA31MR01-02
Customer Number:		K1793-10	K1793-15
Sample Description:	Method Blank	Soil	Soil
		1L-BC-8/9 composite	CB-BC-2
Units	%	%	%
Dioxins			
13C-2378-TCDD	51	50	50
13C-12378-PeCDD	66	62	63
13C-123478-HxCDD	68	65	70
13C-123678-HxCDD	91	77	81
13C-1234678-HpCDD	71	75	78
13C-OCDD	61	65	72
Furans			
13C-2378-TCDF	58	47*	56*
13C-12378-PeCDF	45	44	45
13C-23478-PeCDF	48	46	47
13C-123478-HxCDF	75	67	72
13C-123678-HxCDF	71	57	63
13C-234678-HxCDF	50	45	57
13C-123789-HxCDF	68	72	78
13C-1234678-HpCDF	67	58	65
13C-1234789-HpCDF	69	75	79
Clean-Up Recovery Standard			
37Cl4-2378-TCDD	80	73	75

Notes:

1. Recoveries highlighted with an asterisk (*) are from a DB-225 column.

Table 3a

SUMMARY OF ANALYTICAL RESULTS

Internal Standard Recoveries

Date received:	March 31, 1992
Client name:	Columbia Analytical
Laboratory Project Number:	92CA31MR01
Customer Project Number:	Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2111	07APR92LCB2121
Keystone/NEA Number:	92CA31MR01-02MS	92CA31MR01-02MSd
Customer Number:	K1793-15	K1793-15
Sample Description:	Soil	Soil
Units	%	%
Dioxins		
13C-2378-TCDD	46	48
13C-12378-PeCDD	58	56
13C-123478-HxCDD	64	75
13C-123678-HxCDD	71	62
13C-1234789-HpCDD	74	78
13C-OCDD	70	72
Furans		
13C-2378-TCDF	56*	58*
13C-12378-PeCDF	43	44
13C-23478-PeCDF	46	43
13C-123478-HxCDF	62	64
13C-123678-HxCDF	58	59
13C-234678-HxCDF	55	54
13C-123789-HxCDF	70	66
13C-1234678-HpCDF	61	59
13C-1234789-HpCDF	72	77
Clean-Up Recovery Standard		
37Cl4-2378-TCDD	72	72

Notes:

1. Recoveries highlighted with an asterisk (*) are from a DB-225 column.

Table 3b

SUMMARY OF ANALYTICAL RESULTS

Matrix Spike Samples

Date received: March 31, 1992
Client name: Columbia Analytical
Laboratory Project Number: 92CA31MR01
Customer Project Number: Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2101			07APR92LCB2111		
Keystone/NEA Number:	92CA31MR01-02			92CA31MR01-02MS		
Sample Description:	Measured Levels	Spiked Levels*	Spiked Levels**	Theoretical Levels	Measured Levels	% Recy.
Units	pg/g (ppt)	pg	pg/g (ppt)	pg/g (ppt)	pg/g (ppt)	%
Dioxins						
2378-TCDD	1.06	200	44.13	45.19	55.5	123
12378-PeCDD	1.67	1079	238.08	239.75	225	94
123478-HxCDD	2.54	904	199.47	202.01	313	155
123678-HxCDD	13.6	888	195.94	209.54	227	108
123789-HxCDD	6.43	783	172.77	179.20	240	134
1234678-HpCDD	140	1012	223.30	363.30	415	114
OCDD	1,320	1909	421.23	1741.23	2,080	119
Furans						
2378-TCDF	7.12	188	41.48	48.60	72.5	149
12378-PeCDF	2.03	931	205.43	207.46	289	139
23478-PeCDF	2.25	880	194.17	196.42	297	151
123478-HxCDF	6.07	950	209.62	215.69	288	134
123678-HxCDF	2.22	934	206.09	208.31	289	139
234678-HxCDF	3.67	904	199.47	203.14	286	141
123789-HxCDF	2.29	960	211.83	214.12	285	133
1234678-HpCDF	20.1	897	197.93	218.03	266	122
1234789-HpCDF	2.57	948	209.18	211.75	262	124
OCDF	41.3	1842	406.44	447.74	487	109

Notes:

1. Concentrations marked with an asterisk (*) are the absolute amount of each native analyte spiked into the sample -02MS.
2. Concentrations marked with a double asterisk (**) are the spike levels expressed as pg/g (ppt) for a sample weight of 4.532 grams.

Table 4a

SUMMARY OF ANALYTICAL RESULTS
Matrix Spike Samples

Date received: March 31, 1992
Client name: Columbia Analytical
Laboratory Project Number: 92CA31MR01
Customer Project Number: Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2101			07APR92LCB2121		
Keystone/NEA Number:	92CA31MR01-02			92CA31MR01-02MSd		
Sample Description:	Measured Levels	Spiked Levels*	Spiked Levels**	Theoretical Levels (See Note #3.)	Measured Levels	% Recy.
Units	pg/g (ppt)	pg	pg/g (ppt)	pg/g (ppt)	pg/g (ppt)	%
Dioxins						
2378-TCDD	1.06	200	44.55	45.61	49.6	109
12378-PeCDD	1.67	1079	240.37	242.04	215	89
123478-HxCDD	2.54	904	201.38	203.92	228	112
123678-HxCDD	13.6	888	197.82	211.42	274	130
123789-HxCDD	6.43	783	174.43	180.86	253	140
1234678-HpCDD	140	1012	225.44	365.44	284	78
OCDD	1,320	1909	425.26	1745.26	915	52
Furans						
2378-TCDF	7.12	188	41.88	49.00	60.9	124
12378-PeCDF	2.03	931	207.40	209.43	274	131
23478-PeCDF	2.25	880	196.03	198.28	286	144
123478-HxCDF	6.07	950	211.63	217.70	274	126
123678-HxCDF	2.22	934	208.06	210.28	281	134
234678-HxCDF	3.67	904	201.38	205.05	257	125
123789-HxCDF	2.29	960	213.86	216.15	278	129
1234678-HpCDF	20.1	897	199.82	219.92	249	113
1234789-HpCDF	2.57	948	211.18	213.75	240	112
OCDF	41.3	1842	410.34	451.64	433	96

Notes:
1. Concentrations marked with an asterisk (*) are the absolute amount of each native analyte spiked into the sample -02MSd.
2. Concentrations marked with a double asterisk (**) are the spike levels expressed as pg/g (ppt) for a sample weight of 4.489 grams.

Table 4b

00073

SUMMARY OF ANALYTICAL RESULTS

Matrix Spike Samples

Date received:	March 31, 1992
Client name:	Columbia Analytical
Laboratory Project Number:	92CA31MR01
Customer Project Number:	Portland Dist. Dredging 92-HM-183 & 181

MS File Number:	07APR92LCB2111	07APR92LCB2121	Relative
Keystone/NEA Number:	92CA31MR01-02MS	92CA31MR01-02MSd	Percent
Sample Description:	Soil	Soil	Difference
Units	pg/g (ppt)	pg/g (ppt)	%
Dioxins			
2378-TCDD	55.5	49.6	-11
12378-PeCDD	225	215	-5
123478-HxCDD	313	228	-31
123678-HxCDD	227	274	19
123789-HxCDD	240	253	5
1234678-HpCDD	415	284	-37
OCDD	2,080	915	-78
Furans			
2378-TCDF	72.5	60.9	-17
12378-PeCDF	289	274	-5
23478-PeCDF	297	286	-4
123478-HxCDF	288	274	-5
123678-HxCDF	289	281	-3
234678-HxCDF	286	257	-11
123789-HxCDF	285	278	-2
1234678-HpCDF	266	249	-7
1234789-HpCDF	262	240	-9
OCDF	487	433	-12

Table 4c

CHESTER LabNet - Portland

Center for Analytical Mass Spectrometry

TELEPHONE CONTACT LOG

Person: Jim Bullock
Company: Army Corp of Engineers
Address: Portland

Date: 1/26/93 Time: 3pm
Incoming Call:
Outgoing Call: ✓
Telephone No.: 326-6471

Subject: 92CA31MRΦ1

Discussion:
- Our client was Columbia Analytical.
- 2 sediment samples from W. River
- Sample # 92CA31MRΦ1-Φ2 (K1793-15) reported as:

2378-TCDD	1.06 pg/g
Total-TCDD	1.06 pg/g

- He asked for clarification
- I reviewed the Chros and found that there was one peak in the tetradibin window, which passed all QC, and had a concentration of 1.06 ppt. (Estimated)

Action Items:
- However the 2378-TCDD should have been reported as ND/EDL.
- I manually calculated a sample-specific EDL of 1.91 pg/g for that isomer.
- Sample Sz ≈ 5g. LMCL = 2.0 pg/g

Circulation: file
QAHC
LS.

Signature: L. Chamberlain

Houston
Monroeville
Pittsburgh
Portland

12242 S.W. Garden Place
Building One
Tigard, OR 97223
503-624-2773
FAX 503-624-2653

CHESTER LabNet

January 27, 1993

Army Corps of Engineers
Attn: CENPP-PE-HR, Jim Britton
P.O. Box 2946
Portland, Oregon 97208-2946

RE: Sediment Sample # K1793-15
Laboratory Sample # 92CA31MR01-02

Dear Mr. Britton:

Following up on our phone conversation yesterday, I have made the necessary changes to our data package.

To summarize, the concentration of 2378-TCDD in sample "K1793-15" should have been reported as Not Detected at a sample-specific Estimated Detection Limit of 1.91 ppt (ND/EDL = 1.91). The concentration of Total-TCDD was reported correctly at 1.06 ppt.

If you have further questions, please don't hesitate to call me at 624-2183.

Sincerely,

Laura Chambers
Senior Scientist

LC/ms
Enclosures

cc: file
Hank Chambers
Jeff Sprenger

SUMMARY OF ANALYTICAL RESULTS

2378-Substituted Isomers

Date received:	March 31, 1992
Client name:	Columbia Analytical
Laboratory Project Number:	92CA31MR01
Customer Project Number:	Portland Dist. Dredging 92-HM-183 & 181

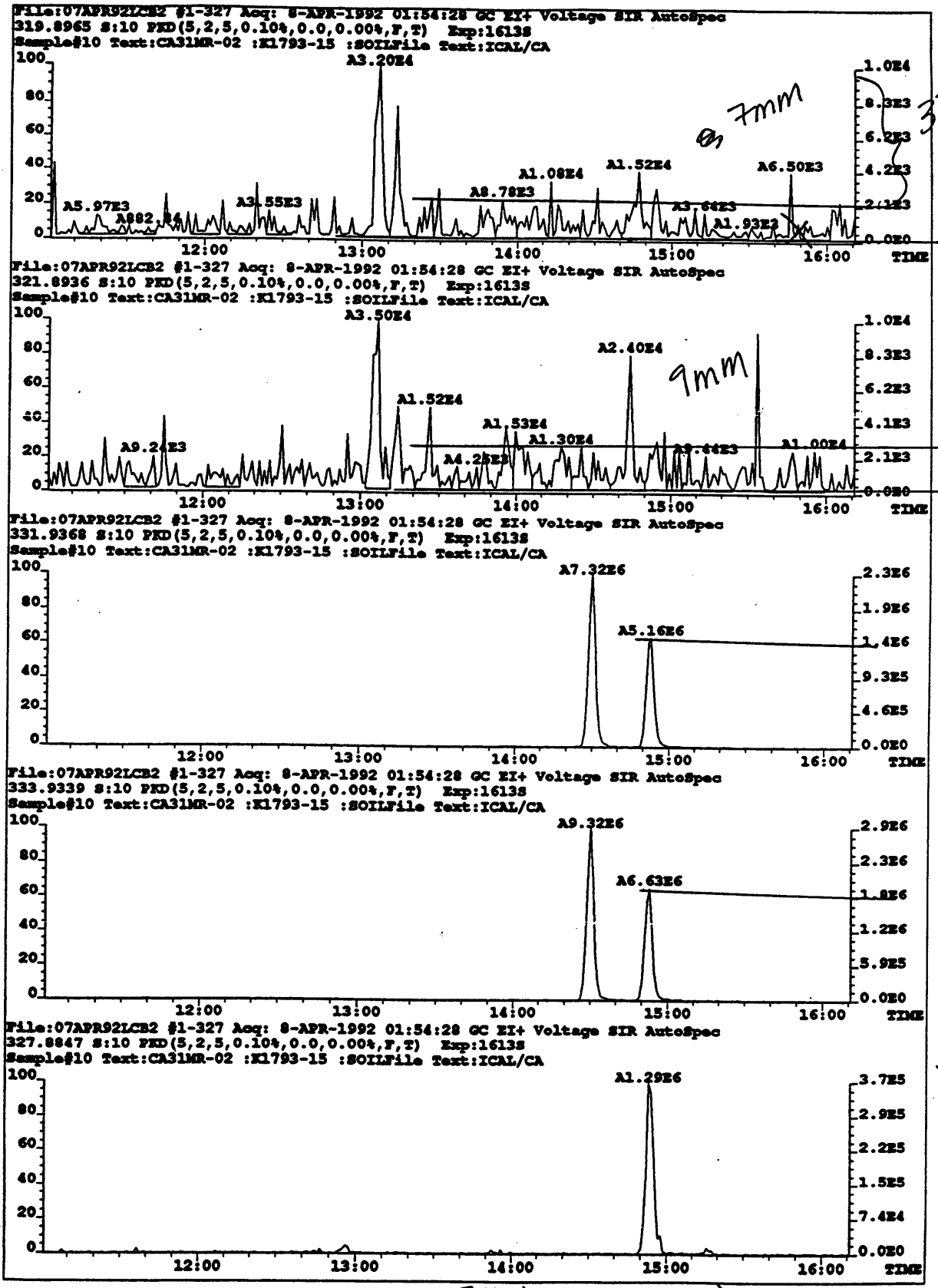
MS File Number:	07APR92LCB2071	07APR92LCB2091	07APR92LCB2101
Keystone/NEA Number:	92CA31MR01-MB	92CA31MR01-01	92CA31MR01-02
Customer Number:		K1793-10	K1793-15
Sample Description:	Method Blank	Soil	Soil
Units	pg/g (ppt)	pg/g (ppt)	pg/g (ppt)
Dioxins			
2378-TCDD	ND/EDL=0.78	EMPC=1.68	~~1.06~~ NO/EDL=1.91
12378-PeCDD	ND/EDL=0.72	EMPC=3.63	EMPC=1.67
123478-HxCDD	ND/EDL=2.30	7.85	2.54
123678-HxCDD	ND/EDL=1.30	18.0	13.6
123789-HxCDD	ND/EDL=1.28	10.5	6.43
1234678-HpCDD	ND/EDL=2.83	358	140
OCDD	EMPC=4.70	2,700	1,320
Furans			
2378-TCDF	ND/EDL=1.08	10.9*	7.12*
12378-PeCDF	ND/EDL=1.84	EMPC=3.36	2.03
23478-PeCDF	ND/EDL=1.65	4.37	2.25
123478-HxCDF	ND/EDL=0.90	7.25	EMPC=6.07
123678-HxCDF	ND/EDL=0.84	2.95	EMPC=2.22
234678-HxCDF	ND/EDL=1.26	6.99	EMPC=3.67
123789-HxCDF	ND/EDL=1.11	EMPC=2.54	EMPC=2.29
1234678-HpCDF	ND/EDL=0.81	49.1	20.1
1234789-HpCDF	ND/EDL=1.00	3.49	2.57
OCDF	ND/EDL=3.17	144	41.3

L 1/26/93

Notes:

1. ND/EDL = Analyte Not Detected at or above the sample specific Estimated Detection Limit.
2. EMPC = Estimated Maximum Possible Concentration.
3. Concentrations highlighted with an asterisk (*) are from a DB-225 column.
4. Concentrations below the LMCL or above the UMCL are ESTIMATES ONLY.

Table 1



& 1/26/93 PSC

$$EDL = 2.5\left[\left(\tfrac{7}{33}\right)(1E4) + \left(\tfrac{9}{33}\right)(1E4)\right] \frac{2270\ ps}{(1.4+1.8)E6\ (4.424g)\ (1.02)} = 1.91\ ppb$$