Results of U. S. Moorings May 1995 Sediment Study

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INTRODUCTION

The berthing areas near docks A and B at the U.S. Moorings have experienced considerable infill and will require dredging if the Essayons and Yaguina are to continue to berth at their present locations. Past sediment quality evaluations have shown the material to be contaminated. The purpose of the 1995 evaluation was to provide additional information as to the nature and extent of this contamination. Each core was subsampled to provide discreet samples representing the proposed dredging prism and each 1-foot interval below the dredging prism. The dredging prism and the first three 1-foot sections below the dredging prism were subjected to chemical analysis.

This report is a summary of results of stratigraphic, physical, and chemical evaluation of sediment cores, collected on May 16, 1995, at the U. S. Moorings located on the west bank of the Willamette River at River Mile (RM) 6.2 (see Figure 1). A total of twelve 4 inch diameter sediment cores were collected from the vicinity of Docks A and B. Sediment lithology was logged and described by Portland State University personnel. The cores were subsampled for chemical and physical analyses which were performed by the USACE Portland Division Material Testing Laboratory or its contract laboratories.

Before describing the 1995 results a little background will be presented reviewing previous physical and chemical data from sediment samples taken in 1989 and 1994 (1,2,3,4,5). Physical and chemical testing of surface sediment samples, collected on June 14, 1994, at the U.S. Moorings were conducted. Surface (approx. 0-5 inches) sediment samples were collected to determine whether serious contamination existed in the area proposed for a small boat moorage. In addition, samples were collected over a representative area of the water portion of the project to create an environmental "image" of the surface sediments. A total of 21 stations were sampled. With compositing, 15 sets of analyses were conducted for TOC, TBT, AVS, metals, PAHs, phenols, phthalates, and pesticides/PCBs. Dioxin/furan analyses were conducted on 4 samples with 2,3,7,8-TCDD detected at 2.0 ppt. In October 1989 three vibracore samples were collected along Dock A, these were tested for contaminants in anticipation of deepening the berthing area for the dredge Essayons. The three samples greatly exceeded established concern levels for the heavy metals lead (Pb), mercury (Hg), and zinc (Zn), several pesticides, and PAHs. Dock A was not dredged as a result of the 1989 evaluation. It was apparent that additional evaluation of the material to be dredged would need to be addressed before considering dredging and management alternatives.

The probable sources of contaminants are speculated to be from upstream. Located upstream from the U.S. Moorings are two Superfund Sites, Doan Lake on the same side of the river and McCormick & Baxter on the opposite side. Adjacent and upstream of the U.S. Moorings is the NW Natural Gas site (previously A.K.A. the Portland Gas and Coke Company and Gasco), an abandoned oil gasification plant, that has soil contaminated with waste products. In 1988 USACE, Portland District collected 16 samples between RM 2.1 nad RM 11.7 (6). Most of the samples were taken along the edges of the navigation channel in the proximity of outfalls and ship moorings. Many of the sediments showed elevated concentrations of the heavy metals cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), and zinc (Zn). There was a high level of DDD and DDT in one sample just upstream from the U.S. Moorings at RM 7.3. The Doan Lake outlet (RM 7.1) appears to be an area of large DDT concentrations.

METHODS

The stratigraphy report prepared by PSU has a complete description of the coring, positioning, and sampling methods. Subsamples were collected for physical and chemical analyses. These samples were labeled as follows: M-ICS-1DP, (A), (B), (C), etc. M is for the U.S. Moorings; ICS is for Impact Coring System; 1 (etc.) is for the core number; DP is for Dredge Prism or A for the first 1-foot interval, B for the second 1-foot interval, and C for the third 1-foot interval. Table 1 provides core elevation data including dredge prism depths and total core lengths. Physical analyses consisted of grain size and volatile solids analyses. Chemical analyses consisted of lead, pesticides, PAHs, TBT, and dioxin/furan analyses.

RESULTS (raw physical and chemical data is contained in Appendix 2)

Physical

Table 2 shows the results of pertinent physical parameters. Due to the presence of contamination only a representative number of samples were subjected to physical analyses. The median grain size was that of medium silt with all samples classified as ML (silt or silt with sand). Percent fines (material passing a 230 sieve) ranged from 75.4% to 95.8% with an average of 94.1% for all samples. Percent clay ranged from 5.7% to 19.4% again with an average for all samples of 15.6%. Volatile solids averaged 9.4% and ranged from 7.5% to a high of 18.3%. A detailed description of core stratigraphy is contained in appendix 1.

Chemical

Metals

The 1994 surface sediment samples were found to be free of heavy metals contamination compared to the 1989 core samples which showed elevated levels of lead (Pb), mercury (Hg), and zinc (Zn). This suggested that elevated metals concentrations are confined to the outer Dock A area or perhaps are located in older deeper sediment layers. No heavy metal concentration exceeded established levels of concern in the 1994 surface samples. Based upon the earlier work, lead (Pb) was the only heavy metal for which chemical analysis was conducted in 1995 (Table 3). Sample M-ICS-7DP exceeded the established screening level of 66 ppm for marine water with a concentration of 322 ppm. A QA duplicate for this sample, M-ICS-7DP QA, had a result of 618 ppm. Sample M-ICS-8C had 416 ppm while M-ICS-12A had 83 ppb. All other sediment samples contained less than 66 ppm lead.

TBT

Six sediment samples were analyzed for tributyltin (TBT) and its degradation produces (DBT and MBT), results are provided in Table 4. No TBT or its decay products were detected in any of the samples at a detection limit of 3 ppb. In the 1994 surface samples TBT exceeded the EPA, Region 10 established concern level (30 ppb) in all of the 15 analyses conducted. Levels ranged from 52 to 410 ppb. It is apparent that TBT contamination is limited to the surface layer at the Moorings.

Pesticides/PCBs

The 1989 cores (3) contained concentrations of dieldrin, DDD, and DDT that exceeded concern levels. No other pesticide was detected. No pesticides were detected in the 1994 surface samples except for DDD, DDE, and DDT. No PCBs were detected in any core (1989) or surface sample (1994). In 1995 a total of 38 sediment samples (plus 4 duplicates) were analyzed for chlorinated pesticides, analyses were not conducted for PCBs based upon previous results. Four duplicates were analyzed for QA/QC. Twelve out of 19 different pesticides were detected, however primary contamination was by lindane, DDT, DDD, and DDE (Table 4). Sixteen samples contained detectable levels of lindane with a maximum value of 540 ppb. DDT was detected in 17 samples with a maximum of 2,500 ppb, DDE in 29 samples with a maximum of 100 ppb, and DDD in 35 samples with a maximum of 2,000 ppb. Due to high levels of sulfur, the EPA Method 8080 Pesticide detection limits were elevated in some samples. It would be safe to say that more hits for pesticides would have been recorded had lower detection limits been achievable. Generally, contamination increased with depth and near dock A (cores 8 through 12).

PAHs

PAHs were detected in all samples collected at the Moorings in 1989, 1994, and 1995. In 1989 total PAHs ranged from 98,850 to 150,460 ppb. In contrast the surface samples taken in 1994 were lower and ranged from 8,374 to 60,230 ppb. The 1994 surface samples collected close to Dock A were more contaminated than other locations. In 1995 of the 38 individual samples analyzed (plus 4 duplicates) all were contaminated with PAHs (Table 5). Low weight PAHs had total concentrations ranging from 2,580 to 503,600 ppb. High weight PAHs had total concentrations ranging from 8,410 to 549,570 ppb.

All of the samples greatly exceeded concern levels for total PAHs as well as established concern levels for total low molecular weight and high molecular weight PAHs. All sixteen individual PAHs were measured in amounts that greatly exceeded concern levels. Generally, contamination increased with depth and off dock A (cores 8 through 12) similar to the pattern noted with the pesticide contamination.

Dioxins/Furans

The cores from 1989 were composited into one sample for dioxin/furans analysis (3). Four surface samples were analyzed in 1994. The results were fairly consistent between the cores and surface samples. The most toxic dioxin congener, 2,3,7,8-TCDD, was detected in the surface samples of 1994 but not the composited core sample of 1989. The concentration ranged from 0.82 to 2.0 parts per trillion (ppt). Six sediment samples were analyzed in 1995, two samples had detectable levels of 2,3,7,8-TCDD at 0.96 and 1.20 ppt (Table 6). There is no current screening level for 2,3,7,8-TCDD in sediment. Thus, the significance of these concentrations, are not easy to evaluate. The furan 2,3,7,8-TCDF was present in all samples tested. Concentrations ranged from 2.0 ppt to 62 ppt with a mean of 35 ppt for all samples.

CONCLUSIONS

Sediment from the U. S. Moorings is clayey, sandy silt high in organic content. PAHs are the major contaminants of concern with individual compounds and total amounts of PAHs detected far above established levels of concern. PAH contamination was evident in all analyses conducted. Pesticides were present but DDT, DDE, DDD, and lindane were the most widespread and present in the highest concentrations. Dioxins and furans were present in all samples though 2,3,7,8-TCDD was found in only 2 of the 6 samples tested. TBT was not detected in any of the 6 samples tested.

Contamination was found throughout the length of the cores. Generally contamination increased with depth and riverside of dock A. Core stratigraphy indicated that the visible contamination is layered within the mud deposits indicating syndeposition. There was no evidence of an active seep, continuous transverse, or longitudinal gradient in contamination abundance. Apparent sharp contacts between product layers and uncontaminated mud indicates low contaminate mobility.

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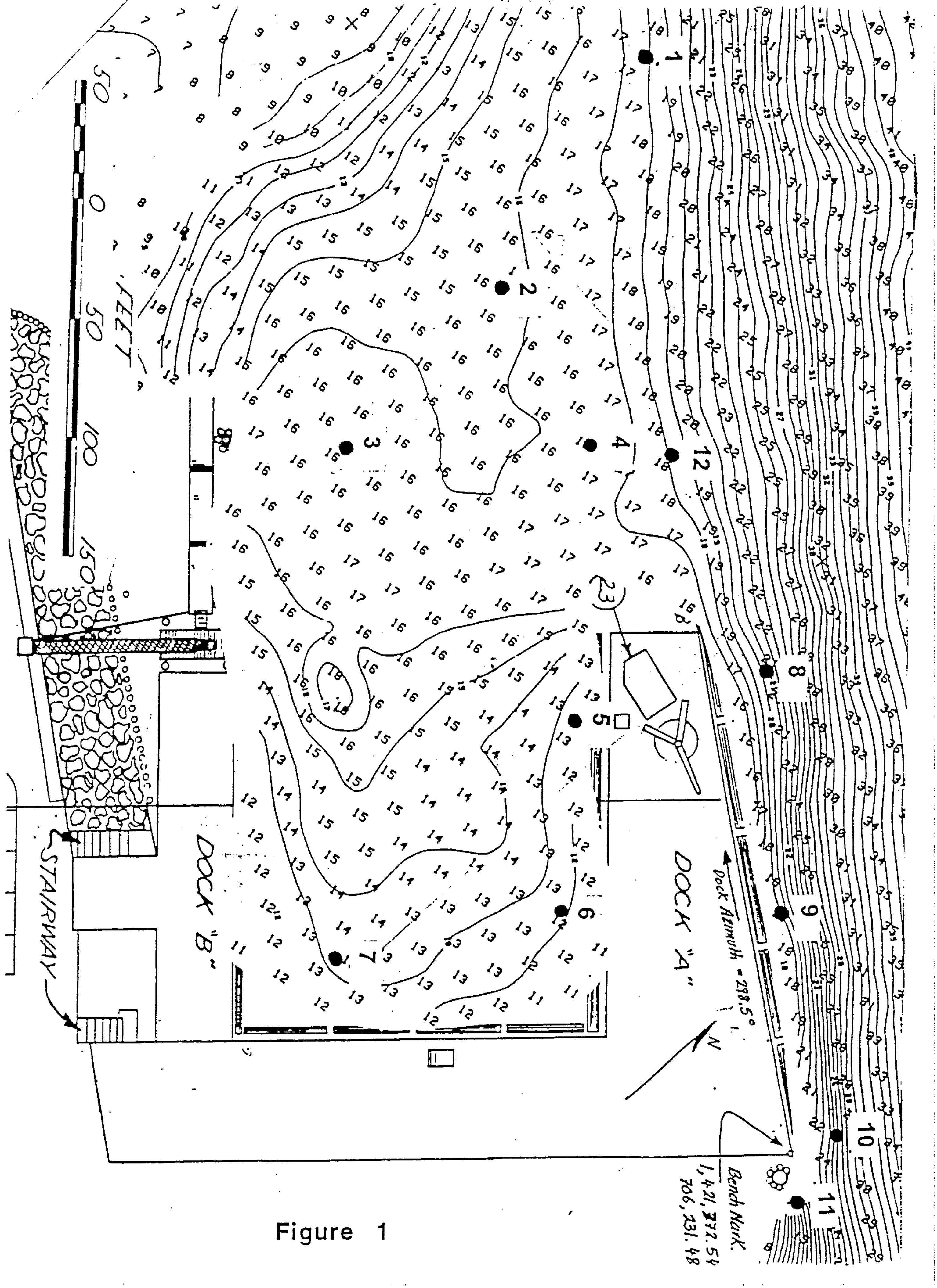
FIGURES


FEET
50
0
50
100
150
STAIRWAY
DOCK "B"
DOCK "A"
Dock Azimuth = 298.5°
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Bench Mark.
1,421,372.54
706,231.48

Figure 1

TABLES

TABLE 1. Core Elevation Data.

Core #	Water Depth Lead Line (ft)	Tide Gage CRD (ft)	Dredging Depth (ft)	Dredging Prism (DP)	Core Length Field Measurment	Core Length Lab Measurment
1	25.2	8.3	20	3.1	9.0	5.0
2	24.0	8.3	20	4.3	7.9	8.1
3	25.0	8.1	20	3.1	8.3	8.7
4	24.6	8.0	20	3.4	8.9	7.7
5	20.8	8.0	18	5.2	8.0	8.2
6	21.0	7.9	18	4.9	8.2	8.5
7	20.1	7.9	18	5.8	5.4	6.2
8	30.0	7.5	28	5.5	8.4	8.8
9	28.0	7.5	28	7.5	7.6	7.2
10	34.5	7.4	28	0.9	8.5	8.4
11	21.0	7.6	28	14.6	3.8	4.0
12	27.5	7.7	28	8.2	14.0	11.5

Location	Sample #	Core Depth
CORE 1	M-ICS-1DP	0.0-3.1
	M-ICS-1A	3.1-
CORE 2	M-ICS-2DP	0.0-4.3
	M-ICS-2A	4.3-5.3
	M-ICS-2B	5.3-6.3
	M-ICS-2C	6.3-
CORE 3	M-ICS-3DP	0.0-3.1
	M-ICS-3A	3.1-4.1
	M-ICS-3B	4.1-5.1
	M-ICS-3C	5.1-6.1
	M-ICS-3D	6.1-7.1
	M-ICS-3E	7.1-
CORE 4	M-ICS-4DP	0.0-3.4
	M-ICS-4A	3.4-4.4
	M-ICS-4B	4.4-5.4
	M-ICS-4C	5.4-6.4
	M-ICS-4D	6.4-
CORE 5	M-ICS-5DP	0.0-5.2
	M-ICS-5A	5.2-6.2
	M-ICS-5B	6.2-7.2
	M-ICS-5C	7.2-

Location	Sample #	Core Depth
CORE 6	M-ICS-6DP	0.0-4.9
	M-ICS-6A	4.9-5.9
	M-ICS-6B	5.9-6.9
	M-ICS-6C	6.9-
CORE 7	M-ICS-7DP	0.0-5.8
CORE 8	M-ICS-8DP	0.0-5.5
	M-ICS-8A	5.5-6.5
	M-ICS-8B	6.5-7.5
	M-ICS-8C	7.5-
CORE 9	M-ICS-9DP	0.0-7.5
	M-ICS-9A	7.5-
CORE 10	M-ICS-10DP	0.0-0.9
	M-ICS-10A	0.9-1.9
	M-ICS-10B	1.9-2.9
	M-ICS-10C	2.9-
CORE 12	M-ICS-12DP	0.0-8.2
	M-ICS-12A	8.2-9.2
	M-ICS-12B	9.2-10.2
	M-ICS-12C	10.2-

TABLE 2: Physical Data.

Location	Site	Date	median mm	sand %finer	vfsand %finer	silt %	clay %	volsol %
CORE 1	M-ICS-1DP	17-May-95	0.019	98.8	96.5	89.0	15.2	8.0
CORE 2	M-ICS-2DP	17-May-95	0.016	99.7	98.3	94.1	15.8	8.5
CORE 3	M-ICS-3DP	17-May-95	0.018	99.4	98.5	92.3	15.6	8.1
	M-ICS-3B	17-May-95	0.013	99.7	98.7	92.9	18.9	8.5
CORE 4	M-ICS-4B	17-May-95	0.02	98.4	91.4	88.0	17.9	7.5
CORE 5	M-ICS-5DP	17-May-95	0.018	99.2	97.6	89.6	17.0	7.6
CORE 6	M-ICS-6DP	17-May-95	0.017	98.8	96.0	95.8	16.7	8.6
CORE 7	M-ICS-7DP	17-May-95	0.021	91.1	83.0	75.4	5.7	18.3
CORE 8	M-ICS-8B	17-May-95	0.019	98.8	93.2	79.1	19.2	9.4
CORE 9	M-ICS-9DP	17-May-95	0.021	97.6	92.7	77.1	17.7	7.9
CORE 10	M-ICS-10DP	17-May-95	0.02	97.0	89.9	75.4	4.0	12.3
CORE 12	M-ICS-12DP uppr	17-May-95	0.017	98.8	94.0	84.7	19.4	8.6
	M-ICS-12DP lowr	17-May-95	0.017	98.8	94.0	84.7	19.4	8.6

TABLE 3: TBT Data.

Location	Site	Date	MBT	DBT	TBT
CORE 2	M-ICS-2B	17-May-95	-3	-3	-3
CORE 3	M-ICS-3B	17-May-95	-3	-3	-3
CORE 6	M-ICS-6B	17-May-95	-3	-3	-3
CORE 8	M-ICS-8DP	17-May-95	-3	-3	-3
	M-ICS-8DP/QA	17-May-95	-3	-3	-3
	M-ICS-8B	17-May-95	-3	-3	-3
CORE 12	M-ICS-12B	17-May-95	-3	-3	-3

TABLE 4: Pesticide Data.

Location	Site	Date	alpha BHC	beta BHC	delta BHC	heptachlor epoxide	endo-sulfan I	endo-sulfan II	endrin aldehyde	endosulfan sulfate	aldrin	chlordane	dieldrin	ddd	dde	ddt	endrin	heptachlor	lindane	toxaphene	methoxy-chlor
CORE 1	M-ICS-1DP	17-May-95	7	-2	-2	-2	-1	-1	-1	-2	-1	-500	2	30	3	10	-2	-1	-1	-4000	-5
	M-ICS-1A	17-May-95	2	-2	-2	7	-1	-1	-1	-2	7	-21	-2	20	2	150	-2	-1	-1	-2000	-5
CORE 2	M-ICS-2DP	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	20	2	-1	-2	-1	-1	-51	-5
	M-ICS-2A	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	20	9	-1	-2	-1	-1	-51	-5
	M-ICS-2B	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-500	-2	40	30	40	-2	-1	-1	-2000	-20
	M-ICS-2C	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	230	30	60	9	-1	-1	-51	-5
CORE 3	M-ICS-3DP	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	30	6	6	4	-1	-1	-1000	-5
	M-ICS-3DP/QA	17-May-95	3	-2	-2	-2	-1	-1	-1	-2	20	-21	3	20	5	-1	-2	-1	-1	-3000	-20
	M-ICS-3A	17-May-95	30	-2	-30	-30	-1	30	-1	-2	-30	-500	-2	50	40	40	-2	-1	10	-3000	-5
	M-ICS-3B	17-May-95	10	-2	-2	-2	-1	7	-1	-2	-30	-21	-2	30	9	-30	-2	-1	4	-2000	-5
	M-ICS-3C	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-500	-5	110	30	10	10	-1	-1	-3000	-5
CORE 4	M-ICS-4DP	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	20	8	8	-2	-1	-1	-3000	-5
	M-ICS-4A	17-May-95	5	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	20	-2	-20	-2	-1	-1	-1000	-5
	M-ICS-4B	17-May-95	3	-2	6	-30	-1	-1	-1	-2	-30	-21	-2	80	7	-1	-2	-1	-1	-2000	-5
	M-ICS-4C	17-May-95	10	-2	-2	-30	6	-1	-1	-2	-1	-21	-2	40	6	-1	-2	-40	-1	-3000	-5
CORE 5	M-ICS-5DP	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-40	-21	-2	30	7	40	-2	-1	5	-3000	-5
	M-ICS-5A	17-May-95	-1	-2	-2	-2	-1	-1	-1	-2	-40	-500	-2	40	7	-1	-2	-1	-1	-4000	-5
	M-ICS-5B	17-May-95	3	-2	3	-20	-1	-1	2	-2	7	-21	-2	90	-30	-40	-2	-1	30	-51	-5
	M-ICS-5C	17-May-95	3	-1	5	-20	-1	-1	-1	-2	4	-21	-2	360	40	-50	-2	2	20	-51	-5
CORE 6	M-ICS-6DP	17-May-95	2	-2	-2	-2	-1	-1	-1	-2	6	-21	-2	80	30	690	-2	-1	40	-51	-5
	M-ICS-6A	17-May-95	5	-2	-2	8	-1	-1	-1	-2	7	-21	-2	50	20	-1	5	-1	40	-51	-5
	M-ICS-6B	17-May-95	6	-2	-2	10	-1	-1	-1	-2	9	-21	-2	-60	40	40	-2	-1	-1	-3000	-5
	M-ICS-6C	17-May-95	6	-2	-2	-2	-1	-1	-1	-2	-20	-1,000	-2	460	-2	-50	-2	-1	160	-3000	-5
CORE 7	M-ICS-7DP	17-May-95	-20	-2	-2	-2	-1	-1	-1	-2	-1	-21	-2	60	-2	-80	-2	-1	240	-2000	-5
	M-ICS-7DP/QA	17-May-95	-80	-80	-80	-80	-80	-80	-80	-80	-100	-3,000	-80	-80	-80	-200	-80	-80	-200	-20000	-300
CORE 8	M-ICS-8DP	17-May-95	2	-2	2	7	-1	6	-1	-2	5	-21	-2	720	9	-50	-2	-1	2	-2000	-5
	M-ICS-8DP/QA	17-May-95	20	-2	-2	-20	-1	-1	-1	-2	-50	-21	7	60	7	-80	-2	-1	9	-3000	-60
	M-ICS-8A	17-May-95	3	-2	8	-2	-1	-1	-1	-2	4	-21	-2	570	40	-120	-2	-1	2	-2000	-5
	M-ICS-8B	17-May-95	-1	-2	-2	4	-1	-1	-1	-2	-1	-500	-2	730	40	-1	-2	-1	-1	-4000	-5
	M-ICS-8C	17-May-95	1	-2	-2	2	-1	-40	-40	-40	4	-500	-2	-40	-1	-40	-2	5	-1	-4000	-100
CORE 9	M-ICS-9DP	17-May-95	-1	-2	2	-2	-1	-1	-1	-2	-1	-21	-2	60	30	-20	-2	-1	-1	-51	-5
	M-ICS-9DP/QA	17-May-95	-20	-2	-2	-30	-1	-1	5	-2	-30	-400	5	80	9	-30	-2	-1	-1	-2000	-30
	M-ICS-9A	17-May-95	-1	-2	-2	-60	-60	-60	-60	-60	-1	-900	-60	1,900	-60	-60	-60	-1	-1	-4000	-200
CORE 10	M-ICS-10DP	17-May-95	-60	-60	-60	-60	-60	-60	-60	-60	60	-1,000	-60	1,200	100	2,500	-60	-60	540	-12000	-300
	M-ICS-10A	17-May-95	6	-2	-2	-60	-60	-60	-60	-60	-1	-21	-60	760	-60	-1	-60	-1	300	-3000	-300
	M-ICS-10B	17-May-95	7	-2	-2	-60	-60	-60	-60	-60	-90	-900	-60	470	-60	-170	-60	-1	360	-4000	-300
	M-ICS-10C	17-May-95	3	-2	-2	5	-1	-50	-50	-50	9	-400	-2	120	3	80	-50	-1	50	-3000	-200
CORE 12	M-ICS-12DP up	17-May-95	1	-2	-2	-2	-1	-1	-1	-2	5	-21	-2	140	40	40	-2	-1	-1	-3000	-5
	M-ICS-12DP lo	17-May-95	4	-2	-2	-20	-1	-1	-1	-2	-30	-500	3	160	5	60	-2	-1	-1	-2000	-5
	M-ICS-12A	17-May-95	-1	-2	-2	-2	-1	-60	-60	-60	-1	-21	-2	1,200	60	200	-2	6	10	-3000	-300
	M-ICS-12B	17-May-95	10	-2	-2	10	-1	-60	-60	-60	-1	-21	-60	-60	-60	-60	-60	5	-1	-4000	-200
	M-ICS-12C	17-May-95	2	-2	-2	-2	-1	-1	-1	-2	5	-900	-2	2,000	70	120	-2	-1	-1	-6000	-5

TABLE 5: Low Weight Polynuclear Aromatic Hydrocarbon Data

location	site	date	2-methyl-naphthalene	acenaph-thene	acenaph-thylene	anthracene	fluorene	naph-thalene	phenan-threne	total lpahs
CORE 1	M-ICS-1DP	17-May-95	<300	900	<300	600	600	550	3,950	6,600
	M-ICS-1A	17-May-95	500	2,340	<300	1,490	1,490	1,040	8,710	15,570
CORE 2	M-ICS-2DP	17-May-95	<300	440	<300	<300	<300	340	1,460	2,240
	M-ICS-2A	17-May-95	1,990	3,880	<300	1,640	2,090	3,680	10,300	23,580
	M-ICS-2B	17-May-95	4,180	3,480	<300	2,790	2,890	2,640	17,700	33,680
	M-ICS-2C	17-May-95	3,980	4,530	<300	3,630	2,690	4,780	20,000	39,610
CORE 3	M-ICS-3DP	17-May-95	<300	1,070	<300	1,120	870	580	6,020	9,660
	M-ICS-3DP/QA	17-May-95	400	1,220	120	720	990	760	5,270	9,480
	M-ICS-3A	17-May-95	21,600	8,480	330	6,260	6,730	2,270	38,400	84,070
	M-ICS-3B	17-May-95	25,600	8,550	550	7,750	7,100	3,700	42,700	95,950
	M-ICS-3C	17-May-95	400	550	<300	900	450	550	4,500	7,350
CORE 4	M-ICS-4DP	17-May-95	<300	350	<300	350	<300	<300	1,880	2,580
	M-ICS-4A	17-May-95	3,950	4,000	<300	5,170	3,610	3,270	31,000	51,000
	M-ICS-4B	17-May-95	2,540	1,790	<300	1,940	1,590	1,040	13,700	22,600
	M-ICS-4C	17-May-95	3,380	1,790	<300	2,190	1,940	1,140	15,600	26,040
CORE 5	M-ICS-5DP	17-May-95	<300	1,090	<300	790	790	540	5,150	8,360
	M-ICS-5A	17-May-95	2,290	2,190	<300	1,890	1,940	1,040	11,800	21,150
	M-ICS-5B	17-May-95	750	1,250	<300	2,450	1,150	750	12,200	18,550
	M-ICS-5C	17-May-95	3,050	3,400	<300	3,740	3,450	1,180	19,200	34,020
CORE 6	M-ICS-6DP	17-May-95	2,600	2,840	1,320	12,200	4,070	1,570	83,800	108,400
	M-ICS-6A	17-May-95	3,900	3,410	<300	2,780	2,680	1,460	15,000	29,230
	M-ICS-6B	17-May-95	12,000	4,880	350	6,920	5,870	2,540	37,400	69,960
	M-ICS-6C	17-May-95	7,680	5,760	300	5,710	5,270	3,400	29,500	57,620
CORE 7	M-ICS-7DP	17-May-95	8,680	9,320	3,220	12,600	11,600	29,800	100,000	175,220
	M-ICS-7DP/QA	17-May-95	3,610	3,660	1,390	5,100	4,260	13,600	44,000	75,620
CORE 8	M-ICS-8DP	17-May-95	1,710	2,440	<300	3,020	2,240	930	16,600	26,940
	M-ICS-8DP/QA	17-May-95	5,850	8,980	630	11,600	8,000	4,100	63,900	103,060
	M-ICS-8A	17-May-95	16,000	25,800	550	17,400	13,900	11,200	89,800	174,650
	M-ICS-8B	17-May-95	12,700	22,100	440	15,800	12,100	9,660	80,400	153,200
	M-ICS-8C	17-May-95	840	6,210	840	4,980	3,000	6,700	25,400	47,970
CORE 9	M-ICS-9DP	17-May-95	5,970	7,860	<300	8,010	6,570	2,390	41,300	72,100
	M-ICS-9DP/QA	17-May-95	10,400	13,500	<300	14,300	14,200	2,670	77,200	132,270
	M-ICS-9A	17-May-95	47,600	70,800	700	45,600	43,600	11,300	284,000	503,600
CORE 10	M-ICS-10DP	17-May-95	9,750	1,130	<300	9,900	10,300	7,940	61,700	100,720
	M-ICS-10A	17-May-95	2,090	3,030	<300	1,290	1,340	3,980	8,110	19,840
	M-ICS-10B	17-May-95	19,600	32,000	700	18,400	21,000	57,700	137,000	286,400
	M-ICS-10C	17-May-95	15,400	22,800	<300	11,400	11,200	25,000	69,000	154,800
CORE 12	M-ICS-12DP uppr	17-May-95	<300	1,670	<300	1,520	1,050	570	7,760	12,570
	M-ICS-12DP lowr	17-May-95	3,800	4,980	<300	5,470	4,040	2,270	27,500	48,060
	M-ICS-12A	17-May-95	5,700	7,780	<300	11,300	8,550	1,500	53,100	87,930
	M-ICS-12B	17-May-95	1,560	8,020	<300	9,100	5,660	3,020	51,500	78,860
	M-ICS-12C	17-May-95	1,190	12,500	<300	7,800	8,280	5,690	48,000	83,460

TABLE 5 (con't): High Weight Polynuclear Aromatic Hydrocarbon Data

location	site	date	benzo-anthracene	benzofluor-anthene	benzo-perylene	benzo-pyrene	chrysene	dibenz-anthracene	ideno-pyrene	fluor-anthracene	pyrene	total hpahs	dibenzo-furan
CORE 1	M-ICS-1DP	17-May-95	1,800	2,950	1,850	1,950	1,850	350	1,750	4,650	5,150	22,300	<300
	M-ICS-1A	17-May-95	3,080	5,130	3,080	3,330	3,180	600	2,980	7,910	8,560	32,720	600
CORE 2	M-ICS-2DP	17-May-95	630	1,170	830	680	780	<300	730	1,650	1,940	8,410	<300
	M-ICS-2A	17-May-95	1,340	2,040	1,690	1,340	1,590	<300	1,390	5,370	5,970	20,730	650
	M-ICS-2B	17-May-95	2,340	3,080	2,440	2,090	2,740	350	1,940	8,410	9,950	33,340	350
	M-ICS-2C	17-May-95	3,830	5,080	3,830	3,880	4,330	500	3,230	13,800	16,500	54,980	<300
CORE 3	M-ICS-3DP	17-May-95	2,520	4,760	3,300	2,570	3,110	490	2,960	7,280	8,350	35,340	<300
	M-ICS-3DP/QA	17-May-95	1,890	3,150	2,240	1,820	2,040	360	2,050	4,960	5,520	24,030	330
	M-ICS-3A	17-May-95	5,970	7,630	5,260	4,450	6,640	810	4,450	17,600	21,800	74,610	1,470
	M-ICS-3B	17-May-95	9,350	11,900	8,700	9,500	9,900	1,350	7,450	28,200	35,000	121,350	1,050
	M-ICS-3C	17-May-95	2,500	4,750	3,000	2,050	3,550	400	2,650	6,850	8,700	34,450	<300
CORE 4	M-ICS-4DP	17-May-95	940	1,630	1,040	1,040	1,140	<300	940	2,770	2,920	12,420	<300
	M-ICS-4A	17-May-95	5,170	5,470	3,320	3,410	5,610	590	3,070	16,400	21,000	64,040	390
	M-ICS-4B	17-May-95	2,340	2,880	1,590	1,490	2,990	<300	1,340	6,570	8,410	27,610	<300
	M-ICS-4C	17-May-95	2,340	2,330	1,340	1,390	3,030	<300	1,000	5,720	8,110	25,260	<300
CORE 5	M-ICS-5DP	17-May-95	2,520	4,260	2,080	1,880	3,120	<300	1,830	6,680	6,780	33,410	350
	M-ICS-5A	17-May-95	3,730	5,820	3,130	3,180	4,380	400	2,890	10,600	11,300	45,430	700
	M-ICS-5B	17-May-95	5,900	10,450	6,550	5,300	7,650	850	6,000	15,900	19,600	78,200	<300
	M-ICS-5C	17-May-95	4,090	5,510	3,550	3,650	4,730	540	3,300	13,600	17,000	55,970	1,330
CORE 6	M-ICS-6DP	17-May-95	26,400	34,600	18,300	20,300	26,300	2,600	18,200	95,900	119,000	361,600	780
	M-ICS-6A	17-May-95	5,850	10,240	5,320	6,290	6,150	1,020	6,000	17,600	19,100	77,570	1,020
	M-ICS-6B	17-May-95	8,710	11,000	6,170	7,560	10,400	1,190	6,320	19,100	25,400	95,850	800
	M-ICS-6C	17-May-95	6,900	10,290	5,370	6,500	7,830	840	5,670	22,600	26,800	92,800	590
CORE 7	M-ICS-7DP	17-May-95	44,200	70,300	39,000	39,100	46,000	7,070	40,900	122,000	141,000	549,570	3,120
	M-ICS-7DP/QA	17-May-95	16,000	27,100	18,600	13,500	18,100	2,970	17,500	46,100	51,700	211,570	1,090
CORE 8	M-ICS-8DP	17-May-95	2,980	3,560	2,290	2,730	3,410	490	2,100	8,050	10,800	36,410	<300
	M-ICS-8DP/QA	17-May-95	15,000	17,370	11,200	14,600	15,000	2,100	10,600	39,300	50,000	175,170	880
	M-ICS-8A	17-May-95	15,400	19,560	11,900	16,500	16,000	1,490	10,600	56,100	68,600	216,150	1,490
	M-ICS-8B	17-May-95	12,800	16,070	9,030	13,300	13,400	1,070	8,450	47,000	57,700	178,820	1,310
	M-ICS-8C	17-May-95	8,620	13,400	8,470	10,600	8,920	940	7,930	30,300	36,900	126,080	<300
CORE 9	M-ICS-9DP	17-May-95	6,170	6,410	2,840	4,330	7,260	400	2,590	17,900	22,300	70,200	700
	M-ICS-9DP/QA	17-May-95	6,230	7,650	5,340	6,650	6,600	1,100	4,970	22,000	26,600	87,140	1,620
	M-ICS-9A	17-May-95	41,300	43,800	19,100	34,700	41,200	3,120	18,400	148,000	175,000	524,620	4,850
CORE 10	M-ICS-10DP	17-May-95	9,710	12,400	6,570	7,790	11,200	880	6,370	37,600	43,400	135,920	13,900
	M-ICS-10A	17-May-95	950	1,500	850	850	1,340	<300	700	4,530	5,170	15,890	<300
	M-ICS-10B	17-May-95	22,400	32,800	17,700	17,300	25,700	2,240	17,200	81,600	90,300	307,240	2,290
	M-ICS-10C	17-May-95	10,300	13,620	8,910	10,600	10,700	1,530	8,810	39,000	45,400	148,870	1,290
CORE 12	M-ICS-12DP uppr	17-May-95	4,290	6,760	2,670	3,950	4,710	380	2,570	10,100	10,600	46,030	330
	M-ICS-12DP lowr	17-May-95	6,350	8,130	5,710	6,750	6,750	1,080	5,270	17,500	22,000	79,540	390
	M-ICS-12A	17-May-95	10,100	11,740	6,230	8,990	11,000	820	5,750	34,300	40,800	129,730	820
	M-ICS-12B	17-May-95	7,920	11,510	8,730	9,390	8,400	1,180	7,780	33,500	37,000	125,410	570
	M-ICS-12C	17-May-95	6,940	8,710	6,080	6,460	7,610	860	5,220	26,800	31,600	100,280	1,000

TABLE 6: Tetra/Octa Clorinated Dioxins and Furans

Location	Site	Date	2378 TCDD	TOTAL TCDD	12378 PECDD	TOTAL PECDD	123478 HXCDD	123678 HXCDD	123789 HXCDD	TOTAL HXCDD	1234678 HPCDD	TOTAL HPCDD	OCDD
CORE 2	M-ICS-2B	17-May-95	-1.20	6.8	-1.9	8.9	2.1	15	5.6	110	270	590	3,400
CORE 3	M-ICS-3B	17-May-95	0.96	3.2	1.1	9.8	3.6	13	6.3	94	220	450	3,100
CORE 6	M-ICS-6B	17-May-95	1.20	6.7	1.9	13.0	4.7	21	6.7	150	420	970	6,900
CORE 8	M-ICS-8DP	17-May-95	-0.80	5.8	1.7	8.9	2.4	17	2.9	120	380	850	5,700
	M-ICS-8DP/QA	17-May-95	-0.77	14.0	-1.3	7.6	3.5	14	4.8	110	250	550	4,300
	M-ICS-8B	17-May-95	-0.95	6.6	0.8	6.7	0.9	9.0	1.5	82	270	550	2,300
CORE 12	M-ICS-12B	17-May-95	-0.64	2.3	1.1	10.0	1.5	13	3.8	120	270	690	4,100

Location	Site	Date	2378 TCDF	TOTAL TCDF	12378 PECDF	23478 PECDF	TOTAL PECDF	123478 HXCDF	123678 HXCDF	234678 HXCDF	123789 HXCDF	TOTAL HXCDF	1234678 HPCDF	1234789 HPCDF	TOTAL HPCDF	OCDF
CORE 2	M-ICS-2B	17-May-95	27	85	34	23	130	78	22	10	11	220	120	21	340	300
CORE 3	M-ICS-3B	17-May-95	62	170	59	36	170	93	29	9.1	10	220	85	22	220	210
CORE 6	M-ICS-6B	17-May-95	32	130	63	36	220	120	36	16	17	360	160	30	530	530
CORE 8	M-ICS-8DP	17-May-95	57	190	150	62	340	270	65	10	48	640	160	40	430	370
	M-ICS-8DP/QA	17-May-95	49	170	90	52	270	140	36	15	16	330	130	23	370	350
	M-ICS-8B	17-May-95	17	82	24	19	100	54	14	3.2	10	280	74	11	170	150
CORE 12	M-ICS-12B	17-May-95	2.0	100	2.6	9.3	110	13	13	5.3	2.5	340	370	3.4	870	130

APPENDIX 1

Stratigraphy of Sediment Cores from the U.S. Moorings Docks A and B, Willamette River, Portland, Oregon

Center for Science Education
Portland State University
Portland, Oregon

GEOLOGY DEPARTMENT

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Karen Garmire
USACE
PO BOX 2946
Portland, Oregon 97208-2946

10/5/95

Dear Karen,

Please find enclosed the final report on the 'Stratigraphy of Sediment Cores from the U.S. Moorings Docks A and B, Willamette River, Portland, Oregon' with the revisions that you requested.

Sincerely,

Curt Peterson, Co-Investigator

c.c. Danil Hancock, Principal Investigator

CHEMICAL DATA

STRATIGRAPHY OF SEDIMENT CORES FROM THE U.S. MOORINGS DOCKS A AND B, WILLAMETTE RIVER, PORTLAND, OREGON

FINAL TECHNICAL REPORT: PART B

Submitted To:

Mark Siipola
U.S. Army Corps of Engineers
Portland, District
Portland, Oregon

By:

Curt D. Peterson, and
Jeffrey A. Jones
Geology Department
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Contract #DACW57-95-M-1499

August 1995

LIST OF FIGURES

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STRATIGRAPHY OF SEDIMENT CORES FROM THE U.S. MOORINGS DOCKS A AND B, WILLAMETTE RIVER, PORTLAND, OREGON

FINAL TECHNICAL REPORT :PART B

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INTRODUCTION AND SCOPE OF WORK

The study design and sampling plan were developed as part of an ongoing investigation by the Portland District Corps of Engneers. Station locations and depth of penetration were confirmed by the contract officer at the time of sampling.

Sediment cores were located using a Sokkia Set 4A Total Station which has an angular precision of 5 " and 5mm + 3ppm (3mm/km) for distance. The Total station was installed on the dock with position relative to the USGS Bench Mark located on the dock. Angles were measured with respect to dock orientaion from the Bench Mark to the NW corner of the dock. In addition to the

Total Station, the positions were checked with the USACOE laser range finder provided by the Portland District. A lead sounding line was used to determine depth to mudline at each location.

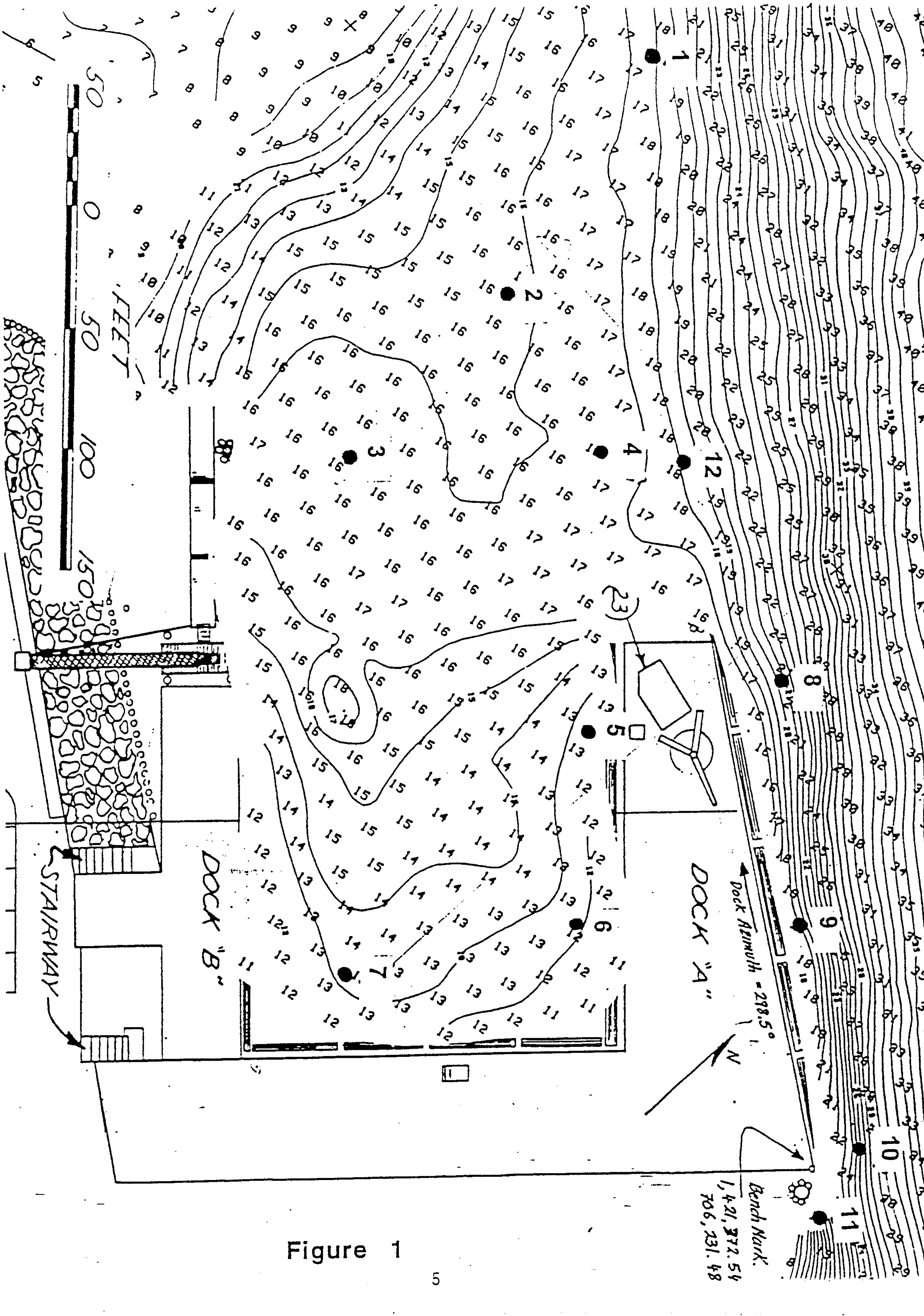
Sediment cores were taken using the impact coring system (ICS) developed and operated by Marine Sampling Systems of Burley, Washington. The system consists of a large tripod frame which supports 4" diameter core tubes up to 20' in length. The cores are driven into the sediment by a non-petroleum based hydraulic impact hammer until the desired penetration is achieved. The number of impacts is controlled manually from the deck of the vessel. Tranducers mounted to monitor and record the penetration of the core tube on the recording fathometer. This system allows the operators to know the progress of the corer and the depth of penetration before retrieving the sample.

Upon retrevial, the depth to sediment surface was measured in the core tube, the excess core tube removed and the core sample measured and marked on the liner to indicate vertical level with respect to the sediment surface, depth of dredge prism and at one foot increments below the dredge prism.

A total of 12 cores were collected from river deposits in the vicinity of the USACE Docks A, B on the Willamette River (Figure 1) in May 1995 for analysis of sediment lithology and possible coal-tar/creosote (product) contamination. The core sites were selected by USACE personnel. Eleven of the cores were extruded on-site by vibration into plastic-wrapped core liners Core #11 was not subsampled for chemical analysis and therefore extruded in the laboratory. Subsampling of the core working halves for determination of contaminant concentration was performed on-site (see Final Technical Report: Part A) and delivered to the U.S. Army Corps of Engineers materials testing laboratory, Troutdale Oregon.

All core archive halves were transported to the PSU Core Lab for core logging and interpretation (this report: Part B). One core (site 11) was taken on a steep embankment, and did not reach contract penetration depth. This short core was frozen, and then thawed prior to extrusion at the PSU Core Lab. No chemical subsampling was performed on this short core.

Archive halves of the 12 cores which were examined were logged for stratigraphic relations of lithology, apparent contaminants, and post-depositional contaminant migration. Lab core logs were drawn to scale and transferred to CAD diagrams (Appendix A). The site stratigraphy was analyzed for potential side-bank or underflow contaminant sources, relative timing of emplacement, and post-depositional migration, based on the observed cores. Two of the logged cores were reopened at the PSU Core Lab for observation by the USACE representative (M. Siipola). Archived cores are presently stored under plastic



FEET
0
50
100
150
STAIRWAY
DOCK "B"
DOCK "A"
Dock Azimuth = 298.5°
N
Bench Mark
1,421,372.54
706,231.48

Figure 1

wrap at room temperature in the PSU Core Lab, awaiting final disposal by the USACE.

METHODS

Prior to core extrusion, the core catcher was removed and the contained sediment was described for general lithology. The bottom of the core was visually examined for any evidence of missing core sections, i.e, gaps above the core catcher. Finally, the unfilled portion of the top of the core pipe was measured to the nearest 0.1 foot to quantify core-section shortening.

Estimates of core recovery and shortening are based on measured starting pipe length, core penetration reported by the driller, and the measured unfilled inner pipe length (Figure 2). The unfilled inner pipe length is the distance from the top of the pipe to the contact with sediment in the core pipe. This distance was measured on-site prior to core extrusion (Appendix B). The outer exposed pipe length is taken to be the difference between the starting pipe length and the reported core penetration. The exposed pipe length is subtracted from the unfilled pipe length to predict the amount of core shortening.

Core shortening is common in vibra-coring/ram coring. It can result from compression or rodding during penetration, and/or loss of the core bottom during pull-out. A lack of apparent core gaps above the core catcher (except for core 12) suggests complete retention of core sections from sites 1-11. The lack of resistant sand or debris layers in the extruded cores (except for core 7) suggests that compression rather than rodding is the likely cause of apparent core shortening. For this report we assume that shortened core lengths for all cores except #11 and #12 (see below) are due entirely to compression.

Archived cores were unwrapped and scraped (horizontally) to remove oxidized mud surfaces prior to core logging at the PSU core lab. Cores were logged to the nearest 0.1 foot interval with respect to lithology, e.g., mud, sand, wood chips, and apparent contaminant concentrations (Appendix C). Lithological contacts were drawn (sharp or gradational) at units of at least 0.5 foot in thickness. Thinner strata are drawn as layers (0.05-0.5 foot thickness) or laminae (less than 0.05 foot thickness).

A generalized core log is shown in Figure 3. Core lithologies are defined on the basis of grain size, and sediment composition. Major recognized lithologies include mud (clay/silt and less than 10% sand), sandy mud (less than 50% sand) muddy sand (more than 50% sand) and sand (less than 10% silt and clay). These lithologies are based on visual observations, and are considered to be qualitative in nature. Sand size is given as fine sand (less than 250 microns in diameter) unless otherwise noted as medium size sand. Visual grain-size estimates were obtained using an ACS grain size comparison card. These estimates are considered to be semi-quantitative in nature. Lithology contacts

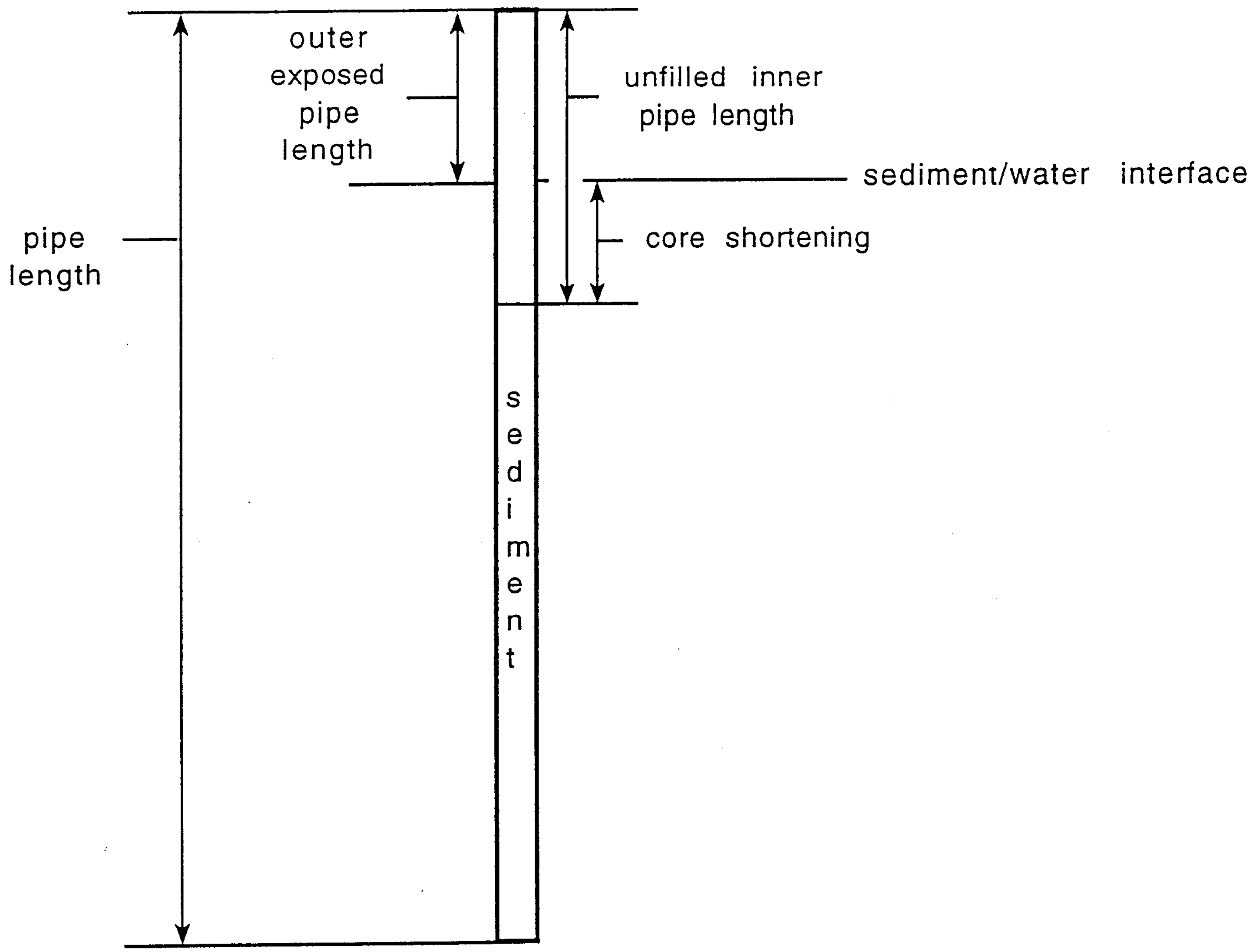

outer
exposed
pipe
length
unfilled inner
pipe length
sediment/water interface
pipe
length
core shortening
s
e
d
i
m
e
n
t

Figure 2

are defined as gradual or sharp, based on observed 90% gradient of change over a distance of 0.05 foot.

Contaminant concentrations (product) in the core sediments were logged on the basis of color, strength of distinctive petroleum odor, and apparent sheen (Appendix C). Color was determined from a Munsel color chart. Background sediment color (uncontaminated mud unexposed to oxidation) was observed to range between very dark gray (5Y 3/1) to dark olive gray (5Y 3/2). Product contaminated sediments, as identified by distinctive petroleum odor, are black. They range from 2.5Y 2/0 to 5Y 2.5/1 in color. Deposits with the strongest petroleum odors were observed to display a blue-black sheen. A few thin layers with exceptionally reflective sheens were observed to be semi-liquid, suggesting very-local concentrations of nearly pure product. The contact relations, distribution and relative abundance of product contaminated muds are described under the Results Section.

RESULTS

Distribution of Core Sites

Cores were taken at three sites along the east side of Dock A (adjacent to the open channel) in water depths 20-34 feet (Figure 1). Four sites were cored between Dock A and Dock B in 20-24 feet water depth. These water depths were recorded on the coring platform and are shown in Table 2. Several additional sites to the north of the slip were also occupied, with one site (#12) reaching 16 feet subsurface depth. One core site (#11) was taken at the east corner of Dock A, but it did not reach contract depth. No cores were taken upstream of the USACE Docks. None of the recovered cores penetrated to river channel sands, reported to be about 20 feet below MSL in the vicinity of Docks A and B (Geotechnical Resources, Inc., 1990). However, increasing layers and/or laminae of sandy mud towards the bottom of core site 12 might indicate proximity to the underlying channel sands at that site.

Penetration and Recovery

Records of reported core penetration, measured core recovery and estimated core shortening are shown in Table 1. Cores #1,2,3,4,5,6, and #8,9,10 penetrated to 11 feet depth subsurface. Cores #8 and #11 are estimated to have penetrated to 9 feet and 7-8 feet depth, respectively. Core site 12 is reported to have reached about 16 feet depth subsurface. Core site elevations relative to Columbia River Datum (CRD) are shown in Table 2. Subsurface depths of core samples taken for contaminant analysis are shown in Table 3, however, the results of those analyses are presented elsewhere.

Core catcher lithologies are dominated by mud for all cores sites except sites #10 and #12 (Appendix B). No core gaps were observed above the core catchers from any of the core sites. Section recovery is assumed to be 100% for

Key to Shading and Abbreviation

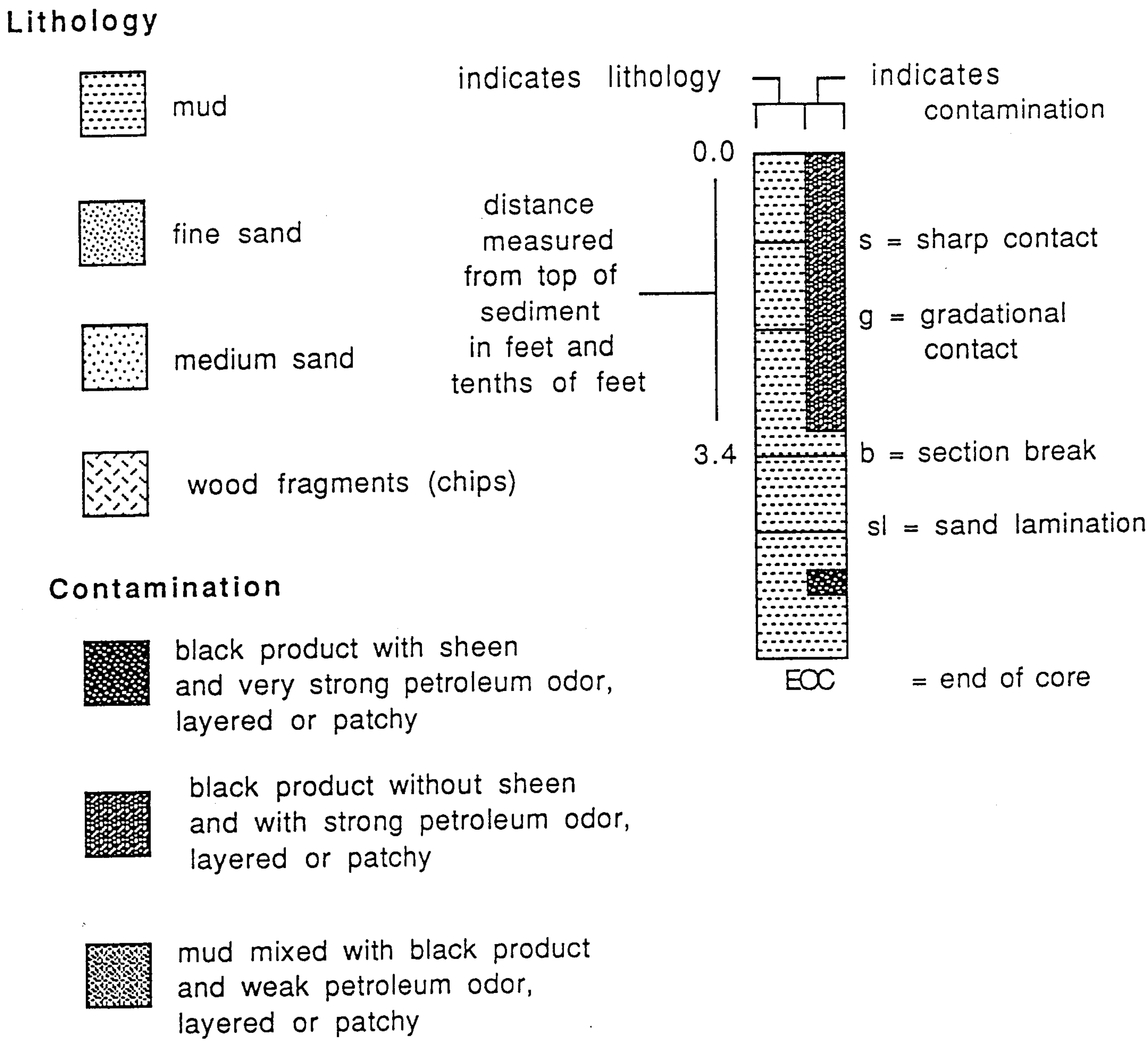


Figure 3

all cores except site #12 which might have lost up to two feet from the core bottom, based on the measured section length, and observed sand in the rim of the empty core catcher (Table 1).

Core shortening is estimated to range between 21% and 32% for cores #1,2,3,4,5,6, and 10. The core shortening is assumed here to result from compression of the mud during core penetration. Vibra-core compression of 10-30% is common for vibra-coring/ram coring of shallow mud in the lower Columbia River (Peterson et al., 1994). Exceptionally high compression (39%) is estimated for core #7. This core encountered a thick wood chip layer at about 3.5 feet depth subsurface. This layer might have been responsible for the large amount of estimated compression. Finally, core #12 is estimated to have only 12% percent of compression, assuming that two feet of core section is missing from the bottom of the core. Alternatively, if all of core #12 shortening is assumed to be due to compression then the estimated compression would total 24%.

TABLE 1 CORE PENETRATION AND ESTIMATED COMPRESSION

Core #	Starting Pipe Length (x.x feet)	Reported Penetration (feet)	Outer Exposed (feet))	Inner Unfilled Pipe) (feet	Compresion Pipe(feet)	Compresion (%)
1	12.0	11.2	0.8	3.6	2.4	21%
2	12.0	11.4	0.6	4.2	3.6	32%
3	12.0	11.4	0.6	3.7	3.1	27%
4	12.0	11.4	0.6	3.1	2.5	22%
5	12.0	11.1	0.9	4.0	3.1	28%
6	12.0	11.2	0.8	3.8	3.0	27%
7	12.0	08.9*	3.1	6.6	3.5	39%
8	12.0	11.0	1.0	3.7	2.7	25%
9	12.0	11.2	0.8	4.4	3.6	32%
10	12.0	11.2	0.8	3.5	2.7	24%
11	12.0	11.2	0.8	8.0		
11adj. **		07.8	0.2	2.4	3.1	31%
12***	17.5	16.0	1.5	3.5	2.0	12%

Notes:

* Core 7 hit dense wood chip layer at 3.75 feet depth, reduced penetration and increased compression.

** Core 11 was taken on inclined slope (assume 33°). Adjusted 'vertical' measurements (11 adj.) are taken to be 0.66 of reported values. The core catcher fingers were bent backwards upon corer pullout, resulting in partial core loss.

*** Core 12 recovered 11.5 feet of sediment (see core log). Reported recovery is 15.5 feet. Either the bottom 2.0 feet of core was lost or compression is twice that estimated (12% x 2=24%). Heavy currents at this site may have made penetration estimates (by driller) unreliable.

Table 2 Core Elevation Data

Core #	Water Depth Lead Line (ft)	Tide Gage CRD (ft)	Dredging Depth (ft)	Dredge Prism (DP)	Core Length Field Measure (ft)	Core Length Lab Measure (ft)
1	25.2	8.3	20	3.1	9	5
2	24.0	8.3	20	4.3	7.9	8.1
3	25.0	8.1	20	3.1	8.3	8.7
4	24.6	8.0	20	3.4	8.9	7.7
5	20.8	8.0	18	5.2	8	8.2
6	21.0	7.9	18	4.9	8.2	8.5
7	20.1	7.9	18	5.8	5.4	6.2
8	30.0	7.5	28	5.5	8.4	8.8
9	28.0	7.5	28	7.5	7.6	7.2
10	34.5	7.4	28	0.9	8.5	8.4
11	21.0	7.6	28	14.6	3.8	4
12	27.5	7.7	28	8.2	14	11.5

Table 3 Core Samples

Location	Sample #	Core Depth (ft)
Core 1	M-ICS-1DP	0.0-3.1
	M-ICS-1A	3.1-
Core 2	M-ICS-2DP	0.0-4.3
	M-ICS-2A	4.3-5.3
	M-ICS-2B	5.3-6.3
	M-ICS-2C	6.3-
Core 3	M-ICS-3DP	0.0-3.1
	M-ICS-3A	3.1-4.1
	M-ICS-3B	4.1-5.1
	M-ICS-3C	5.1-6.1
	M-ICS-3D	6.1-7.1
	M-ICS-3E	7.1-
Core 4	M-ICS-4DP	0.0-3.4
	M-ICS-4A	3.4-4.4
	M-ICS-4B	4.4-5.4
	M-ICS-4C	5.4-6.4
	M-ICS-4D	6.4-
Core 5	M-ICS-5DP	0.0-5.2
	M-ICS-5A	5.2-6.2
	M-ICS-5B	6.2-7.2
	M-ICS-5C	7.2-
Core 6	M-ICS-6DP	0.0-4.9
	M-ICS-6A	4.9-5.9
	M-ICS-6B	5.9-6.9
	M-ICS-6C	6.9-
Core 7	M-ICS-7DP	0.0-5.8
Core 8	M-ICS-8DP	0.0-5.5
	M-ICS-8A	5.5-6.5
	M-ICS-8B	6.5-7.5
	M-ICS-8C	7.5-
Core 9		
	M-ICS-9DP	0.0-7.5
	M-ICS-9A	7.5-
Core 10	M-ICS-10DP	0.0-0.9
	M-ICS-10A	0.9-1.9
	M-ICS-10B	1.9-2.9
	M-ICS-10C	2.9-
Core 12	M-ICS-12DP	0.0-8.2
	M-ICS-12A	8.2-9.2
	M-ICS-12B	9.2-10.2
	M-ICS-12C	10.2-

Condition of Cores

Core sedimentary structures were observed for evidence of penetration or vibratory-extrusion disturbance. Such features might include parting, convolute beds, down-bowed (convex-up) layers, and sand intrusion contacts along core-pipe walls. These features were rare to non-existent in the observed cores. The recovered core sections are considered to be intact and relatively undeformed, with the exception of depth variable compression. Exposed core surfaces were substantially oxidized to a depth of about 0.05 foot. The oxidation largely hid evidence of core contamination, as the contaminated sections oxidized to colors similar to those of the uncontaminated muds. The black color of the contaminated layers might, in part, result from local iron reduction (Fe^{++}) associated with clays/hydroxides in contact with the organic-rich (low Eh) product.

Core Logs

Laboratory core logs are shown for each of the 12 cores in Appendix C. Generalized CAD diagrams of the core logs are in Appendix A.

Core #1 is dominated by mud and shows little or no apparent contamination. The mud increases in firmness from top to bottom of the measured five foot section.

Core #2 is dominated by mud, and shows substantial contamination, increasing with depth from 3 feet to the End of Core (EOC) at 8 feet measured depth. Some contaminate layers have sharp upper and lower contacts indicating event deposition and little post-depositional mobility in the muds.

Core #3 is dominantly mud, with substantial contamination from 2.5 feet to EOC at 8.5 feet measured depth. Several layers at 3 feet , 4 feet, 6-7 feet and 8 feet depth in core #3 display black product sheens with petroleum odor. Contaminated layers below four feet depth are generally continuous (across-core) and show sharp contacts. Upper contaminated zones (2-4 feet depth) are patchy, suggesting resuspension and deposition of product saturated rip-ups and mud balls.

Core #4 is dominated by mud and has some contaminated layers at depths of 3.7 feet, 4.6 feet, 5.1 feet and 6.8 feet. A sandy layer is associated with the contamination at 3.7 feet depth in core #4.

Core #5 is mud with substantial contamination at measured depths of 3.3-4 feet, about 5 feet, 7-8 feet. A medium sand layer was observed at EOC in core #5. The vertically continuous contaminated zone from 3.2-4 feet is finely laminated suggesting contaminant deposition over many depositional cycles. By comparison, thick layers of contaminant are found at the greater depths of 5 and

7-8 feet. These thick layers in the lower core sections imply direct deposition of concentrated product out of the water column.

Core #6 is dominated by mud with muddy sand layers at four feet and 8.2-8.4 feet. Apparent contamination starts at about 3.5 feet and increases down core to EOC at about 8 feet depth in core #6.

Core #7 changes from mud (0-3.5 feet depth) to wood chips contaminated by black product (petroleum odor) to a measured depth of six feet.

Core #8 is dominated by mud, but contains one sand layer at 5 feet depth and several sand laminae at greater depths. The core shows patchy contamination at the core top, and decreasing contamination down core to about seven feet depth.

Core #9 is dominated by mud, and has substantial contamination at measured depths of 2-4 feet, and 5.5-7 feet depth. There is no apparent migration of the black product across a sharp bottom contact with mud at the bottom of the wood chips (six feet depth).

Core #10 is missing the top 4.0 feet of section. See adjacent core #11 for representative lithology. The remainder of core #10 shows relatively little contamination with black layers restricted to 4.5-5 feet, 6 feet and 7.5 feet measured depth.

Core #11 is dominated by mud, and shows relatively little contamination in the upper four feet, the maximum penetration of this short core. (The bottom of this core was lost on pullout as was evidenced by reversed core catcher fingers).

Core #12 is dominated by mud with sand layers and sand laminae increasing in thickness and frequency at depths below five feet. The core shows contamination starting at the surface and increasing in concentration with depth to 10 feet. A detrital wood chip layer, oxidized mud clasts and medium sand laminae between 10 and 11.5 feet depth might indicate proximity to channel sands below.

DISCUSSION

The cores taken in the vicinity of the USACE Docks A and B record continuous sections of mud accumulation to depths of 10-15 feet subsurface (Core Logs Appendix A). The thick muds have been deposited over river channel sands, reported to be about 20 feet depth below MSL. The recovered mud sections apparently represent a relatively brief period of time (half a century) as indicated by the presence of product contaminants down to end of core (EOC) depths. First order estimates of net sedimentation rate during this interval are on the order of 0.2-0.4 feet per year, i.e, 10-15 feet in 50 yr. It is not known what extents such high sedimentation rates are due to local flow conditions around the USACE Docks, or system wide sedimentation in the lower reaches of the Willammetter River. Additional coring is needed to test whether high sedimentation rates occur along channel margins located upriver of the study area.

The contaminants (black product) are layered within the mud deposits, indicating syndepositional origins for both materials. There is no evidence of immediate side bank or underflow supply of the contaminant at the USACE Docks A, B. For example, contaminated cores are found both inside the slip (cores #5,6,7) and on the open channel side of Dock A (core# 9)(Figure 2). An across-channel margin traverse of cores #3, 2, 4 and 12 shows no continuous gradient in contaminant abundance from southwest to northeast. Nor is there any apparent trend in contaminant abundance upstream-downstream within the study site. Additional cores outside the study area are needed to address potential upriver-sources of the contaminant, and to discriminate between on-site and off-site contaminant supply (see Recommendations).

The apparent distribution of contaminant product varies from continuous (across-core) layers to patchy discontinuous zones. This variability suggests different mechanisms of contaminant transport and deposition, ranging from concentrated product deposition to product/mud resuspension and redeposition. A general decrease in apparent contaminant concentration upsection in 7 out of the 11 recovered cores (Appendix A) indicates a diminished supply of the contaminant product in recent years. However, weakly laminated- and/or very patchy distributions of product in 4 out of the 11 upper core sections indicates recent resuspension and redeposition of contaminant at those sites. The time histories of contaminant supply rate and of contaminant resuspension-redeposition at the USACE Docks are not well constrained. Deeper cores (to subsurface depths of 20 feet) are needed to fully characterize the contaminant distribution throughout the mud sections in the study area (see Recommendations).

The apparent sharp contacts between product layers and uncontaminated mud in the recovered cores demonstrate very low mobility of the product in the muds. The lack of continuous diffusion gradients in the upper core-sections confirm the general immobility of the contaminant in the undisturbed mud deposits. Physical disturbance of these deposits is likely to be the most important mechanism of ongoing contaminant dispersal in the study area (see Recommendations).

RECOMMENDATIONS

The observed down-core distribution of deposit contamination in the study area is based on the relative color and odor characteristics of discrete layers and patchy areas in the sediment. The chemical sampling of bulk sediment intervals in this investigation was not performed to discriminate between contaminated and uncontaminated sediment layers. We suggest that a calibration curve of sediment color -to- product concentration be developed from representative cores to better quantify contaminant stratigraphy in the study area deposits.

Specific origins of the contaminants in the study area were not established in this study. Additional off-site coring and late-historic dating of the contaminated deposits are necessary to constrain the timing and supply of contaminants to the USACE Dock sites. We recommend that Cs-137 dating be performed on representative cores from the study area to constrain the timing of the original contaminant deposition and the timing of apparent resuspension-deposition of the contaminant(s). Cs-137 dating is based on atmospheric bomb-blast markers from the late 1950s to early 1970's. In addition, GC-Mass Spec. or HPLC should be used to better finger-print the contaminant(s) and establish late-historic changes (upcore) in contaminant supply. Deeper coring (to 20 feet depth subsurface) is needed to identify the onset of contamination in the study area. These stratigraphic tools can be used to establish the time history of sediment contamination and contaminant redistribution in the lower Willamette River system.

Finally, the distribution of contaminant at some core-tops indicates the ongoing mixing of product into modern sediments. The origin of the contaminant resuspension (on-site or upriver) is not known. However, the presence of patchy contamination in the upper core sections suggests near bottom transport of product-weighted mud flocks, rip-ups and mud balls. Additional analysis of natural and artificial sediment resuspension in this reach of the lower Willamette River is required to constrain mechanisms of future contaminant resuspension and dispersal in the study area.

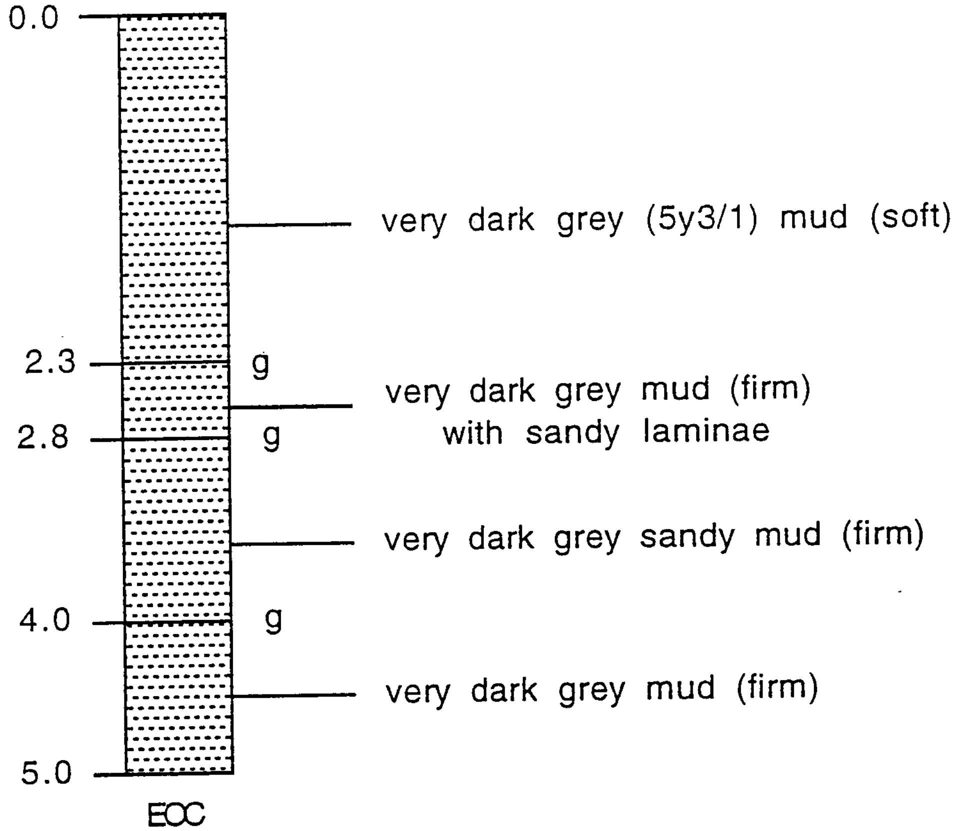
REFERENCES

Geotechnical Resources Inc., 1990. Site Plan and Cross Section A-A'. from Borings made by USACE. Job 683, Figs. 2 and 3, provided by M. Siipola (USACE, Portland District).

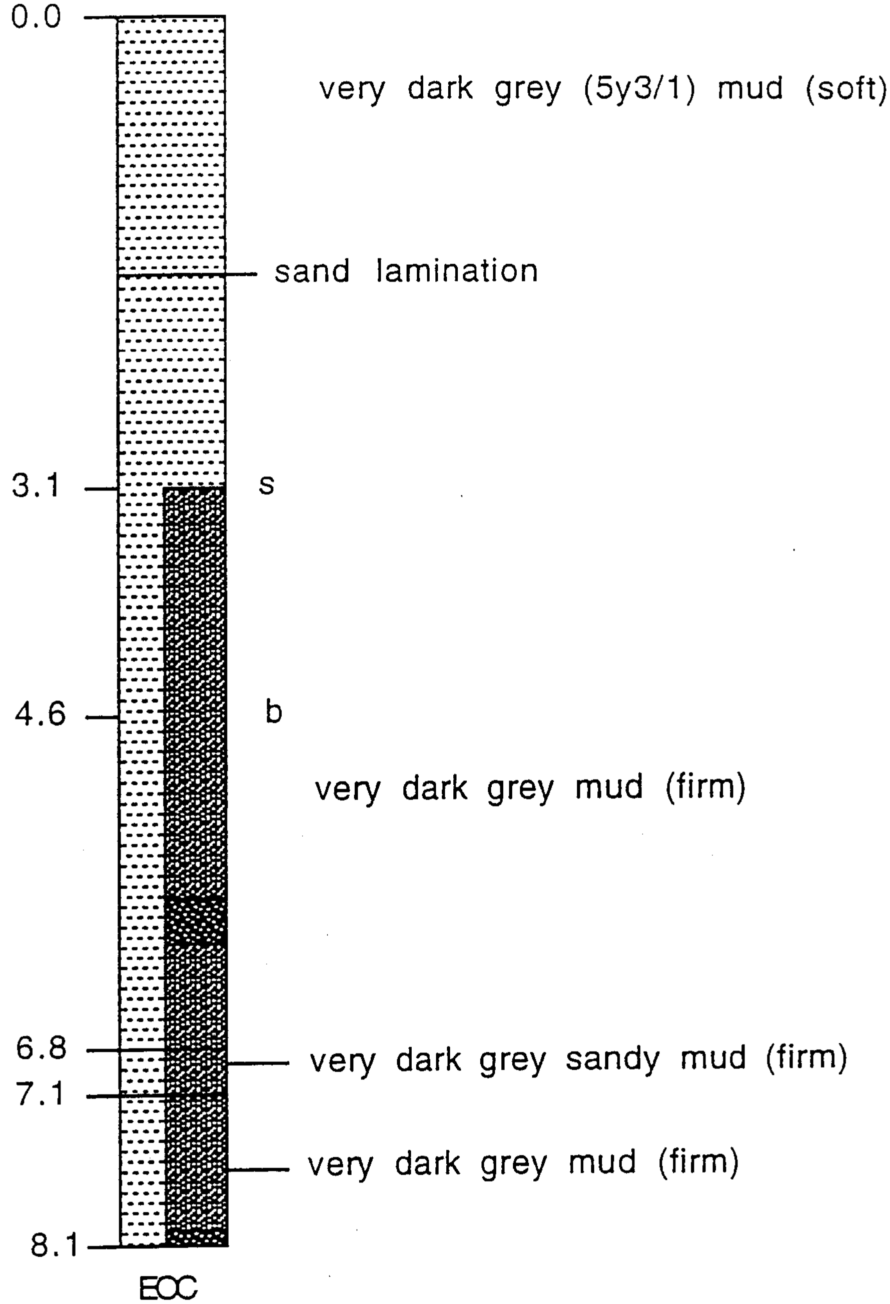
Peterson, B., C. D., Peterson, K., Volker, J., Wyatt, M., Marsh, G., Rose, and T. Horning, 1994. Vibracore subsurface investigation of late Holocene liquefaction site in the central Cascadia Margin: Hunting Island, Columbia River, Washington. Field Study Report to U.S. Geological Survey, 12 p.

APPENDIX A GENERALIZED CORE LOGS

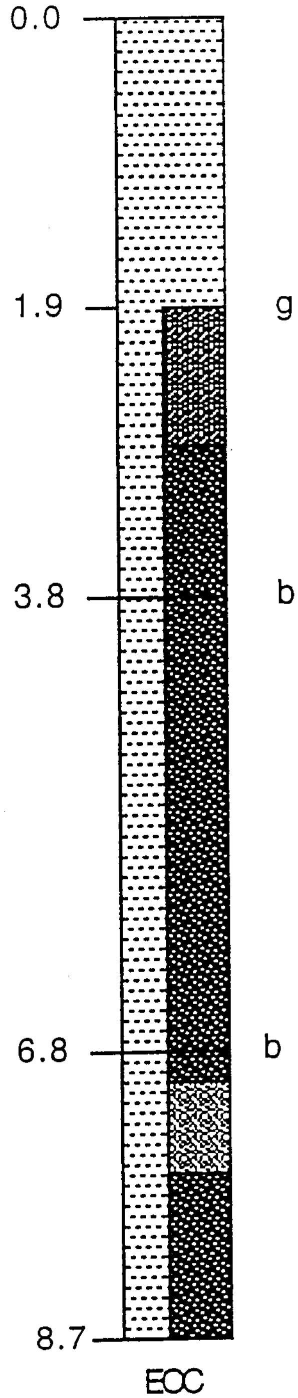
Appendix A Core #1



Appendix A Core #2

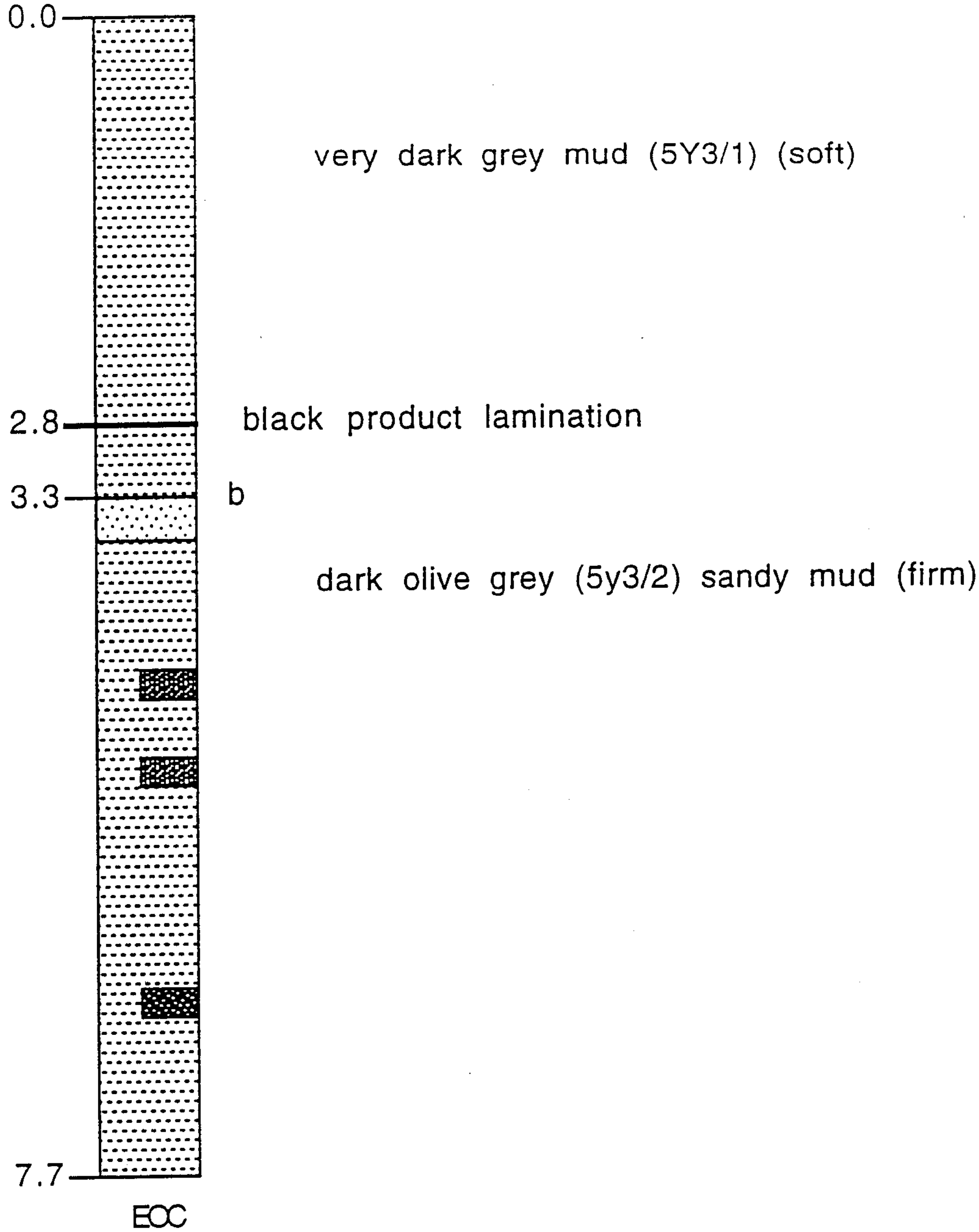


Appendix A Core #3

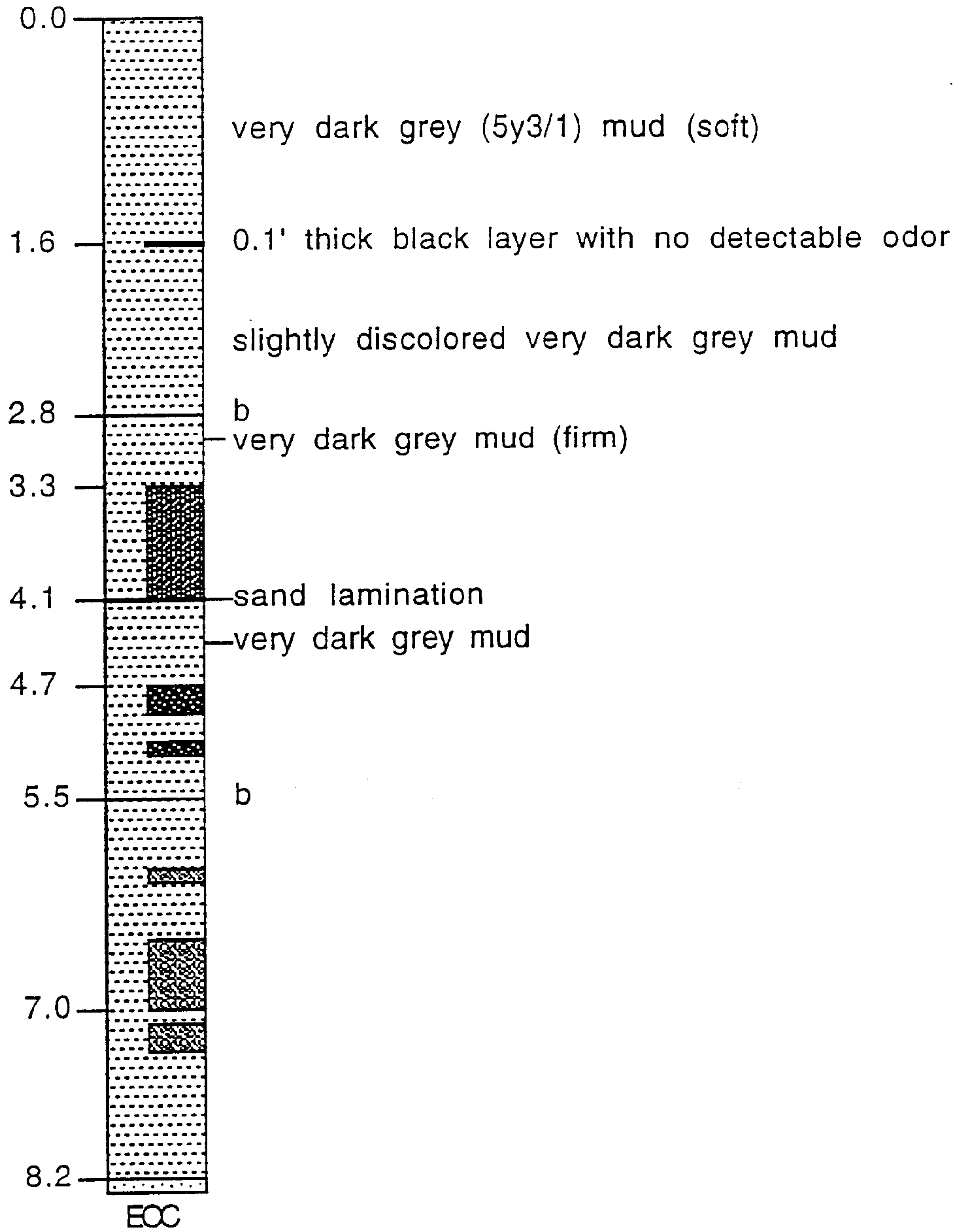


very dark grey (5y3/1) mud (soft)

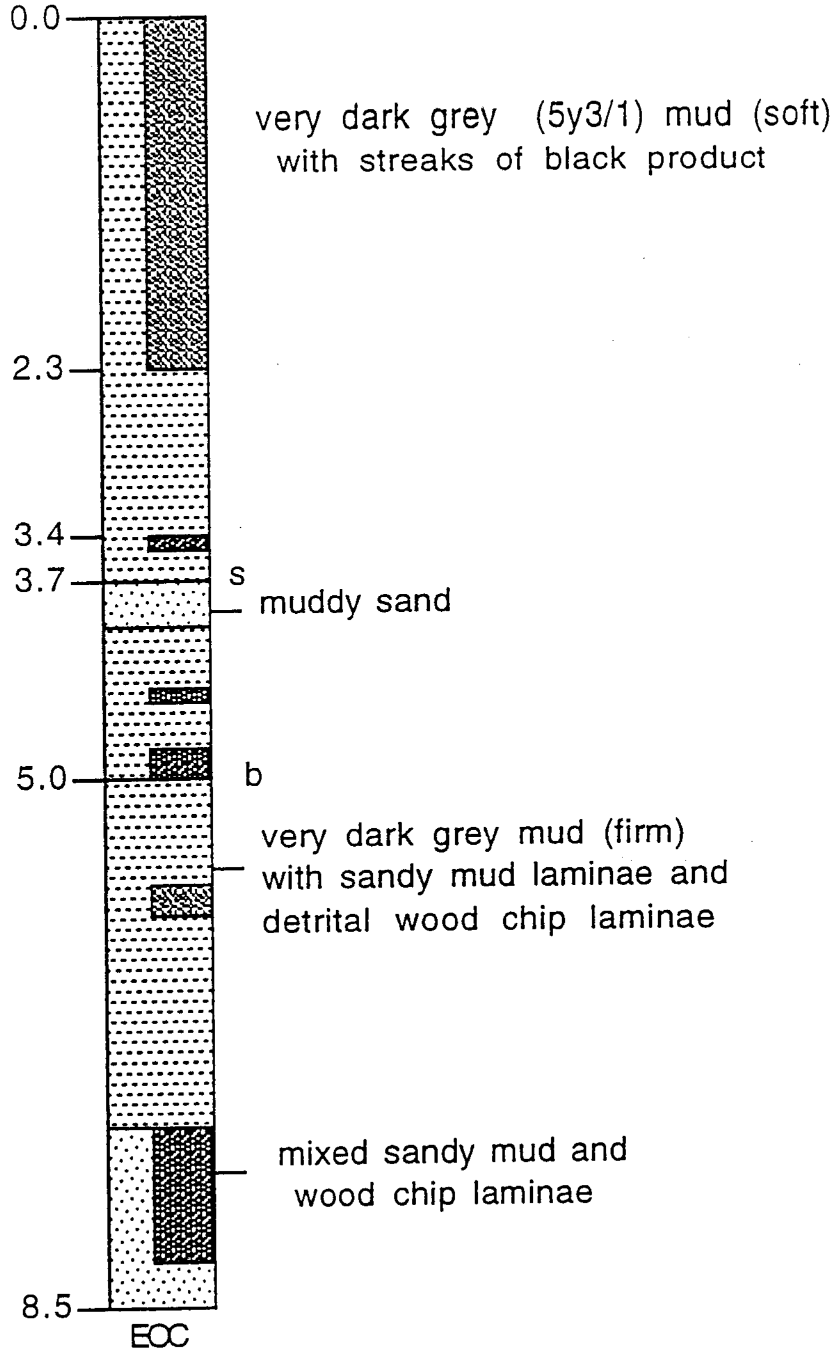
Appendix A Core #4



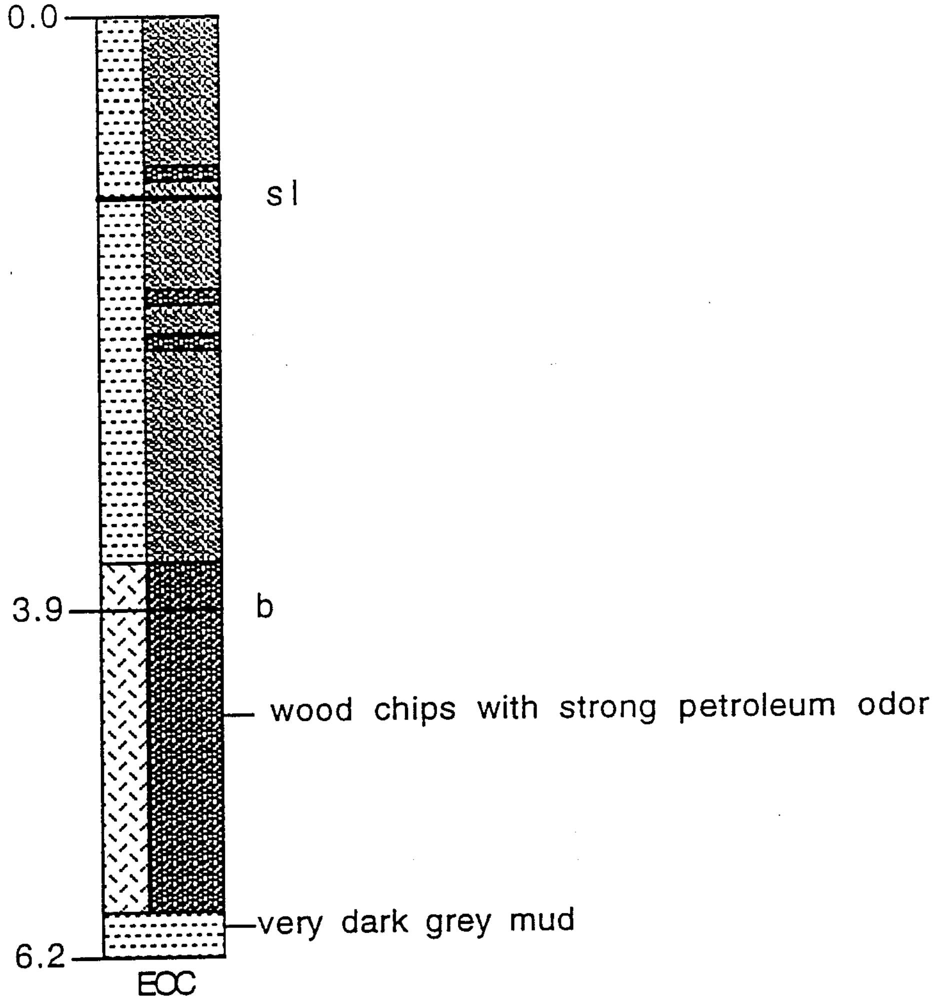
Appendix A Core #5



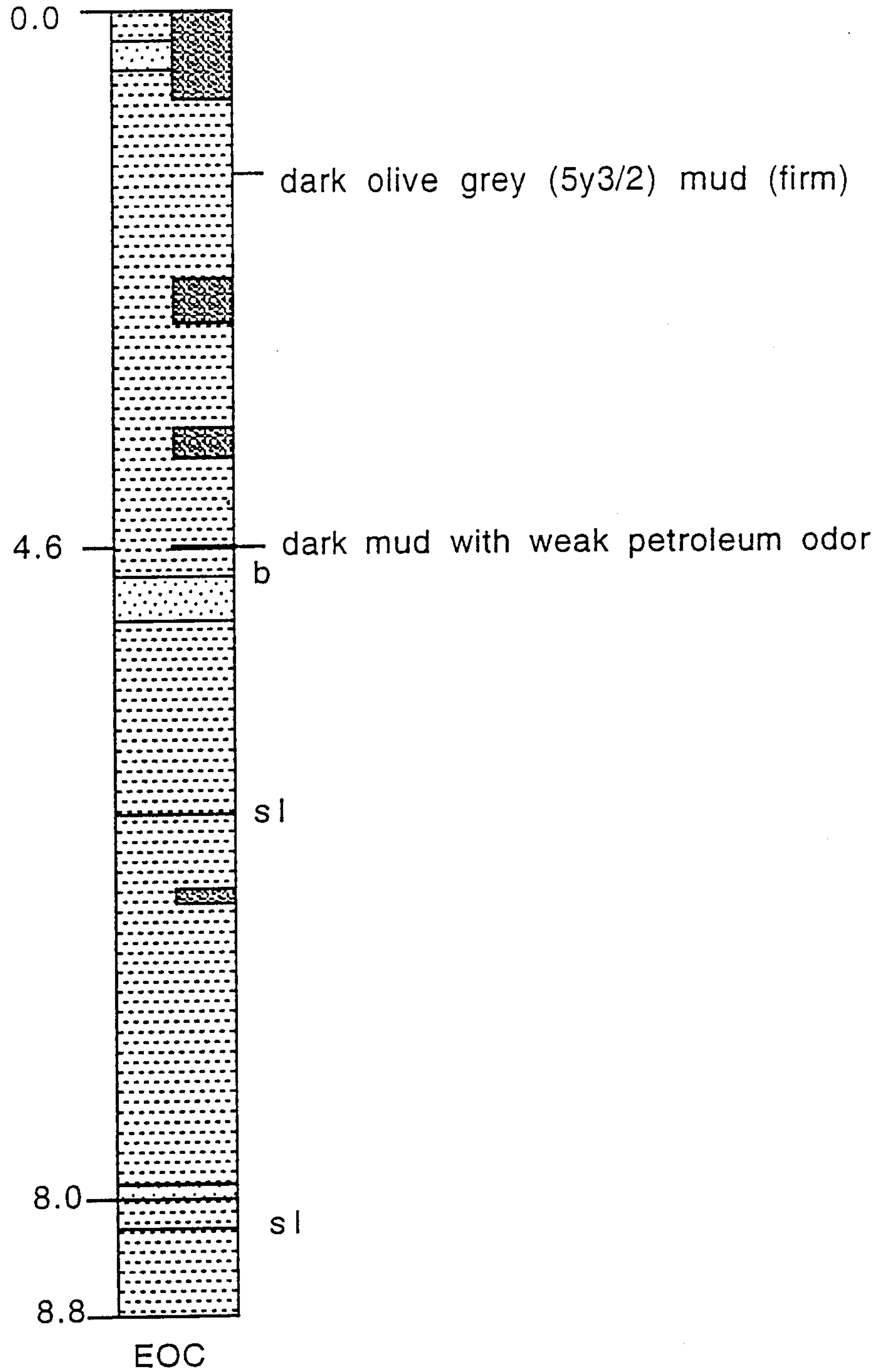
Appendix A Core #6



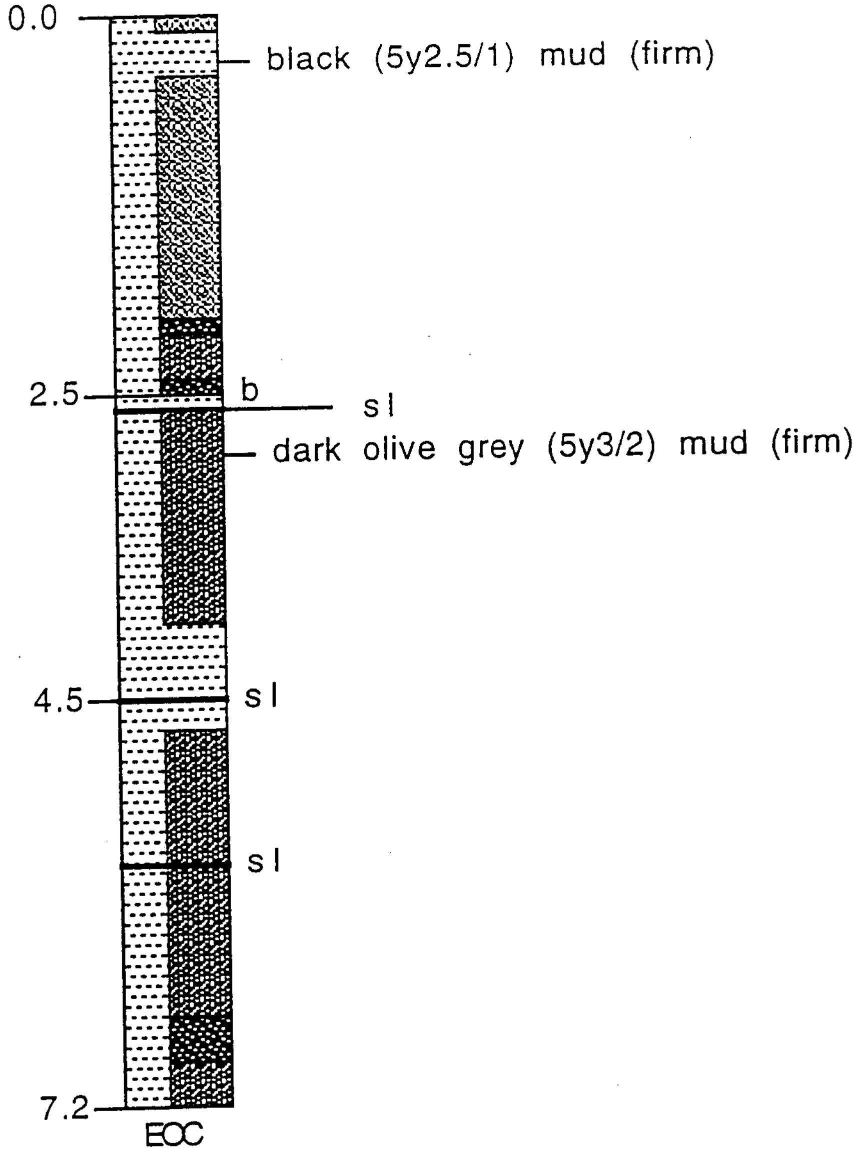
Appendix A Core #7



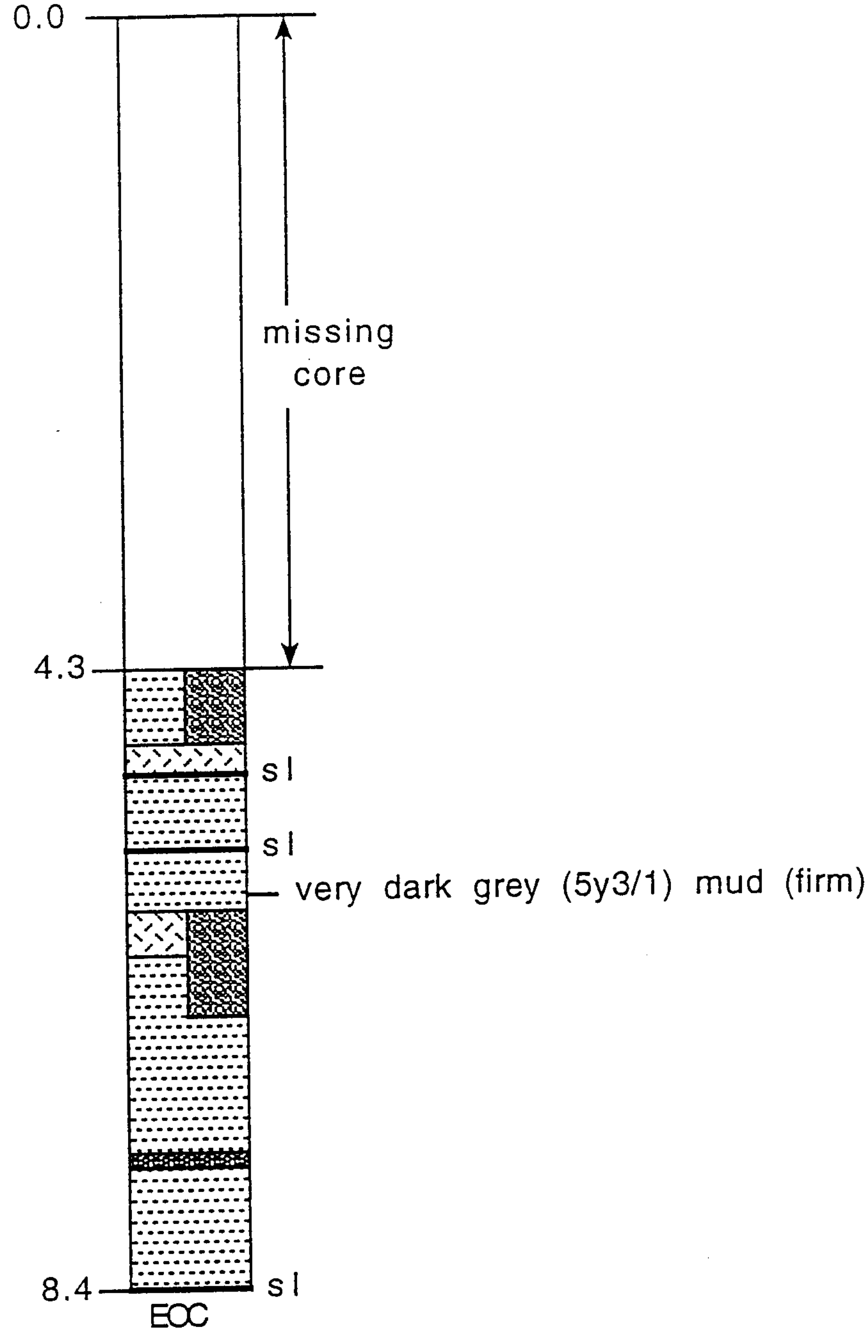
Appendix A Core #8



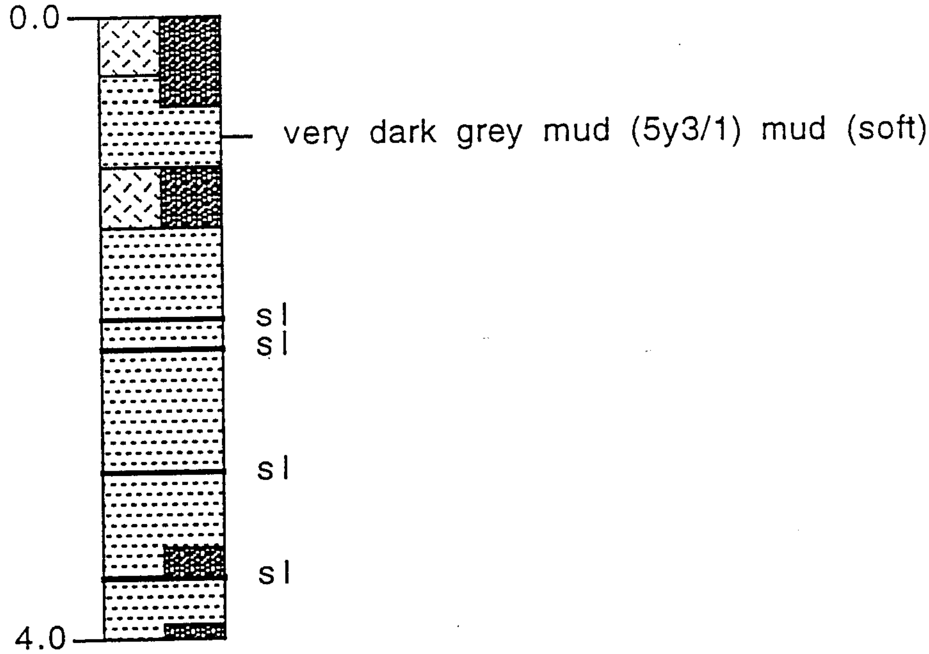
Appendix A Core #9



Appendix A Core #10

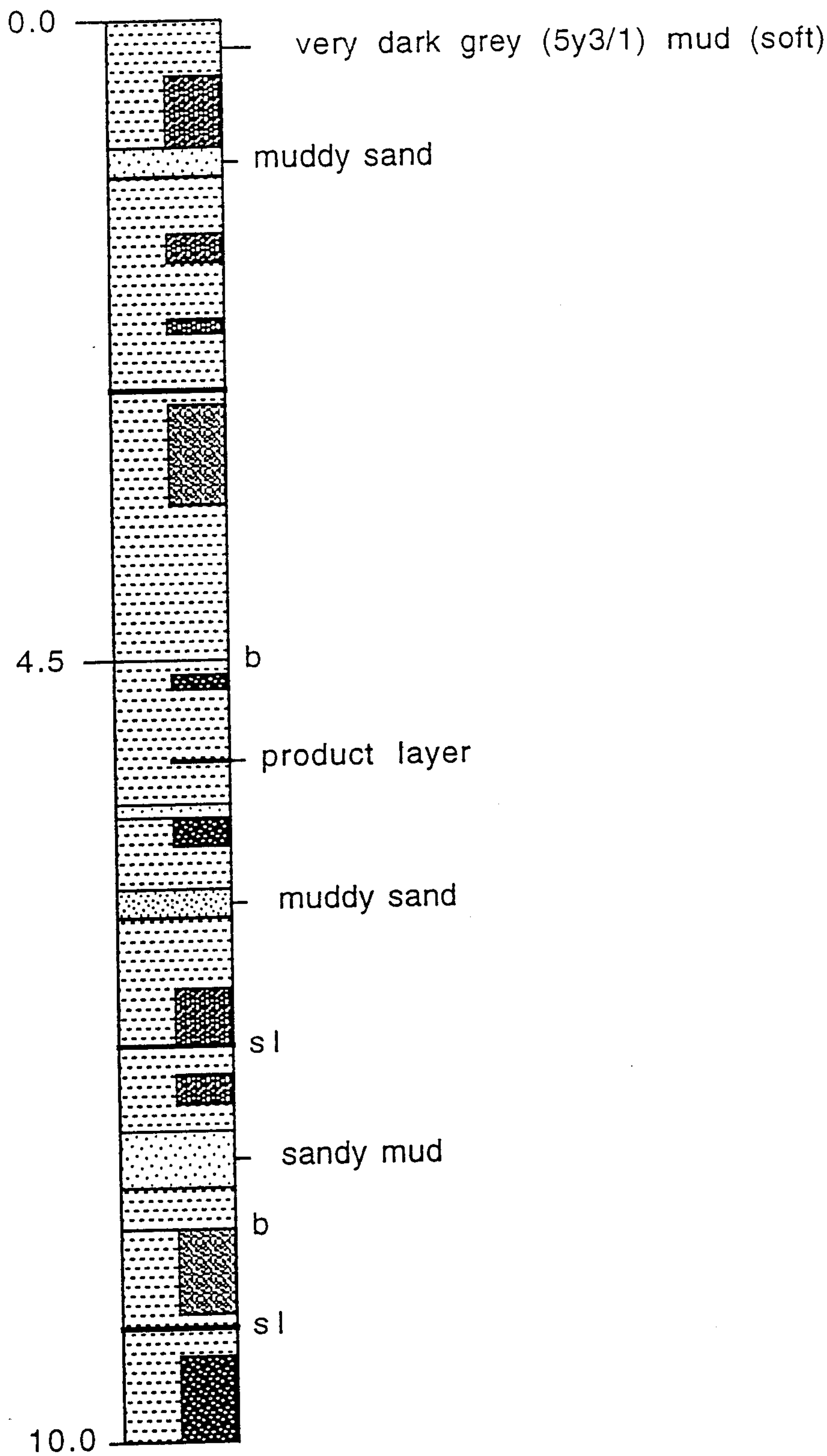


Appendix A Core #11

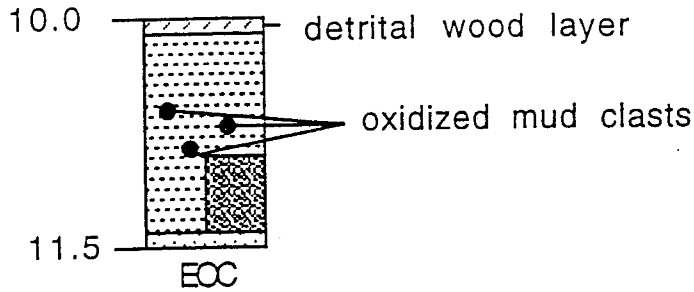


*all depths should be reduced by 1/3 -- assuming core taken on 33 degree slope.

Appendix A Core #12A



Appendix A Core #12B



APPENDIX B CORE SITE FIELD NOTES

SITE #	TIME	WATER DEPTH (FT, IN)	MAX. PEN. (FT, IN)	INNER CORE GAP (FT, IN)	RECOVERED CORE (FT, IN.)
5/16 1	9:34	~~23~~ 25.2	~~8.11~~ 11.2	~~0.38~~	
STIFF SILT					
2.	~10:15	24.0	~~11.2~~ 11.4	~~0.49.6~~	
organics/mud					
3	~~10:55~~ 10:55	~~23.2~~ 25	11.4	0.44	0.100
mud/organics (t.or)					
4	11:24	24.0	11.4	0.37	
mud/org.					
5	11:47	20.8	11.1	0.48	
mud/org					
6	12:13	21.0	11.2	0.46	
mud/org (some sand/oil)					
7	1:10	20.1	8.9	0.79	
mud/org/wood					
~~8~~ 11	1:55	~21	11.2	0.96	
thick mud/oil (~45° slope) ARCHIVE →					
10	3:30	~~39.7~~ ~~38.6~~ 34.5	11.2	~~41.5~~ 0.42	
hollow, residue sand					
9	4:30	28	11.2	0.53	
dense mud/organics (oily)					
8	5:11	30	~11	0.43	
5/17 12	10:09	28	16	0.42	
mostly empty, some sandy mud					

APPENDIX C DRAWN-TO-SCALE CORE LOGS

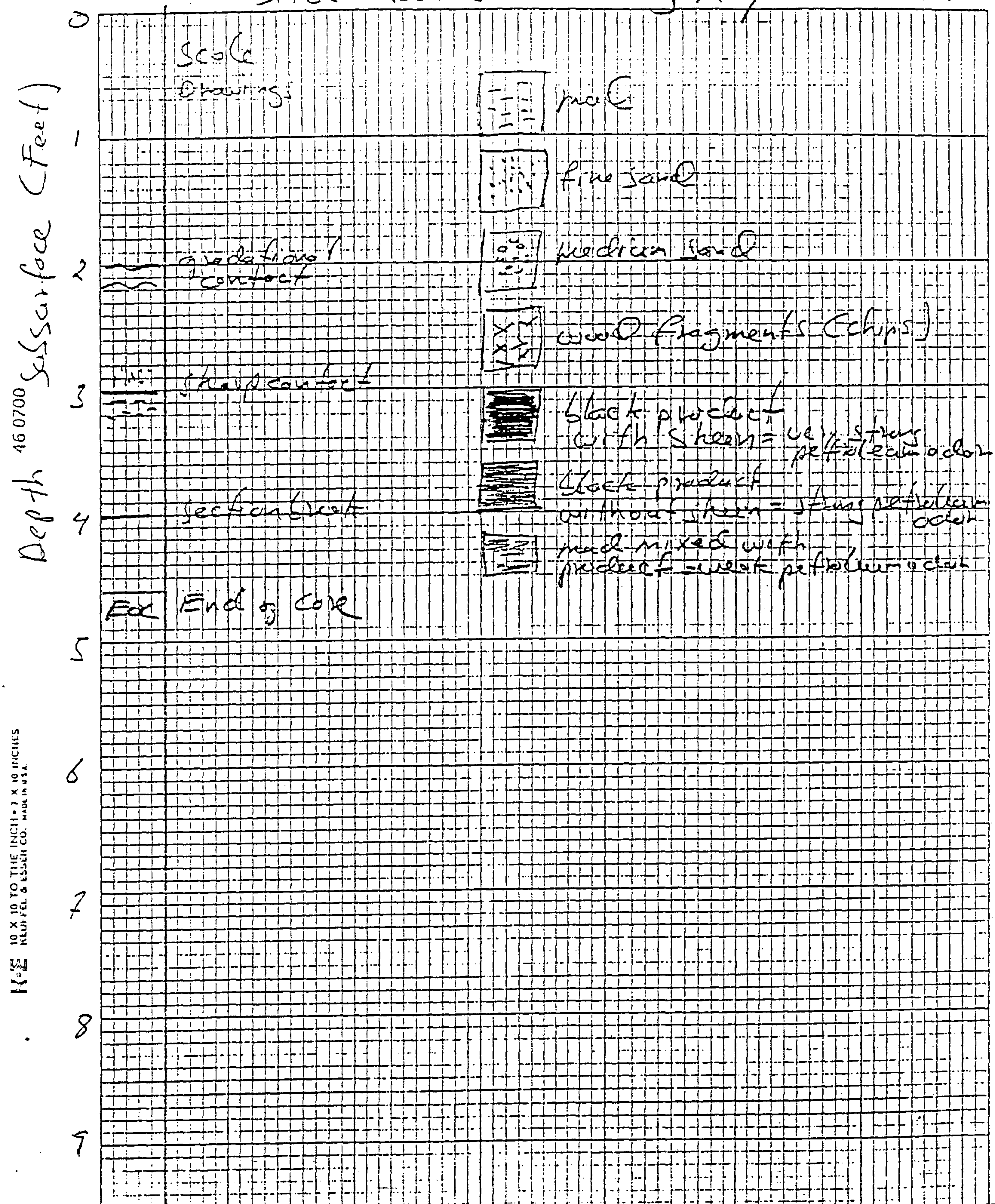
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0700

O-835

	Pipe Length	Subsurface Penetration	Exposed pipe	Inner Core	Subsurface Compression	% Compression	Notes
#1	12.0	11.2	0.8	3.6	2.7	24%	
#2	12.0	11.4	0.6	4.2	3.6	32%	
#3	12.0	11.4	0.6	3.7	3.1	27%	
#4	12.0	11.4	0.6	3.1	2.5	22%	
#5	12.0	11.1	0.9	4.0	3.1	28%	
#6	12.0	11.2	0.8	3.8	3.0	27%	
#7	12.0	8.9	3.1	6.6	3.5	39%	* hit dense wood chip layer 5.75' de[illegible]
#8	12.0	11.0	1.0	3.7	2.7	25%	
#9	12.0	11.2	0.8	4.4	3.6	32%	
#10	12.0	11.2	0.8	3.5	2.7	24%	
#12	12.5	11.0	1.5	3.5	2.0	?	* bottom two feet missing ?

34

Depth [illegible] - [illegible] Core Log Key [illegible]



Depth USACE - Docks Core # 1 CDP 5/25/95

0' 0 - 2.3'
very dark gray (5Y 3/1) mud (soft)

1

2
gradual ↓
2.3 - 2.8'
very dark gray mud with sandy laminae
3 gradual ↓
2.8 - 4.0'
very dark gray sandy mud (firm)
4 gradual
4.0 - 5.0
very dark gray mud (firm)
section break
5 EC

6

7

8

9

10

46 0700

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Depth USACE-Docks Core #2 CDP 5/25/95

0

0-3.1'

very dark grey (5Y 3/1) mud (soft)

1

0.05ft thick muddy sand laminae

2

3 sharp

3.1-4.6

very dark grey mud (soft) with layers of black product (2.5Y 2/0) strong petroleum odor

4

section break

4.6-6.8

5

very dark grey mud (firm) with layers of black product

6 black sheen petroleum odor (patchy)

6.8-7.1'

7 very dark grey sandy mud (firm) with layers of black product

7.1-8.1'

very dark grey mud (firm) with layers of product

8

EOC black sheen petroleum odor

9

10

46 0700

10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Depth USACE - Docks Core #3 CDP 5/25/95

0 0-3.8'
very dark gray (5Y 3/1) mud (soft) with layers of black product (2.5Y 2/0)

1

2

petroleum odor

3 black sheen petroleum odor

section break

4 3.8-6.8' black sheen
very dark gray mud (firm) with layers of black product (patchy)

5 black sheen
petroleum odor

6

black sheen petroleum odor

section break

7 6.8-8.7'
very dark gray mud with layers of black product

8 black sheen petroleum odor

EOC

9

10

Depth USACE - Docks (ore #4) AJ 5/25/95

0

0-3.3'
very dark grey mud (5Y 3/1) soft

1

2

black layer

3

section break
3.3-7.7'
dark olive grey (5Y 3/2) sandy mud, firm
muddy sand layer

4

5

6

black sheen, petroleum order

7

section break
EOC

8

9

10

460700

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Depth

USACE-Docks Cove #5 CDP 5/26/95

0'
0-2.8'
very dark gray (5Y3/1) mud (soft)

1
0.1' thick layer (black) no detectable odor

2
slightly discolored (very dark gray) mud
section break

3
2.8-5.5
very dark gray mud (firm) with layers of black product (2.5Y 2/0) strong petroleum odor (no sheen) mixed with mud (patchy)

4
← sandy mud (0.05' thick) layer

black product with sheen - strong petroleum odor

5
section break
5.5-8.2'

6
very dark gray mud

patchy distribution (not continuous layers)

7
black product - strong petroleum odor

8
8.2-8.3' layer of medium sand (thickness unknown

9

10

USACE-Docks Core #6CDP 5/25/95

0

0-3.7'
very dark gray (5Y 3/1) mud (soft) with streaks of black (2.5Y 2/0) product?

1

2

3

- 0.1' thick layer of black product (petroleum odor)
sharp

3.7-4.0
muddy sand

4

4.0-5.0
very dark gray mud (firm)

black product - strong petroleum odor -
section break

5

5.0-8.2
very dark gray mud (firm) with sandy mud laminae and woodchip (detrital) laminae

6

- faint petroleum odor

7

mixed sandy mud and woodchip laminae in black product

black product with sheen - strong petroleum odor

8

8.2-8.4
sandy mud

EOC 8.4-8.5
mud

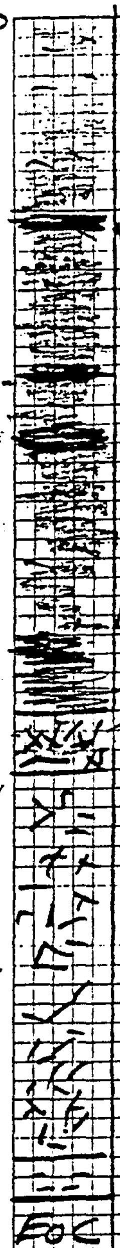
9

10

KE 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0700

USACE - Docks Core # 7 CDP 5/23/95

0


0-3.6
black mud (5Y 2.5/1) mud (soft) with petroleum (strong odor) product

1
0.05 sand laminae

2
black product (2.5Y 2/0)

3

3.6-3.9 wood chips with strong petroleum odor
Section break

4
3.9-5.9
wood chips with strong petroleum odor

5

5.9-6.1
very dark gray mud

6

EOC

7

8

9

10

Depth USACE-Docks Core #8 CDP 5/23/95

0 0-4.8
dark olive grey (5Y 3/2) mud (firm)
sandy mud layer

1

diffuse (patchy) layers of dark grey mud
2 mixed with product (weak petroleum odor)

3

4

dark mud - weak petroleum odor
section break
5 4.8-5.1 medium sand
5.1-8.7
dark olive grey (5Y 3/2) mud (firm)

6

sand lamina 0.05' thick

7 dark mud - weak petroleum odor

sand layer 0.1' thick
8
sand lamina 0.05' thick

9 EOC

10

46 0700

DEPTH CUSACE-Docks Core #9 CDB 5/28/95

0 — 0-2.4

black (5Y 2.5/1) mud (firm) with dispersed product (petroleum odor)

1 — weak petroleum odor

2 — black product (with sheen) strong petroleum odor

section break

2.4-7.2

3 — dark olive gray (5Y 3/2) mud firm

sandy lamination 0.05' thick

black product (strong petroleum odor)

4

sand laminae 0.05' thick

5 — black product (patchy)

sand laminae 0.05' thick

6

black product with sheen (strong petroleum odor)

7

EOC

8

9

10

46 0700

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Pgph USACE-DOCKS Core #10 CPB 5/28/95

0
0-4.3'
missing

1

2

3
MISSING

4
4.3-8.5
very dark gray (5Y 3/1) mud (firm) slight petroleum odor
wood chips

5
sand laminae 0.05' thick

6
wood chips
mud (black)

7
black product (strong petroleum odor)

8
sandy mud layers alternating with mud
sand laminae 0.05' thick
EOC

9

10

Depth USACE-Docks Core #11 CDP 6/2/95

0 0-3.0
very dark gray mud (5y 3/1) mud (soft)

1 patchy black product with wood chips
strong petroleum odor
wood chips apparently line top of core surface
suggest unknown lag

2 sand laminae (0.05' thick)

3 3.0-4.0
very dark gray mud (firm) with sand laminae
sand laminae (under product)
black product (strong petroleum odor)
but no sheen

4

all depths should be reduced by
1/3 - assuming core taken on
33° slope.

5

6

7

8

46 0700

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Depth USACE - DOCKS Core #12A CDP 5/28/95 Part A

0 — 0-4.5'
very dark grey (5Y 3/1) mud (soft) with black layers of product (2.5Y 2/0) with petroleum odor

1 — muddy sand layer (medium sand)

2 — black product (strong petroleum odor)

sand laminae 0.05' thick

3 — patchy black (weak petroleum odor)

4 — section break
4.5 - 8.5

5 — black product with sheen (strong petroleum odor)

6 — muddy sand layer

black product (no sheen) with petroleum odor

7 — sand laminae

8 — sandy mud layer

section break
8.5 - 11.4
very dark grey mud with patchy product weak petroleum odor

9 — sand laminae (0.05' thick)

black product with sheen very - strong petroleum odor

10

460700

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Depth USACE-Locks Core #12B COP 5/28/95 Part B

10 detrital wood layer 0.1' thick

oxidized mud crust

11 patchy product

Sand laminae (medium)

12

13

14

15

46 0700

APPENDIX D SHIP LOGS

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ. DATE: 5/17/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: Danil Hancock OPERATOR: B. Jankowski

CORE NO.: 12 CORE TUBE LENGTH: 17.5'

WATER DEPTH: 28' TIDE: ______ START TIME ______

COMMENTS: Long Core Tube, Slightly Harder @ ~ 8 BML, Harder @ ~ 12.5' BML

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		18.4				18.4			
1	10:14	11.4'							
2		10.0	4 BPF						
3		9.0	5 BPF						
4	:17	8.0	5 BPF						
5		6.0	EST 6 BPF	* Tight wire					
6		5.0	11 BPF						
7		4.0	16 BPF						
8		3.0	18 BPF						
9	10:27	2.0	22 BPF	16.4		4.6	13.8		
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 17.5 / 3.5 LENGTH CORE ACQUIRED: 14.0

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ. DATE: 5/16/95

JOB NAME: I.O.S. Moorings

OBSERVER/CLIENT REP.: Danil Hancock OPERATOR: B. Jaworski

CORE NO.: 8 CORE TUBE LENGTH: 12.0

WATER DEPTH: 28 TIDE: 7.5 START TIME

COMMENTS: Penetrometer S/N Very Poor? Blow Counts Est Transducer? — Transducer Bolt Came out — No Blow Counts, Penetration From Acq. Transd. w/ Tube Coupled Wave

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2							
1	17:10	9.7							
2		8.0							
3	:14	6.0							
4		22 Est →		11.0					
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 3.5 LENGTH CORE ACQUIRED: 8.5

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: PORTLAND STATE UNIV. DATE: 5/12/95

JOB NAME: U.S. MOORINGS

OBSERVER/CLIENT REP.: DANIL HANCOCK OPERATOR: B JAWORSKI

CORE NO.: 9 CORE TUBE LENGTH: 12.0

WATER DEPTH: 30 TIDE: 7.5' START TIME

COMMENTS: VERY HARD FROM (9.5-8.8) ~3.7 BML TO 4.4 BML ~ 25BPF
2ND FREE FALL, HARDER - 6.2 BML TO 7.2 BML

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2				12.9			
1	16:21	9.5	FF	3.7					
2		~~10.~~ 9.0	24BPF	4.2					
3		7.0	3BPF	6.2					
4		5.0	7BPF	8.2					
5		3.0	10BPF	10.2					
6	:33	2.0	12BPF	11.2		3.0/ 4.8			
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 4.3 LENGTH CORE ACQUIRED: 7.7

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Port DATE: 5/16/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: David Hancock OPERATOR: B. Jaworski

CORE NO.: 10 / CORE TUBE LENGTH: 12.0

WATER DEPTH: 34.5 TIDE: START TIME

COMMENTS: Lost 1.2 out of Bottom of Core

38.5
30.6

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2'				12.9			
1	15.30	9.8		3.4					
2	31	8.0	4 BPF	5.2					
3	:32	6.0	12 BPF						
4	36	4.0	16 BPF	9.2		6.0	6.9		
5		3.0	20 BPF			~~4.7~~	~~8.2~~		
6		2.0		11.2		4.7	8.2		
7									
8									
9									
10									
11									
12									

-28
-20
7

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 3.5' LENGTH CORE ACQUIRED: 8.5'

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ DATE: 5/16/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: David Hancock OPERATOR: B. Jaworski

CORE NO.: 11 CORE TUBE LENGTH: 12.0

WATER DEPTH: 21' * TIDE: ______ START TIME ______

COMMENTS: * Bottom Slope Very Steep ~ 45°

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2				12.9			
1	13:52	6.8	FF	6.4					
2		5.0	6BPF	8.2					
3	14:00	4.0	9BPF	9.2					
4		3.0	10BPF						
5		2.0	9BPF	11.2		4.4			
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: ~8.0 LENGTH CORE ACQUIRED: ______

NOTES: ______

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: PORTLAND STATE UNIV DATE: 5/16/95

JOB NAME: U.S MOORINGS

OBSERVER/CLIENT REP.: DANIL HANCOCK OPERATOR: B. JAWORSKI

CORE NO.: 7 / CORE TUBE LENGTH: 12.0

WATER DEPTH: - TIDE: START TIME

COMMENTS: 2ND FREE FALL -7 BML → -9 BML — HIT "HARD" CONTACT @ 8.9'

INTRVL NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2'				12.9			
1	13:11	7.8	FF	5.4					
2		6.0	7BPF	7.2		7.7	5.2		
3		4.3	~2BPF	8.9'					
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 6.7 LENGTH CORE ACQUIRED: 5.3

NOTES:

-9

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ. DATE: 5/11/

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: Daniel Hancock OPERATOR: B. Jadorski

CORE NO.: 6 / CORE TUBE LENGTH: ______

WATER DEPTH: 21.0 TIDE: ______ START TIME ______

COMMENTS: ______

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2				12.9			
1	12:11	3.5	FF	9.7					
2		2.0		11.2'		4.2			
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 3.8 LENGTH CORE ACQUIRED: 8.2'

NOTES: ______

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ. DATE: 5/16/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: Daniel Hancock OPERATOR: B. Jaworski

CORE NO.: 5 / CORE TUBE LENGTH: 12.0

WATER DEPTH: 20.8 TIDE: ______ START TIME ______

COMMENTS:

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2							
1	11:46	4.2	FF	9.0					
2	:47	3.0	5 BPF	10.2					
3		2.0	~7 BPF	11.1'		3.0/4.2			
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 4.0 LENGTH CORE ACQUIRED: 8.0

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State DATE: 5/16/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: Daniel Hancock OPERATOR: B. Jaworski

CORE NO.: 4 / CORE TUBE LENGTH: 12.0

WATER DEPTH: 24.6' TIDE: ______ START TIME ______

COMMENTS:

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2				12.9			
1	11:23	2.8		10.4					
2		1.8	63PF	11.4		3.3	9.6'		
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 3.0 LENGTH CORE ACQUIRED: 9.0

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State DATE: 5/16/95

JOB NAME: U.S Moorings

OBSERVER/CLIENT REP.: Danil Hancock OPERATOR: B. Jaworski

CORE NO.: 3 CORE TUBE LENGTH: 12.0

WATER DEPTH: 25 TIDE: ______ START TIME ______

COMMENTS:

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2							
1	10:55	1.8	FF	11.4					
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 3.6 LENGTH CORE ACQUIRED: 8.4'

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ. DATE: 5/16/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: Daniel Hancock OPERATOR: B. Jaworski

CORE NO.: 2 CORE TUBE LENGTH: 12.0

WATER DEPTH: 24.0' TIDE: ______ START TIME ______

COMMENTS: No Driving

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2				12.9			
1	10:08	1.8	FF	11.4		4.0	8.9 ??		
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: 4.1 LENGTH CORE ACQUIRED: 7.9

NOTES:

MARINE SAMPLING SYSTEMS

P.O. BOX 290
BURLEY, WA. 98322
(206) 857-3336

CLIENT: Portland State Univ. DATE: 5/16/95

JOB NAME: U.S. Moorings

OBSERVER/CLIENT REP.: Dan Hancock OPERATOR: B. Jaworski

CORE NO.: #1 CORE TUBE LENGTH: 12.0

WATER DEPTH: 25.2' TIDE: ______ START TIME ______

COMMENTS: Harder Mtl. Thin layer? ~12 BPF then 4BPF

INTRVL. NO.	TIME	PENETRATION DISTANCE	BLOW CNT. (BLOWS/FT.)	PENETRATION TOTAL	CHANGE	ACQUISITION DISTANCE	ACQUISITION TOTAL	CHANGE	RECOVERY %
0		13.2				12.9			
1	09:34	4.6	FF	9.0		3.6	9.3/9.0		
2		2.0	~4BPF	11.2					
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

DISTANCE TOP OF CORE TUBE TO TOP OF CORE: ______ LENGTH CORE ACQUIRED: ______

NOTES: ______

APPENDIX 2

Raw Data
Physical and Chemical

Physical and Chemical Raw Date Not Included Because of Size

(Contact Mark Siipola at 503-808-4885)