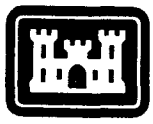

US Army Corps of Engineers
Portland District

Sediment Physical and Chemical Analyses on the Cowlitz and Columbia Rivers Subsequent to the 18 May 1980 Mt St. Helens Eruption

SEDIMENT PHYSICAL AND CHEMICAL ANALYSES ON THE COWLITZ AND COLUMBIA RIVERS SUBSEQUENT TO THE 18 MAY 1980 MT. ST. HELENS ERUPTION

By

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ABSTRACT

Water quality chemical analyses, elutriate analyses, and physical analyses were performed on sediments deposited by the 18 May 1980 mudflows in the Cowlitz and Columbia Rivers. Water and sediment samples were obtained from 20 May through 25 November 1980.

In-situ water quality testing indicated that dissolved oxygen, pH, temperature, and oxidation reduction potential were within the ranges suitable for survival of salmonids. Water quality in Spirit Lake was the exception. Turbidity was determined to be very high in the Cowlitz and Toutle Rivers.

Water quality and sediment chemical data indicated that the majority of the sediments sampled were within the sand and gravel grain size range, contained approximately 20% ash, and did not contain excessive levels of the contaminants analyzed. An exception was elutriate, total phenolic compound numbers which were higher than would normally be expected given the other sediment and water quality findings. These high levels were determined by this study and others to be from non-point source discharges and widespread in the drainage basin.

Physical analyses indicate the mudflow material is angular to subangular in shape, very dense and mixed with pebble to rubble size pieces of pumice. The sediment is also graded coarse to fine from upstream to downstream and from mid-channel to the bank.

SEDIMENT PHYSICAL AND CHEMICAL ANALYSES

INTRODUCTION

The U.S. Army Corps of Engineers is responsible for maintaining adequate depths for waterborne traffic in authorized Federal navigation projects. It also plans and constructs flood control structures in areas of high flooding potential. Following the 18 May 1981, Mount St. Helens mudflows in the Toutle, Cowlitz, and Columbia Rivers, the Corps was faced with an emergency situation in regards to both its navigation and flood control responsibilities. Both the Columbia and Cowlitz River channels were blocked to navigation and additional flooding of several municipalities along the Toutle and Cowlitz watersheds was likely. Physical and chemical data regarding the sediments in the channels were needed to determine (1) best management techniques for materials removed from the channels; (2) potential contaminants of concern in the sediments; (3) the need for further in-depth studies during the dredging and flood-control operations; and (4) potential physical and chemical impacts from proposed operations pursuant to the evaluation requirements of Section 404 of Public Law 92-500.[1] This section of the law requires that impacts of a sediment disposal operation in navigable waters be evaluated following a set of specific testing guidelines.

Accordingly, a series of reconnaissance surveys were performed which involved sampling and testing water and sediment for various chemical and physical characteristics.

TESTING PROGRAM

The tests performed consisted of (1) a standard agricultural sediment analysis to assess impacts of upland disposal of sediment and determine if soil amendments should be added (table 1, figure 1); (2) elutriate and receiving water tests to assess potential water quality chemical impacts from open water disposal of sediments (table 2); (3) bulk sediment analyses to determine the presence of contaminants of concern which could cause long-term impacts at the sediment disposal sites (table 3, figure 1); (4) physical sediment analyses including various density measurements, void ratios, water content, and roundness gradation (table 4); and (5) In-situ water quality analyses to help evaluate sediment/water interactions and impacts from Corps' operations.

The testing program consisted of nine separate sampling and testing episodes beginning on 20 May 1980 and ending November 1980.

ANALYTICAL METHODS

The majority of the elutriate and all of the bulk sediment analyses were performed by U.S. Geological Survey (USGS) following the procedures discussed in the USGS publication, "Native Water, Bottom Material and Elutriate Analyses of Selected Estuaries and Rivers in Western Oregon and Washington".[2] The exceptions to this are cyanide, phenolics, orthophosphate and phosphate elutriate analyses. These were performed by the Corps' North Pacific Division Materials Laboratory on eluate provided by USGS using methods described in the 14th Edition of Standard Methods for Examination of Water and Wastewater.[3]

Physical analyses of sediments were performed by the Corps' North Pacific Division Materials Laboratory using both standardized and in-house methods. Either a Mark V or Hydrolab 8000 water quality testing system was used to measure dissolved oxygen, pH, oxidation reduction potential (ORP), conductivity, and temperature. Turbidity was measured with a YSI turbidimeter.

The 20 and 21 May sediment samples were obtained by hand. Ponar, pipe, or coring apparati were used to obtain subsequent sediment samples.[4] An eight-liter Van Dorn water sampler was used to collect water samples. Sediment and water containers were prepared using standard methods for acid rinsing.[3]

RESULTS

Chemical Analyses

An agricultural analysis was performed on sediments collected from the Cowlitz River's mouth on 20 May. The sediments contained sufficient trace elements to support vegetation but would require additional organic amendments and nutrients for significant plant growth.

Elutriate analyses were performed with sediments collected on the following locations and dates:

1. Mouth of Cowlitz River on 21 May 1980;
2. Cowlitz river miles (RM) .2, 2.0, and 3.5; Carroll Channel, midway between the Cowlitz and Columbia; and Columbia RM 71.4 on 28 May 1980; and
3. Cowlitz RM 12.8 on 4 June 1980.

Water samples were collected for use in elutriate tests and laboratory analyses at Columbia RM 67.01 on 21 May, and Columbia RM 71.4 on 28 May and 4 June.

Bulk sediment analyses for 20 parameters were performed on sediments collected from the mouth of the Cowlitz River on 21 May (table 3, figure 1). Sediments collected in the river mouth on 28 May and Cowlitz RM 12.8 on 4 June underwent bulk analyses for nitrogen and phosphorus.

No contaminants of concern except for phenols were detected during the elutriate, water, and bulk chemical tests (figure 2). Phenols were found to be excessive when compared to 1976 EPA criteria (1 ug/l)[5]; but the new EPA criteria promulgated in November 1980[6] indicated the parameter was probably not of concern in terms of Corps operations. However, eleven phenolic compounds of concern were identified in the new criteria and have yet to be identified in the Cowlitz-Toutle system.

The phenols chemical analysis groups a large number of phenolic compounds, some of which can be highly toxic. Further research is being coordinated with USGS and the National Marine Fisheries Service (NMFS) to assess the types of phenolics present and their potential impact. Also, on 12 August, additional sampling in Spirit Lake and Toutle River was

performed to identify the source. High levels (675 ug/l) were found in Spirit Lake, whereas the Toutle contained levels (1 to 10 ug/l) which were an order of magnitude lower.

The tests performed on Toutle River indicated that the water there was of much better quality than that of Spirit Lake except for turbidity. The high levels of this parameter are attributed to high suspended solids levels in the river.

In-situ Water Quality Analyses

Hydrolab or Mark V data was obtained at Cowlitz RM .2 and 1.3, Carrolls Channel, and Columbia RM 70.55 and 67.75 on 29 May; on North Toutle River immediately upstream of the Weyerhauser Green Mountain Mill and downstream of Camp Baker, on South Fork Toutle River off the Highway 4 bridge, and on the main stem of Toutle River at the Tower Road bridge on 14 July; on Johnsons, Brownell, Thirteen, and Eighteen Creeks, and South Fork Toutle River on 16 July 1980; and on South Fork Toutle River and Spirit Lake on 12 August.

Turbidity measurements were made in Columbia River at various locations upstream and downstream of the mouth of Cowlitz on 18 June; in the Toutle River on 14 July; and in the Toutle River and Spirit Lake on 12 August (figure 3). It ranged from 4.4 to 21 NTU in the Columbia; 60 to 735 NTU in the Toutle, and 100 to 130 NTU in Spirit Lake.

The dissolved oxygen, pH and temperature levels were suitable for survival of the fish at all locations except Spirit Lake. The water in the lake was very poor in quality. The dissolved oxygen was too low to support fish and the conductivity was higher than is generally found in the ocean. The pH was within EPA criteria (6.5 to 9.0).

Since turbidity appears to be the parameter of greatest concern in terms of fisheries as well as Corps operations, the National Marine Fisheries Service (NMFS) is performing extensive turbidity monitoring in the Cowlitz, Toutle, and Columbia Rivers. This research has been coordinated with the Corps so that information can help determine impacts of dredging and disposal operations.

Physical Analyses

Sediment physical analyses included density of material in place, density of median solids, void ratio, percent volatile solids, percent organic material, water content in place, and roundness gradation. Sediments were collected for physical analysis from the Cowlitz River mouth on 20 May and from the mouth, RM .2, 2.0, 3.5, and 8.5 on 27 and 28 May 1980 (figure 4). They were collected from the mudflows on the banks at RM 9.5, 11, 12.1, 12.9, 13.5, 14, and 15 on 3 June and from the river at RM 9, 10, 11, 12, 12.8, 14, 16, 19.5, and at the Highway 4 intersection of the Toutle River on 4 June. On 18 June, sediments were collected from Columbia River at RM 64, 64.57, 65.75, 66.47, 67.07, 67.75, 68.19, 68.75, 67.95, 69.75, 70.75, 71.38, 71.75, and 72.19 and opposite lights 29A and 31.

Sediments contained up to 20 percent fine ash at the mouth of the Cowlitz. A significant percentage of large sized material from gravel to

boulder in size were in both the Toutle and Columbia Rivers with lesser amounts present in the Cowlitz.

The 27 to 29 May and 3 to 4 June physical samples indicated that sediments tended to become progressively coarser from the mouth of Cowlitz River upstream (figure 5).

Sediments which settled on shore were finer grained than those found in the main channel of the river and resembled that which shoaled at the mouth of the river. The bank material was well-drained in some areas but in others it was still plastic. If left unamended, it will be a poor media for plant growth as its organic and nutrient content is low and it forms a surface crust which may inhibit aeration of the subsurface sediments.

The erodibility of the rivers would normally be decreased by the substantial percentage of gravel, rubble, boulders, and logs which were discovered in the sediments. As the fine sediments are removed, the percentage of rock in the surface of the sediments would increase, eventually forming an armored bed which would offer more resistance to erosion. Dredging the river will help restore project depths and remove the embedded stones thus allowing shoals of finer material to move downstream.

CONCLUSIONS

The parameter of most concern discovered in the foregoing studies was turbidity. The suspended sediments which cause this problem are expected to continue at high levels for years and possibly decades due to continuing erosion of ash and mudflow material in the blast area of Mount St. Helens. Phenolics are also of some concern though the 1980 EPA water quality criteria indicated that significant impacts were unlikely.

The eleven phenolic compounds listed in the 1980 criteria are to be further studied by NMFS and USGS to assure that significant levels are not present. The results of their studies will be used to help determine impacts from any release of this parameter which is attributable to Corps operations.

The physical data on sediments indicated that the majority were composed of sand with significant percentages of ash, silt and larger grain sized materials up to boulder in size. However, the continuing influx of newly eroded material from the blast area may input varying sediment types in the future.

Detailed information concerning the Corps testing program is contained in the Corps publication "Mount St. Helens Eruption; Impacts on the Toutle, Cowlitz and Columbia River Systems." This publication is intended primarily as an in-house document and as such, it is continually updated to include new data which is produced by both Corps and other research groups.

REFERENCES

1. U.S. Environmental Protection Agency, (Wednesday, December 24, 1980), "Guidelines for Specification of Disposal Sites for Dredged or Fill Material," Federal Register, Vol. 40, Part 230.

2. Rinella, Frank A., and Greg Fuhrer, n.d., "Native Water, Bottom Material and Elutriate Analyses of Selected Estuaries and Rivers in Western Oregon," U.S. Geological Survey, Open File Report 81 - _____ (in review).

3. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1976. Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, Washington, D.C.

4. U.S. Army Engineer District, February 1980. "Supplemental, Interim Procedures for Evaluating and Testing Discharges of Dredged Materials," Portland District, OR.

5. U.S. Environmental Protection Agency, Quality Criteria for Water, 1976. USAEPA 440/9-76-023 Washington, D.C.

6. U.S. Environmental Protection Agency, (Friday, November 28, 1980) "Quality Criteria Documents; Availability," Federal Register, Vol. 45, No. 231.

Figure 1
ANALYSIS OF SEDIMENTS FROM COWLITZ RIVER AFTER MUD FLOW COMPARED TO AVERAGE CRUSTAL ABUNDANCES AVERAGE SURFACE SOILS

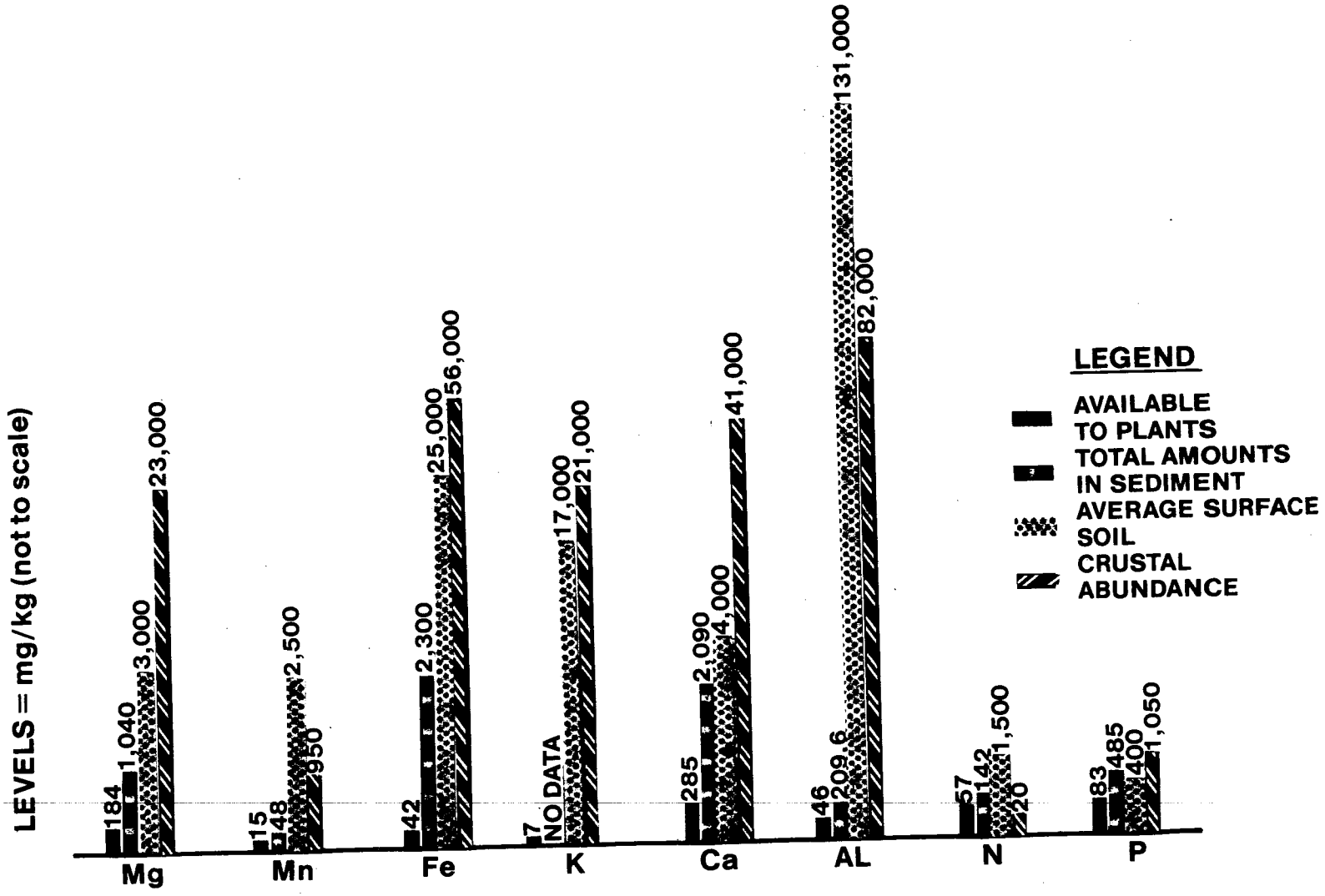
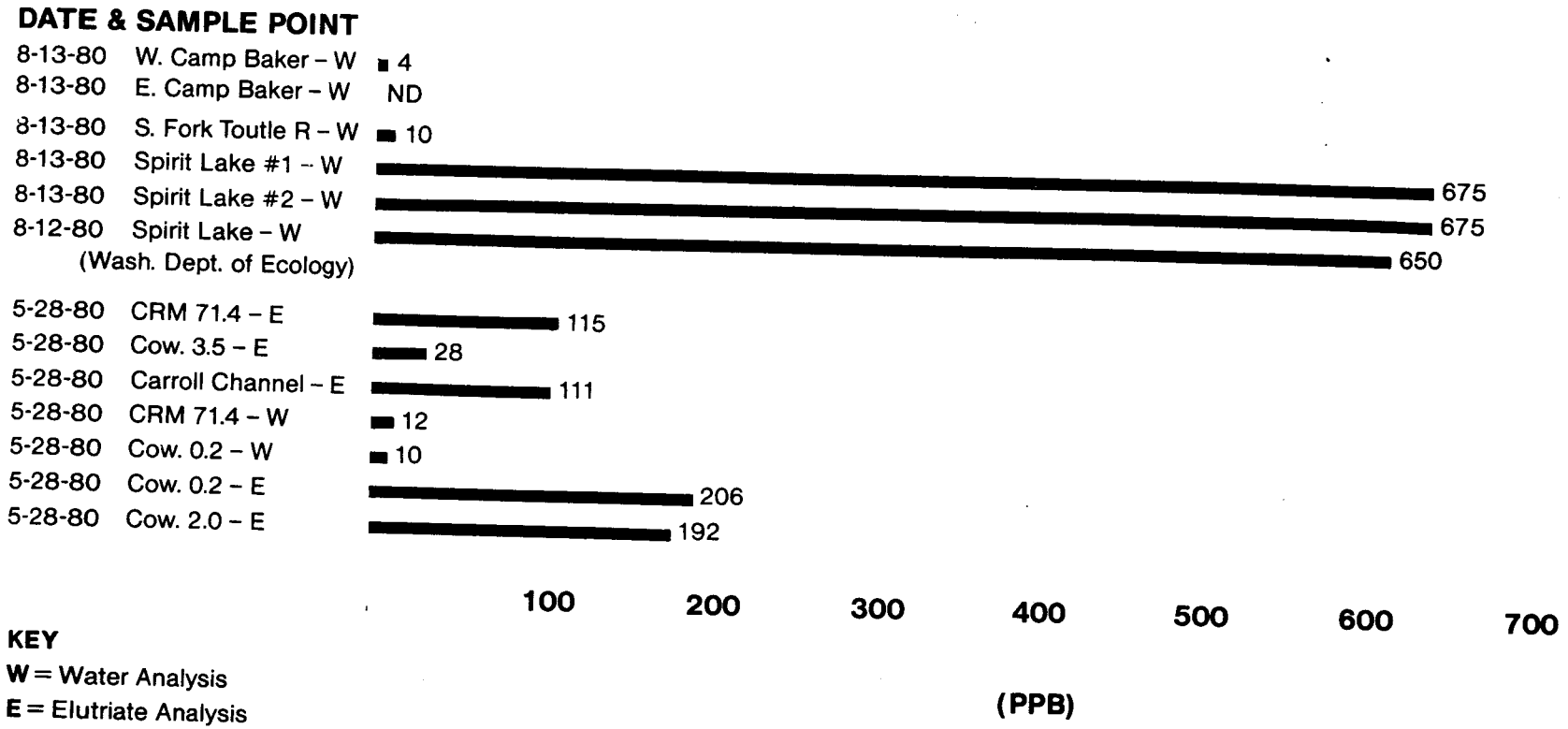


Figure 2
PHENOL LEVELS

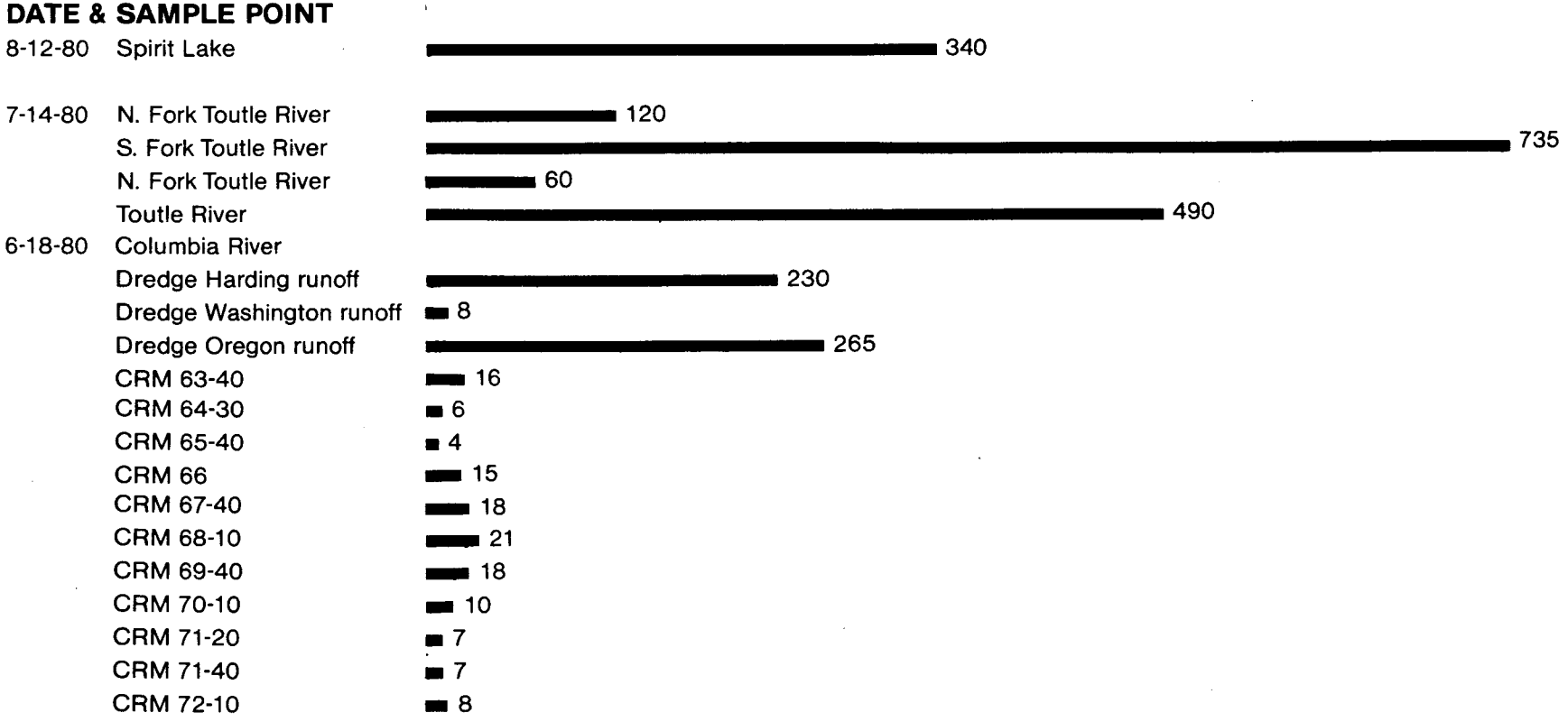


KEY

W = Water Analysis

E = Elutriate Analysis

Figure 3
(NTU)
TURBIDITY LEVELS



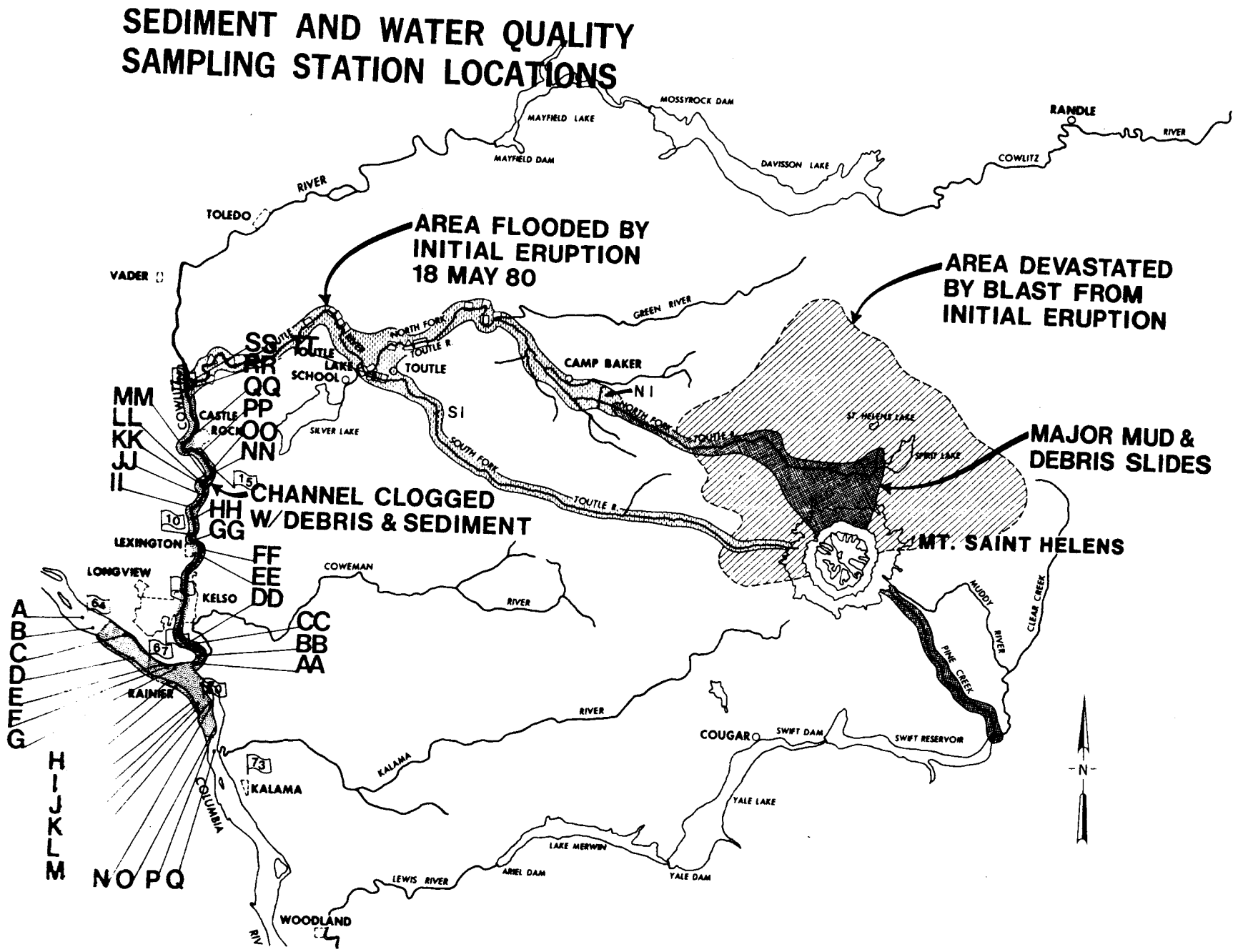

SEDIMENT AND WATER QUALITY
SAMPLING STATION LOCATIONS
AREA FLOODED BY
INITIAL ERUPTION
18 MAY 80
AREA DEVASTATED
BY BLAST FROM
INITIAL ERUPTION
MAJOR MUD &
DEBRIS SLIDES
CHANNEL CLOGGED
W/DEBRIS & SEDIMENT
MT. SAINT HELENS
MOSSYROCK DAM
MAYFIELD LAKE
MAYFIELD DAM
DAVISSON LAKE
RANDLE
COWLITZ
RIVER
TOLEDO
VADER
GREEN RIVER
NORTH FORK
TOUTLE R.
TOUTLE
LAKE
SCHOOL
CAMP BAKER
SILVER LAKE
CASTLE
ROCK
SOUTH FORK
ST. HELENS LAKE
SPIRIT LAKE
LEXINGTON
LONGVIEW
KELSO
COWEMAN
RIVER
MUDDY
CLEAR CREEK
PINE CREEK
RAINIER
COUGAR
SWIFT DAM
SWIFT RESERVOIR
KALAMA
COLUMBIA
YALE LAKE
LAKE MERWIN
YALE DAM
ARIEL DAM
LEWIS RIVER
WOODLAND
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FIGURE 4

Figure 5
COWLITZ RIVER SEDIMENT STRATIFICATION OF MT. ST. HELENS MUDFLOW

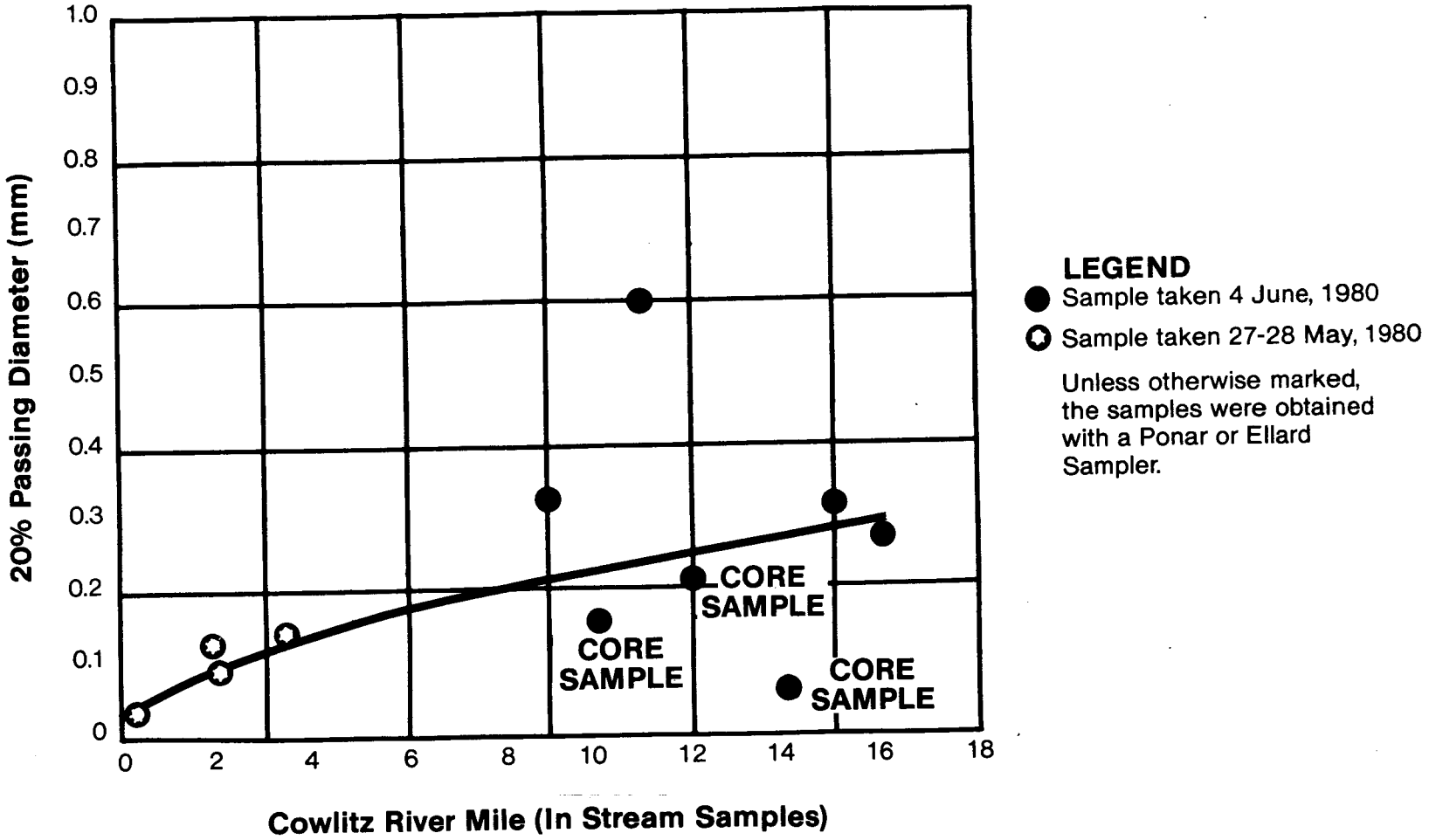

TABLE 1
AGRICULTURAL ANALYSIS OF SEDIMENTS FROM COWLITZ RIVER*

Collected 20 May 1980

	pm dry weight (mg/kg)
Kjeldahl Nitrogen	52.5
Manganese	15.1
Magnesium	184
Iron	41.8
pH	6.4
Potassium	37.5
Nitrate Nitrogen	4.3
Total Phosphorus	83.6
Ortho-Phosphate Phosphorus	29.2
Calcium	285
Aluminum	48.5
Sulfate	89.9
Chlorides	118.8

*- Sample shaken with acetic acid. Filtered through 0.45mm membrane filter. Testing was done to evaluate potential for use of sediment in agricultural applications.

Sediment sample was taken from a shoal at the mouth of Cowlitz River. The shoal was a result of mudflows caused by the 18 May 1980 eruption of Mt. St. Helens.

TABLE 2
WATER AND SEDIMENT CHEMICAL DATA

PARAMETERS	Elutriate Analyses						Receiving Water 5/29/80		
	Cowlitz RM .2E	Cowlitz RM 2.0	Cowlitz RM 2.0E	Cowlitz RM 3.5	Carroll Channel	Columbia* RM 71.4E	Cowlitz RM .2W	Columbia RM 67+75	Columbia RM 71.4
Field Water Quality Measurements									
Dissolved Oxygen, mg/l		10.85			10.5		10.86	10.56	10.12
Nitrogen, Ammonia mg/l					.09	.01			
ORP		243			245		259	263	260
Conductance, UMHO/CM	112		121	130	190	180	83		128.5
Temperature, C		11.5			13.5		13.6	14.1	14.1
pH	7.3	7.33	7.8	7.1	7.86	7.1	7.5	7.73	7.73
Laboratory Chemical Analyses									
Arsenic, ug/l	1		1				1		1
Barium, ug/l	5		2				2		10
Beryllium, ug/l	1		1				1		1
Cadmium, ug/l	8.6		3	.47	.07	.04	.69		.18
Carbon, Organic mg/l	1.3		2.6	4.8	6.9	4.9	2.2		3.2
Chromium, ug/l	0		0	0	0	0	0		0
Copper, ug/l	8		2	8	03	3	5		3
Cyanide, ug/l	4		1						
Iron, ug/l	270		10	230	80	20	70		20
Lead, ug/l	3		1	2	1	3	3		2
Manganese, ug/l	150		160	100	420	540	130		5
Mercury, ug/l	0		0	0	0	0	0		0
Nickel, ug/l	3		6				3		1
Nitrogen, Ammonia mg/l	.01		0	.01	.09	.01	.01		.03
Nitrogen, Organic mg/l	.31		.21				.13		.41

TABLE 2 (CONTINUED)
WATER AND SEDIMENT CHEMICAL DATA

PARAMETERS	Elutriate Analyses						Receiving Water 5/29/80		
	Cowlitz RM .2E	Cowlitz RM 2.0	Cowlitz RM 2.0E	Cowlitz RM 3.5	Carroll Channel	Columbia* RM 71.4E	Cowlitz RM .2W	Columbia RM 67+75	Columbia RM 71.4
Phenol, ug/l	206		192	28	111	115	10		12
Phosphorus, Total ug/l	34		27						34
Orthophosphate, ug/l	16		19	18		17	10		21
Sulfate, mg/l	11		10						10
Zinc, ug/l	30		3.4	22	2.2	4.2	6.6		2.3
Ametryne, ug/l			0						0
Atrazone, ug/l			0						
Atrazine, ug/l			0						0
Cyanazine, ug/l			0						0
Cyprazine, ug/l			0						0
Prometone, ug/l			0						0
Prometryne			0						0
Propazine, ug/l			0						0
Simazine, ug/l			0						0
Simetone, ug/l			0						0
Simetryne, ug/l			0						0
Bulk Sediment Analyses, mg/kg									
Nitrogen, Ammonia	3.7								
Nitrogen, Total Kjeldahl	37								
Phosporus	460								

*Was elutriated with water from Columbia RM 71.4 obtained on 6-4-80.

TABLE 3
BULK SEDIMENT CHEMICAL ANALYSIS OF THE COWLITZ RIVER SEDIMENTS[1]

21 May 1980

Parameter	Value	Corps' Guidelines[2]
Nitrogen, Kjeldahl-N, mg/kg	116	1,000
Nitrogen, NH_4-N, mg/kg	26	----
Phosphorus, total -P, mg/kg	485	420
Carbon, Organic, g/kg	2.3	60
Carbon, Inorganic, g/kg	0	----
Carbon, Total, g/kg	2.3	----
Arsenic, Total, ug/g	1	3
Barium, Total, ug/g	0	----
Beryllium, Total, ug/g	0	----
Cadmium, Total, ug/g	0	----
Chromium, Total, ug/g	0	----
Chromium, Total, ug/g	0	----
Copper, Total, ug/g	26	25
Cyanide, Total, ug/g	0.55	----
Iron, Total, ug/g	2,300	17,000
Lead, Total, ug/g	0	40
Manganese, Total, ug/g	48	300
Mercury, Total, ug/g	0.01	1
Nickel, Total, ug/g	0	20
Zinc, Total, ug/g	8	90

TABLE 3 (CONTINUED)
BULK SEDIMENT CHEMICAL ANALYSIS OF THE COWLITZ RIVER SEDIMENTS[1]

Parameter	Value	Corps' Guidelines[2]
Aluminum* ug/g	209	———
Antimony ug/g	10	———
Bismuth* ug/g	21	———
Boron* ug/g	6	750
Gallium* ug/g	6	———
Germanium* ug/g	15	———
Silica* mg/g	2	———
Silver* ug/g	.2	———
Tin* ug/g	15	———
Titanium* ug/g	63	———
Zirconium* ug/g	.2	———

Moisture Loss	=	22.20%
Gross Ignition Loss	=	23.24%
Net Ignition Loss	=	1.04%

1. Sediment was a composite sample from Columbia River stations CR-902 and 903.

2. The Corps' guidelines were established by Portland District for comparison purposes only and possess no legal standing. The levels given in the guidelines are at the low end of the levels commonly found in moderately polluted sediments.

*- Digested and filtered sediment sample. Data is semi-quantitative only. Was corrected for size and moisture loss.

TABLE 4
SEDIMENT ANALYSIS, COLUMBIA RIVER
Sediments after 18 May 1980 Mount St. Helens Eruption

Sample	River Mile	Date Collected	Void Ratio	Density of Mat'l in place gms/liter	Density of Median Solids gms/liter	Percent Volatile Solids	Percent Water Content in Place	Roundness Grade	D20/mm[1]
A	CRM 64	18 Jun 80	0.860	1908	2689	0.69	32.0	Angular to subangular	0.18
B	CRM 64.57	18 Jun 80	0.905	1938	2787	0.18	32.5	"	0.15
C	CRM 65.75	18 Jun 80	0.838	1981	2804	0.17	29.9	"	0.13
D	CRM 66.47	18 Jun 80	1.049	1824	2687	0.35	39.0	"	0.14
E	CRM 67.07	18 Jun 80	0.931	1903	2743	0.57	34.0	"	0.17
F	CRM 67.75	18 Jun 80	0.901	1896	2703	0.22	33.3	"	0.43
G	CRM 67.95 (#1)	--	0.838	1914	2679	0.20	23.8	"	0.4
H	CRM 67.95 (#2)	--	0.904	1890	2695	0.19	33.6	"	0.4
I	CRM 68.19	18 Jun 80	0.738	1982	2705	0.21	27.3	"	0.83
J	Light 29A[2]	18 Jun 80	0.659	2032	2711	0.24	24.3	"	0.37
K	Light 31[3]	18 Jun 80	0.751	1988	2730	0.19	27.5	"	0.39
L	CRM 68.75	18 Jun 80	0.738	1987	2715	0.22	27.2	"	0.54
M	CRM 69.75	18 Jun 80	0.811	1952	2723	0.19	29.8	"	0.29
N	CRM 70.75	18 Jun 80	0.688	2069	2805	0.16	24.5	"	0.21
O	CRM 71.38	18 Jun 80	0.753	1993	2741	0.24	27.5	"	0.18
P	CRM 71.75	18 Jun 80	0.871	1936	2751	0.21	31.7	"	0.18
Q	CRM 72.19	18 Jun 80	0.903	1887	2688	0.37	33.6	"	0.29

[1] 80 percent of material is coarser than reported grain size.

[2] At dredge WASHINGTON disposal site on Cottonwood Island.

[3] At dredge OREGON disposal site on Cottonwood Island.

Sample	River Mile	Date Collected	Void Ratio	Density of Mat'l in place gms/liter	Density of Median Solids gms/liter	Percent Volatile Solids	Percent Organic Mat'l	Percent Water Content in Place	Roundness Grade	Grain Size
AA	River Mouth	27 May 80	0.711	1981	2678	0.57	0.62	26.6	Subangular to Subrounded	Silty Sand
BB	R.M. 0.2	28 May 80	1.107	1801	2688	0.38	0.41	41.2	Angular to Subanguiar	Sandy Silt
DD	R.M. 3.5	28 May 80	0.835	2087	2994	0.05	0.11	27.9	"	Sand
EE	R.M. 8.5	27 May 80	0.713	2026	2758	0.17	0.22	25.9	"	Sand
CC	R.M. 2.0	28 May 80	0.822	2083	2973	0.08	0.12	27.7	"	Silty Sand
GG	Cowlitz R.M. 9.6 East Bank Horseshoe Curve	3 Jun 80	0.977	1830	2640	0.78	0.82	37.0	"	Silt
II	Cowlitz R.M. 11.1 East Bank Horseshoe Curve	3 Jun 80	1.148	1746	2603	1.16	1.41	44.1	"	Sandy Silt
KK	Cowlitz R.M. 12.1 Horseshoe Curve	3 Jun 80	1.287	1694	2586	2.96	3.08	49.8	Angular	Sandy Silt
LL	Cowlitz R.M. 12.9 S. End Horseshoe Curve	3 Jun 80	0.813	1931	2687	0.57	0.64	30.2	Angular to Subangular	Silty Sand
MM	Cowlitz R.M. 13.5 N. End Horseshoe Curve	3 Jun 80	1.209	1744	2643	0.73	0.80	45.7	Angular to Subangular	Sandy Silt
NN	Cowlitz R.M. 14 N. End Horseshoe Curve	3 Jun 80	0.750	1959	2679	0.49	0.74	28.0	"	Silty Sand
NN	Cowlitz R.M. 14 East Side Horseshoe Curve	3 Jun 80	0.555	2090	2695	0.31	0.49	20.6	"	Gravelly Silty Sand
FF	Cowlitz R.M. 9	4 Jun 80	0.736	1978	2698	0.12	0.14	27.3	"	Sand
HH	Cowlitz R.M. 10	4 Jun 80	0.998	1825	2669	1.79	3.07	37.4	"	Sand
JJ	Cowlitz R.M. 12	4 Jun 80	0.861	1953	2774	0.21	0.24	31.0	"	Sand
KK	Cowlitz R.M. 12.8	4 Jun 80	1.066	1805	2663	0.44	-	40.0	"	Sand
OO	Cowlitz R.M. 14 Core	4 Jun 80	0.848	1953	2761	0.20	0.21	30.7	"	Sand
QQ	Cowlitz R.M. 16	4 Jun 80	0.905	1884	2684	0.46	0.54	33.7	"	Sand