Appendices

Appendix A- Source Loading Data and Figures

Appendix B- Under-Pier Survey: Seattle Waterfront

Appendix C- Scour Potential Model Results

Appendix A- Source Loading Data and Figures

Table A-1. CSOs and Storm Drains along the Seattle central waterfront.

Outfall	Outfall Location	Total Area (acres)	Combined Area (acres)	Separated Area (acres)	Combined Sewer Capacity (cfs) (e)/ Overflow Event
CSO 069	Vine St.	139.6	139.6	0	7.3
CSO 070	University St.	78.3	45.4	32.9	12.4
CSO 071	Madison St.	12	3.1	8.9	3.1
CSO 072	S. Washington St.	159	109.2	27.8 b	13.2
		--	--	22 c	--
SD-A	Pine St.	4.2	0	4.2	Storm 6 (a)
SD-B	University St.	21	0	21	Storm 6 (a)
SD-C	Seneca St.	3.6	0	3.6	Storm 6 (a)
SD-D	Madison St.	13	0	13	All (d)
SD-E	3rd Ave.	22	0	22	All (c)
SD-500	S. Washington St.	6.8	0	6.8	All (d)

(a) Catch basins and overflows equipped with low flow diversion structure to allow runoff from smaller storms to continue to discharge to combined sewer to reduce pollutant loading to Elliott Bay. Overflows on separate storm drain designed for Design Storm #6:
1.5 inches over 14 hours with peak intensity of 0.3 inches/hr.

(b) Partial separation of 27.8 acres located west of I-5 discharges to Lake Union.

(c) Partial separation of approximately 22 acres along 3rd Avenue rerouted to 102-inch Metro interceptor.

(d) No low flow diversion. All runoff routed directly to Elliott Bay.

(e) Combined sewer capacities from Brown and Caldwell (1988).

Table A-2. Summary of CSO discharges during October 1993-1994 study period (c).

Month	Denny Way (a) (W027)	King (a) (W028)	Conn. (a) (W029)	Vine (b) (069)
Oct-93	4.26	0	0.01	0.14
Nov-93	31.16	1.89	0	0.24
Dec-93	105.98	6.58	0.14	0.52
Jan-94	2.5	0	0	0.2
Feb-94	108.3	5.4	0.33	0.37
Mar-94	19.85	0.21	0	0.21
Apr-94	1.86	0	0	0.24
May-94	0	0	0	0.1
Jun-94	13.74	0.97	0.05	0.13
Jul-94	0	0	0	0.12
Aug-94	0	0	0	0.02
Sep-94	0.3	0	0	0.1
Oct-94	34.04	3.37	1.47	0.14

Units: million gallons.

(a) Overflow volume measured by Metro.
(b) Volume estimated based on average annual overflow of 3.3 Mgal/yr as reported in Brown and Caldwell (1988).
(c) No overflows predicted in CSOs 070, 071, and 072 because measured precipitation did not exceed Design Storm 6.

Table A-3. Estimated volumes discharged to Elliott Bay from waterfront sources.

Source	Average Dischage (Mgal) Average Annual Recent	Total During Study Period (d)	Average Annual Future
Duwamish River	343,500	222,500	343,500
CSOs			
Denny Way	405 b	322	455 c
Vine	3.3	2.5	0.1 e
University	2.8 a	0	0.21 e
Madison	0.7 a	0	0.04 e
S. Washington	0.8 a	0	0.01 e
King	55	18	33 c
Connecticut	90	2	93 c
SDs			
SD-A	0.4	0	0.4
SD-B	1.7	0	1.7
SD-C	0.3	0	0.3
SD-D	11	3	11
SD-500	5	1.5	5
Industrial Discharges	6.8	7.4	6.8

a) Prior to partial separation projects completed in 1990s.
b) Average based on 1981-1983 base period (Romberg 1995 pers. comm.).
c) 1998 annualized baseline assuming West Point treatment plant capacity at 400 MGD (KCMS 1995).
d) October 1993-October 1994.

References:
Metro CSOs: KCMS 1995.
City CSOs: Brown and Caldwell 1988.

Table A-4. Rainfall Records for October 1993 to October 1994.

	Sandpoint		SeaTac	
	1993-1994	1951-1980 Average	1993-1994	1951-1980 Average
Oct-93	1.61	3.4	1.54	3.43
Nov-93	2.76	5.36	2.2	5.6
Dec-93	6.23	6.29	4.48	6.33
Jan-94	2.42	5.94	2.51	6.14
Feb-94	4.26	4.2	4.47	4.22
Mar-94	2.45	3.7	3.17	3.59
Apr-94	2.82	2.46	2.27	2.4
May-94	1.22	1.66	1.43	1.58
Jun-94	1.52	1.53	1.25	1.38
Jul-94	1.36	0.89	0.28	0.74
Aug-94	0.20	1.38	0.16	1.27
Sep-94	1.14	2.03	1.69	2.02
Oct-94	3.51	3.4	3.22	3.43
Total	31.50	42.24	28.67	42.13

Rainfall in inches.

Table A-5. Duwamish River Basin Contributing Areas (Auburn to mouth).

	Total Area (acres)	Land Use (acres)				
		Single Family	Multi-Family	Commercial	Industrial	Open
Tukwila (a)	26,240	3,936	5,248	6,560	0	10,496
Black River basin (b)	14,976	2,240	3,008	3,744	0	5,984
Turning Basin (c)	5,120	1,280	256	1,536	256	1,792
Percent impervious	--	40	60	85	75	0
Percent pervious	--	60	40	15	25	100
Elliott Bay (d)	4,701	623	0	620	3,458	0
Percent impervious	--	40	60	75	70	0
Percent pervious	--	60	40	25	30	100
Total	51,037	8,079	8,512	12,460	3,714	18,272

(a) From Auburn gauging station to Tukwila gauging station.
(b) Black River Basin.
(c) From Tukwila gauging station to turning basin on Duwamish River.
(d) From turning basin to mouth of Duwamish River.

T[illegible] A-6. Summary of Pollutant Source Data.

	TSS (mg/L)	Mercury Total (ug/L)	Mercury Particulate-bound Calculated (h) (mg/kg)	Mercury Particulate-bound Measured (mg/kg DW)	Mercury Street Dust (mg/kg)	PAH (a) Total (ug/L)	PAH (a) Particulate-bound Calculated (j) (mg/kg DW))	PAH (a) Particulate-bound Measured (mg/kg DW)	PAH (a) Street Dust (mg/kg DW)
Green River at Auburn	4.3 b	0.2 n	21.7 n	0.05 o	--	--	--	0.6 k	--
Duwamish basin (Auburn to Elliott Bay)									
Residential	101 c	0.5 J f	5	0.2 l	0.06 g	2.8 c,m	56	2.6	5.1 g
Commercial	46 c	0.5 J f	11	0.23 l	0.1 g	4.6 c,m	74	21	8.[illegible] g
Industrial	59 c	0.5 J f	8	0.26 l	0.06 g	1.3 c,m	22	8.3	9.4 g
Open	101 d	0.5 J f	5	0.1 l	0 g	-- m	--	0.08 l	0 g
Subtotal									
Metro CSOs	121 e	0.35 e	3	1.8 l	--	2.7 e	13	10 l	--
City of Seattle CSOs	121 e	0.35 e	3	0.48 l	--	2.7 e	13	8.5 l	--
Total Duwamish River	5.9 b	0.259 p	24.5	0.328 s				5 s	
Downtown Waterfront CSOs									
Vine (069)	121 e	0.35 e	3	2.23 l	--	2.7 e	13	21.5 l	--
University (070)	121 e	0.35 e	3	0.48 l	--	2.7 e	13	8.5 l	--
Madison (071)	121 e	0.35 e	3	0.48 l	--	2.7 e	13	8.5 l	--
S. Washington (072)	121 e	0.35 e	3	0.48 l	--	2.7 e	13	8.5 l	--
Denny Way (W027)	125 r	0.27	2.21 r	3.22 l	--	5.0 r	36	12.1 l	--
King (W028)	121 e	0.35 e	3	1.8 l	--	2.7 e	13	10 l	--
Connecticut (W029)	121 e	0.35 e	3	0.385 l	--	2.7 e	13	3 l	--
Downtown Waterfront Storm Drains									
SD-A	46	0.5 J f	11	0.23 l	0.1 g	4.6 c,m	74	21 l	--
SD-B	46	0.5 J f	11	0.23 l	0.1 g	4.6 c,m	74	21 l	--
SD-C	46	0.5 J f	11	0.23 l	0.1 g	4.6 c,m	74	21 l	--
SD-D	46	0.5 J f	11	0.23 l	0.1 g	4.6 c,m	74	21 l	--
SD-500	59	0.5 J f	8	0.26 l	0.06 g	1.3 c,m	22	8.3 l	--
Industrial discharges	59	0.5 J	8	0.26 l		1.3	22	8.3 l	

(a) Sum of LPAH and HPAH
(b) Geometric mean for 45 samples colected between 1989 and 1993 (Metro 1990, 1994). Station A319 near Auburn and Station 0305 at the Spokane Street bridge.
(c) Geometric mean for samples collected between 1986 and 1988 from storm drains in Seattle (Merrill 1989 personal communication).
(d) Assume same concentration as residential.
(e) Average of samples collected from Michigan, Denny, Hanford, and Lander CSOs (Cooley et al. 1984; Romberg 1994 personal communication).
(f) Mercury undetected in 20 stormwater samples collected from residential, commercial, and industrial areas in Bellevue, WA (Galvin and Moore 1982).
Mercury detected in less than 10 percent of urban runoff sampes collected as part of Nationwide Urban Runoff Study (U.S. EPA 1983). Concentrations range from 0.6 to 1.2 ug/L.
(g) Urban street dust samples collected from Bellevue, WA (Galvin and Moore 1982).
(h) Particulate fraction estimated as ratio of bulk water concentration and TSS concentration, assuming that all of mercury is particulate-bound.
(i) Assume same concentration as industrial.
(j) Particulate fraction estimated as ratio of bulk water concentration and TSS concentration, assuming that 10 percent of the PAH is dissolved (Galvin and Moore 1982).
(k) Single sample of suspended particulate collected from Green River near Auburn (Curl 1982).
(l) Geometric mean of samples collected from storm drain manholes and catch basins by Tetra Tech (1988a), KJC (1987), and Herrera (1994).
(m) PAH detected in less than 10 percent of urban runoff samples collected as part of NURP; concentrations ranged from 25 to 119 ug/L (U.S. EPA 1983).
(n) Average value based on samples collected by the U.S. Geological Survey (17 samples collected between 12/70 and 9/71), Ecology (18 samples collected between 12/70 and 9/71), and Metro (22 samples collected between 4/76 and 1/82).
(o) Estimated based on concentration measured in 4 sediment samples collected from turning basin (Tetra Tech 1988b; Metro 1990, 1994).
(p) Average of 22 samples collected by Metro from 1976 to 1982 in the Duwamish River at the Spokane Street bridge.
(r) Geometric mean for samples collected by Metro in 1992-1993 Romberg 1994 personal communication). PAH measured in 6 suspended particulate samples; mercury measured in 6 water samples. PAH particulate data reported as wet weight. Wet weight concentrations converted to dry weight assuming samples contained 50 percent solids.
(s) Geometric mean for 10 suspended particulate samples collected in the Duwamish River between turning basin and Spokane Street in 1981 (Romberg et al. 1984).

PIER 55

Pier 55 is made of wood piling with sprinkler systems installed between the piling rows. The piling are rows running in a north-south direction with 1-5 feet between piling and approximately 10 feet between piling rows. Large water pipes are hanging down 4-6 feet below the decking and run in an east-west direction and will limit access during high tide. Wave curtains are located on several piling rows running in a north-south direction and extend down to the high water mark. A large 10 foot by 10 foot wood box hangs below decking to the high water mark. A 4 inch water or sewer pipe is located in the center of the pier and is busted with water coming out. At approximately 25-35 feet from the south edge of the pier, a 6 inch pipe is hanging down 2.5-3 feet below decking. Timbers at several points are nailed between piling and will block access during high tides.

T[illegible] A-8. Total Suspended Solids Loads for October 1993 to October 1994.

	Total Susperded Solids Load (kg)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	123,583	134,557	389,656	589,749	271,596	636,327	478,582	196,527	245,430	102,456	76,574	88,842	143,637	3,477,515
Duwamish basin (Auburn to Elliott Bay)														
Residential	68,857	149,824	195,562	83,496	252,161	104,037	101,083	31,578	41,275	3,433	3,570	74,937	170,141	1,279,954
Commercial	38,683	79,136	107,590	47,015	136,516	59,165	55,835	18,160	23,382	1,974	2,053	41,253	90,913	701,675
Industrial	12,399	25,849	34,704	15,059	44,251	18,894	17,988	5,780	7,476	628	654	13,304	29,589	226,574
Open	4,327	33,199	23,034	4,737	40,158	3,139	10,850	0.0	1,676	0.0	0.0	8,704	32,758	162,581
Subtotal	124,265	288,008	360,889	150,306	473,085	185,236	185,756	55,519	73,808	6,035	6,277	138,198	323,401	2,370,784
Metro CSOs	600	3,538	11,344	115	9,911	3,239	60	0	1,357	0	0	261	5,896	36,321
City of Seattle CSOs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Duwamish River	180,073	208,671	565,684	822,335	412,597	889,445	672,608	274,853	343,522	141,544	106,052	133,867	224,290	4,975,541
Downtown Waterfront CSOs														
Vine (069)	64	110	239	91	170	96	110	46	60	55	9.0	46	60	1,157
University (070)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madison (071)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. Washington (072)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denny Way (W027)	2,015	14,745	50,149	1,183	51,241	9,391	771	0	6,503	0.0	0.0	142	16,109	152,248
King (W028)	0.0	866	3,015	0.0	2,478	96	0.0	0.0	445	0.0	0.0	0.0	1,543	8,442
Connecticut (W029)	4.5	0.0	64.2	0.0	151	0.0	0.0	0.0	22.4	0.0	0.0	0.0	673	915
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	24.4	62.6	107	27.6	89.9	21.2	41.3	8.6	19.2	25.1	1.5	13.1	66.4	508
SD-500	16.4	42.0	72.1	18.5	60.3	14.2	27.7	5.8	12.9	16.9	1.0	8.8	44.6	341
Industrial discharges	100	172	189	166	176	151	119	100	84	84	80	85	155	1,662

PIER 54

The south edge of Pier 54 is a fire station with the two fire boats moored to a single floating slip running in a east-west direction approximately 50-55 feet with restricted access on the ramp. The general condition of the southern section of the pier is good, with the piling made of concrete and spaced approximately 10-12 feet apart for easy access. The piling under the main section of pier 54 is wood and is deteriorated, with several sections patched and new piling at random locations. Sprinkler pipes are running north-south with the 4-6 inch supply lines running east-west hanging down 3-4 feet below the decking, limiting access at high water. Wave barriers are hanging down 5-6 feet and running in a north-south direction. The piling rows are approximately 9-10 feet apart with the spacing between the piling ranging from no clearance to 10 feet. Along the bulkhead, a 30-36 inch storm drain dumps into the Sound, approximately 50 feet north of the sheet pile at the north edge of pier 53. Several sewer and water lines active and nonactive are hanging below the decking with access limited under the lines during high tide.

Table A-10. PAH Loads for October 1993 to October 1994.

	Total PAH Load (g)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	74	81	234	354	163	382	287	118	147	61	46	53	86	2,087
Duwamish basin (Auburn to Elliott Bay)														
Residential	179	390	508	217	656	271	263	82	107	9	9	195	442	3,328
Commercial	812	1,662	2,259	987	2,867	1,242	1,173	381	491	41	43	866	1,909	14,735
Industrial	103	215	288	125	367	157	149	48	62	5	5	110	246	1,881
Open	0.4	2.7	1.8	0.4	32	0.3	0.9	0.0	0.1	0.0	0.0	0.7	2.6	13.0
Subtotal	1,095	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19,957
Metro CSOs	6.0	35.0	114	1.0	990	32.0	1.0	0.0	14.0	0.0	0.0	3.0	59.0	364
City of Seattle CSOs	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamish River	900	1,048	2,873	4,112	2,127	4,472	3,363	1,374	1,721	708	530	669	1,155	25,052
Downtown Waterfront CSOs														
Vine (069)	1.4	2.4	5.1	2.0	37	2.1	2.4	1.0	1.3	1.2	0.2	1.0	1.3	25
University (070)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	24.3	177.7	604	14.3	618	113.2	9.3	0.0	78.4	0.0	0.0	1.7	194.2	1835
King (W028)	0.0	8.7	30.2	0.0	248	1.0	0.0	0.0	4.5	0.0	0.0	0.0	15.4	84.4
Connecticut (W029)	0.0	0.0	0.2	0.0	05	0.0	0.0	0.0	0.1	0.0	0.0	0.0	2.0	2.7
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	1.0	1.0	2.3	1.0	1.9	0.4	0.9	0.2	0.4	0.5	0.0	0.3	1.4	10.7
SD-500	0.0	0.0	0.6	0.0	0.5	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.4	2.8
					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial discharges	1.0	1.4	1.6	1.0	1.5	1.3	1.0	0.8	0.7	0.7	0.7	0.7	1.3	13.8

PIER 46

Starting at approximately 500 feet south of the north face of pier 46, the pier is in excellent shape. It appears to have been recently constructed with both the piling and decking made of concrete and the piling rows on approximately 20 foot centers and the piling approximately 5-6 feet apart. The decking is approximately 15-17 feet above MLLW allowing good access during high water. There is bumper pile on approximately 10 foot centers on the west face of the pier, but a small boat can pass between the bumper pile and the structural piling rows easily. As you move to the north along the west face of the pier, the bulk head also moves away from the face with it making a sharp turn to the right, (East) at approximatelt 120 feet from the northwest corner of the pier, figure 1. The general pattern of the pier continues the same as the west face as you move around the northwest corner of the pier. At 250 feet from the northwest corner, the concrete section of the pier is interfaced with wood piling on the northern edge of the pier. The bumper piling are separated by 6-8 feet along the north face, with structural pile set inside the bumper pile 12-18 inches that are only 24-36 inches apart, not allowing access from the north face of the pier. The piling rows inside the pier are approximately 8 feet apart and are separated by 12-18 inches apart in a north south direction not allowing access going in an east west direction. At approximately 50 feet south of the north face the wood pile is joined to the continuation of the newer concrete section, with access very easy from the northwest end of the pier.

In the wood section of the pier, sprinkler systems are installed between every row of piling. running north-south with 2 4-6 inch supply lines running east-west approximately 12-18 inches above the high water mark. Wave barriers are placed in a north-south direction, approximately 80 feet apart. The barriers extend down from the decking 12-18 inches below the high water mark.

The Washington State passenger ferry, "Skagit" is moored along side a 60-75 foot barge at the north-east corner of pier 46. It appears the ferry is permanently moored there when not in service. The "Golden Alaska", a bottom dragger, is moored to the west of the state ferry along the north edge of the pier. Logs are floating between the fishing vessel and the pier that appear to be used for a stand-off for the fishing boat.

Table A-12. Mercury Loads (Coarse) for October 1993 to October 1994.

	Mercury Load--Coarse (g) (sil-size and larger particles)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	1.3	1.4	4.1	6.1	2.8	6.6	5.0	2.0	2.6	1.1	0.8	0.9	1.5	36
Duwamish basin (Auburn to Elliott Bay)														
Residential	2.8	6.0	7.8	3.3	10.1	4.2	4.0	1.3	1.7	0.1	0.1	3.0	6.8	51
Commercial	1.8	3.6	5.0	2.2	6.3	2.7	2.6	0.8	1.1	0.1	0.1	1.9	4.2	32
Industrial	0.6	1.3	1.8	0.8	2.3	1.0	0.9	0.3	0.4	0.0	0.0	0.7	1.5	12
Open	0.1	0.7	0.5	0.1	0.8	0.1	0.2	0.0	0.0	0.0	0.0	0.2	0.7	3.4
Subtotal	5.3	11.6	15.1	6.4	19.5	8.0	7.7	2.4	3.2	0.2	0.2	5.8	13.2	99
Metro CSOs	0.2	1.3	4.1	0.0	3.6	1.2	0.0	0.0	0.5	0.0	0.0	0.1	2.1	13
City of Seattle CSOs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamish River	11.8	13.9	38.7	53.9	29.4	59.2	44.1	18.0	22.6	9.3	7.0	8.8	15.9	333
Downtown Waterfront CSOs														
Vine (069)	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
University (070)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	0.9	6.5	22.2	0.5	22.6	4.2	0.3	0.0	2.9	0.0	0.0	0.1	7.1	67
King (W028)	0.0	0.3	1.1	0.0	0.9	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.6	3.1
Connecticut (W029)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial discharges	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PIER 48

Pier 48 appears to be well maintained with a large fishing boat moored to the south edge of the pier and a large fuel barge moored to the west end of the pier. An oil boom is encompassing the fishing boat and extends inside the south edge of the pier approximately 30 feet, thus not allowing easy access to run survey lines between the piling in a north-south direction. wave barriers run in a north-south direction at approximately ???? foot intervals, going west to east. The wave barriers extend down from the decking approximately 48-56 inches to the high water mark. Sprinkler systems are installed between every row of piling, running in a north-south direction. The piling rows are approximately 8-10 feet apart running north-south, with the individual piling separated 12-24 inches. Access between rows in an east-west direction can be done at random points along the piling rows, but only at lower tides , as the wave barriers extend down to the high water mark, approximately every 135 feet, as you move east west. The sprinkler system is supplied by 4, 4-6 inch water pipes running in an east-west direction approximately 30-35 feet apart.

Access is limited along the north face, as the bumper pile are 5-6 feet apart, with another pile between the bumper pile, at the north face, thus limiting access to the interior of the pier. At the north-east end of the pier a large floating ramp is lying next to the pier limiting access to the piling for approximately 75-80 feet out from the shoreline, figure 2.

A-14. Total Suspended Solids Loads (Fines) for October 1993 to October 1994.

	Total Suspended Solids Load---FINES (kg) (silt-size and smaller particles)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	107,517	117,064	339,000	513,082	236,289	553,605	416,366	170,979	213,524	89,137	66,619	77,292	124,964	3,025,438
Duwamish basin (Auburn to Elliott Bay)														
Residential	59,906	130,347	170,139	72,642	219,380	90,512	87,942	27,473	35,909	2,987	3,106	65,195	148,023	1,113,560
Commercial	33,654	68,848	93,603	40,903	118,769	51,474	48,576	15,799	20,342	1,718	1,786	35,890	79,095	610,457
Industrial	10,787	22,489	30,192	13,101	38,499	16,438	15,649	5,029	6,504	547	569	11,574	25,742	197,120
Open	3,764	28,883	20,039	4,121	34,937	2,731	9,440	0.0	1,458	0.0	0.0	7,573	28,499	141,446
Subtotal	108,110	250,567	313,973	130,766	411,584	161,155	161,608	48,301	64,213	5,251	5,461	120,232	281,359	2,062,582
Metro CSOs	522	2,830	9,869	100	8,623	2,818	52	0.0	1,180	0.0	0.0	227	5,130	31,351
City of Seattle CSOs	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamish River	156,664	181,544	492,145	715,431	358,960	773,817	585,169	239,122	293,864	123,143	92,265	116,464	195,132	4,328,721
Downtown Waterfront CSOs														
Vine (069)	56	96	208	79	148	83	96	40.3	52	48.0	7.8	40	52	1,006
University (070)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	1,753	12,828	43,630	1,029	44,579	8,170	671	0.0	5,657	0.0	0.0	123	14,015	132,456
King (W028)	0.0	753	2,623	0.0	2,156	83	0.0	0.0	387	0.0	0.0	0.0	1,343	7,345
Connecticut (W029)	3.9	0.0	56	0.0	131	0.0	0.0	0.0	19	0.0	0.0	0.0	586	796
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	21.3	54.5	93.5	24.0	78.2	18.4	36.0	7.5	16.7	21.9	1.3	11.4	57.8	442
SD-500	14.3	36.6	62.7	16.1	52.5	12.4	24.1	5.0	11.2	14.7	0.9	7.6	38.8	297
Industrial discharges	87	150	164	144	153	132	103	87	73	73	70	74	135	1,446

PIER 52,52A,53

The entire ferry dock structure seems to encompass three pier sections. The new section appears to be the most southerly section with the older section on the north. Pier 52, appears to be recently constructed, as the southern section is made of concrete pile and concrete decking. Access is easily obtained when approaching from the south as the piling are approximately 10 feet apart at the face, with slightly less than 10 feet as you move under the decking. The interior piling are made up of a four pile structure as two of the four pile are at a slight angle, to create lateral support, figure 3. At low tide access is somewhat limited as the piling get closer together. At high tide access is still available, as the decking is 15-17 feet above MLLW. Some utilities run in an east-west direction, less than 12-15 inches below the decking. This access from the south is limited to only the pier 52 section, as the newer section attaches to the old section, Pier 52A, the clearance under the decking and wave barriers is restricted to low tide access only, as the wave barriers extend down to the high water mark. The piling spacing, in the pier 52A section will allow movement between the piling rows as the spacing is approximately 6-10 feet in both the east-west and north-south direction. Sprinklers are installed between the wood piling rows with 4-6 inch water pipe running every 35-40 feet in a east-west direction. The water supply lines are hanging down approximately 3 feet above the high water mark. Both Pier 52A and Pier 53 are wood structures with the piling not evenly spaced at the intersection points of the two piers. To gain access in the north-south direction one must enter either form the north or the south, only at few spots can you go the full length in a north-south line. Steel cables are hanging from the piling structures below the north and south loading ramps limiting access under the ramps. At very low tides a small boat can gain access under the cables. Access in an east-west direction can be done but only at lower tides as again the wave barriers limit the clearance.

Two guide structures are currently active on the west side of the ferry slip, with the third under construction to the south of the Bremerton ferry slip. A 30-35 by 45-55 foot floating dock is located at the south-west corner of pier 52 and is used for the foot passenger ferry traffic.

Table A-15. PAH Loads (Fines) for October 1993 to October 1994.

	PAH Load--Fines (g) (silt-size and smaller particles)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	59	65	187	283	130	305	230	94	118	43.2	36.8	42.6	68.9	1,669
Duwamish basin (Auburn to Elliott Bay)														
Residential	143	312	407	174	525	216	210	66	86	7.1	7.4	156	354	2,662
Commercial	650	1,330	1,808	790	2,294	994	938	305	393	33.2	34.5	693	1,527	11,788
Industrial	82	172	230	100	294	126	119	38	50	4.2	4.3	88.3	197	1,504
Open	0.3	2.1	1.5	0.3	2.6	0.2	0.7	0.0	0.1	0.0	0.0	0.6	2.1	11
Subtotal	876	1,815	2,446	1,064	3,114	1,336	1,268	409	528	45	46	938	2,080	15,965
Metro CSOs	4.8	28.0	91.2	0.8	79.2	25.6	0.8	0.0	11.2	0.0	0.0	2.4	47.2	291
City of Seattle CSOs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamsh River	720	838	2299	3289	1701	3577	2690	1099	1377	566	424	535	924	20,041
Downtown Waterfront CSOs														
Vine (069)	1.1	1.9	4.1	1.6	2.9	1.6	1.9	0.8	1.0	1.0	0.2	0.8	1.0	20
University (070)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	19	142	484	11	494	91	7.4	0.0	63	0.0	0.0	1.4	155	1468
King (W028)	0.0	6.9	24.1	0.0	19.8	0.8	0.0	0.0	3.6	0.0	0.0	0.0	12.3	68
Connecticut (W029)	0	0	0	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.6	2.3
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	0.8	0.8	1.8	0.8	1.5	0.4	0.7	0.1	0.3	0.4	0.0	0.2	1.1	8.9
SD-500	0.0	0.0	0.5	0.0	0.4	0.1	0.2	0.0	0.1	0.1	0.0	0.1	0.3	1.8
Industrial discharges	0.8	1.1	1.2	0.8	1.2	1.0	0.8	0.7	0.6	0.6	0.5	0.6	1.0	10.9

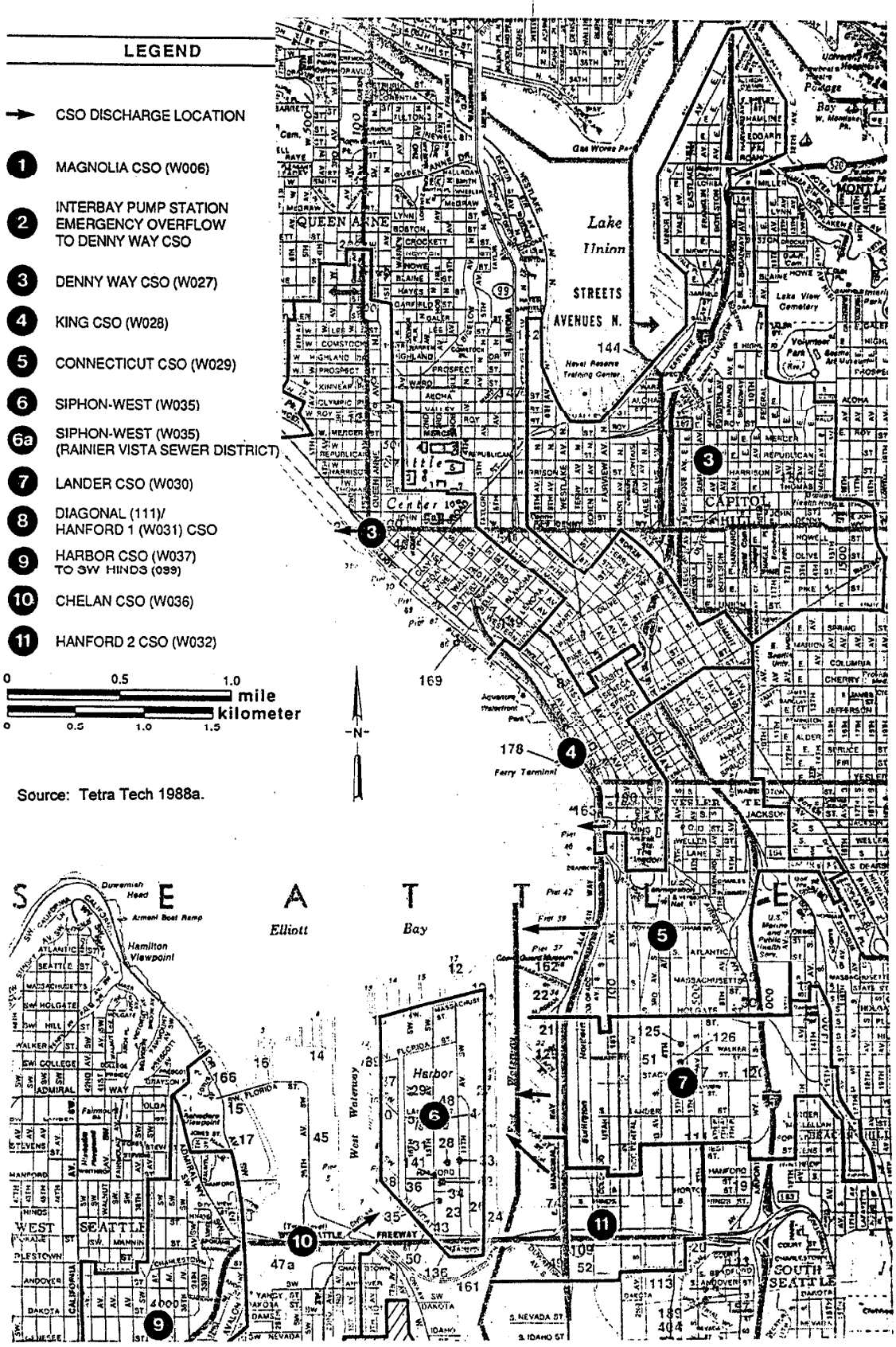


Figure A-3. Metro CSOs along the Seattle waterfront.

Table A-17 Annual Loading Summary for Existing and Future Conditions.

	MERCURY LOAD (grams/yr)					PAH LOAD (grams/yr)				
	RECENT			1993-1994	FUTURE	EXISTING			1993-1994	FUTURE
SOURCE	Average	Min (b)	Max (b)	Study Period (e)	Average	Average	Min (b)	Max (b)	Study Period	Average
Green River at Auburn	269	132	356	181	269	3,101	1,525	4,107	2,087	3,101
Residential	238	134	319	256	238	3,096	1,744	4,143	3,328	3,096
Commercial	639	360	855	161	639	58,325	32,859	78,040	14,735	58,325
Industrial	146	82	195	59	146	4,645	2,617	6,215	1,881	4,645
Open	135	78	180	16	135	108	62	144	13	108
Metro CSCs (a)	620	242	899	65	552	3,444	1,342	4,992	364	3,064
Seattle CSOs (c)	17	6.7	25	0.0	0.18	307	120	445	0.0	3.1
Total Duwamish River	2,516	1,250	3,336	1,663	2,515	38,357	19,062	50,847	25,052	38,339
Denny Way CSO	423	182	688	336	476	2,309	992	3,752	1,835	2,594
Vine CSO	3.37	1.33	4.9	2.33	0.1	32	13	47	25	1
SD-A	0.01	0.00	0.02	0.00	0.01	1.32	0.00	1.79	0.0	1.32
Industrial Discharges	0.39	0.38	0.42	0.43	0.39	13	12	13	14	13
Univ. CSO	0.62	0.00	0.9	0.0	0.04	10.9	0.0	13.0	0.0	0.6
SD-B	0.07	0.00	0.09	0.00	0.07	6.2	0.0	8.4	0.0	6.22
SD-C	0.01	0.00	0.02	0.00	0.01	1.1	0.0	1.4	0.0	1.06
Madison CSO	0.15	0.00	0.22	0.00	0.01	2.7	0.0	3.9	0.0	0.2
SD-D	0.43	0.08	0.57	0.12	0.43	39.1	7.3	51.9	0.0	39
Wash. CSO	0.18	0.00	0.26	0.00	0.00	3.1	0.0	4.7	0.0	0.0
SD-500	0.27	0.06	0.35	0.09	0.27	8.5	1.9	11.3	2.8	8.5
King CSO	45	10.7	66	15	27	252	60	366	84	151
Conn. CSO	16	0.4	24	0.35	16	124	3	184	2.7	128
TOTAL	3,006	1,445	4,121	2,018	3,036	41,160	20,150	55,309	27,015	41,283

Table A-7. Source Discharges for October 1993 to October 1994.

	Flow													
	Oct-93 (AF)	Nov-93 (AF)	Dec-93 (AF)	Jan-94 (AF)	Feb-94 (AF)	Mar-94 (AF)	Apr-94 (AF)	May-94 (AF)	Jun-94 (AF)	Ju-94 (AF)	Aug-94 (AF)	Sep-94 (AF)	Oct-94 (AF)	Total (AF)
Green River at Auburn	23,298	25,367	73,458	111,180	51,201	119,960	90,222	37,049	46,268	19,315	14,436	16,748	27,078	655,581
Duwamish basin (Auburn to Elliott Bay)														
Residential	553	1,203	1,570	670	2,024	835	811	253	331	28	29	60	1,366	10,273
Commercial	682	1,395	1,896	829	2,406	1,043	984	320	412	35	36	727	1,602	12,365
Industrial	170	355	477	207	608	260	247	79	103	9	9	183	407	3,113
Open	35	266	185	38	322	25	87	0.0	13	0.0	0.0	70	263	1,305
Subtotal	1,439	3,219	4,127	1,744	5,360	2,162	2,129	653	859	71	74	1,581	3,637	27,056
Metro CSOs	4	24	76	1	66	22	0	0	9	0	0	2	40	243
City of Seattle CSOs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Duwamish River	24,741	28,609	77,661	112,924	56,628	122,144	92,352	37,702	47,137	19,386	14,510	18,331	30,755	682,880
Downtown Waterfront CSOs														
Vine (069)	0.4	0.7	1.6	0.6	1.1	0.6	0.7	0.3	0.4	0.4	0.1	0.3	0.4	7.8
University (070)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Madison (071)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
S. Washington (072)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Denny Way (W027)	13	96	325	7.7	332	60.9	5.0	0.0	42.2	0.0	0.0	0.9	104	987
King (W028)	0.0	5.8	20	0.0	16.6	0.6	0.0	0.0	3.0	0.0	0.0	0.0	10	57
Connecticut (W029)	0.0	0.0	0.4	0.0	1.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	4.5	6.1
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	0.4	1.1	1.9	0.5	1.6	0.4	0.7	0.2	0.3	0.4	0.0	0.2	1.2	9.0
SD-500	0.2	0.6	1.0	0.3	0.8	0.2	0.4	0.1	0.2	0.2	0.0	0.1	0.6	4.7
Industrial discharges	1.37	2.37	2.59	2.28	2.42	2.08	1.63	1.38	1.16	1.16	1.1	1.17	2.13	23

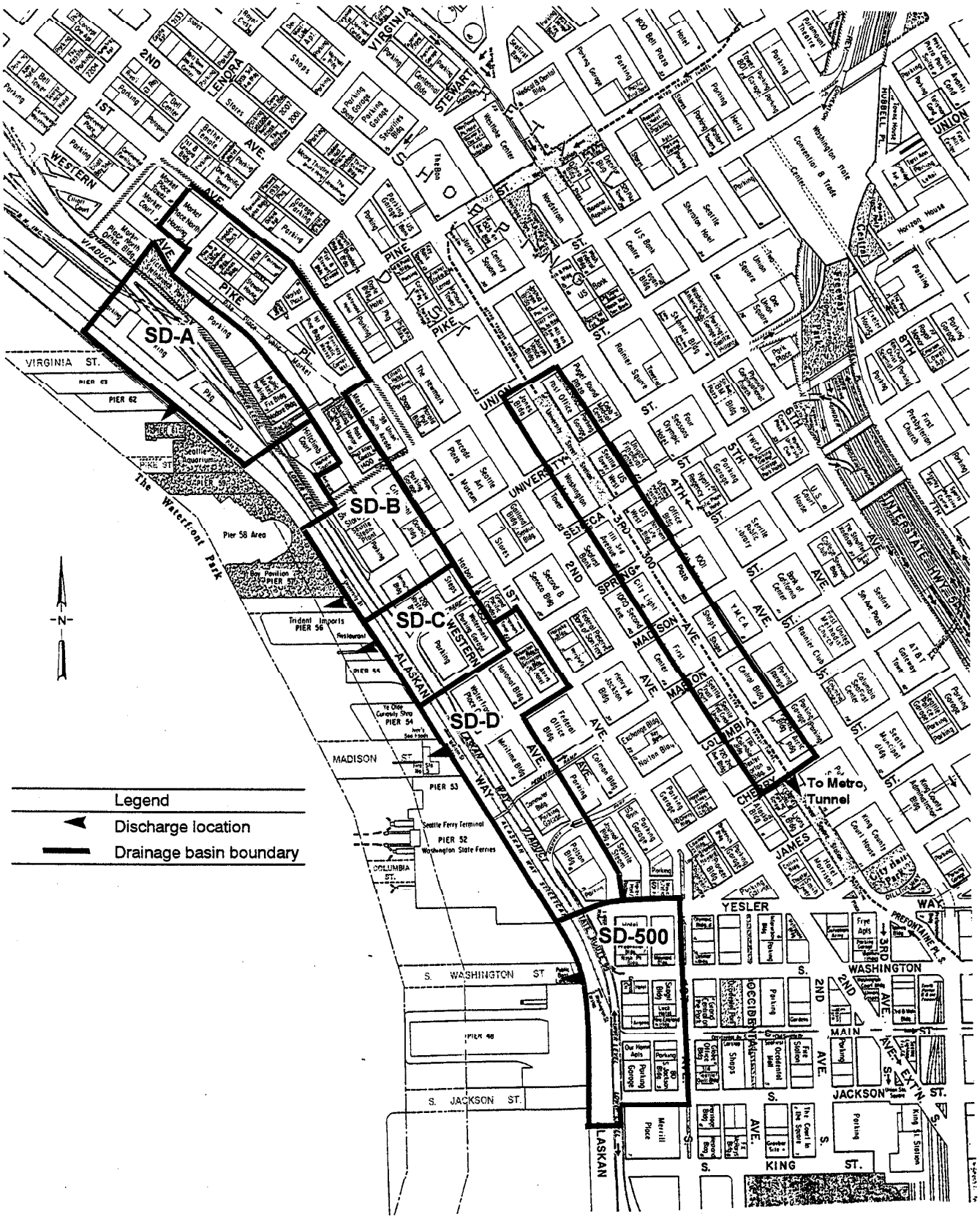


Figure A-2. Storm drains along the Seattle waterfront.

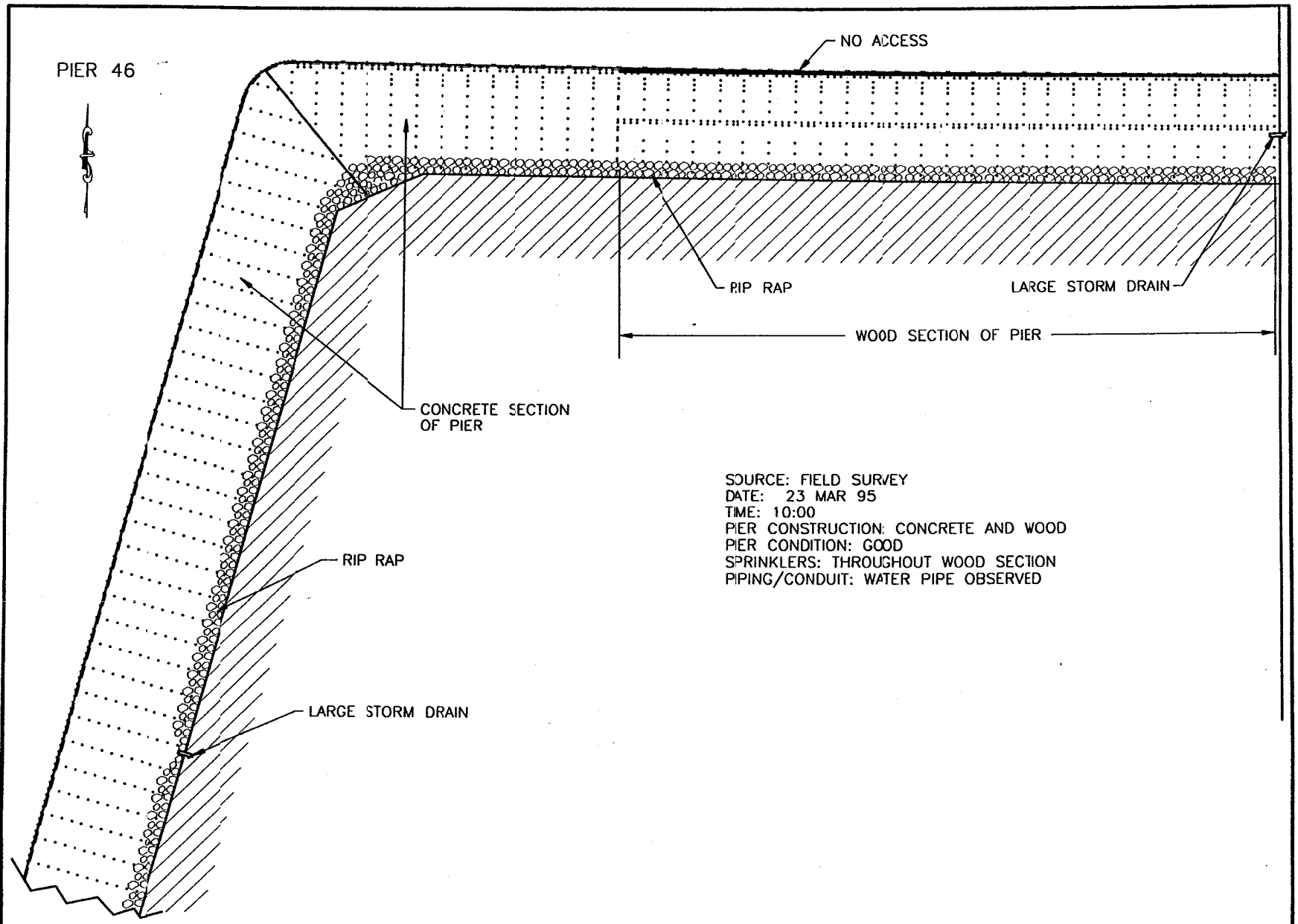
Table A-9. Mercury Loads for October 1993 to October 1994.

	Total Mercury Load (g)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	6	7	20	31	14	33	25	10	13	5	4	5	7	181
Duwamish basin (Auburn to Elliott Bay)														
Residential	14	30.0	39.1	16.7	504	20.8	20.2	6.3	8.3	0.7	0.7	15.0	34.0	256
Commercial	8.9	18.2	24.8	10.8	314	13.6	12.8	4.2	5.4	0.5	0.5	9.5	20.9	161
Industrial	3.2	6.7	9.0	3.9	115	4.9	4.7	1.5	1.9	0.2	0.2	3.5	7.7	58.9
Open	0.4	3.3	2.3	0.5	40	0.3	1.1	0.0	0.2	0.0	0.0	0.9	3.3	16.3
Subtotal	26	58	75	32	97	40	39	12	16	1.3	1.4	29	66	493
Metro CSOs	1.1	6.4	20.4	0.2	178	5.8	0.1	0.0	2.4	0.0	0.0	0.5	10.6	65.4
City of Seattle CSOs	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamish River	59	69	194	270	147	296	221	90	113	46	35	44	80	1,663
Downtown Waterfront CSOs														
Vine (069)	0.1	0.2	0.5	0.2	04	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.1	2.3
University (070)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	4.5	33	111	2.6	13	21	1.7	0.0	14.4	0.0	0.0	0.3	35.6	336
King (W028)	0.0	1.6	5.4	0.0	45	0.2	0.0	0.0	0.8	0.0	0.0	0.0	2.8	15
Connecticut (W029)	0.0	0.0	0.0	0.0	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	0.01	0.01	0.02	0.01	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.12
SD-500	0.00	0.01	0.02	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.09
Industrial discharges	0.03	0.04	0.05	0.04	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.04	0.43

Appendix B- Under-Pier Survey: Seattle Waterfront

Table A-11. Total Suspended Solids Loads (Coarse) for October 1993 to October 1994.

	Total Suspended Solids Load---COARSE (kg) (sand-size and larger particles)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	16,066	17,492	50,655	76,667	35,308	82,723	62,216	25,549	31,906	13,319	9,955	11,549	18,673	452,077
Duwamish basin (Auburn to Elliott Bay)														
Residential	8,951	19,477	25,423	10,854	32,781	13,525	13,141	4,105	5,366	446	464	9,742	22,118	166,394
Commercial	5,029	10,288	13,987	6,112	17,747	7,691	7,259	2,361	3,040	257	267	5,363	11,819	91,218
Industrial	1,612	3,360	4,511	1,958	5,753	2,456	2,338	751	972	82	85	1,729	3,847	29,455
Open	562	4,316	2,994	616	5,221	408	1,411	0.0	218	0.0	0.0	1,132	4,259	21,136
Subtotal	16,154	37,441	46,916	19,540	61,501	24,081	24,148	7,217	9,595	785	816	17,966	42,042	308,202
Metro CSOs	78.0	460	1,475	15	1,288	421	7.8	0.0	176	0.0	0.0	34	766	4,722
City of Seattle CSOs	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamish River	23,409	27,127	73,539	106,904	53,638	115,628	87,439	35,731	44,658	18,401	13,787	17,403	29,158	646,820
Downtown Waterfront CSOs														
Vine (069)	8.3	14.4	31.0	11.8	221	12.4	14.4	6.0	7.8	7.2	1.2	6.0	7.8	150
University (070)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	262.0	1,916.8	6,519	154	6,661	1,221	100	0.0	845	0.0	0.0	18.4	2,094	19,792
King (W028)	0.0	112.5	392	0.0	322	12	0.0	0.0	58	0.0	0.0	0.0	201	1,098
Connecticut (W029)	0.6	0.0	8.3	0.0	196	0.0	0.0	0.0	2.9	0.0	0.0	0.0	88	119
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	3.2	8.1	14.0	3.6	11.7	2.8	5.4	1.1	2.5	3.3	0.2	1.7	8.6	66.1
SD-500	2.1	5.5	9.4	2.4	7.8	1.8	3.6	0.7	1.7	2.2	0.1	1.1	5.8	44.3
Industrial discharges	13.0	22.4	24.5	21.6	22.9	19.7	15.4	13.1	11.0	11.0	10.4	11.1	20.2	216



PIER-46 April 10, 1995

Table A-13. PAH Loads (Coarse) for October 1993 to October 1994.

	PAH Load--Coarse (g) (silt-size and larger particles)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	14.8	16.1	46.8	70.8	32.6	76.4	57.4	23.6	29.5	12.3	9.2	10.7	17.2	417
Duwamish basin (Auburn to Elliott Bay)														
Residential	35.8	77.9	101.7	43.4	131.1	54.1	52.6	16.4	21.5	1.8	1.9	39.0	88.5	666
Commercial	163	332	452	198	573	249	235	76.3	98.2	8.3	8.6	173.3	381.8	2,947
Industrial	20.6	42.9	57.6	25.0	73.5	31.4	29.9	9.6	12.4	1.0	1.1	22.1	49.1	376.2
Open	0.1	0.5	0.4	0.1	0.6	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0.5	2.6
Subtotal	219	454	612	266	779	334	317	102	132	11	12	235	520	3,992
Metro CSOs	1.2	7.0	22.8	0.2	19.8	6.4	0.2	0.0	2.8	0.0	0.0	0.6	11.8	72.8
City of Seattle CSOs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Total Duwamish River	180	210	575	822	425	894	673	275	344	142	106	134	231	5,010
Downtown Waterfront CSOs														
Vine (069)	0.3	0.5	1.0	0.4	0.7	0.4	0.5	0.2	0.3	0.2	0.0	0.2	0.3	5
University (070)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	4.9	35.5	120.9	2.9	123.5	22.6	1.9	0.0	15.7	0.0	0.0	0.3	38.8	367
King (W028)	0.0	1.7	6.0	0.0	5.0	0.2	0.0	0.0	0.9	0.0	0.0	0.0	3.1	16.9
Connecticut (W029)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	0.2	0.2	0.5	0.2	0.4	0.1	0.2	0.0	0.1	0.1	0.0	0.1	0.3	2.4
SD-500	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3
Industrial discharges	0.2	0.3	0.3	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.3	2.7

PIER 48

SOURCE: FIELD SURVEY
DATE: 28 MAR 95
TIME: 1330 HRS
ELEV. OF DECK 10 FT.
@ 1330 HRS.
PIER CONSTRUCTION: WOOD
PIER CONDITION: GOOD
SPRINKLERS: THROUGHOUT-EACH ROW
PIPING/CONDUIT: THROUGHOUT

TYPICAL PILING IS 12-24" APART
RUNNING NORTH-SOUTH WITH
8-10' APART RUNNING EAST-WEST

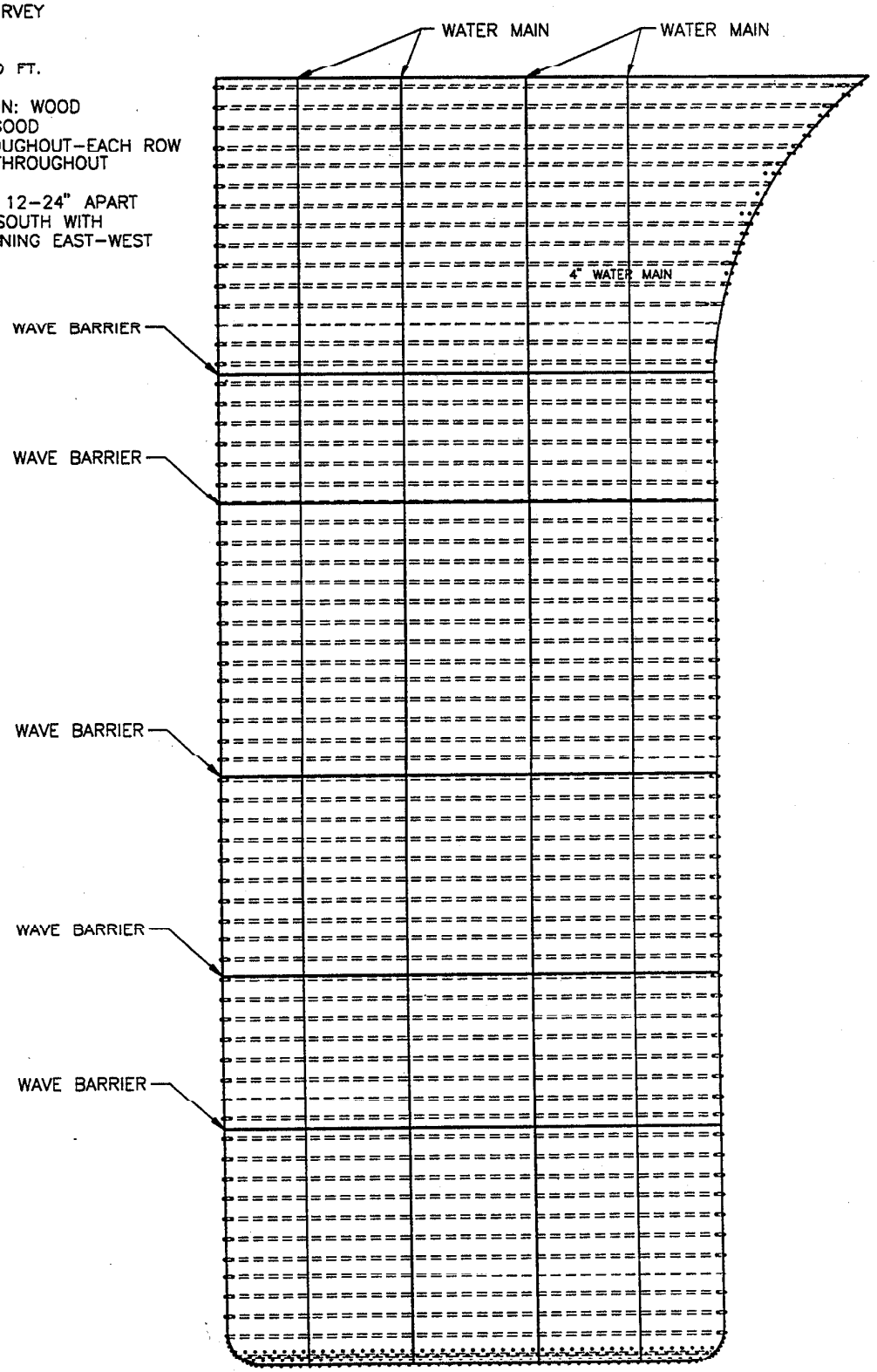


Table A-15. Mercury Loads (Fines) for October 1993 to October 1994.

	Mercury Load-- Fines (g) (silt-size and smaller particles)													
	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Total
Green River at Auburn	5.1	5.6	16.2	24.5	11.3	26.5	19.9	8.2	10.2	4.3	3.2	3.7	6.0	145
Duwamish basin (Auburn to Elliott Bay)														
Residential	11.0	24.0	31.3	13.4	40.3	16.6	16.2	5.1	6.6	0.6	0.6	12.0	27.2	205
Commercial	7.1	14.6	19.8	8.6	25.1	10.9	10.3	3.3	4.3	0.4	0.4	7.6	16.7	129
Industrial	2.6	5.4	7.2	3.1	9.2	3.9	3.7	1.2	1.6	0.1	0.1	2.8	6.2	47
Open	0.3	2.7	1.8	0.4	3.2	0.2	0.9	0.0	0.1	0.0	0.0	0.7	2.6	13
Subtotal	21.0	46.6	60.1	25.5	77.9	31.7	31.1	9.6	12.6	1.0	1.1	23.0	52.7	394
Metro CSOs	0.9	5.1	16.3	0.2	14.3	4.7	0.1	0.0	2.0	0.0	0.0	0.4	8.5	52.4
City of Seattle CSOs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Duwamish River	47.2	55.4	155	216	117	237	176	72	91	37	28	35	64	1,331
Downtown Waterfront CSOs														
Vine (069)	0.1	0.2	0.4	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.1	1.9
University (070)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Madison (071)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. Washington (072)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Denny Way (W027)	3.6	26	89	2.1	91	17	1.4	0.0	11	0.0	0.0	0.2	28	269
King (W028)	0.0	1.2	4.3	0.0	3.6	0.1	0.0	0.0	0.6	0.0	0.0	0.0	2.2	12.2
Connecticut (W029)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
Downtown Waterfront Storm Drains														
SD-A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SD-D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
SD-500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Industrial discharges	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3

PIER 52

SOURCE: FIELD SURVEY
DATE: 30 & 31 MAR 95
TIME: 0100–0500 HRS
PIER CONSTRUCTION: 52A AND 53 = WOOD
PIER 52 = CONCRETE
PIER CONDITION: GOOD
SPRINKLERS: THROUGHOUT WOOD CONSTRUCTION
PIPING/CONDUIT: THROUGHOUT

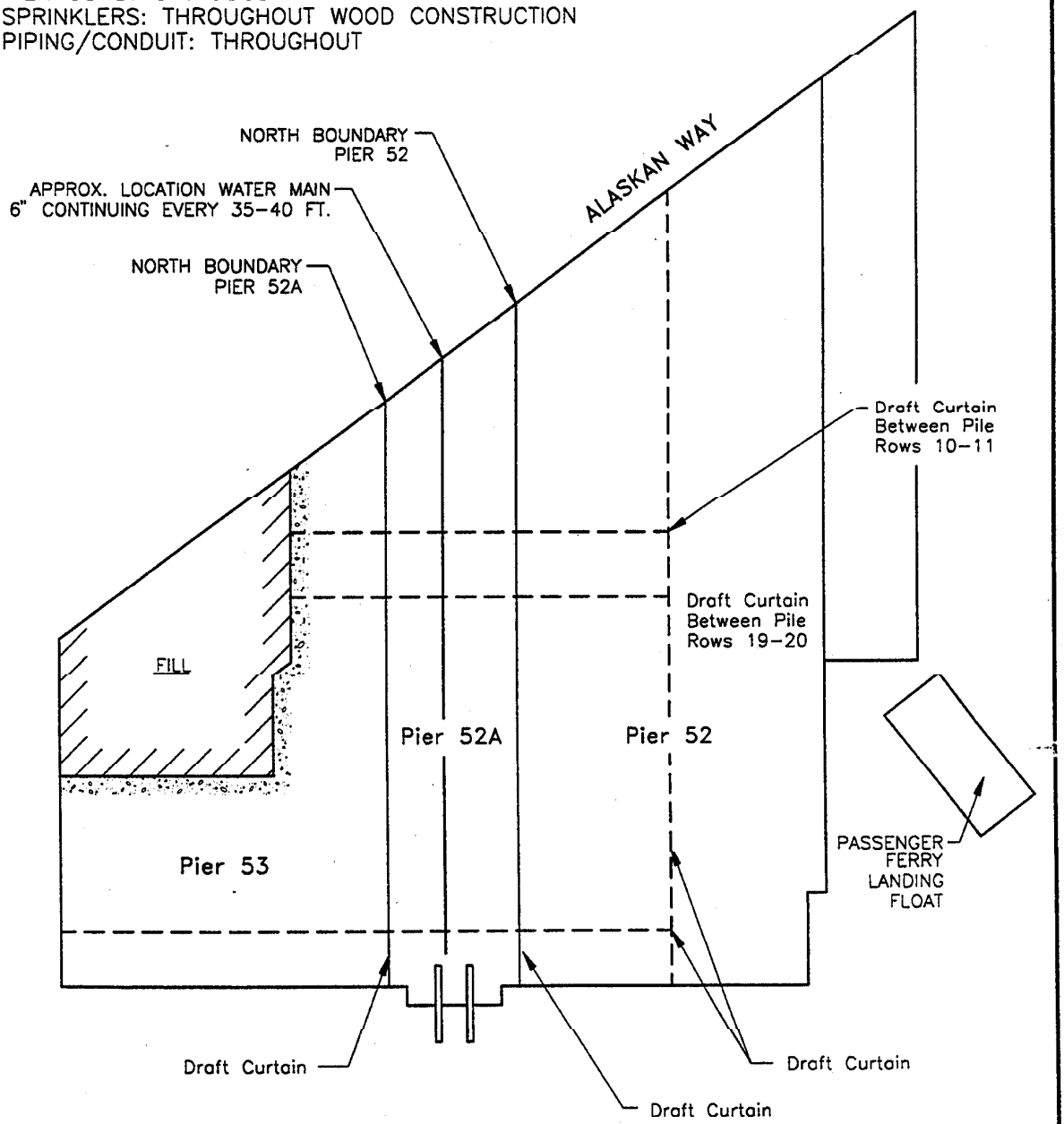


Table A-17. Annual Loading Summary for Existing and Future Conditions.

SOURCE	DISCHARGE VOLUME (Mgal/yr) RECENT Average	Min (b)	Max (b)	1993-1994 Study Period (e)	FUTURE Average	Pollutant Concentration TSS (mg/L)	Mercury (mg/kg)	PAH (mg/kg)	TSS LOAD (kg/yr) RECENT Average	Min (b)	Max (b)	1993-1994 Study Period (e)	FUTURE Average
Green River at Auburn	317,600	156,200	420,600	213,588	317,600	4.3	0.052	0.6	5,169,099	2,542,233	6,845,475	3,477,515	5,169,099
Residential	3,115	1,755	4,168	3,347	3,115	101	0.20	2.60	1,190,818	670,910	1,593,364	1,279,954	1,190,818
Commercial	15,952	8,987	21,344	4,029	15,952	46	0.23	21	2,777,403	1,564,727	3,716,204	701,675	2,777,403
Industrial	2,506	1,412	3,353	1,014	2,506	59	0.26	8.3	559,627	315,321	748,775	226,574	559,627
Open	3,523	2,039	4,713	425	3,523	101	0.1	0.08	1,346,790	779,479	1,801,709	162,581	1,346,790
Metro CSOs (a)	752	293	1,090	79	669	121	1.8	10	344,405	134,190	499,204	36,321	306,392
Seattle CSOs (c)	79	31	114	0.0	0.8	121	0.48	8.5	36,089	14,060	52,348	0	366
Total Duwamish River	343,527	170,717	455,382	222,502	343,366	5.9	0.328	5	7,671,469	3,812,360	10,169,370	4,975,541	7,667,873
Denny Way CSO	405	174	658	322	455	125	2.21	12.1	191,616	82,324	311,316	152,248	215,272
Vine CSO	3.3	1.3	4.8	2.5	0.1	121	2.23	21.5	1,511	595	2,198	1,157	46
SD-A	0.4	0.0 (f)	0.5	0	0.4	46	0.23	21	63	0	85	0.0	63
Industrial Dscharges	6.8	6.5	7.2	7.4	6.8	59	0.26	8.3	1,519	1,447	1,612	1,662.4	1,519
Univ. CSO	2.8	0.0 (f)	4.1	0	0.2	121	0.48	8.5	1,282	0	1,878	0.0	73
SD-B	1.7	0.0 (f)	2.3	0	1.7	46	0.23	21	296	0	400	0.0	296
SD-C	0.3	0.0 (f)	0.4	0	0.3	46	0.23	21	50	0	68	0.0	50
Madison CSO	0.7	0.0 (f)	1.0	0	0.04	121	0.48	8.5	321	0	458	0.0	18
SD-D	11	2.0	14	2.9	11	46	0.23	21	1,863	348	2,472	508	1,863
Wash. CSO	0.8	0.0 (f)	1.2	0	0.01	121	0.48	8.5	366	0	550	0.0	2.3
SD-500	4.6	1.0	6.1	1.5	4.6	59	0.26	8.3	1,027	223	1,362	341	1,027
King CSO	55	13	80	18	33	121	1.8	10	25,189	5,954	36,639	8,442	15,114
Conn. CSO	90	2	134	2.0	93	121	0.385	3	41,219	916	61,370	915	42,593
TOTAL	344,109	170,916	456,296	222,859	343,972				7,937,791	3,904,168	10,589,779	5,140,815	7,945,809

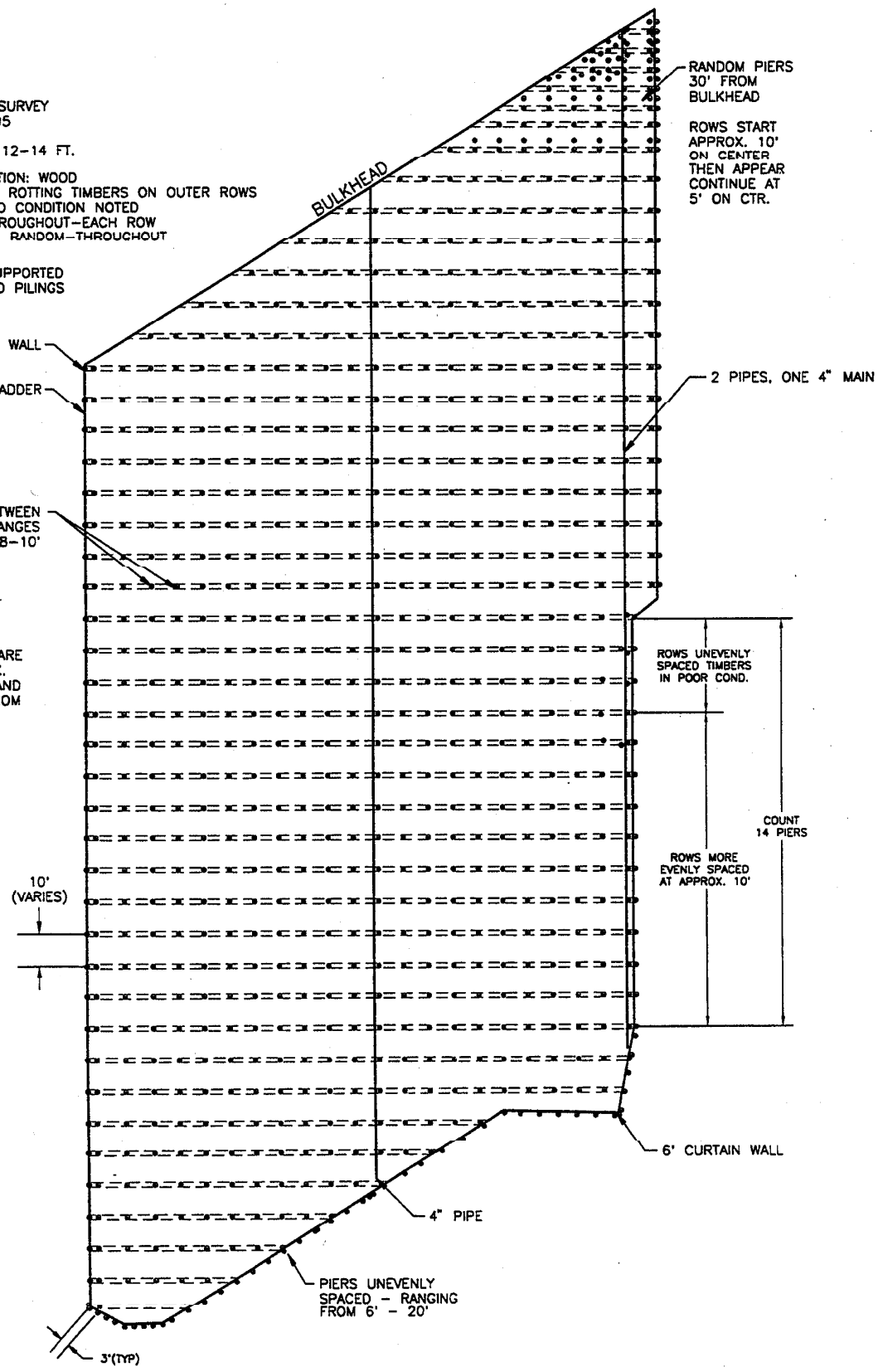
(continued)

a) CSO volumes based on hydraulic model of combined sewer system (Swarner, 1995 personal communication; Culp, Wesner, Culp; 1985).
b) Range in annual discharge volumes estimated using minimum rainfall of 20 in/yr and maxmum rainfall of 47.5 in/yr (1943-1983 records)
c) Average CSO volumes based on hydraulic model of combined sewer system (Brown and Caldwell 1988). Minimum and maximum flows calculated based on Culp, Wesner, Culp 1985 estimates for Metro CSOs.
d) Overflow from low flow diversion structures estimated assuming that 90 percent of rainfall in an average year is less than the 1-year design storm (Ecology 1992).
e) 13-month study period from October 1993 through October 1994.
f) Assume no storms exceed the 1-year event (i.e., no overflows).

PIER 54

SOURCE: FIELD SURVEY
DATE: 28 MAR 95
TIME: 1130 HRS
ELEV. OF DECK 12-14 FT.
@ 1130 HRS.
PIER CONSTRUCTION: WOOD
PIER CONDITION: ROTTING TIMBERS ON OUTER ROWS
OTHERWISE GOOD CONDITION NOTED
SPRINKLERS: THROUGHOUT-EACH ROW
PIPING/CONDUIT: RANDOM-THROUGHOUT

CONCRETE PADS
THROUGHOUT SUPPORTED
BY METAL CASED PILINGS



PIER-54 April 6, 1995

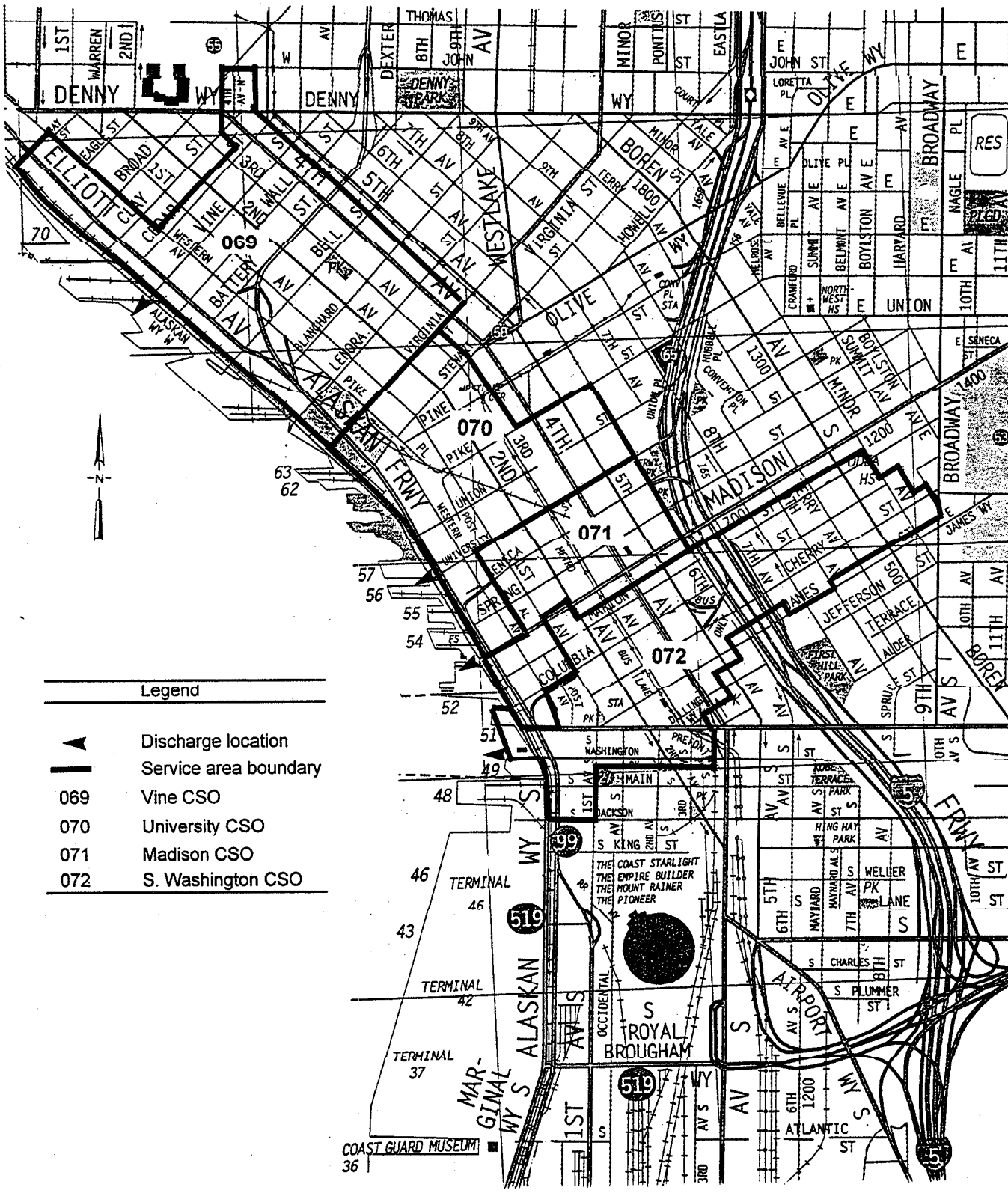
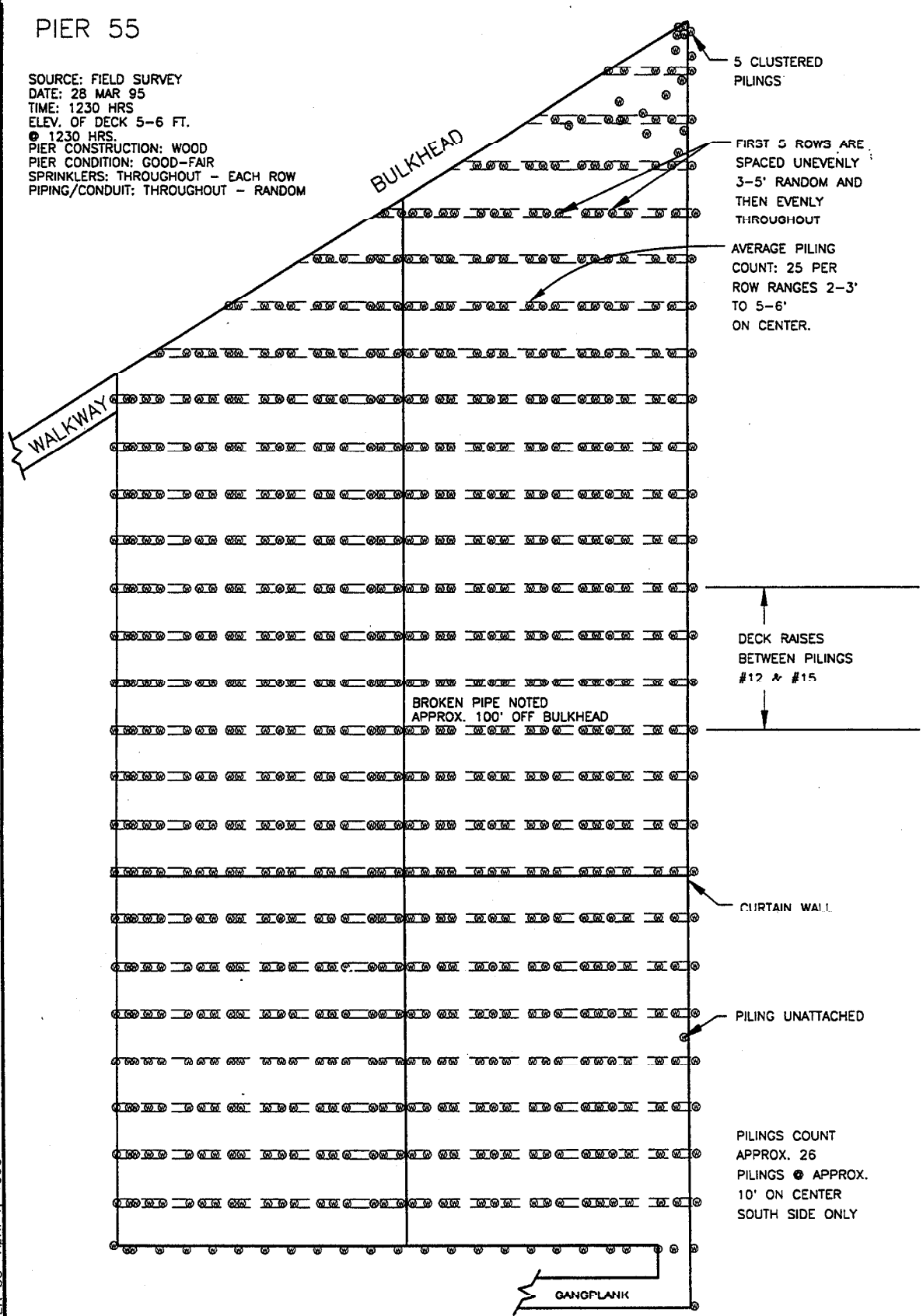


Figure A-1. City of Seattle CSOs along the Seattle waterfront.

PIER 55

SOURCE: FIELD SURVEY
DATE: 28 MAR 95
TIME: 1230 HRS
ELEV. OF DECK 5-6 FT.
@ 1230 HRS.
PIER CONSTRUCTION: WOOD
PIER CONDITION: GOOD-FAIR
SPRINKLERS: THROUGHOUT - EACH ROW
PIPING/CONDUIT: THROUGHOUT - RANDOM



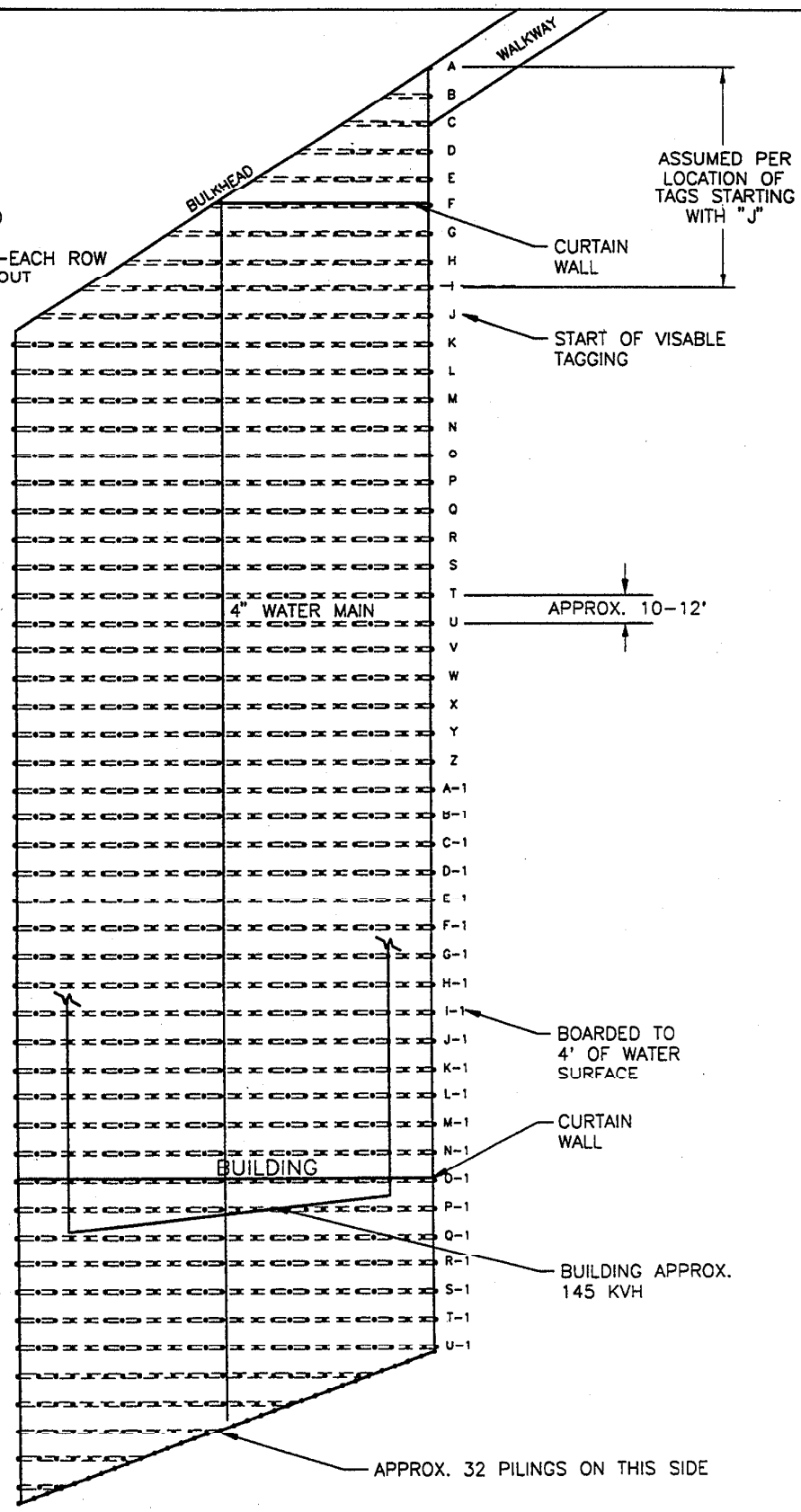
PIER-55 April 4, 1995

PIER 56

Pier 56 is a wood pier with sprinkler pipes running between piling rows. The sprinkler system is serviced with 4-6 inch feeder lines running in a east west direction and is approximately 18-20 inches below decking. A wave barrier is located 30 feet east of the pier head, running in a north-south direction and extends down from the decking approximately 5-6 feet. Another wave barrier is located approximately 60 feet from the pier face and extends down from the decking approximately 5 feet. Near the north end of the walkway, between piers 55-56, several cross braces will block access during any stage of the tide. Under the walkway between piers 55-56 the spacing between the piling is 10-15 feet and makes for easy access. A wave barrier is located along a short section of the piles, 14-15 feet long, in under the walkway, and is running north-south. This wave barrier extends approximately 6 feet below the decking. Near the bulkhead under pier 56, cross bracing and utility pipes make access very difficult, both in the north-south and east-west direction. Some of the utilities are running east-west extending west towards the pier terminus and hung down very close to the high water mark. Close to the bulkhead a 4-6 inch pipe is lying in a wooden trough and extends down below the decking to the high water mark and runs in an east-west direction blocking north-south access. Approximately 75 feet west of the bulkhead a wave barrier extends down from the decking and runs along a piling row in a north-south direction.

PIER 56

SOURCE: FIELD SURVEY
DATE: 28 MAR 95
TIME: 1330 HRS
ELEV. OF DECK 10 FT.
@ 1330 HRS.
PIER CONSTRUCTION: WOOD
PIER CONDITION: GOOD
SPRINKLERS: THROUGHOUT–EACH ROW
PIPING/CONDUIT: THROUGHOUT

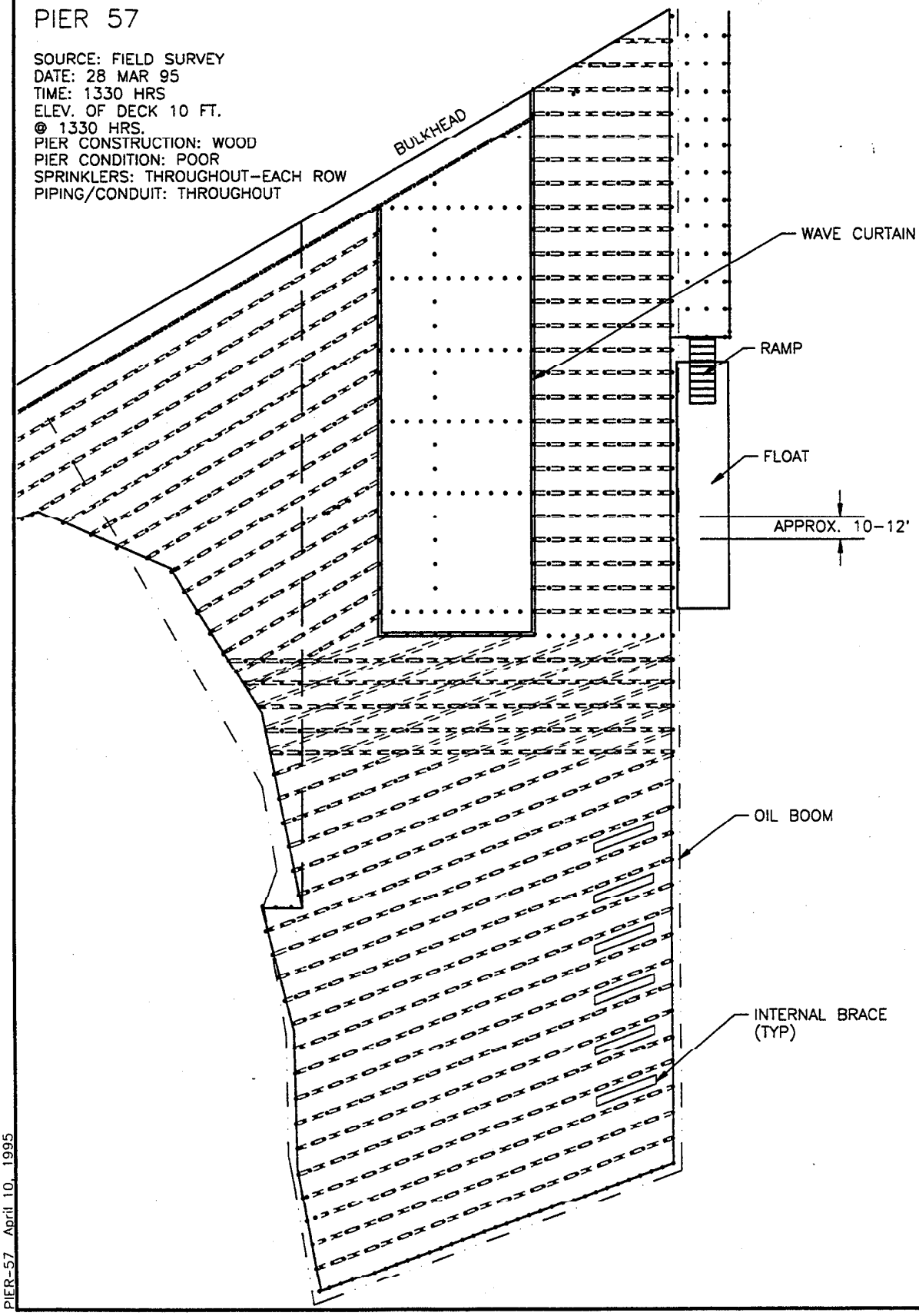


PIER 57

Some construction is being performed on the western end of the pier. A containment oil boom is surrounding the entire pier and is secured to the bulkhead at both the north and south side of the pier/bulkhead contact point. The piling rows are some what parallel to the west face of the pier running in a north-south direction, but become somewhat random at approximately 75-100 feet east of the face. Access is very difficult in this 75-100 section. Piling are driven in at an angle along the south face to provide some lateral support but many of these piling have broken off and are not secured to any thing. A passenger float, approximately 100 by 20 feet, is secured to the south center section of the pier and is used for loading tours of the Seattle water front. A ramp is connecting the pier and float and is used for passenger access. At approximately 200 feet east of the pier west face, the entire pier structure changes under the decking. The configuration of the piling rows change to a east west direction with the timbers on the piling 2-3 feet below the decking, making passage very difficult in a north south direction. The distance between the piling is 0.5-1.5 feet with wave barriers and large timbers making passage in all directions very difficult. Near the sea wall and out 15-25 feet, utility pipes are hanging down 18-24 inches, which is very close to high water mark. Steam lines are exhausting under the pier near the center of the pier next to the sea wall. Near the sea wall, a lot of cross bracing and timbers are attached between piling. At approximately 60 feet north of the south face, the newer piling are supporting a new section on pier that is built into a circular walk way that is attached to pier 59 and the aquarium. Access under the newer section of pier 57 is very good at high water and is easily reached by a small boat.

PIER 57

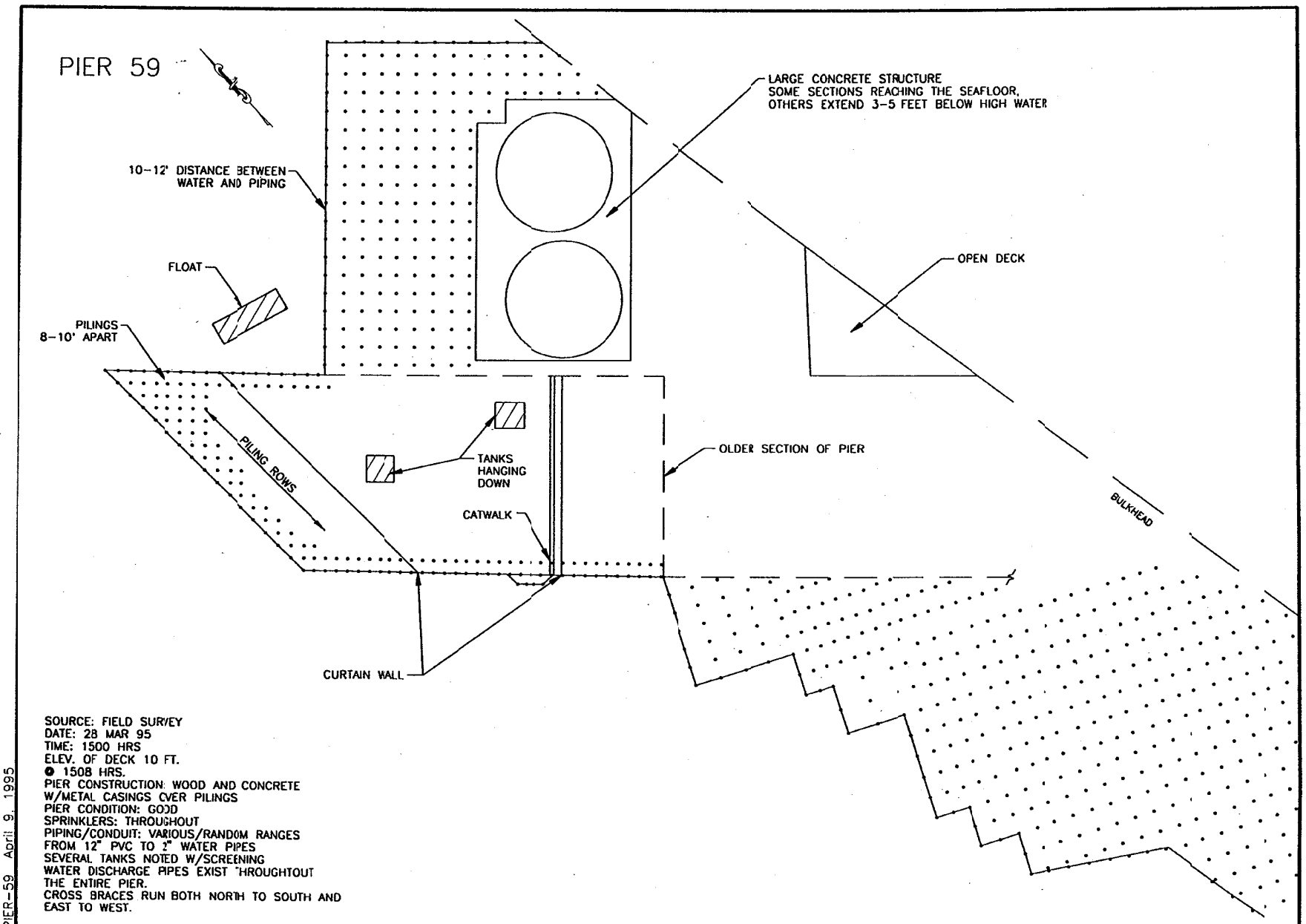
SOURCE: FIELD SURVEY
DATE: 28 MAR 95
TIME: 1330 HRS
ELEV. OF DECK 10 FT.
@ 1330 HRS.
PIER CONSTRUCTION: WOOD
PIER CONDITION: POOR
SPRINKLERS: THROUGHOUT-EACH ROW
PIPING/CONDUIT: THROUGHOUT



PIER-57 April 10, 1995

PIER 58-59

Pier 57 is connected to 58-59 by a walkway built out over the water. The piling under the walk way are approximately 10-15 feet apart allowing good access under this section of pier 58-59. At the western end of pier 59 it appears the piling is in poor condition as it has may cross braces and timbers attached across from piling to piling and several piling have a large cap on them made of concrete. The piling rows run in a north-south direction with the rows approximately 6-8 feet apart, and the piling spaced 2-5 feet apart. The entire structure under the decking is inter-connected with water pipes both for water discharge and sprinkler pipes as well as pipes plumbed for sea water intakes for the aquarium. Some large pipes, 10-12 inches on the western end of the pier are hanging below the decking 2-2.5 feet. Several of the 4-6 inch sprinkler pipe are hanging almost to the high water mark, which will not allow access under the pier during moderately high tides. At approximately 80-100 feet in from the east edge of the pier, a wave barrier run north-south along a row of piling. At approximately 150-175 feet in from the west end of the pier, two large wood box structures, about 10 foot square, are hanging down from the decking. The structures have some sort of fencing around them, which extends into the water at mid tide. At approximately 100 feet in from the west edge of the pier, another wave barrier extends to the high water line with a cat walk along side the barrier running in a north-south direction. On the older section of the pier, as seen on the figure, there is a lot of timbers across piling in both the north-south and east-west direction making access difficult to move through that section of the pier. On the northern section of the pier, a large concrete structure, as shown on the figure, extends to the seafloor, around the concrete base some sections cantilever out from the center concrete structure and some block access at low tides. In the newer section of the pier access is good although the piling run in a circular pattern in the center with rows of piling difficult to make out.



SOURCE: FIELD SURVEY
DATE: 28 MAR 95
TIME: 1500 HRS
ELEV. OF DECK 10 FT.
● 1508 HRS.
PIER CONSTRUCTION: WOOD AND CONCRETE
W/METAL CASINGS OVER PILINGS
PIER CONDITION: GOOD
SPRINKLERS: THROUGHOUT
PIPING/CONDUIT: VARIOUS/RANDOM RANGES
FROM 12" PVC TO 2" WATER PIPES
SEVERAL TANKS NOTED W/SCREENING
WATER DISCHARGE PIPES EXIST THROUGHTOUT
THE ENTIRE PIER.
CROSS BRACES RUN BOTH NORTH TO SOUTH AND
EAST TO WEST.

PIER-59 April 9, 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Sensitivity Test 3
21 July 1995
Dutch model based on Blaauw and van de Kaa (1978) and Verhey (1983).

Vessel type	RV Ferry	RV Ferry	RV Ferry	RV Ferry	RV Ferry	RV Ferry
Number of propellers	1	1	1	1	1	1
Propeller diameter, ft. (D)	8	8	8	8	8	8
Propeller speed, rpm (n)	250	250	250	250	250	250
Water depth, ft (h)	38	35	33	32	28	26
Shaft depth, ft. (s)	7	7	7	7	7	7
Shaft elevation, ft. (z)	31	28	26	25	21	19
Effective diamater, ft (Do)	5.66	5.66	5.66	5.66	5.66	5.66
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Distance, ft (x)	100	150	200	300	400	450
Sediment size, mm (d50)	0.4	0.4	0.4	0.4	0.4	0.4
Gravitational acceleration, cm/sec2 (g)	980	980	980	980	980	980
Sediment density, kg/m3 (ps)	2650	2650	2650	2650	2650	2650
Water density, kg/m3 (pw)	1022	1022	1022	1022	1022	1022
Eflux velocity, cm/sec (Vo)	962	962	962	962	962	962
Axial velocity, cm/sec (Vxo)	151	101	76	50	38	34
Bottom velocity, cm/sec (Vxz)	34	59	58	45	36	33
Froude number (F)	4.34	7.45	7.37	5.73	4.58	4.13
Scour, ft. (S)	0.1	0.4	0.4	0.2	0.2	0.1

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 1
Normal Operations and water level at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Tug	Tug	Tug	Tug	Tug	Tug
Number of propellers	1	1	1	1	1	1
Propeller diameter (D), ft.	6	6	6	6	6	6
Shaft depth (s), ft.	5	5	5	5	5	5
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	60	60	60	60	60	60
Water depth (h), ft.	34	35	35	36	46	55
Shaft elevation (Z), ft.	29	30	30	31	41	50
Distance behind prop (X), ft.	100	165	200	300	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	4.24	4.24	4.24	4.24	4.24	4.24
Propeller efflux velocity (Vo), cm/sec.	173	173	173	173	173	173
Prop axis velocity (Vxo), cm/sec.	16	9	8	5	4	3
Bottom velocity (Vxz), cm/sec.	5	6	5	4	3	2
Densimetric Froude number (F)	0.57	0.72	0.69	0.53	0.39	0.30
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.0	0.0	0.0

Ship type	Trawler	Trawler	Trawler	Trawler	Trawler	Trawler
Number of propellers	1	1	1	1	1	1
Propeller diameter (D), ft.	14	14	14	14	14	14
Shaft depth (s), ft.	12	12	12	12	12	12
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	60	60	60	60	60	60
Water depth (h), ft.	35	35	35	48	57	72
Shaft elevation (Z), ft.	23	23	23	36	45	60
Distance behind prop (X), ft.	100	125	200	300	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	9.90	9.90	9.90	9.90	9.90	9.90
Propeller efflux velocity (Vo), cm/sec.	404	404	404	404	404	404
Prop axis velocity (Vxo), cm/sec.	98	76	46	29	21	17
Bottom velocity (Vxz), cm/sec.	43	45	37	23	17	13
Densimetric Froude number (F)	5.46	5.74	4.70	2.96	2.21	1.69
Maximum scour depth (S), ft.	1.1	1.3	0.7	0.1	0.0	0.0

Ship type	Tyee	Tyee	Tyee	Tyee	Tyee	Tyee
Number of propellers	2	2	2	2	2	2
Propeller diameter (D), ft.	3.6	3.6	3.6	3.6	3.6	3.6
Shaft depth (s), ft.	5	5	5	5	5	5
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	360	360	360	360	360	360
Water depth (h), ft.	34	35	35	35	42	53
Shaft elevation (Z), ft.	29	30	30	30	37	48
Distance behind prop (X), ft.	100	200	300	320	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.55	2.55	2.55	2.55	2.55	2.55
Propeller efflux velocity (Vo), cm/sec.	623	623	623	623	623	623
Prop axis velocity (Vxo), cm/sec.	44	22	15	14	11	9
Bottom velocity (Vxz), cm/sec.	12	16	13	12	10	8
Densimetric Froude number (F)	1.52	1.97	1.59	1.52	1.22	0.97
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.0	0.0	0.0

Ship type	USNS Ship	USNS Ship	USNS Ship	USNS Ship	USNS Ship	USNS Ship
Number of propellers	2	2	2	2	2	2
Propeller diameter (D), ft.	15	15	15	15	15	15
Shaft depth (s), ft.	20	20	20	20	20	20
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	50	50	50	50	50	50
Water depth (h), ft.	78	90	105	119	120	150
Shaft elevation (Z), ft.	58	70	85	99	100	130
Distance behind prop (X), ft.	100	200	300	395	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	10.61	10.61	10.61	10.61	10.61	10.61
Propeller efflux velocity (Vo), cm/sec.	361	361	361	361	361	361
Prop axis velocity (Vxo), cm/sec.	173	114	90	76	75	66
Bottom velocity (Vxz), cm/sec.	1	17	26	29	29	23
Densimetric Froude number (F)	0.12	2.19	3.29	3.65	3.64	2.94
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.0	0.0	0.0

1 August 1995

ELLIOTT BAYWATERFRONT RECONTAMNATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Sensitivity Test 1
24 July 1995
Dutch model based on Blaauw and van de Kaa (1978) and Verhey (1983).

Vessel type	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry
Number of propellers	1	1	1	1	1	1	1	1	1	1	1
Propeller diameter, ft. (D)	11	10	12	11	11	11	11	11	11	11	11
Propeller speed, rpm (n)	250	250	250	250	250	250	250	225	275	250	250
Water depth, ft (h)	33	33	33	33	33	33	33	33	33	33	33
Shaft depth, ft. (s)	11	11	11	10	12	11	11	11	11	11	11
Shaft elevation, ft. (z)	22	22	22	23	21	22	22	22	22	22	22
Effective diamater, ft (Do)	7.78	7.07	8.49	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78
Thrust coefficent (K)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.31	0.39
Distance, ft (x)	100	100	100	100	100	90	110	100	100	100	100
Sediment size, mm (d50)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gravitational acceleration, cm/sec2 (g)	980	980	980	980	980	980	980	980	980	980	980
Sediment density, kg/m3 (ps)	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650
Water density kg/m3 (pw)	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022
Eflux velocity, cm/sec (Vo)	1322	1202	1443	1322	1322	1322	1322	1190	1455	1245	1396
Axial velocity, cm/sec (Vxo)	286	236	340	286	286	317	260	257	314	269	302
Bottom velocity, cm/sec (Vxz)	135	112	161	126	145	126	140	122	149	127	143
Froude number (F)	17.13	14.16	20.39	15.98	18.31	15.98	17.73	15.42	18.85	16.12	18.09
Scour, ft. (S)	16.3	7.1	34.8	12.3	21.6	13.3	18.0	12.0	21.5	13.7	19.1

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 2
Normal Operations and water level at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Trawler	Trawler	Trawler	Trawler	Trawler	Trawler
Number of propellers	1	1	1	1	1	1
Propeller diameter (D), ft.	14	14	14	14	14	14
Shaft depth (s), ft.	12	12	12	12	12	12
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	60	60	60	60	60	60
Water depth (h), ft.	34	34	38	44	51	61
Shaft elevation (Z), ft.	22	22	26	32	39	49
Distance behind prop (X), ft.	100	125	200	300	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	9.90	9.90	9.90	9.90	9.90	9.90
Propeller efflux velocity (Vo), cm/sec.	404	404	404	404	404	404
Prop axis velocity (Vxo), cm/sec.	98	76	46	29	21	17
Bottom velocity (Vxz), cm/sec.	46	47	35	24	18	14
Densimetric Froude number (F)	5.86	6.00	4.44	3.10	2.32	1.81
Maximum scour depth (S), ft.	1.5	1.6	0.5	0.1	0.0	0.0

Ship type	Tyee	Tyee	Tyee	Tyee	Tyee	Tyee
Number of propellers	2	2	2	2	2	2
Propeller diameter (D), ft.	3.6	3.6	3.6	3.6	3.6	3.6
Shaft depth (s), ft.	5	5	5	5	5	5
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	360	360	360	360	360	360
Water depth (h), ft.	30	40	44	44	40	55
Shaft elevation (Z), ft.	25	35	39	39	44	50
Distance behind prop (X), ft.	100	200	300	313	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.55	2.55	2.55	2.55	2.55	2.55
Propeller efflux velocity (Vo), cm/sec.	623	623	623	623	623	623
Prop axis velocity (Vxo), cm/sec.	44	22	15	14	11	9
Bottom velocity (Vxz), cm/sec.	17	14	11	11	9	8
Densimetric Froude number (F)	2.13	1.74	1.43	1.40	1.16	0.96
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.0	0.0	0.0

Ship type	Royal Victorian	Royal Victorian	Royal Victorian	Royal Victorian	Royal Victorian	Royal Victorian
Number of propellers	2	2	2	2	2	2
Propeller diameter (D), ft.	8	8	8	8	8	8
Shaft depth (s), ft.	7	7	7	7	7	7
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	100	100	100	100	100	100
Water depth (h), ft.	49	59	67	71	74	81
Shaft elevation (Z), ft.	42	52	60	64	67	74
Distance behind prop (X), ft.	100	200	300	365	400	500
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	5.66	5.66	5.66	5.66	5.66	5.66
Propeller efflux velocity (Vo), cm/sec.	385	385	385	385	385	385
Prop axis velocity (Vxo), cm/sec.	127	84	66	58	55	48
Bottom velocity (Vxz), cm/sec.	8	29	35	36	36	34
Densimetric Froude number (F)	1.06	3.73	4.48	4.59	4.53	4.36
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.0	0.0	0.0

1 August 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 5
Normal Operations and water level at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Spirit of Seattle	Spirit of Seattle	Spirit of Seattle	Spirit of Seattle
Number of propellers	2	2	2	2
Propeller diameter (D), ft.	4.7	4.7	4.7	4.7
Shaft depth (s), ft.	4	4	4	4
Thrust coefficient (K)	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	180	180	180	180
Water depth (h), ft.	24	22	18	12
Shaft elevation (Z), ft.	20	18	14	8
Distance behind prop (X), ft.	50	100	150	200
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	3.32	3.32	3.32	3.32
Propeller efflux velocity (Vo), cm/sec.	407	407	407	407
Prop axis velocity (Vxo), cm/sec.	148	97	76	64
Bottom velocity (Vxz), cm/sec.	13	59	67	63
Densimetric Froude number (F)	1.58	7.48	8.46	7.94
Maximum scour depth (S), ft.	0.0	0.2	0.4	1.0

Ship type	Good Times	Good Times	Good Times	Good Times
Number of propellers	2	2	2	2
Propeller diameter (D), ft.	3.7	3.7	3.7	3.7
Shaft depth (s), ft.	3	3	3	3
Thrust coefficient (K)	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	180	180	180	180
Water depth (h), ft.	26	23	21	15
Shaft elevation (Z), ft.	23	20	18	12
Distance behind prop (X), ft.	50	100	150	200
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.62	2.62	2.62	2.62
Propeller efflux velocity (Vo), cm/sec.	320	320	320	320
Prop axis velocity (Vxo), cm/sec.	101	66	52	44
Bottom velocity (Vxz), cm/sec.	4	36	42	41
Densimetric Froude number (F)	0.49	4.54	5.28	5.25
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.1

1 August 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 4
Normal Operations and water level at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Chief Seattle	Chief Seattle	Chief Seattle	Chief Seattle
Number of propellers	3	3	3	3
Propeller diameter (D), ft.	3.5	3.5	3.5	3.5
Shaft depth (s), ft.	3	3	3	3
Thrust coefficient (K)	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	180	180	180	180
Water depth (h), ft.	22	21	15	10
Shaft elevation (Z), ft.	19	18	12	7
Distance behind prop (X), ft.	25	50	75	100
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.47	2.47	2.47	2.47
Propeller efflux velocity (Vo), cm/sec.	303	303	303	303
Prop axis velocity (Vxo), cm/sec.	140	92	72	61
Bottom velocity (Vxz), cm/sec.	0	12	49	56
Densimetric Froude number (F)	0.00	1.58	6.16	7.14
Maximum scour depth (S), ft.	0.0	0.0	0.1	0.4

Ship type	Alki	Alki	Alki	Alki
Number of propellers	2	2	2	2
Propeller diameter (D), ft.	4	4	4	4
Shaft depth (s), ft.	3	3	3	3
Thrust coefficient (K)	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	180	180	180	180
Water depth (h), ft.	22	21	15	10
Shaft elevation (Z), ft.	19	18	12	7
Distance behind prop (X), ft.	25	50	75	100
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.83	2.83	2.83	2.83
Propeller efflux velocity (Vo), cm/sec.	346	346	346	346
Prop axis velocity (Vxo), cm/sec.	173	114	89	75
Bottom velocity (Vxz), cm/sec.	0	15	60	70
Densimetric Froude number (F)	0.00	1.96	7.63	8.84
Maximum scour depth (S), ft.	0.0	0.0	0.3	1.1

1 August 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 3
Washington State Super Ferry Operations at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Idle	Idle	Idle	Idle	Idle	Idle
Number of propellers	1	1	1	1	1	1
Propeller diameter (D), ft.	12	12	12	12	12	12
Shaft depth (s), ft.	12	12	12	12	12	12
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	50	50	50	50	50	50
Water depth (h), ft.	34	33	32	30	25	18
Shaft elevation (Z), ft.	22	21	20	18	13	6
Distance behind prop (X), ft.	50	100	120	200	300	400
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	8.49	8.49	8.49	8.49	8.49	8.49
Propeller efflux velocity (Vo), cm/sec.	289	289	289	289	289	289
Prop axis velocity (Vxo), cm/sec.	126	59	48	27	18	13
Bottom velocity (Vxz), cm/sec.	6	30	31	24	17	13
Densimetric Froude number (F)	0.81	3.77	3.97	3.07	2.16	1.62
Maximum scour depth (S), ft.	0.0	0.3	0.4	0.2	0.1	0.3

Ship type	Normal	Normal	Normal	Normal	Normal	Normal
Number of propellers	1	1	1	1	1	1
Propeller diameter (D), ft.	12	12	12	12	12	12
Shaft depth (s), ft.	12	12	12	12	12	12
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	140	140	140	140	140	140
Water depth (h), ft.	34	33	32	30	25	18
Shaft elevation (Z), ft.	22	21	20	18	13	6
Distance behind prop (X), ft.	50	100	120	200	300	400
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	8.49	8.49	8.49	8.49	8.49	8.49
Propeller efflux velocity (Vo), cm/sec.	808	808	808	808	808	808
Prop axis velocity (Vxo), cm/sec.	353	165	135	77	49	36
Bottom velocity (Vxz), cm/sec.	18	83	88	68	48	36
Densimetric Froude number (F)	2.26	10.57	11.12	8.59	6.05	4.53
Maximum scour depth (S), ft.	0.1	5.7	7.2	4.2	2.8	5.2

1 August 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 6
Normal Operations and water level at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Sightseer	Sightseer	Sightseer	Sightseer	Sightseer	Sightseer
Number of propellers	1	1	1	1	1	1
Propeller diameter (D), ft.	3.7	3.7	3.7	3.7	3.7	3.7
Shaft depth (s), ft.	3	3	3	3	3	3
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	180	180	180	180	180	180
Water depth (h), ft.	23	21	20	18	11	8
Shaft elevation (Z), ft.	20	18	17	15	8	5
Distance behind prop (X), ft.	25	50	75	100	150	200
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.62	2.62	2.62	2.62	2.62	2.62
Propeller efflux velocity (Vo), cm/sec.	320	320	320	320	320	320
Prop axis velocity (Vxo), cm/sec.	82	38	25	18	11	8
Bottom velocity (Vxz), cm/sec.	0	5	11	13	11	8
Densimetric Froude number (F)	0.00	0.66	1.41	1.60	1.39	1.05
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.0	0.0	0.0

Ship type	Fishing Boat	Fishing Boat	Fishing Boat	Fishing Boat
Number of propellers	1	1	1	1
Propeller diameter (D), ft.	3	3	3	3
Shaft depth (s), ft.	3	3	3	3
Thrust coefficient (K)	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	300	300	300	300
Water depth (h), ft.	10	9	6	4
Shaft elevation (Z), ft.	7	6	3	1
Distance behind prop (X), ft.	25	50	75	100
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	2.12	2.12	2.12	2.12
Propeller efflux velocity (Vo), cm/sec.	433	433	433	433
Prop axis velocity (Vxo), cm/sec.	88	41	26	19
Bottom velocity (Vxz), cm/sec.	26	33	26	19
Densimetric Froude number (F)	3.33	4.18	3.26	2.43
Maximum scour depth (S), ft.	0.0	0.1	0.1	0.5

1 August 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Operations Area 2
Normal operations going astern and water level at Low Tide (MLLW).
Dutch model (Blaauw and van de Kaa, 1978; Verhey, 1983) used for all propellers.

Ship type	Bowthruster	Bowthruster	Bowthruster	Bowthruster	Bowthruster
Number of propellers	1	1	1	1	1
Propeller diameter (D), ft.	6	6	6	6	6
Shaft depth (s), ft.	5.8	5.8	5.8	5.8	5.8
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	120	120	120	120	120
Water depth (h), ft.	32	32	30	18	7
Shaft elevation (Z), ft.	26.2	26.2	24.2	12.2	1.2
Distance behind prop (X), ft.	25	50	75	100	150
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	4.24	4.24	4.24	4.24	4.24
Propeller efflux velocity (Vo), cm/sec.	346	346	346	346	346
Prop axis velocity (Vxo), cm/sec.	163	82	54	41	27
Bottom velocity (Vxz), cm/sec.	0	1	11	32	27
Densimetric Froude number (F)	0.00	0.15	1.38	4.11	3.44
Maximum scour depth (S), ft.	0.0	0.0	0.0	0.1	6.7

Ship type	Royal Victorian	Royal Victorian	Royal Victorian	Royal Victorian	Royal Victorian
Number of propellers	2	2	2	2	2
Propeller diameter (D), ft.	8	8	8	8	8
Shaft depth (s), ft.	7	7	7	7	7
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35
Shaft speed (n), RPM	100	100	100	100	100
Water depth (h), ft.	38	33	32	28	26
Shaft elevation (Z), ft.	31	26	25	21	19
Distance behind prop (X), ft.	100	200	300	400	450
Mean grain size (d50), mm.	0.4	0.4	0.4	0.4	0.4
Effective propeller diameter (Do), ft.	5.66	5.66	5.66	5.66	5.66
Propeller efflux velocity (Vo), cm/sec.	385	385	385	385	385
Prop axis velocity (Vxo), cm/sec.	127	84	66	55	51
Bottom velocity (Vxz), cm/sec.	29	64	59	53	50
Densimetric Froude number (F)	3.64	8.16	7.46	6.69	6.33
Maximum scour depth (S), ft.	0.0	0.5	0.5	0.5	0.5

1 August 1995

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Sensitivity Test 2
24 July 1995
Dutch model based on Blaauw and van de Kaa (1978) and Verhey (1983).

Vessel type	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry	WS Ferry
Number of propellers	1	1	1	1	1	1	1	1	1	1
Propeller diameter, ft. (D)	11	11	11	11	11	11	11	11	11	11
Propeller speed, rpm (n)	250	250	250	250	250	250	250	250	250	250
Water depth, ft (h)	34	34	34	33	32	31	31	30	25	18
Shaft depth, ft. (s)	11	11	11	11	11	11	11	11	11	11
Shaft elevation, ft. (z)	23	23	23	22	21	20	20	19	14	7
Effective diamater, ft (Do)	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.31
Distance, ft (x)	25	50	75	81	100	133	150	200	300	400
Sediment size, mm (d50)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gravitational acceleration, cm/sec2 (g)	980	980	980	980	980	980	980	980	980	980
Sediment density, kg/m3 (ps)	2650	2650	2650	2650	2650	2650	2650	2650	2650	2650
Water densty, kg/m3 (pw)	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022
Eflux velocity, cm/sec (Vo)	1322	1322	1322	1322	1322	1322	1322	1322	1322	1245
Axial velocity, cm/sec (Vxo)	1143	571	381	353	286	215	190	143	95	67
Bottom velocity, cm/sec (Vxz)	0	22	89	113	145	152	145	124	92	67
Froude number (F)	0.00	2.76	11.30	14.30	18.31	19.18	18.32	15.73	11.65	8.47
Scour, ft. (S)	0.0	0.[illegible]	4.5	9.7	21.6	27.1	23.8	16.8	12.6	18.6

Appendix C- Scour Potential Model Results

Scour Model Results

Sensitivity Analysis Results

ELLIOTT BAY WATERFRONT RECONTAMINATION STUDY
PROPELLER SCOUR OF REMEDIAL CAP

Sensitivity Test 4
24 July 1995
Dutch model based on Blaauw and van de Kaa (1978) and Verhey (1983).

Vessel type	RV Ferry	RV Ferry	RV Ferry	RV Ferry	RV Ferry	RV Ferry
Number of propellers	1	1	1	1	1	1
Propeller diameter, ft. (D)	8	8	8	8	8	8
Propeller speed, rpm (n)	250	250	250	250	250	250
Water depth, ft (h)	38	35	33	32	28	26
Shaft depth, ft. (s)	7	7	7	7	7	7
Shaft elevation, ft. (z)	31	28	26	25	21	19
Effective diamater, ft (Do)	5.66	5.66	5.66	5.66	5.66	5.66
Thrust coefficient (K)	0.35	0.35	0.35	0.35	0.35	0.35
Distance, ft (x)	100	150	200	300	400	450
Sediment size, mm (d50)	0.4	0.4	0.4	0.4	0.4	0.4
Gravitational acceleration, cm/sec2 (g)	980	980	980	980	980	980
Sediment density, kg/m3 (ps)	2650	2650	2650	2650	2650	2650
Water density, kg/m3 (pw)	1022	1022	1022	1022	1022	1022
Eflux velocity, cm/sec (Vo)	962	962	962	962	962	962
Axial velocity, cm/sec (Vxo)	151	101	76	50	38	34
Bottom velocity, cm/sec (Vxz)	34	59	58	45	36	33
Froude number (F)	4.34	7.45	7.37	5.73	4.58	4.13
Scour, ft. (S)	0.1	0.4	0.4	0.2	0.2	0.1