4. EFFLUENT CHEMICAL CHARACTERIZATION

The Study Plan indicated that existing effluent monitoring data (e.g., chemical parameters) collected at the basin discharge points would be obtained and evaluated to help compare concentrations at the edge of the acute and chronic mixing zones to the ambient water quality criteria. In addition, effluent samples used in the toxicity testing program would be analyzed for key parameters (e.g., total suspended solids, total and dissolved aluminum, total iron, total organic carbon, BOD, pH, alkalinity, and nitrogen and phosphorus compounds) using analytical methods which are U.S. EPA-approved (e.g., 40 CFR 136). This chapter also includes a brief discussion of the relationship between Potomac River flows and total suspended solids concentrations, as measured at Little Falls which is upstream of the Aqueduct discharges.

4.1 EXISTING AQUEDUCT EFFLUENT CHEMISTRY DATA

Aqueduct staff collect and chemically analyze effluent grab samples when basins are cleaned (and discharges to the Potomac are made). These samples are analyzed on-site by Aqueduct staff for the following water quality parameters: total aluminum, total iron, pH, total dissolved solids, total suspended solids and total solids. It should be understood that because of the way the basins and reservoirs are cleaned (fire hoses at Dalecarlia and front end loaders at Georgetown), grab sample data can be quite variable from minute to minute. Thus, mean effluent concentration data are probably the most reliable when evaluating the discharges. Summary data from the period 1997 through the first part of 2001 are presented in Tables 4-1a,b and 4-2a,b for discharges from the Dalecarlia and Georgetown facilities. More detailed data are available showing the exact times during each day that the grab samples were collected. Table 4-1 provides the mean, minimum and maximum values for each parameter for each discharge. Table 4-2 was provided to compare average effluent concentrations for each year by facility.

Overall mean total aluminum data for the four Dalecarlia Basins averaged 2,273 mg/L for the period 1997-2001. Similar total aluminum data for the Georgetown discharges yielded a mean concentration of 1,510 mg/L. The District of Columbia's Department of Health does not have a surface water quality standard for aluminum (Title 21, Chapter 11, §1104.6). U.S. EPA, however, presents a freshwater acute water quality criterion concentration of 0.750 mg/L, and a chronic criterion of 0.087 mg/L measured as total recoverable aluminum in the water column (63 Fed Reg 68360, 10 December 1998). Several important caveats to the Agency's 0.087 mg/L chronic criterion are also discussed in footnote "L" of EPA's Federal Register announcement, indicating that the value may not be applicable to all waterbodies. These cautions include:

- Total aluminum associated with clay particles might be less toxic that aluminum associated with aluminum hydroxide.

- The 0.087 mg/L chronic criterion value is based on toxicity tests using brook trout and striped bass in low pH water (6.5-6.6). This is lower than the pH of the Potomac River where organism exposure would occur.

- EPA is aware that many pristine high quality waters in the U.S. contain more than 0.087 mg/L aluminum when either total recoverable or dissolved aluminum is measured.

- As discussed in U.S. EPA's aluminum criteria document (EPA 1988, p. 22), if the chronic criterion would have been calculated using the normal criterion derivation approach (i.e., not lowered to protect the striped bass and brook trout under low pH conditions), the chronic criterion would have been 0.748 mg/L rather than the 0.087 mg/L value.

For the reasons bulleted above, if EPA's 0.87 mg/L chronic criterion is exceeded, the Agency suggests that a Water Effect Ratio might yield a more appropriate site-specific standard for aluminum.

Simple comparison of the mean effluent concentration for Dalecarlia versus the Agency's acute criterion indicates that a dilution factor of approximately 3,000 would be required to reduce concentrations to the criterion value (2,273 / 0.750). Three points need to made to clarify this comparison:

- Aluminum is the most abundant metallic element in the earth's crust with an average of 8.2 percent (Bodek et al. 1988). Shacklette and Borngen (1984) state that the geometric mean of aluminum in soils in the conterminous United States is 2.5 percent [=25,000 mg/kg].

- Actual field measurements made by EA during the dilution study (Chapter 2) indicated that total aluminum concentrations in the water column immediately downstream from Outfalls 002 and 003 are substantially lower. More specifically, total aluminum concentrations on the nearshore side at the first transect downstream from Outfall 002 (520 meters) averaged only 1.153 mg/L with the highest single value of 1.93 mg/L (see Table 2.1-4). Similarly, total aluminum concentrations at the nearshore side of the first transect downstream from Outfall 003 (70 meters) averaged 1.949 mg/L with the highest single value of 3.87 mg/L (see Table 2.1-3). Based on these data, it appears that a substantial amount of the total aluminum released to the water column is quickly lost to the sediments and is no longer directly available to water column species.

- Although simple comparisons between end-of-pipe total aluminum concentrations and EPA's ambient criterion would suggest that acute toxicity might be expected, the acute effluent toxicity testing (see Chapter 3) shows no acute toxicity to the three laboratory test species (i.e., LC50 values > 100 percent effluent).

Therefore, although effluent concentrations of aluminum are high, effluent toxicity testing does not suggest that the aluminum present in the samples is as bioavailable or toxic as the data used to determine EPA's aluminum criterion (which uses laboratory grade aluminum salts in clean water) would suggest.

4.2 EFFLUENT CHEMISTRY DATA GENERATED BY EA

As part of each of the effluent toxicity tests conducted as part of this program, samples were also analyzed for a variety of chemical parameters which are summarized in Table 4-3. Total aluminum concentrations measured in Dalecarlia and Georgetown samples are entirely consistent with the datasets produced by the Aqueduct (see Section 4.1). EA's dataset, however, also includes information on *dissolved* aluminum which shows that in each of the five effluent samples for which both total and dissolved aluminum data exist, the percentage of dissolved aluminum is considerably less than 1 percent of the total value. This is entirely consistent with the results obtained using U.S. EPA's geochemical speciation model MINTEQ. This result also helps explain why a given concentration of total aluminum in Aqueduct effluent samples is substantially less toxic than would be expected based upon simple comparisons to the results presented in U.S. EPA's (1988) aluminum criteria document (which requires the use of laboratory grade aluminum salts in clean water).

4.3 HISTORICAL POTOMAC RIVER FLOWS AND SUSPENDED SEDIMENT CONCENTRATIONS

To provide baseline information on the Potomac River for evaluations of the potential impacts of Washington Aqueduct discharges, historical river flow and suspended sediment data were obtained from the USGS.

4.3.1 Potomac River Flow Data

Daily Potomac River flows at Little Falls were obtained for the 20-year period, 1980 to 1999. A frequency distribution of these flow data by month is provided in Table 4-4. This table indicates that median (50-percentile) flows vary between 57.7 cms in October to 517.9 cms in March. The Washington Aqueduct's existing permit restricts discharges to times when river flows are above a 3.47-ft gage height, which corresponds to 153 cms (5,400 cfs). Table 4-4 indicates that flows greater than 153 cms occur less than 30 percent of the time during July, and less than 20 percent of the time during August to October. This makes it necessary for the Aqueduct to clean reservoirs and basins during the higher flow periods (e.g., springtime) in order to last until the next significant opportunity in the late fall.

4.3.2 Potomac River TSS Data

Suspended sediment concentrations were collected approximately once each month by the USGS at Chain Bridge during the 1980-1999 period. A frequency distribution of this suspended sediment data is provided in Table 4-5. On each day that a suspended sediment concentration was available, the value was multiplied by the Potomac River flow in order to determine a sediment load. A frequency distribution of the resulting sediment loads in the Potomac River is also provided in Table 4-5.

The suspended sediment concentrations have a median (50-percentle) value of 15 mg/L. During high flow conditions, suspended sediment concentrations increase rapidly above the 15-mg/L level. The relationship between suspended sediment and Potomac River flow is illustrated in Figure 4-1. At river flows less than 400 cms, the 15-mg/L value is typical of suspended sediment concentrations. However, at higher flows between 500 and 1,000 cms, suspended sediment concentrations increase to between 50 and 200 mg/L.

The frequency distribution of sediment load (Table 4-5) can be used to place in perspective the magnitude of solids being discharged from the Aqueduct's outfalls. The 25 May 2000 event at Dalecarlia Basin 3 discharged approximately 17,800 kg of solids. This solids mass is less than a 10-percentile value of daily Potomac River suspended sediment loads. Stated differently, 90 percent of the days each year, the daily mass of solids passing Little Falls exceeds the amount released from a discharge of Outfall 002. The 3 May 2000 event at Georgetown Reservoir discharged an estimated 153,600 kg of solids. This solids mass is between a 40- and 45-percentile value of daily Potomac River suspended sediment loads.

4.4 REFERENCES

Bodek, I., W.J. Lyman, W.F. Reehl, and D.H. Rosenblatt. 1988. *Environmental Inorganic Chemistry: Properties, Processes, and Estimation Methods*. SETAC Special Publication Series, Pergamon Press, New York.

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Figure 4-1 Relationship Between Suspended Solids and Potomac River Flow, USGS Data at Chain Bridge, 1980-1999

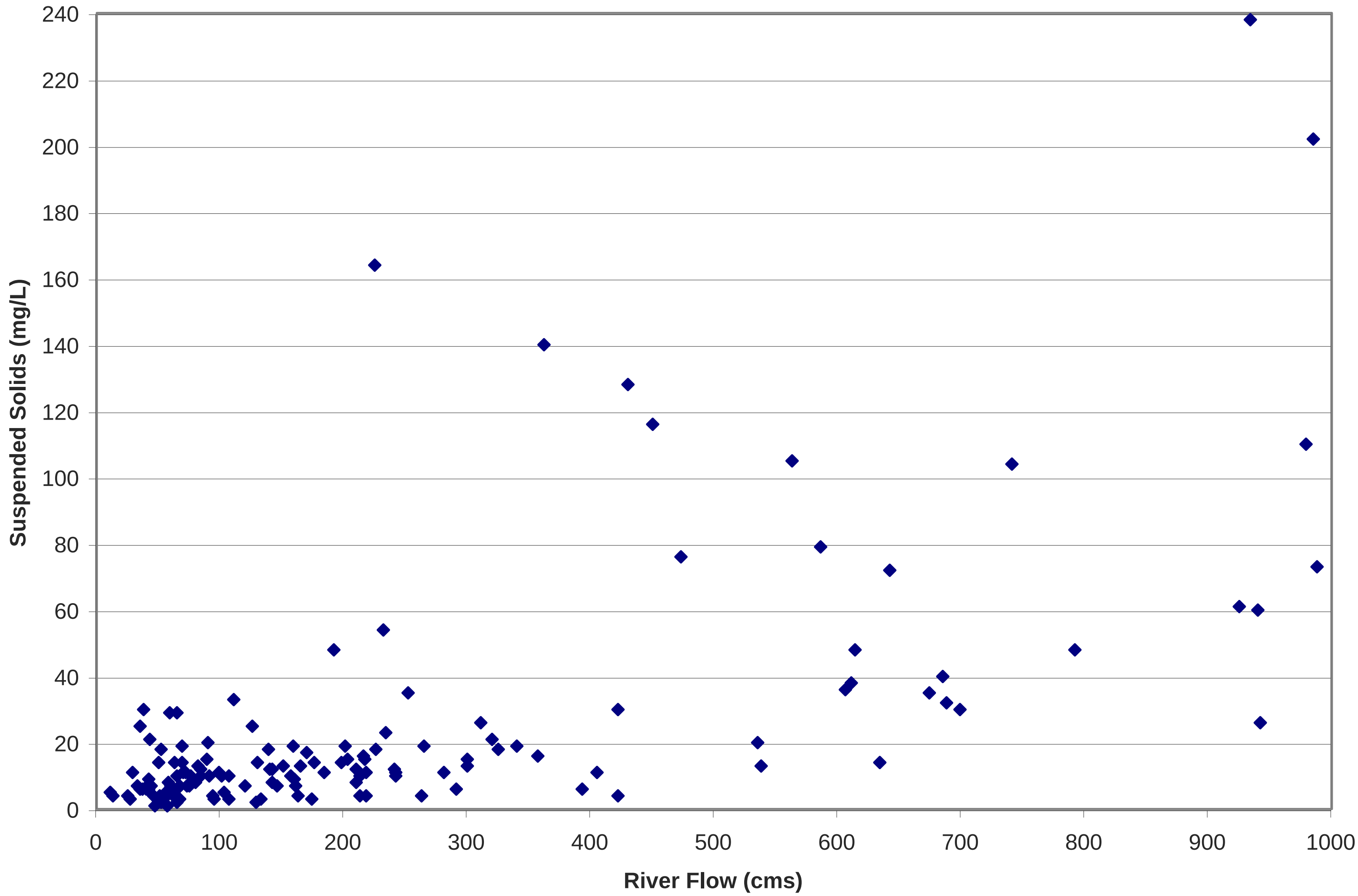

Table 4-1a Summary of chemistry monitoring data by analyte for each Dalecarlia Basin for the years 1997-2001

Dalecarlia Basin 1

Analyte	Units	n	Min	Mean	Max
Aluminum, total	mg/L	24	109	2,480	7,520
Dissolved Solids	mg/L	30	0	3,906	27,700
Iron, total	mg/L	24	27	552	2,710
pH	s.u.	186	6.50	7.11	7.97
Suspend Solids	mg/L	30	50	15,300	55,600
Total solids	mg/L	30	838	24,200	66,600

Dalecarlia Basin 2

Analyte	Units	n	Min	Mean	Max
Aluminum, total	mg/L	27	3	1,270	3,630
Dissolved Solids	mg/L	34	0	2,840	31,100
Iron, total	mg/L	27	4	217	744
pH	s.u.	240	6.17	7.16	7.72
Suspend Solids	mg/L	34	4	9,430	30,400
Total solids	mg/L	34	115	12,300	42,300

Dalecarlia Basin 3

Analyte	Units	n	Min	Mean	Max
Aluminum, total	mg/L	17	15.1	3,000	6,450
Dissolved Solids	mg/L	22	0	6,120	34,100
Iron, total	mg/L	17	4	560	1500
pH	s.u.	137	6.63	7.15	7.94
Suspend Solids	mg/L	23	72	20,800	38,300
Total solids	mg/L	22	303	26,900	47,000

Dalecarlia Basin 4

Analyte	Units	n	Min	Mean	Max
Aluminum, total	mg/L	14	1,250	2,350	4,200
Dissolved Solids	mg/L	19	337	1,550	6,710
Iron, total	mg/L	14	83	396	804
pH	s.u.	102	6.09	7.09	7.80
Suspend Solids	mg/L	19	3,940	18,000	38,700
Total solids	mg/L	20	6,150	19,900	44,500

Table 4-1b Summary of chemistry monitoring data by analyte for each Georgetown Basin for the years 1997-2001

Georgetown Basin 1

Analyte	Units	n	Min	Mean	Max
Aluminum, total	mg/L	8	104	2,508	8,803
Dissolved Solids	mg/L	10	3	491	1,605
Iron, total	mg/L	7	13	284	866
pH	s.u.	64	6.61		8.03
Suspend Solids	mg/L	10	904	20,337	69,220
Total solids	mg/L	10	1060	20,828	69,570

Georgetown Basin 2

MyName	Units	n	Min	Mean	Max
Aluminum, total	mg/L	7	0.348	511	2,276
Dissolved Solids	mg/L	10	79	522	2,134
Iron, total	mg/L	7	0.094	56	207
pH	s.u.	56	6.61		7.54
Suspend Solids	mg/L	10	5	2,954	12,400
Total solids	mg/L	10	23	3,476	14,214

Table 4-2a Average yearly concentrations measured during chemistry monitoring for each Dalecarlia Basin from 1997-2001

Analyte	Units	Year	n	Dalecarlia Basin 1	Dalecarlia Basin 2	Dalecarlia Basin 3	Dalecarlia Basin 4
Aluminum	mg/L	1997	15	3,210	1,490	2,770	2,210
Aluminum	mg/L	1998	13	2,220	1,270	2,820	1,760
Aluminum	mg/L	1999	24	3,060	1,170	4,180	2,490
Aluminum	mg/L	2000	20	2,410	1,430	1,830	2,020
Aluminum	mg/L	2001	10	651	800	3,500	2,970
Dissolved Solids	mg/L	1997	18	3,640	1,700	8,840	1,130
Dissolved Solids	mg/L	1998	17	3,640	1,640	2,760	771
Dissolved Solids	mg/L	1999	30	9,600	6,580	1,970	1,220
Dissolved Solids	mg/L	2000	26	1,350	504	12,600	589
Dissolved Solids	mg/L	2001	14	1,400	2,220	662	3,830
Iron	mg/L	1997	15	1,220	372	1,400	752
Iron	mg/L	1998	13	436	267	810	249
Iron	mg/L	1999	24	513	202	673	370
Iron	mg/L	2000	20	248	121	156	152
Iron	mg/L	2001	10	47.3	61.4	378	222
pH	s.u.	1997	135	7.11	7.04	7.09	6.81
pH	s.u.	1998	116	7.19	7.20	7.16	7.12
pH	s.u.	1999	162	7.06	7.16	7.30	7.35
pH	s.u.	2000	164	7.09	7.38	6.97	7.10
pH	s.u.	2001	88	**Average pH was not reported**			
Suspend Solids	mg/L	1997	18	27,500	12,700	38,200	29,500
Suspend Solids	mg/L	1998	17	16,900	7,520	19,200	10,000
Suspend Solids	mg/L	1999	30	10,600	6,820	26,500	13,500
Suspend Solids	mg/L	2000	27	11,100	13,900	8,810	16,600
Suspend Solids	mg/L	2001	14	3,620	3,300	31,500	12,900
Total solids	mg/L	1997	18	48,900	14,400	47,000	32,000
Total solids	mg/L	1998	17	20,500	9,150	22,000	10,800
Total solids	mg/L	1999	30	20,200	13,400	28,500	14,700
Total solids	mg/L	2000	27	14,900	14,400	21,500	17,100
Total solids	mg/L	2001	14	5,020	5,520	31,500	16,700

Table 4-2b Average yearly concentrations measured during chemistry monitoring for each Georgetown Basin from 1997-2001

MyName	Units	Year	n	Georgetown 1	Georgetown 2
Aluminum, total	mg/L	1997	2	3,329	2,276
Aluminum, total	mg/L	1998	2	109	198
Aluminum, total	mg/L	2000	4	427	
Aluminum, total	mg/L	2001	7	8,250	26
Dissolved Solids	mg/L	1997	4	804	1,906
Dissolved Solids	mg/L	1998	4	154	154
Dissolved Solids	mg/L	2000	4	475	
Dissolved Solids	mg/L	2001	8	547	183
Iron, total	mg/L	1997	2	866	207
Iron, total	mg/L	1998	2	27	60
Iron, total	mg/L	2000	3	62	
Iron, total	mg/L	2001	7	403	4
pH	s.u.	1997	22	**Average pH was not reported**	
pH	s.u.	1998	45	**Average pH was not reported**	
pH	s.u.	2000	27	**Average pH was not reported**	
pH	s.u.	2001	26	**Average pH was not reported**	
Suspend Solids	mg/L	1997	4	18810.00	12240.00
Suspend Solids	mg/L	1998	4	909.00	1948.00
Suspend Solids	mg/L	2000	4	6531.50	
Suspend Solids	mg/L	2001	8	68905.00	194.67
Total solids	mg/L	1997	4	19,614	14,146
Total solids	mg/L	1998	4	1,063	2,102
Total solids	mg/L	2000	4	7,006	
Total solids	mg/L	2001	8	69,452	377

Table 4-3 Analytical Chemistry Results Obtained from Effluent Toxicity Testing Program

	Location and Sample Collection Dates					
Analyte - units	Dalecarlia #2 09/09/99	Georgetown #2 12/01/99	Georgetown#2 05/03/00	Dalecarlia #3 05/25/00	Dalecarlia #2 12/18/00	Dalecarlia #2 04/18/01
Aluminum (Total) - mg/L	945	1,200	1,300	1,020	1,830	270
Aluminum (Diss.) - mg/L	0.093	0.593	0.016	<0.20 – U	--	<0.10 – U
Iron (Total) - mg/L	118	186	154	--	69	--
Alkalinity - mg/L	88.3	590	--	88.2	166	--
Hardness - mg/L	124	NV	136	144	84	104
Ammonia - mg/L	2.5	3.6	16.4	9.2	7.1	2.2
BOD 5-Day - mg/L	24.8	87.3	55.2	<40	92	78
pH- pH units	7.3	6.87	6.89	6.68		
TKN - mg/L	<0.50	52.0	48.3	36.5	<12.5	3.0
TOC - mg/L	240	259	129	86.1	80	120
Total Phosphorus - mg/L	10.5	44.7	19.9	14.7	1.93	5.7
TSS - mg/L	6,350	13,900	12,300	8,030	7,900	2,500
Nitrite - mg/L	<0.10 -U	<0.5 –U	2.2*	2.6*	0.1	0.027
Nitrate - mg/L	0.74	1.1	2.2*	2.6*	2.39	1.7
Phosphate - mg/L	<0.10 - U	<0.5 - U	<0.05 - U	7.2	--	--

U = Compound analyzed but not detected in the sample at the Reporting Limit concentration.
* = Concentration is for nitrate plus nitrite.
NV = No value.

Table 4-4 Frequency Distribution of Daily USGS Potomac River Flows at Little Falls, 1980-1999

Percent (%)	Flow (cms)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	32.0	46.7	114.9	125.9	75.0	22.7	6.6	4.9	14.5	23.3	21.1	27.9
1	38.2	79.8	126.2	137.0	98.5	33.1	10.1	8.2	18.6	24.6	22.4	32.3
5	58.9	119.1	176.6	155.9	129.3	45.8	32.5	23.9	26.5	27.4	35.1	42.2
10	98.8	150.3	203.8	176.6	150.3	64.8	39.9	31.1	31.1	30.8	42.5	64.5
15	116.0	172.9	224.7	210.0	172.3	85.7	47.8	35.1	35.1	35.4	58.3	74.7
20	133.0	190.7	249.6	232.3	184.8	95.1	55.5	38.8	37.9	37.6	62.5	101.6
25	144.9	214.2	285.8	251.9	206.0	107.0	62.3	43.9	40.2	40.5	68.8	123.7
30	163.0	242.8	336.8	285.8	223.9	117.7	67.6	48.1	42.7	42.7	77.0	142.9
35	180.8	262.3	382.1	308.5	242.2	127.6	74.1	52.9	45.8	47.3	87.7	159.3
40	215.6	291.5	416.0	333.9	262.6	139.8	81.2	57.2	50.7	50.7	95.7	175.5
45	245.1	314.1	464.1	387.7	288.7	153.4	89.4	62.0	55.2	54.3	105.6	195.0
50	273.7	350.9	517.9	427.3	314.1	173.8	96.5	66.8	61.1	57.7	117.4	213.9
55	300.0	379.2	568.8	472.6	345.3	196.7	106.7	73.0	66.2	61.4	131.3	239.1
60	331.1	430.2	628.3	551.9	379.2	213.1	119.4	80.9	70.5	65.9	145.5	268.9
65	367.9	475.4	690.5	622.6	427.3	242.2	129.9	88.6	75.3	71.6	169.5	308.5
70	407.5	554.7	769.8	704.7	483.9	268.3	151.7	99.9	84.6	79.2	203.8	350.9
75	455.6	639.6	891.5	803.7	551.9	305.6	171.2	112.9	95.7	90.8	252.2	416.0
80	534.9	730.1	1024.5	942.4	650.9	342.4	192.4	135.8	111.5	110.4	302.8	486.8
85	633.9	891.5	1211.2	1129.2	817.9	399.0	227.0	167.3	140.7	191.3	365.1	571.7
90	959.4	1151.8	1528.2	1415.0	1064.1	489.6	294.3	249.0	207.2	328.3	503.7	733.0
95	1417.8	1533.9	2181.9	1842.3	1434.8	733.0	393.4	404.7	339.6	489.6	772.6	1010.3
99	2733.8	2943.2	3679.0	3254.5	2510.2	1307.5	699.0	1066.9	1432.0	1202.8	2300.8	2196.1
Mean	435.4	540.0	737.6	647.3	479.8	250.6	139.0	122.9	136.2	126.1	251.7	337.1
Max	9226	5915	5066	4330	3538	2623	1157	1899	7415	2372	8292	2711
Obs	620	565	620	600	620	600	620	620	600	589	570	589

Table 4-5 Frequency Distribution of Suspended Sediment Concentration and Load, (USGS Data at Chain Bridge, 1980-1999)

Percentile (%)	Suspended Sediment (mg/L)	Sediment Load (1,000 kg/day)
1	1	4.6
5	3	9.0
10	4	19.1
15	5	26.4
20	6	39.9
25	7	59.9
30	10	76.4
35	11	92.5
40	12	145
45	13	170
50	15	218
55	19	282
60	21	466
65	30	924
70	45	2,117
75	73	4,382
80	105	8,106
85	140	16,821
90	215	24,174
95	342	48,365
Mean	85	13,601
Obs	184	183