US Army Corps of Engineers
Hydrologic Engineering Center

Suspended Sediment Discharges in Streams

April 1969

TP-19

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
April 1969	Technical Paper	

4. TITLE AND SUBTITLE	
Suspended Sediment Discharges in Streams	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	
Charles E. Abraham	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5F. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
US Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687	TP-19

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/ MONITOR'S ACRONYM(S)
	11. SPONSOR/ MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Presented at the AGU Golden Anniversary Meeting in Washington, DC, 21-25 April 1969.

14. ABSTRACT
Records of continuous daily suspended sediment and water discharges from four different river drainage areas were used to develop flow weighted regression relationships that relate daily suspended sediment discharges to streamflow. The method can be used to estimate suspended sediment loads stochastically for rivers with little measured data. Results which compared observed sediment loads to computed loads using this method are promising and appear to provide a better fit to field measurements than either the flow-duration or sediment rating curve methods.

15. SUBJECT TERMS
sediment load computations, sediment discharge-streamflow relationships, flow weighted regression analyses

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
U	U	U	UU	26	19b. TELEPHONE NUMBER

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SUSPENDED SEDIMENT DISCHARGES IN STREAMS[1]

Charles E. Abraham[2]

INTRODUCTION

This paper demonstrates a technique for relating daily suspended sediment discharges to streamflow using a procedure that weights each observation in proportion to the water discharge. The methods employed can be used to generate suspended sediment loads stochastically. Factors such as rate of change in flow, time since peak flow and an index of sediment-producing conditions in the basin are used to estimate suspended sediment discharge.

Aside from needs to improve the prediction of sediment loads for planning studies, the analysis of short-period loads, such as daily or weekly amounts, can be important to predict the performance of water resource projects adequately. For example, the water-surface elevation of a reservoir when large inflows occur can influence the pattern of sediment deposition in the reservoir.

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(1) For presentation at the AGU Golden Anniversary Meeting in Washington, D.C., 21-25 April 1969.

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REGRESSION TECHNIQUE

Logarithmic relations are used in this investigation for correlating observed daily suspended sediment discharges with streamflow. The distribution of observed data does not always follow the same linear relationship for both high and low flows. Therefore, large errors frequently occur in estimating annual or monthly sediment (bulk) loads from a single linear logarithmic relation of sediment and water discharge.

For purposes of estimating bulk sediment loads, the prediction of sediment discharge at high flows is of primary importance. Conversely, errors in estimating sediment discharges from a logarithmic relation at low flows are insignificant compared to similar errors for high flows. If the logarithms of each event have equal weight, the low-flow events unduly influence the resulting relation. Since the estimate of total bulk sediment is the usual objective, a technique is used whereby each observation is weighted in proportion to its flow. This is done by entering each event into the regression analysis a number of times in proportion to the water discharge of that event.

REGRESSION EQUATION

Excessive erosion from extremely high flood flows frequently causes unusually high sediment concentrations for several months or even years after a flood, and these unusually high sediment discharges for relatively short durations can transport more than twenty times the average annual sediment load. Also, suspended sediment concentrations are usually higher during periods of increasing flow than during corresponding periods for decreasing flow. Based on these considerations, the following equation was found to be of most value in predicting suspended sediment discharge:

$$Q_s = a\, Q^b\, T^c\, F^d \qquad (1)$$

where:

Q_s = Suspended sediment discharge (tons/day)

Q = Mean daily water discharge (cfs)

T = Time in days since the preceding peak flow when flow is decreasing. Ratio of the preceding period flow to current flow when flow is increasing.

F = Index of basin condition due to antecedent floods; 1.0 for normal conditions and greater than 1.0 for excessive sediment loads caused by an antecedent flood that exceeded Q_c (see equations (2) and (3))

a,b,c,d = Regression constant and coefficients

The occurrence of excessive sediment concentrations reflected in the variable F is a function of the magnitude of the water discharge. When the water discharge exceeds a threshold discharge determined from observations, the variable F is computed as follows:

$$F = S_i/Q_c \qquad (2)$$

and

$$S_i = (Q_i + S_{i-1})R \qquad (3)$$

where:

F	=	Index of basin condition (see definition for equation 1)
S_i	=	Current-period flow
S_{i-1}	=	Preceding-period flow
Q_c	=	Threshold discharge in cfs above which the basin runoff will produce higher than normal sediment loads for some duration in the future.
Q_i	=	Current-period water discharge in cfs
R	=	Basin recovery coefficient less than one (usually .90 to .99)

BASIC DATA

Records of continuous daily suspended sediment and water discharges used in these investigations were obtained from the U.S. Geological Survey on punched computer cards. Gaging station locations and lengths of record used are given in table 1.

TABLE 1

GAGING STATIONS

Gaging Station	Drainage Area (sq. mi.)	Suspended Sediment Discharge Record (Water Years, Inclusive)
Eel River at Scotia, Calif.	3,113	1958-1965
Cottonwood Cr. at Cottonwood, Calif.	922	1963-1965
Thomes Cr. nr. Paskenta, Calif.	190	1963-1965
Nacimiento River nr. Bryson, Calif.	140	1961-1965

These streams all drain from the Pacific coast mountain ranges, and the Eel River, Cottonwood Creek and Thomes Creek are located in the northern portion of California and the Nacimiento River is located in the southern portion. Runoff-producing rainfall normally occurs on all of these basins only during the October through June period. The Eel River, Cottonwood Creek and Thomes Creek basins receive considerably more rainfall than the Nacimiento River basin. The suspended sediment discharge records include an extremely large flood that occurred on the three northern California basins in December 1964. This flood caused major landslides and widespread flood damage, and the maximum daily suspended sediment loads in these streams following this flood were more than 10 times those normally experienced for similar water discharges before the flood.

CORRELATION STUDIES

Using the relation from equation 1, the regression constant and coefficients were calculated from the given records. Separate analyses were performed for the first half of each record and for the full record. For the records that include three and five years, instead of actually splitting the records the half-record analyses were performed for only the first one and two years, respectively. The standard error of estimates (S_e) and determination coefficients (R^2), relating the logarithms of flows, were computed for each of three different relations:

(1) Q_s versus Q, (2) Q_s versus Q and T, and (3) Q_s versus Q, T and F. The resulting statistics for these analyses are shown in table 2.

TABLE 2

COMMON LOGARITHM STATISTICS

Stream Name		Q_s vs Q_2		Q_s vs Q, T		Q_s vs Q,T,F	
		S_e	R^2	S_e	R^2	S_e	R^2
Eel River:	Full Record	.29	.95	.28	.95	.21	.97
	Half Record	.23	.95	.20	.96	.19	.97
Cottonwood Cr.:	Full Record	.32	.93	.31	.93	.27	.95
	Half Record	.30	.89	.25	.93	.24	.93
Thomes Cr.:	Full Record	.58	.88	.57	.89	.39	.95
	Half Record	.28	.93	.23	.95	.23	.96
Nacimiento River:	Full Record	.46	.91	.38	.94	.35	.95
	Half Record	.36	.93	.26	.96	.25	.97

The full records of suspended sediment discharge on the three Northern California streams include the large December 1964 flood which is a dominant factor in these analyses. The five-year record for the Nacimiento River does not include any particularly large floods.

As a test of the relationships derived, the regression coefficients for equation 1 were calculated from data for the first halves of the suspended sediment discharge records. Using these values, equation 1 was then applied to daily water discharges to reconstitute the observed daily suspended sediment discharges for the full record at each gaging station. The computed and observed values in tons for the Eel River are shown in exhibit A. Each year of computed data is shown on separate pages with the months across the top of the page and day of the month in the first column. Immediately following the day number is a C or O, which indicate computed and observed values, respectively. Monthly and annual summaries showing computed and observed values are also given following the daily data.

Although computer output data similar to that in exhibit A were obtained for the three remaining gaging stations, the results are too voluminous to include in this presentation. The annual summaries of computed and observed suspended sediment loads, with the corresponding errors for estimated values, are shown in table 3 for all gaging stations.

TABLE 3

OBSERVED AND COMPUTED
ANNUAL SUSPENDED SEDIMENT LOADS

STREAM	WATER YEAR	SUSPENDED LOAD IN 1000 TONS OBSERVED	COMPUTED	ERROR (%)
Eel River	1958*	29,420	30,320	+ 3
	1959*	9,940	7,980	-20
	1960*	15,120	19,810	+31
	1961*	8,280	7,760	- 6
	1962	4,760	4,880	+ 2
	1963	21,190	22,890	+ 8
	1964	5,650	4,900	-13
	1965	167,820	110,750	-34
Cottonwood Creek	1963*	488	460	- 6
	1964	48	27	-44
	1965	1,450	2,072	+43
Thomes Creek	1963*	906	954	+ 5
	1964	25	40	+60
	1965	10,814	8,691	-20
Nacimiento River	1961*	9	9	0
	1962*	143	145	+ 1
	1963	22	16	-27
	1964	15	3	-80
	1965	5	2	-60

* Record used to compute regression coefficients

In order to compare results obtained herein with results obtainable with commonly-used techniques, annual suspended sediment loads for two streams were computed by the Flow-Duration, Sediment-Rating Curve Method.[1] Flow duration curves were drawn from water discharge data for each year of suspended sediment discharge record, and the sediment rating curves were drawn from daily

1 Analysis of Flow-Duration, Sediment-Rating Curve Method of Computing Sediment Yield, Sedimentation Section, Hydrology Branch, Bureau of Reclamation, April 1951.

suspended sediment discharge data. Data from the half-record periods were used to draw the sediment rating curves. The annual suspended sediment loads were then computed for the full-record periods. These values, shown in table 4 with the observed loads and corresponding errors, indicate considerably larger errors in general than those in table 3.

TABLE 4

ANNUAL SUSPENDED SEDIMENT LOADS COMPUTED
BY THE FLOW-DURATION, SEDIMENT RATING CURVE METHOD
FOR THE EEL RIVER AND THOMES CREEK

STREAM	WATER YEAR	SUSPENDED LOAD IN 1000 TONS OBSERVED	COMPUTED	ERROR (%)
Eel River	1958	29,420	41,000	+39
	1959	9,940	10,450	+ 5
	1960	15,120	20,300	+34
	1961	8,280	7,430	-10
	1962	4,760	7,400	+55
	1963	21,190	17,300	-18
	1964	5,650	7,120	+26
	1965	167,820	91,500	-45
Thomes Creek	1963	906	864	- 5
	1964	25	23	- 8
	1965	10,814	3,500	-68

CONCLUSIONS

Results of this investigation are generally promising. The statistics in table 2 indicate that the addition of variables T and F of equation 1, each significantly helped to explain some of the remaining error variance in the suspended sediment discharge after correlation with flow alone.

Also, the actual estimates of annual suspended sediment loads are generally improved over those computed by the Flow-Duration, Sediment Rating Curve Method.

In order to apply the proposed procedure, a simultaneous record of daily sediment and water discharges is required for a duration that includes a wide range of expected quantities. However, if the regression coefficients follow some regional trend or correlate with basin features, a means for more general application is possible. The testing of this procedure in other regions is required before any general application is made.

ACKNOWLEDGMENTS

This study was made in The Hydrologic Engineering Center, Sacramento District, U.S. Corps of Engineers, and various members of the Center assisted during the conduct of the study and preparation of the paper.

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EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1958

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	96	213	244	15107	115716	83981	437219	974	244	26	3	2
1O	56	67	156	15000	136000	81700	385000	1200	74	12	0	0
2C	74	177	213	21163	85962	41358	964280	937	540	23	3	2
2O	48	63	113	28800	115000	46900	858000	1120	74	12	0	0
3C	42	143	192	19289	344715	24012	938517	967	545	22	3	1
3O	36	33	121	19200	352000	32000	698000	1150	74	12	0	0
4C	24	117	167	9597	380624	15740	361896	2930	565	20	2	1
4O	26	26	90	8490	276000	23900	292000	1180	74	12	0	0
5C	22	97	153	6058	396855	10705	206412	2184	327	17	2	1
5O	27	33	69	4700	286000	16400	174000	1060	74	12	0	0
6C	201	83	148	4135	196022	8142	124707	1937	262	15	2	1
6O	170	31	86	2640	151000	9830	138000	961	74	6	0	0
7C	935	67	150	3014	293448	6188	76982	1684	223	14	2	2
7O	400	28	75	2520	282000	8500	67200	878	74	6	0	0
8C	505	65	132	2374	312729	5245	46228	1426	208	11	2	2
8O	230	38	49	2580	211000	7360	44400	851	48	6	0	0
9C	1003	181	118	2207	324180	4432	31018	1297	206	10	2	2
9O	1500	31	52	3630	248000	6060	26700	667	44	6	0	0
10C	45354	253	104	95031	447627	3479	24515	1245	438	9	2	2
10O	100000	67	54	145000	358000	4960	20000	642	78	6	0	0
11C	13300	750	92	179829	166112	2939	21282	2418	552	7	1	1
11O	19000	1750	70	117000	141000	4390	19400	832	120	4	0	0
12C	2602	1082	83	124518	1698131	2513	18967	2873	371	7	1	1
12O	2500	1070	66	153000	1560000	3900	18600	1080	111	4	0	0
13C	179387	37954	77	270063	1016193	2186	15938	2690	260	6	1	2
13O	330000	168000	64	240000	916000	3070	15700	1010	77	4	0	0
14C	87645	1054243	72	81430	341157	1891	13855	1592	193	6	1	2
14O	140000	1180000	59	54800	360000	2500	12800	674	42	4	0	0
15C	8912	102092	226	38555	1063252	5122	11202	1233	153	5	1	2
15O	9400	154000	48	29700	829000	3560	10700	413	42	3	0	0
16C	2824	21734	1837	28287	878183	5718	9014	983	131	5	1	2
16O	2700	34200	6890	22500	626000	3960	9270	408	42	3	0	0
17C	1405	8663	65620	15562	452245	3621	7837	1005	106	5	1	2
17O	1200	12200	131000	11700	390000	2540	7540	345	30	3	0	0
18C	828	5396	358893	9619	877207	2688	7370	1828	95	5	1	2
18O	630	7630	432000	6800	1050000	1620	7000	335	30	3	0	0
19C	537	5600	97561	6510	1931938	2169	6083	1819	82	5	1	2
19O	337	7460	106000	4780	1860000	1010	6130	397	30	3	0	0
20C	329	3680	98007	4757	612764	3887	4863	1339	76	4	1	2
20O	190	3990	83100	3620	491000	3830	5080	392	30	3	0	0
21C	248	2475	314605	3674	205991	128360	4390	1127	204	4	1	2
21O	130	3230	543000	2740	224000	258000	4680	453	30	3	0	0
22C	189	1720	484084	2692	98212	220647	4319	1929	132	4	4	1
22O	112	2300	538000	2380	129000	212000	4710	355	30	3	0	0
23C	270	1245	113087	2682	67925	116339	3962	2407	95	4	3	1
23O	619	1670	116000	5050	98300	84200	4500	562	30	3	0	0
24C	749	989	73863	42097	748214	129347	2750	1620	74	4	3	2
24O	1360	1120	82400	68600	1310000	84900	3360	829	16	1	0	0
25C	1511	800	37386	135542	3261569	159754	2011	1140	60	13	2	2
25O	1220	757	35000	122000	2290000	102000	2630	604	16	1	0	0
26C	2121	665	25520	160652	656121	97151	1484	771	51	13	2	2
26O	1710	555	28200	149000	696000	69200	1920	500	10	1	0	0
27C	1677	555	18750	150646	208728	46396	1260	538	43	9	1	2
27O	920	410	19100	96800	294000	31500	1820	259	16	1	0	0
28C	893	466	84037	122740	96403	26312	1149	446	37	7	1	1
28O	366	333	163000	87900	142000	17700	1330	162	16	1	0	0
29C	533	387	321092	743038	0	26519	1106	345	33	6	1	1
29O	175	227	308000	1030000	0	50600	1110	131	16	1	0	0
30C	367	296	78445	1389000	0	356362	1069	284	29	5	1	2
30O	110	185	61800	1380000	0	383000	1160	110	16	0	0	0
31C	271	0	29350	341177	0	251622	0	252	0	4	1	0
31O	98	0	23900	316000	0	158000	0	97	0	0	0	0
MONTHLY SUMMARY												
C	354896	1252178	2204308	4031044	17278221	1791825	3351687	44220	6334	293	54	50
O	615270	1581504	2678562	4136930	15821300	1719090	2842740	19657	1438	139	0	0

ANNUAL SUMMARY

COMPUTED LOAD = 30315111 TONS, OBSERVED LOAD = 29416630 TONS

C - COMPUTED

O - OBSERVED

EXHIBIT A

ELL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1959

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	2	3	5	305	6416	8434	9346	173	13	2	0	0
1O	0	0	2	205	4800	3680	7200	85	5	1	1	0
2C	3	3	4	202	4026	7577	5626	144	13	1	0	1
2O	0	0	1	161	2910	3530	2760	49	5	1	1	0
3C	2	3	4	135	2743	7087	4030	128	11	1	0	1
3O	0	0	1	90	2050	3310	1880	39	5	1	1	0
4C	1	3	4	106	2042	6378	3036	114	11	1	0	1
4O	0	0	1	225	1590	3000	1330	46	5	1	1	0
5C	1	3	3	19438	1566	4489	2424	104	10	1	0	1
5O	0	0	1	99400	2200	2800	942	69	5	1	1	0
6C	1	3	3	219326	1249	3586	2072	90	10	1	0	1
6O	0	2	1	326000	1600	2850	929	54	5	1	1	0
7C	1	3	3	47286	1048	2909	1631	79	9	1	0	0
7O	0	2	0	63500	1090	2120	940	44	5	1	1	0
8C	1	2	3	308282	879	2595	1282	70	9	1	0	0
8O	0	2	0	395000	709	1670	644	39	5	1	0	0
9C	1	3	3	801198	796	1983	1018	63	8	1	0	0
9O	0	3	1	975000	732	1050	583	27	5	1	0	0
10C	1	6	2	280994	3031	1629	845	57	7	1	0	0
10O	0	4	0	301000	2350	879	466	19	5	1	0	0
11C	1	7	2	143373	14427	1364	714	54	7	1	0	0
11O	0	4	0	204000	13300	702	365	17	3	1	0	0
12C	1	7	2	1404353	7913	1191	632	52	7	1	0	0
12O	0	4	1	1970000	8340	653	305	17	3	0	0	0
13C	1	8	2	324795	3991	1096	575	49	5	1	0	0
13O	0	4	1	605000	3680	623	347	17	3	0	0	0
14C	1	28	2	60618	137098	1072	512	48	4	1	0	1
14O	0	59	0	108000	480000	556	270	17	3	0	0	0
15C	1	94	2	22928	1068507	915	429	48	5	1	0	1
15O	0	326	0	40600	980000	390	194	17	3	0	0	0
16C	1	173	2	10631	739738	775	374	47	5	1	0	1
16O	0	134	0	17800	686000	303	218	17	3	0	0	0
17C	2	91	2	5798	719163	682	315	43	4	1	0	2
17O	0	87	1	10600	630000	345	178	17	3	0	0	0
18C	2	38	2	3445	438682	640	277	39	3	1	0	11
18O	0	25	1	6450	427000	281	140	17	3	0	0	3
19C	2	196	2	2320	280298	604	254	34	4	1	0	44
19O	0	196	1	4340	261000	280	140	17	3	0	0	15
20C	2	2120	5	1681	115777	509	225	30	3	1	1	58
20O	0	2460	1	2760	168000	246	140	11	3	0	0	28
21C	2	620	48	1285	70690	469	209	27	3	0	1	82
21O	0	1190	20	1860	113000	218	140	11	2	0	0	34
22C	2	196	172	1015	33557	466	180	25	3	0	1	31
22O	0	323	207	1340	50600	220	82	11	2	0	0	12
23C	2	84	119	831	16797	1975	160	23	3	0	1	17
23O	0	132	225	862	20600	880	72	11	2	0	0	5
24C	2	42	91	2417	10361	6488	147	23	2	0	1	9
24O	0	55	199	4300	10700	4300	81	11	2	0	0	3
25C	2	25	255	19790	7002	3646	125	22	2	0	1	6
25O	0	29	689	61100	8290	2500	134	11	2	0	0	2
26C	2	17	650	60711	5195	7884	419	22	2	0	1	4
26O	0	16	3880	110000	7900	10200	154	6	2	0	0	2
27C	2	12	13372	42477	4185	10030	974	20	2	0	1	3
27O	0	11	55300	85800	7490	11500	419	6	2	0	0	1
28C	2	9	16956	192450	3506	4160	670	18	2	0	1	2
28O	0	9	44200	293000	5670	3600	157	6	2	0	0	1
29C	2	7	3596	54114	0	2790	400	16	2	0	1	7
29O	0	6	6800	61400	0	1810	116	6	2	0	0	1
30C	1	6	1185	22874	0	12975	285	15	2	0	1	5
30O	0	3	1280	21000	0	19100	128	6	2	0	0	1
31C	2	0	520	11212	0	27026	0	14	0	0	1	0
31O	0	0	386	9070	0	29700	0	6	0	0	0	0
MONTHLY SUMMARY												
C	49	3810	37021	4066392	3700684	133425	39189	1691	171	22	11	290
O	0	5086	113200	5779863	3901601	113496	21454	726	100	11	7	108

ANNUAL SUMMARY

COMPUTED LOAD = 7982755 TONS, OBSERVED LOAD = 9935652 TONS

C - COMPUTED

O - OBSERVED

4374

EXHIBIT A

EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1960

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	2	1	1	9	18783	837	36304	1054	2787	20	6	1
1O	1	0	0	12	42400	862	23000	629	2640	8	2	0
2C	2	1	1	7	338068	739	20613	1094	1963	19	5	2
2O	1	0	0	7	425000	611	9970	479	1810	8	3	0
3C	2	1	1	6	44867	2536	13472	965	1440	18	4	2
3O	1	1	0	4	54900	3620	6930	372	1080	4	1	0
4C	2	1	2	5	32554	92497	9024	817	1067	17	4	1
4O	1	1	0	5	39500	165000	5010	280	580	3	1	0
5C	2	1	1	4	23496	336875	6684	694	822	16	3	1
5O	1	1	0	3	36000	309000	3680	265	404	3	2	0
6C	1	1	1	4	17980	674765	5078	567	628	14	3	1
6O	0	0	0	2	25500	522000	4020	222	322	3	2	0
7C	1	1	1	10	355924	479039	3823	487	488	13	3	1
7O	0	0	0	8	611000	434000	4320	127	305	3	2	0
8C	3	1	1	596	10040039	616356	2945	430	403	11	3	1
8O	1	0	0	2070	5380000	493000	3570	100	258	3	1	0
9C	4	1	1	2682	3641912	158477	2318	391	323	10	3	1
9O	0	0	0	8620	2820000	165000	2980	97	179	3	0	0
10C	4	1	2	907	938523	59487	1878	361	241	9	2	1
10O	0	0	0	1890	1130000	65900	2450	95	120	3	0	0
11C	4	1	2	359	256126	31222	1669	348	201	9	2	1
11O	0	0	1	668	502000	36500	2530	88	89	3	0	0
12C	3	1	3	1774	95134	57496	1457	318	169	8	2	1
12O	0	0	4	2970	194000	78000	1940	78	72	4	0	0
13C	2	1	7	1480	49254	266877	1149	297	142	7	2	1
13O	0	0	2	2300	92700	202000	1320	83	57	5	1	0
14C	2	1	9	645	24741	95718	1121	280	121	7	2	1
14O	0	0	1	1100	51000	69300	1170	75	67	5	1	0
15C	2	1	8	405	15008	40474	1104	258	104	28	1	1
15O	0	0	1	585	26700	30600	1000	49	37	5	1	0
16C	2	1	7	235	10335	23449	868	237	90	37	4	1
16O	0	0	1	258	17700	18500	672	53	35	4	1	0
17C	2	1	5	138	7428	15470	695	222	79	19	3	1
17O	0	0	1	122	14000	13000	530	40	30	2	1	0
18C	2	1	4	96	6225	11299	593	192	70	13	2	1
18O	0	0	1	75	12300	15900	450	49	35	2	1	0
19C	1	1	3	76	5660	8508	574	183	62	12	3	0
19O	0	0	1	54	10900	12000	393	43	23	3	1	0
20C	1	2	2	65	4035	6612	524	167	57	9	2	0
20O	0	0	1	48	7080	8700	301	31	19	5	0	0
21C	1	2	2	162	3129	5369	446	157	48	8	2	0
21O	0	0	1	95	5500	6800	249	35	42	5	0	0
22C	3	2	2	896	2648	4266	427	147	43	7	2	0
22O	0	0	1	853	4730	5740	261	39	60	4	0	0
23C	3	2	4	2112	2215	3283	437	565	35	7	2	0
23O	0	0	1	2510	4020	4930	250	289	34	2	0	0
24C	3	2	15	1306	1873	2744	396	29097	31	6	1	1
24O	0	0	25	1110	3260	4040	209	47600	39	2	0	0
25C	3	2	147	2521	1582	2308	353	57234	33	6	1	1
25O	0	0	618	5510	1750	4080	184	70400	20	2	0	0
26C	3	2	560	19941	1379	1943	328	156096	30	4	1	1
26O	0	0	1060	25600	1080	3190	143	131000	9	2	0	0
27C	2	2	179	12914	1244	1950	1582	61136	28	4	1	1
27O	0	0	174	15000	1610	3390	1370	42400	7	2	0	0
28C	2	1	57	25735	1075	13268	4915	23688	26	4	1	1
28O	0	0	66	57000	1330	14100	5720	16400	6	2	0	0
29C	2	1	27	19932	942	13545	3880	12152	24	3	1	1
29O	0	0	36	28100	1030	12900	2480	9880	6	2	0	0
30C	2	1	17	32277	0	55240	1910	6728	22	3	1	1
30O	0	0	22	60800	0	92500	929	6900	6	1	0	0
31C	2	0	12	25795	0	130632	0	4089	0	8	1	0
31O	0	0	17	51300	0	110000	0	4960	0	1	0	0
MONTHLY SUMMARY												
C	71	41	1082	153392	15942178	3213280	126568	360450	11577	359	72	26
O	6	3	2035	268679	11516990	2905163	88031	333158	8391	104	21	0

ANNUAL SUMMARY

COMPUTED LOAD = 19808795 TONS, OBSERVED LOAD = 15122581 TONS

C - COMPUTED

O - OBSERVED

4375

EXHIBIT A

EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1961

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	1	1	202430	380	367296	2960	5949	4021	255	19	4	2
1O	0	0	317000	207	344000	1740	4650	1200	37	6	2	0
2C	1	1	380141	336	108088	2261	4206	4095	227	17	3	1
2O	0	0	373000	125	196000	1350	6700	1190	35	6	2	0
3C	1	1	42063	223	102530	1914	4687	2783	219	16	3	1
3O	0	0	55400	108	165000	1140	7230	857	35	3	1	0
4C	0	1	11035	192	33136	1258	4605	1887	212	15	3	1
4O	0	0	14500	82	47400	920	6770	526	49	3	1	0
5C	1	1	4241	170	14652	1774	3912	1453	641	14	3	1
5O	0	0	6690	66	24900	1470	6300	552	73	5	1	0
6C	2	1	2201	150	8416	4620	3070	1412	473	12	2	1
6O	0	0	3500	56	12700	7170	5430	747	98	5	1	0
7C	4	1	1351	134	5554	10056	2206	2873	373	11	2	1
7O	1	0	2000	64	7950	14300	3970	807	93	3	1	0
8C	4	1	397	140	3863	6742	1720	2100	319	11	2	1
8O	1	0	1050	55	11300	7810	2720	475	64	3	0	0
9C	4	1	661	140	67445	24090	1346	1701	259	10	5	1
9O	1	0	512	50	205000	37600	1780	456	48	4	0	0
10C	2	2	558	387	339321	36229	1129	4364	217	10	5	1
10O	1	1	383	63	323000	42200	1090	2510	34	4	0	0
11C	2	2	607	294	982945	33301	954	18878	186	9	4	1
11O	0	0	509	55	955000	36500	1020	15800	21	4	1	0
12C	2	4	482	239	451153	31022	841	23987	166	7	3	1
12O	0	1	368	48	418000	24100	738	20800	21	4	1	0
13C	3	14	328	181	148041	14828	783	9437	142	7	5	1
13O	0	6	154	39	212000	13300	577	5230	24	2	1	0
14C	3	48	237	142	126478	12147	722	5470	130	6	4	1
14O	0	24	65	31	188000	15400	497	2120	28	2	1	0
15C	2	377	242	120	96340	223484	680	3529	113	5	3	1
15O	0	291	68	25	131000	278000	365	1280	27	2	0	0
16C	2	162	6449	103	75162	192914	612	2527	100	4	2	2
16O	0	100	13000	20	101300	148000	290	803	21	2	0	0
17C	1	74	819248	91	36713	228322	549	1857	82	4	2	2
17O	0	52	582000	19	49400	197000	244	495	16	2	0	0
18C	1	257	511083	81	19800	133267	516	1442	70	4	2	2
18O	0	1250	440000	22	28100	97000	220	328	15	3	0	0
19C	1	1239	147062	72	11700	59408	496	1189	62	4	2	7
19O	0	3340	159000	14	18900	49900	203	290	14	3	0	0
20C	1	473	41628	65	7755	59888	478	998	56	3	2	6
20O	0	983	59900	17	17900	66800	179	271	13	2	0	0
21C	1	146	13992	58	5363	30303	1894	871	49	3	1	2
21O	0	264	21200	9	21500	26200	994	233	13	1	0	0
22C	1	79	7219	53	3933	20370	5799	740	45	3	1	1
22O	0	134	13900	9	21400	22700	11200	195	12	1	0	0
23C	1	94	4263	148	3015	25836	13414	641	40	2	1	1
23O	0	434	12300	21	12300	30700	15500	141	8	1	1	0
24C	1	15111	2770	204	2354	20205	12916	539	34	2	1	1
24O	0	49900	8470	36	7840	17300	8760	131	8	1	0	0
25C	1	137025	1947	272	1943	55489	4898	466	32	2	1	1
25O	0	250000	3540	60	5450	35700	2500	113	7	1	0	0
26C	2	65356	1431	252	1436	37084	3364	413	28	2	1	1
26O	0	109000	3090	36	3720	23300	1490	90	7	0	0	0
27C	2	9463	1113	835	1189	47279	2496	381	24	2	3	1
27O	0	14300	1700	478	3420	23800	1040	70	9	0	0	0
28C	2	2930	869	1560	1000	25916	1921	340	23	2	3	1
28O	0	2950	795	739	2730	13200	719	50	6	0	1	0
29C	2	1205	689	2875	0	14150	1750	286	20	6	3	1
29O	0	932	471	6240	0	8730	675	54	6	0	0	0
30C	2	1047	549	80163	0	9813	3710	269	18	6	2	1
30O	0	2100	365	131000	0	6150	1150	68	6	1	0	0
31C	1	0	438	629500	0	7111	0	263	0	5	2	0
31O	0	0	311	668000	0	4560	0	53	0	2	0	0
MONTHLY SUMMARY												
C	52	235120	2208224	719530	3026618	1374041	91623	101214	4616	222	80	43
O	4	436081	2195242	807787	3535940	1251040	95001	57935	848	76	15	0

ANNUAL SUMMARY

COMPUTED LOAD = 7761382 TONS, OBSERVED LOAD = 8279969 TONS

C - COMPUTED

O - OBSERVED

4978

EXHIBIT A

EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1962

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	1	9	39383	323	337	9470	3649	582	76	3	0	0
1O	0	1	53100	53	110	9990	2740	165	6	5	0	0
2C	1	7	99375	300	325	31212	3328	498	66	3	0	0
2O	0	0	140000	45	117	36700	2710	96	6	2	0	0
3C	1	5	12022	270	311	30673	2903	430	58	3	0	0
3O	0	0	15700	43	93	21300	2430	85	5	1	0	0
4C	1	4	3175	244	296	31109	2315	388	54	3	0	0
4O	0	0	2470	41	84	19300	1490	68	5	1	0	0
5C	1	3	1358	209	282	50716	1981	344	48	3	0	0
5O	0	1	734	32	98	58200	1210	65	5	1	0	0
6C	1	3	777	167	281	287077	1920	308	43	2	0	0
6O	0	0	421	29	182	257000	1260	84	5	1	0	0
7C	1	2	506	105	6997	162019	1786	274	37	2	2	1
7O	0	0	282	19	18100	118000	1550	74	5	1	0	0
8C	1	2	396	92	169940	49938	4656	244	34	2	6	1
8O	0	0	209	13	182000	39600	1910	65	4	1	2	0
9C	1	2	326	86	178194	24931	4771	237	29	2	24	1
9O	0	0	129	17	174000	25500	2000	84	7	1	6	0
10C	0	2	233	83	231269	15215	3408	543	27	2	24	1
10O	0	0	68	8	205000	25300	1730	142	6	1	6	0
11C	2	2	181	80	66942	11118	2414	403	24	2	11	1
11O	0	0	55	8	60300	21000	1160	117	6	1	5	0
12C	3	2	144	74	27303	8214	1995	298	23	2	6	1
12O	0	0	50	16	30600	14700	891	65	6	1	5	0
13C	4	2	120	72	285320	5816	1891	248	18	1	5	1
13O	0	0	46	16	422000	9100	1050	40	3	1	6	0
14C	6	1	104	67	658175	4415	1804	190	17	1	4	1
14O	0	0	44	7	596000	5110	1130	31	1	1	5	0
15C	4	1	93	62	504070	3687	1646	161	14	1	3	1
15O	0	1	38	7	411000	4250	964	24	3	1	2	0
16C	3	1	83	56	580568	3313	1395	145	13	1	2	0
16O	0	0	28	11	354000	4830	906	24	4	1	1	0
17C	2	1	86	47	249182	2953	1103	131	14	1	2	0
17O	0	0	131	0	181000	4040	710	18	5	1	0	0
18C	2	1	576	44	92421	2493	906	119	13	1	2	1
18O	0	0	482	9	97600	3230	516	18	3	1	0	0
19C	2	1	3534	12551	55245	2154	764	102	12	1	2	5
19O	0	0	3530	52600	61000	3140	445	17	3	1	0	0
20C	1	3	56348	315858	27251	2011	690	99	11	1	1	2
20O	0	0	58700	392000	43700	2470	384	17	4	1	0	0
21C	1	4	114345	20000	14811	1883	534	90	9	1	1	1
21O	0	0	110000	36400	32100	1940	301	12	4	1	0	0
22C	1	6	27372	5614	9442	6895	426	79	9	1	1	1
22O	0	2	26800	7910	21200	5220	236	12	5	1	0	0
23C	1	19	7804	2744	6601	25742	379	77	8	1	1	1
23O	0	18	7130	2750	15200	35600	181	12	5	1	0	0
24C	1	322	3410	1673	4901	13839	380	71	7	1	1	1
24O	0	958	2070	1250	12700	10600	170	11	6	1	0	0
25C	1	13909	1905	1093	3588	8012	369	69	6	1	1	1
25O	0	29800	851	636	7280	4080	148	11	6	0	0	0
26C	2	22992	1205	780	2711	6042	325	62	5	1	1	0
26O	0	27000	382	410	4650	2430	115	14	3	0	0	0
27C	5	4259	848	637	2094	5308	871	57	5	1	1	0
27O	1	3090	238	320	3550	2780	309	10	3	0	0	0
28C	12	1158	604	517	1789	4738	1595	163	5	1	1	2
28O	6	680	137	257	3500	2720	872	7	4	0	0	1
29C	20	1253	477	459	0	4473	1982	121	4	1	1	1
29O	13	998	97	185	0	2980	1060	7	6	0	0	1
30C	18	24989	378	389	0	4287	879	96	4	1	1	1
30O	13	48900	80	156	0	2860	397	6	8	0	0	1
31C	15	0	349	358	0	4111	0	86	0	0	1	0
31O	4	0	63	144	0	2990	0	6	0	0	0	0
MONTHLY SUMMARY												
C	114	68915	377577	365061	3180345	823869	53065	6717	694	48	106	26
O	37	111459	424115	495398	2938194	756960	30915	1407	142	29	38	3

ANNUAL SUMMARY
COMPUTED LOAD = 4876537 TONS, OBSERVED LOAD = 4758697 TONS

C - COMPUTED
O - OBSERVED

EXHIBIT A

438

EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1963

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	8	91	3161	579	6559721	2683	191462	3476	277	33	2	2
1O	1	27	6410	532	4260000	1090	157000	2280	110	4	1	0
2C	5	76	50435	446	802630	2187	73150	3251	235	30	2	2
2O	1	18	298000	327	1010000	674	82700	2440	90	4	1	0
3C	5	64	1298675	391	238531	1897	41307	3065	207	27	2	1
3O	1	17	1190000	308	414000	702	43700	2810	73	7	1	0
4C	4	58	127944	340	112601	1405	35513	2982	179	24	2	1
4O	1	13	234000	282	212000	485	36000	2940	51	7	1	0
5C	3	49	36915	275	68718	1152	32496	14444	159	23	2	1
5O	1	12	81900	193	134000	386	43900	15900	43	5	1	0
6C	3	46	15944	235	39999	991	862164	15040	144	22	2	1
6O	1	5	39200	151	84800	392	593000	7870	36	5	1	0
7C	2	39	8039	189	27613	868	745809	13365	128	21	2	1
7O	1	5	16800	136	51600	320	480000	5090	34	5	1	1
8C	2	36	4576	175	20350	735	539846	10239	114	18	2	1
8O	1	5	8590	138	40600	270	284000	4640	33	5	1	1
9C	11	38	2876	153	17844	628	253749	7087	106	16	1	1
9O	4	11	5010	142	33600	271	157000	3590	32	4	1	1
10C	27242	104	1945	142	19133	557	137794	4646	97	15	1	1
10O	91000	12	3330	103	44600	224	136000	1990	26	3	2	0
11C	60119	212	1439	127	44706	509	140716	4488	88	14	1	1
11O	113000	40	2080	65	54500	153	94900	2070	21	3	2	0
12C	773932	2866	1104	118	27645	446	368481	3932	82	13	1	1
12O	1150000	12430	1920	69	42200	120	252000	1600	16	3	1	0
13C	939188	2618	4433	102	48630	416	424128	2815	73	12	1	1
13O	1560000	6800	10500	49	102000	108	234000	1110	12	5	1	0
14C	120508	1073	11703	93	52465	404	611329	2259	68	10	1	1
14O	213000	1440	19500	33	48100	142	361000	1030	11	4	1	0
15C	42200	561	37442	86	26862	1136	731418	1831	62	9	1	1
15O	75500	384	119000	32	23900	160	418000	700	14	3	1	0
16C	12836	357	117436	85	18386	2227	288707	1588	55	8	1	1
16O	28400	137	174000	27	22300	1340	161000	581	14	3	1	0
17C	5044	275	35924	82	16379	3213	126594	1493	49	7	1	1
17O	10500	122	47300	23	19000	1880	85300	518	13	3	1	0
18C	2446	223	17979	78	10827	3058	64805	1448	42	7	1	5
18O	4560	96	24900	22	14900	1180	49900	477	9	4	1	0
19C	436	170	10511	71	7619	1909	54564	1406	39	6	1	4
19O	341	71	13600	17	12600	610	49000	586	14	4	1	0
20C	324	133	5973	67	5633	1433	39848	1263	34	5	1	2
20O	236	41	9440	17	9510	514	31400	537	14	3	0	0
21C	237	114	3752	64	4272	1222	27449	1231	31	5	1	1
21O	150	26	8070	12	5520	339	21700	524	13	3	0	0
22C	199	99	2563	60	3311	1110	19710	1124	24	5	1	1
22O	139	25	7130	12	3680	345	16300	519	9	3	0	1
23C	2866	87	1838	56	2530	2891	14715	981	22	5	1	1
23O	2060	15	4800	7	3030	1040	11400	502	6	3	0	1
24C	1654	75	1401	54	2084	13872	10306	884	84	4	1	1
24O	1150	18	3740	15	2920	11100	8680	390	7	3	0	1
25C	955	71	1049	53	1709	6595	8457	787	92	4	1	2
25O	739	35	1910	11	2610	5630	7830	328	9	2	0	1
26C	669	191415	823	52	1463	4535	7783	662	67	4	1	2
26O	454	477000	940	7	2060	3920	6410	253	12	2	0	1
27C	217	324532	741	49	1244	108111	5921	563	56	3	1	2
27O	106	486000	697	11	1380	286000	4720	188	12	2	0	0
28C	182	30186	676	47	1077	1377592	4461	480	47	3	1	2
28O	80	61100	562	11	1210	1040000	3200	140	8	1	0	0
29C	153	8603	628	162	0	720666	3974	410	41	3	1	2
29O	57	14400	438	18	0	473000	2610	147	4	1	0	0
30C	128	4083	645	2482	0	790532	3797	367	33	3	1	1
30O	40	6090	560	7330	0	482000	2350	148	4	1	0	0
31C	105	0	631	765459	0	474954	0	317	0	2	2	0
31O	41	0	764	1360000	0	335000	0	146	0	1	0	0
MONTHLY SUMMARY												
C	1991693	568355	1809212	772371	8183981	3529934	5920451	107923	2735	361	37	43
O	3251065	1066417	2294991	1370100	6657650	2649395	3835000	62044	750	106	21	8

ANNUAL SUMMARY

COMPUTED LOAD = 22387075 TONS, OBSERVED LOAD = 21187547 TONS

C - COMPUTED

O - OBSERVED

EXHIBIT A

4387

EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1964

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	1	14	1159	757	7790	592	1814	236	34	3	1	0
1O	0	2	570	150	10700	118	248	44	2	3	0	0
2C	1	13	945	746	6963	1443	2170	247	27	3	1	0
2O	0	4	425	168	8570	1190	376	45	1	3	0	0
3C	1	14	798	658	5031	1452	1435	265	24	3	1	0
3O	0	4	327	192	6260	956	208	47	3	3	0	0
4C	1	1414	645	521	3597	712	1058	329	22	3	0	0
4O	0	4600	288	114	4890	238	168	62	3	3	1	0
5C	4	5065	441	407	2698	523	849	388	44	3	0	1
5O	25	12100	241	71	3160	140	116	73	3	3	1	0
6C	16	16867	404	1200	2211	505	704	239	52	3	2	0
6O	16	47900	217	257	3200	137	89	40	4	3	1	0
7C	9	17679	366	6063	1752	485	595	162	62	3	1	1
7O	7	36200	217	8420	2110	147	66	22	4	3	1	0
8C	5	10291	258	3768	1324	391	522	127	67	3	1	1
8O	6	11900	163	3600	1340	91	54	16	4	6	1	0
9C	3	118494	234	1837	1088	331	454	112	64	2	1	0
9O	2	141000	510	757	1100	57	51	12	4	2	1	0
10C	6	28460	1960	1513	906	276	421	98	62	2	1	1
10O	2	31800	1110	642	902	66	76	11	6	2	0	0
11C	125	5824	917	1269	796	1373	382	91	42	2	1	1
11O	131	5370	362	641	852	6720	65	11	6	2	0	0
12C	132	2072	623	1009	676	18552	346	84	34	2	1	1
12O	445	1610	220	367	617	41400	55	11	6	2	1	0
13C	44	1054	462	868	588	13949	308	80	28	2	1	1
13O	308	714	145	270	429	19400	68	11	5	1	0	0
14C	26	26440	376	2047	498	6468	291	78	21	2	1	0
14O	73	94000	93	483	322	4100	100	11	5	1	0	0
15C	75	148210	312	1888	506	3607	261	69	18	2	1	0
15O	157	218000	61	658	348	1700	127	7	4	1	0	0
16C	263	33437	265	1357	495	2494	251	62	16	1	1	0
16O	551	31600	51	383	401	1050	98	6	4	1	0	0
17C	230	10233	222	4453	420	1852	239	61	13	1	1	1
17O	337	7210	42	3210	321	671	69	6	7	1	0	0
18C	180	4451	189	75410	359	1478	222	61	12	1	0	0
18O	170	2760	56	102000	210	441	81	6	11	1	0	0
19C	67	6126	178	177372	316	1198	191	144	11	1	0	0
19O	45	13100	61	164000	158	380	50	10	9	1	0	0
20C	33	46354	1564	1478298	284	990	166	105	9	1	1	0
20O	14	46200	1930	1660000	117	202	24	9	7	1	0	0
21C	19	13969	5315	1448352	264	928	143	77	8	1	1	0
21O	7	9870	6860	1300000	97	224	33	9	6	1	0	0
22C	22	5561	1754	218491	228	2305	129	63	8	1	1	0
22O	17	2530	1270	360000	68	560	32	8	4	1	0	0
23C	415	96892	1025	79285	210	3369	123	54	8	1	2	0
23O	1710	249000	429	145000	66	1090	31	8	6	1	0	0
24C	196	322230	737	42075	200	3513	117	48	6	1	2	0
24O	655	348000	316	77700	57	782	31	5	8	1	0	0
25C	172	49674	636	50714	191	2454	102	39	6	1	1	0
25O	249	45800	260	89600	98	703	24	4	8	1	0	0
26C	136	17624	543	47666	177	1738	91	38	6	1	1	0
26O	158	13700	132	74400	61	445	23	2	6	0	0	0
27C	74	8153	509	28292	151	1362	80	34	5	1	1	0
27O	53	5110	123	36700	31	280	17	2	4	1	0	0
28C	48	4259	1357	18336	145	1187	70	28	5	1	0	0
28O	35	2400	357	24100	37	206	20	2	3	1	0	0
29C	34	2534	1787	13741	146	1038	67	73	4	1	0	0
29O	19	1190	598	20300	44	186	32	4	3	0	0	0
30C	23	1675	1607	14324	0	921	71	43	4	1	0	0
30O	9	719	336	24100	0	155	41	2	3	0	0	0
31C	16	0	1046	9546	0	859	0	36	0	1	0	0
31O	3	0	512	11600	0	142	0	2	0	0	0	0
MONTHLY SUMMARY												
C	2378	1005163	28682	3732262	39918	78344	13569	3571	719	53	25	12
O	5204	1384453	18282	4109883	46566	83977	2473	508	149	50	7	0

ANNUAL SUMMARY

COMPUTED LOAD = 4914795 TONS, OBSERVED LOAD = 5651552 TONS

C - COMPUTED

O - OBSERVED

EXHIBIT A

EEL RIVER AT SCOTIA, CALIFORNIA - SEDIMENT DISCHARGE IN TONS

YEAR 1965

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1C	0	10	61182	63365	10315	3389	1073	2200	60	4	4	1
1O	0	10	81500	350000	48700	8600	2030	8630	71	11	9	3
2C	0	29	91020	66320	8174	2185	877	1693	55	4	4	1
2O	0	24	81700	290300	38100	4120	1250	6320	50	11	6	3
3C	0	88	51792	319930	6236	1430	765	1370	50	18	4	1
3O	0	130	51300	848000	28700	2240	1100	4400	48	12	6	2
4C	0	57	15232	179078	5040	1101	674	1149	46	18	3	1
4O	0	90	12400	496000	22000	1670	878	3310	46	12	5	2
5C	0	59	6036	761464	6018	870	555	973	42	13	2	1
5O	0	85	4490	2180000	28800	1450	731	2960	38	12	4	2
6C	0	26	2971	3327704	21618	699	479	824	38	11	2	1
6O	0	28	2240	4310000	55700	1110	693	2520	31	11	4	1
7C	0	12	1781	1088567	11577	644	447	719	36	9	2	1
7O	0	17	1140	2490000	33600	1010	718	1940	27	11	3	1
8C	1	10	1209	271237	7281	587	417	630	34	7	2	1
8O	0	23	548	872000	20100	870	520	1360	26	9	3	1
9C	1	72	1017	134302	5297	549	1188	555	32	6	1	1
9O	0	1220	385	407000	13300	876	761	1020	17	9	3	1
10C	1	5945	1491	122027	3925	516	4263	521	30	6	1	1
10O	0	26600	1900	418000	10200	829	8800	976	19	9	3	1
11C	0	17313	49288	154160	3098	490	4616	444	27	5	1	1
11O	0	42400	85000	674000	7890	740	11500	865	21	7	2	1
12C	0	31942	28142	117826	2497	454	3153	393	25	4	1	1
12O	0	59800	35400	423000	6330	673	5420	686	18	7	2	1
13C	1	16839	7543	70470	2042	424	2237	350	22	4	1	1
13O	1	27100	5280	305000	5180	610	3180	550	14	7	2	1
14C	0	3713	3582	46756	1773	391	1607	310	21	4	1	1
14O	2	3450	1640	211000	4300	560	2270	529	14	7	2	1
15C	0	1207	2554	36898	1532	363	13126	274	21	4	1	1
15O	1	897	1360	203000	3700	533	113000	494	14	7	2	1
16C	0	595	2041	29365	1273	354	171530	240	20	4	1	1
16O	0	316	842	161000	3050	526	550000	466	14	7	2	1
17C	0	324	1344	25159	1163	348	50873	218	20	3	1	2
17O	0	228	375	110000	3020	501	205000	467	14	6	2	1
18C	0	194	986	21412	1028	829	90166	196	18	3	1	3
18O	0	117	337	110000	2670	509	307000	396	16	5	2	1
19C	0	122	5024	19801	965	661	266044	175	17	3	1	2
19O	0	69	9370	123000	2310	521	724000	359	15	5	3	1
20C	0	85	175142	18945	883	580	109115	158	15	2	1	2
20O	0	59	236000	121000	2170	405	287000	333	14	6	2	1
21C	0	64	2522591	15362	776	524	73961	143	13	2	1	1
21O	0	45	3570000	108000	1950	340	223000	297	31	5	1	1
22C	0	60	40488685	11559	759	487	43251	129	12	2	1	1
22O	0	25	40000000	79400	1910	321	149000	278	51	6	1	1
23C	0	73	44750577	44109	744	816	23216	122	10	2	1	1
23O	0	25	57000000	205000	1740	317	88000	298	20	6	1	1
24C	0	212	7099413	564857	652	812	13452	110	9	2	2	1
24O	0	53	19000000	1450000	1720	303	62100	213	15	5	2	1
25C	0	996	2244803	188602	575	816	9276	103	9	2	3	1
25O	0	1850	8500000	498000	1430	387	43800	169	13	5	3	1
26C	0	5119	1731543	74120	534	813	7063	95	8	2	2	1
26O	0	6710	7500000	203000	1480	525	30000	136	14	5	3	1
27C	1	3454	974747	40629	2245	1183	5815	87	7	2	2	1
27O	0	2130	4200000	138000	3430	1880	25700	120	16	5	2	1
28C	4	93599	573027	25668	5276	4690	4655	81	7	2	2	1
28O	18	212000	2600000	94700	16200	13800	21600	97	18	4	2	1
29C	25	193059	269989	18309	0	1831	3686	75	5	2	2	1
29O	30	237000	1500000	69800	0	7580	17000	82	14	4	3	1
30C	29	25661	135475	14352	0	1225	2932	70	5	2	1	1
30O	32	32000	760000	63600	0	2170	11900	80	14	4	3	1
31C	18	0	101187	12268	0	1147	0	65	0	1	1	0
31O	22	0	490000	51000	0	1510	0	81	0	4	3	0
MONTHLY SUMMARY												
C	87	400850	101401414	7875623	113234	31211	910512	14470	713	150	54	29
O	106	654506	145733207	18059500	369724	57486	2902951	40432	733	224	91	37

ANNUAL SUMMARY

COMPUTED LOAD = 110748348 TONS, OBSERVED LOAD = 167818997 TONS

C - COMPUTED

O - OBSERVED

4385

EXHIBIT A

Technical Paper Series

TP-1 Use of Interrelated Records to Simulate Streamflow
TP-2 Optimization Techniques for Hydrologic Engineering
TP-3 Methods of Determination of Safe Yield and Compensation Water from Storage Reservoirs
TP-4 Functional Evaluation of a Water Resources System
TP-5 Streamflow Synthesis for Ungaged Rivers
TP-6 Simulation of Daily Streamflow
TP-7 Pilot Study for Storage Requirements for Low Flow Augmentation
TP-8 Worth of Streamflow Data for Project Design - A Pilot Study
TP-9 Economic Evaluation of Reservoir System Accomplishments
TP-10 Hydrologic Simulation in Water-Yield Analysis
TP-11 Survey of Programs for Water Surface Profiles
TP-12 Hypothetical Flood Computation for a Stream System
TP-13 Maximum Utilization of Scarce Data in Hydrologic Design
TP-14 Techniques for Evaluating Long-Tem Reservoir Yields
TP-15 Hydrostatistics - Principles of Application
TP-16 A Hydrologic Water Resource System Modeling Techniques
TP-17 Hydrologic Engineering Techniques for Regional Water Resources Planning
TP-18 Estimating Monthly Streamflows Within a Region
TP-19 Suspended Sediment Discharge in Streams
TP-20 Computer Determination of Flow Through Bridges
TP-21 An Approach to Reservoir Temperature Analysis
TP-22 A Finite Difference Methods of Analyzing Liquid Flow in Variably Saturated Porous Media
TP-23 Uses of Simulation in River Basin Planning
TP-24 Hydroelectric Power Analysis in Reservoir Systems
TP-25 Status of Water Resource System Analysis
TP-26 System Relationships for Panama Canal Water Supply
TP-27 System Analysis of the Panama Canal Water Supply
TP-28 Digital Simulation of an Existing Water Resources System
TP-29 Computer Application in Continuing Education
TP-30 Drought Severity and Water Supply Dependability
TP-31 Development of System Operation Rules for an Existing System by Simulation
TP-32 Alternative Approaches to Water Resources System Simulation
TP-33 System Simulation of Integrated Use of Hydroelectric and Thermal Power Generation
TP-34 Optimizing flood Control Allocation for a Multipurpose Reservoir
TP-35 Computer Models for Rainfall-Runoff and River Hydraulic Analysis
TP-36 Evaluation of Drought Effects at Lake Atitlan
TP-37 Downstream Effects of the Levee Overtopping at Wilkes-Barre, PA, During Tropical Storm Agnes
TP-38 Water Quality Evaluation of Aquatic Systems
TP-39 A Method for Analyzing Effects of Dam Failures in Design Studies
TP-40 Storm Drainage and Urban Region Flood Control Planning
TP-41 HEC-5C, A Simulation Model for System Formulation and Evaluation
TP-42 Optimal Sizing of Urban Flood Control Systems
TP-43 Hydrologic and Economic Simulation of Flood Control Aspects of Water Resources Systems
TP-44 Sizing Flood Control Reservoir Systems by System Analysis
TP-45 Techniques for Real-Time Operation of Flood Control Reservoirs in the Merrimack River Basin
TP-46 Spatial Data Analysis of Nonstructural Measures
TP-47 Comprehensive Flood Plain Studies Using Spatial Data Management Techniques
TP-48 Direct Runoff Hydrograph Parameters Versus Urbanization
TP-49 Experience of HEC in Disseminating Information on Hydrological Models
TP-50 Effects of Dam Removal: An Approach to Sedimentation
TP-51 Design of Flood Control Improvements by Systems Analysis: A Case Study
TP-52 Potential Use of Digital Computer Ground Water Models
TP-53 Development of Generalized Free Surface Flow Models Using Finite Element Techniques
TP-54 Adjustment of Peak Discharge Rates for Urbanization
TP-55 The Development and Servicing of Spatial Data Management Techniques in the Corps of Engineers
TP-56 Experiences of the Hydrologic Engineering Center in Maintaining Widely Used Hydrologic and Water Resource Computer Models
TP-57 Flood Damage Assessments Using Spatial Data Management Techniques
TP-58 A Model for Evaluating Runoff-Quality in Metropolitan Master Planning
TP-59 Testing of Several Runoff Models on an Urban Watershed
TP-60 Operational Simulation of a Reservoir System with Pumped Storage
TP-61 Technical Factors in Small Hydropower Planning
TP-62 Flood Hydrograph and Peak Flow Frequency Analysis
TP-63 HEC Contribution to Reservoir System Operation
TP-64 Determining Peak-Discharge Frequencies in an Urbanizing Watershed: A Case Study
TP-65 Feasibility Analysis in Small Hydropower Planning
TP-66 Reservoir Storage Determination by Computer Simulation of Flood Control and Conservation Systems
TP-67 Hydrologic Land Use Classification Using LANDSAT
TP-68 Interactive Nonstructural Flood-Control Planning
TP-69 Critical Water Surface by Minimum Specific Energy Using the Parabolic Method

TP-70 Corps of Engineers Experience with Automatic Calibration of a Precipitation-Runoff Model
TP-71 Determination of Land Use from Satellite Imagery for Input to Hydrologic Models
TP-72 Application of the Finite Element Method to Vertically Stratified Hydrodynamic Flow and Water Quality
TP-73 Flood Mitigation Planning Using HEC-SAM
TP-74 Hydrographs by Single Linear Reservoir Model
TP-75 HEC Activities in Reservoir Analysis
TP-76 Institutional Support of Water Resource Models
TP-77 Investigation of Soil Conservation Service Urban Hydrology Techniques
TP-78 Potential for Increasing the Output of Existing Hydroelectric Plants
TP-79 Potential Energy and Capacity Gains from Flood Control Storage Reallocation at Existing U.S. Hydropower Reservoirs
TP-80 Use of Non-Sequential Techniques in the Analysis of Power Potential at Storage Projects
TP-81 Data Management Systems of Water Resources Planning
TP-82 The New HEC-1 Flood Hydrograph Package
TP-83 River and Reservoir Systems Water Quality Modeling Capability
TP-84 Generalized Real-Time Flood Control System Model
TP-85 Operation Policy Analysis: Sam Rayburn Reservoir
TP-86 Training the Practitioner: The Hydrologic Engineering Center Program
TP-87 Documentation Needs for Water Resources Models
TP-88 Reservoir System Regulation for Water Quality Control
TP-89 A Software System to Aid in Making Real-Time Water Control Decisions
TP-90 Calibration, Verification and Application of a Two-Dimensional Flow Model
TP-91 HEC Software Development and Support
TP-92 Hydrologic Engineering Center Planning Models
TP-93 Flood Routing Through a Flat, Complex Flood Plain Using a One-Dimensional Unsteady Flow Computer Program
TP-94 Dredged-Material Disposal Management Model
TP-95 Infiltration and Soil Moisture Redistribution in HEC-1
TP-96 The Hydrologic Engineering Center Experience in Nonstructural Planning
TP-97 Prediction of the Effects of a Flood Control Project on a Meandering Stream
TP-98 Evolution in Computer Programs Causes Evolution in Training Needs: The Hydrologic Engineering Center Experience
TP-99 Reservoir System Analysis for Water Quality
TP-100 Probable Maximum Flood Estimation - Eastern United States
TP-101 Use of Computer Program HEC-5 for Water Supply Analysis
TP-102 Role of Calibration in the Application of HEC-6
TP-103 Engineering and Economic Considerations in Formulating
TP-104 Modeling Water Resources Systems for Water Quality
TP-105 Use of a Two-Dimensional Flow Model to Quantify Aquatic Habitat
TP-106 Flood-Runoff Forecasting with HEC-1F
TP-107 Dredged-Material Disposal System Capacity Expansion
TP-108 Role of Small Computers in Two-Dimensional Flow Modeling
TP-109 One-Dimensional Model for Mud Flows
TP-110 Subdivision Froude Number
TP-111 HEC-5Q: System Water Quality Modeling
TP-112 New Developments in HEC Programs for Flood Control
TP-113 Modeling and Managing Water Resource Systems for Water Quality
TP-114 Accuracy of Computer Water Surface Profiles - Executive Summary
TP-115 Application of Spatial-Data Management Techniques in Corps Planning
TP-116 The HEC's Activities in Watershed Modeling
TP-117 HEC-1 and HEC-2 Applications on the Microcomputer
TP-118 Real-Time Snow Simulation Model for the Monongahela River Basin
TP-119 Multi-Purpose, Multi-Reservoir Simulation on a PC
TP-120 Technology Transfer of Corps' Hydrologic Models
TP-121 Development, Calibration and Application of Runoff Forecasting Models for the Allegheny River Basin
TP-122 The Estimation of Rainfall for Flood Forecasting Using Radar and Rain Gage Data
TP-123 Developing and Managing a Comprehensive Reservoir Analysis Model
TP-124 Review of U.S. Army corps of Engineering Involvement With Alluvial Fan Flooding Problems
TP-125 An Integrated Software Package for Flood Damage Analysis
TP-126 The Value and Depreciation of Existing Facilities: The Case of Reservoirs
TP-127 Floodplain-Management Plan Enumeration
TP-128 Two-Dimensional Floodplain Modeling
TP-129 Status and New Capabilities of Computer Program HEC-6: "Scour and Deposition in Rivers and Reservoirs"
TP-130 Estimating Sediment Delivery and Yield on Alluvial Fans
TP-131 Hydrologic Aspects of Flood Warning - Preparedness Programs
TP-132 Twenty-five Years of Developing, Distributing, and Supporting Hydrologic Engineering Computer Programs
TP-133 Predicting Deposition Patterns in Small Basins
TP-134 Annual Extreme Lake Elevations by Total Probability Theorem
TP-135 A Muskingum-Cunge Channel Flow Routing Method for Drainage Networks
TP-136 Prescriptive Reservoir System Analysis Model - Missouri River System Application
TP-137 A Generalized Simulation Model for Reservoir System Analysis
TP-138 The HEC NexGen Software Development Project
TP-139 Issues for Applications Developers
TP-140 HEC-2 Water Surface Profiles Program
TP-141 HEC Models for Urban Hydrologic Analysis

TP-142 Systems Analysis Applications at the Hydrologic Engineering Center
TP-143 Runoff Prediction Uncertainty for Ungauged Agricultural Watersheds
TP-144 Review of GIS Applications in Hydrologic Modeling
TP-145 Application of Rainfall-Runoff Simulation for Flood Forecasting
TP-146 Application of the HEC Prescriptive Reservoir Model in the Columbia River Systems
TP-147 HEC River Analysis System (HEC-RAS)
TP-148 HEC-6: Reservoir Sediment Control Applications
TP-149 The Hydrologic Modeling System (HEC-HMS): Design and Development Issues
TP-150 The HEC Hydrologic Modeling System
TP-151 Bridge Hydraulic Analysis with HEC-RAS
TP-152 Use of Land Surface Erosion Techniques with Stream Channel Sediment Models
TP-153 Risk-Based Analysis for Corps Flood Project Studies - A Status Report
TP-154 Modeling Water-Resource Systems for Water Quality Management
TP-155 Runoff simulation Using Radar Rainfall Data
TP-156 Status of HEC Next Generation Software Development
TP-157 Unsteady Flow Model for Forecasting Missouri and Mississippi Rivers
TP-158 Corps Water Management System (CWMS)
TP-159 Some History and Hydrology of the Panama Canal
TP-160 Application of Risk-Based Analysis to Planning Reservoir and Levee Flood Damage Reduction Systems
TP-161 Corps Water Management System - Capabilities and Implementation Status