Techniques of Water-Resources Investigations of the United States Geological Survey

Chapter C3

COMPUTATION OF FLUVIAL-SEDIMENT DISCHARGE

By George Porterfield

Book 3

APPLICATIONS OF HYDRAULICS

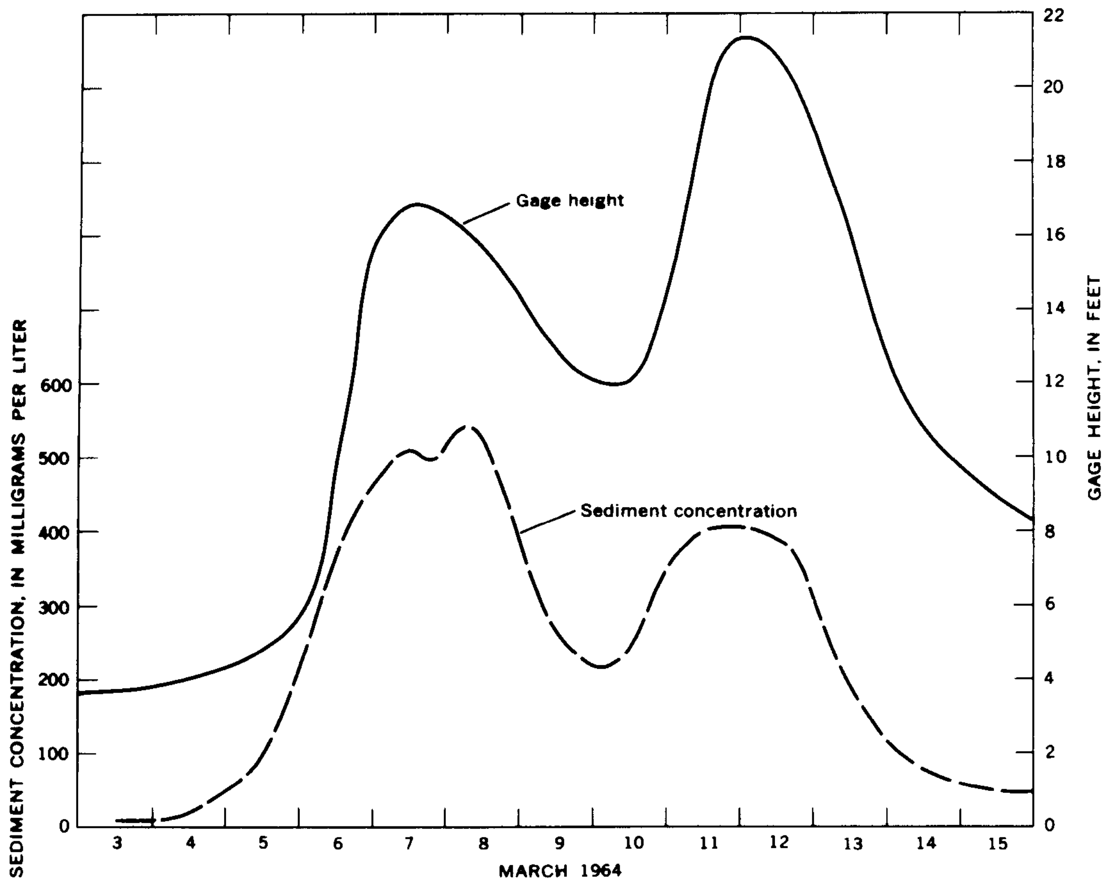

Figure 23.—Gage height and sediment concentration, Susquehanna River at Harrisburg, Pa.

figure 19, because the source area of the water and sediment was local as well as upstream and the concentration continued to increase until the discharge started to decrease. Even so, there was a small secondary concentration peak March 8. The second water-discharge peak on March 11-12, although higher than the first peak, had a lower concentration because less soil was readily available for erosion after the first few days of rain.

The hydrograph of the discharge and suspended-sediment concentrations of the Willamette River at Portland, Ore., during the recordbreaking floods of December 1964 (fig. 24) is a good example of the relation between discharge and concentration for a large flood on a large river. The discharge continued to increase for 4 days until it reached a peak. Sediment concentration, however, reached the maximum value the second day following the beginning of the rise and decreased over 50 percent by the time the water discharge reached a maximum value. Several common characteristic trends may be noted here: (1) The large increase in discharge at the outset caused a minor increase in concentration, (2) the discharge increased slowly for several days to reach a maximum value whereas the concentration increased rapidly and reached a maximum value, in less time, and (3) the water discharge receded slowly, being sustained by additional rainfall and contributions from bank and channel storage, whereas the concentration receded rapidly after reaching the maximum value.

Snowmelt discharge and sediment concentration

The relation between water discharge and

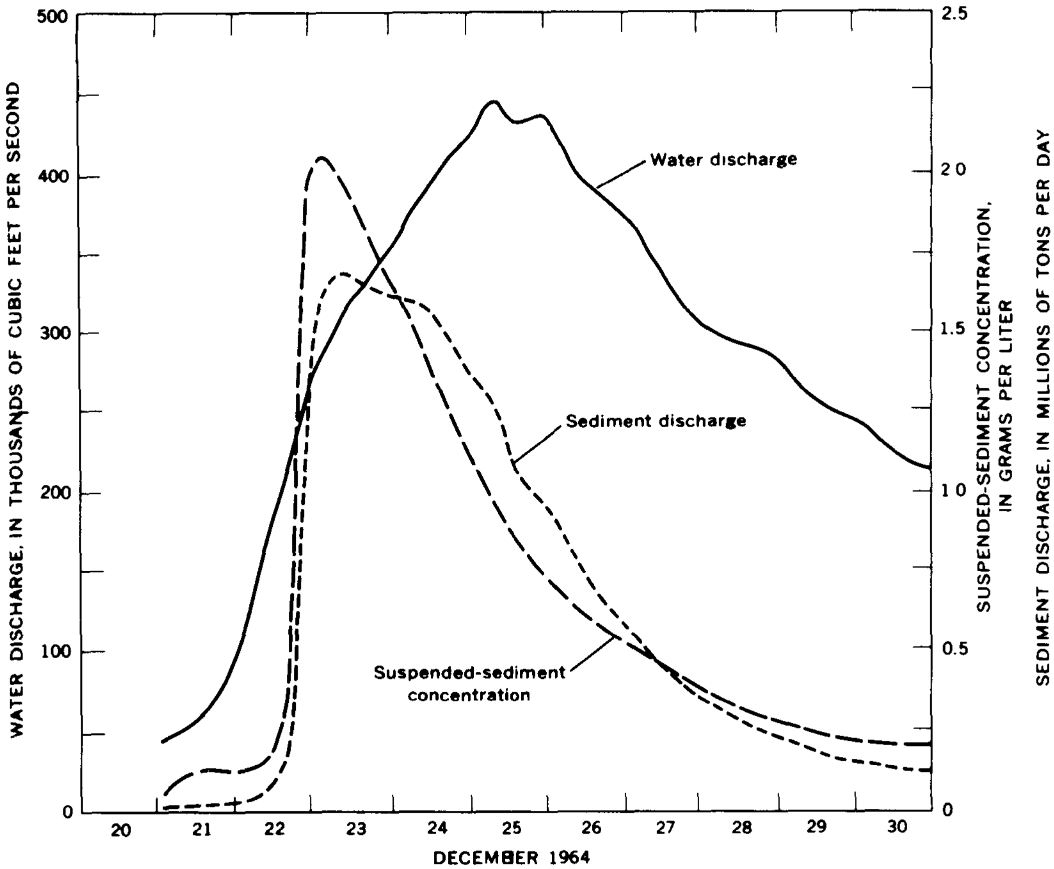

Figure 24.—Suspended-sediment concentration, sediment discharge, and water-discharge, Willamette River at Portland, Oreg., December 21-30, 1964. (After Waananen and others, 1971, p. 116.)

suspended-sediment concentration during snowmelt generally is different from that during periods of runoff from rainfall; also the correlation is poorer during snowmelt. This change in relation must be considered when constructing the concentration graph and interpreting the sediment-transport curve.

Increases in concentration relative to increases in water discharge are small during snowmelt runoff as compared with rainfall runoff, and sharp concentration peaks do not occur at or near the time of the water peak such as those illustrated in figures 16 and 17. Gage-height and concentration graphs of a 10-day snowmelt period are shown in figure 25.

The peak and trough of the diurnal fluctuations of sediment may or may not be in phase with those for water. The time the water peak occurs at the station is related to the distance between the snowmelt source and the gage, and the amount of lag between water and concentration peaks is a function of the distance between the sampling point and the source of the material. This relation may be determined usually from two samples per day.

The relation between daily values of water discharge and sediment concentration in a stream with substantial snowmelt runoff is shown in figure 26. The water discharge and concentration were low during the winter months. The first appreciable snowmelt in late March contained a large quantity of sediment. The snowmelt runoff continued to increase throughout April, although the concentration decreased after the initial rise and remained generally below 4,000 mg/l during the major snowmelt period in May

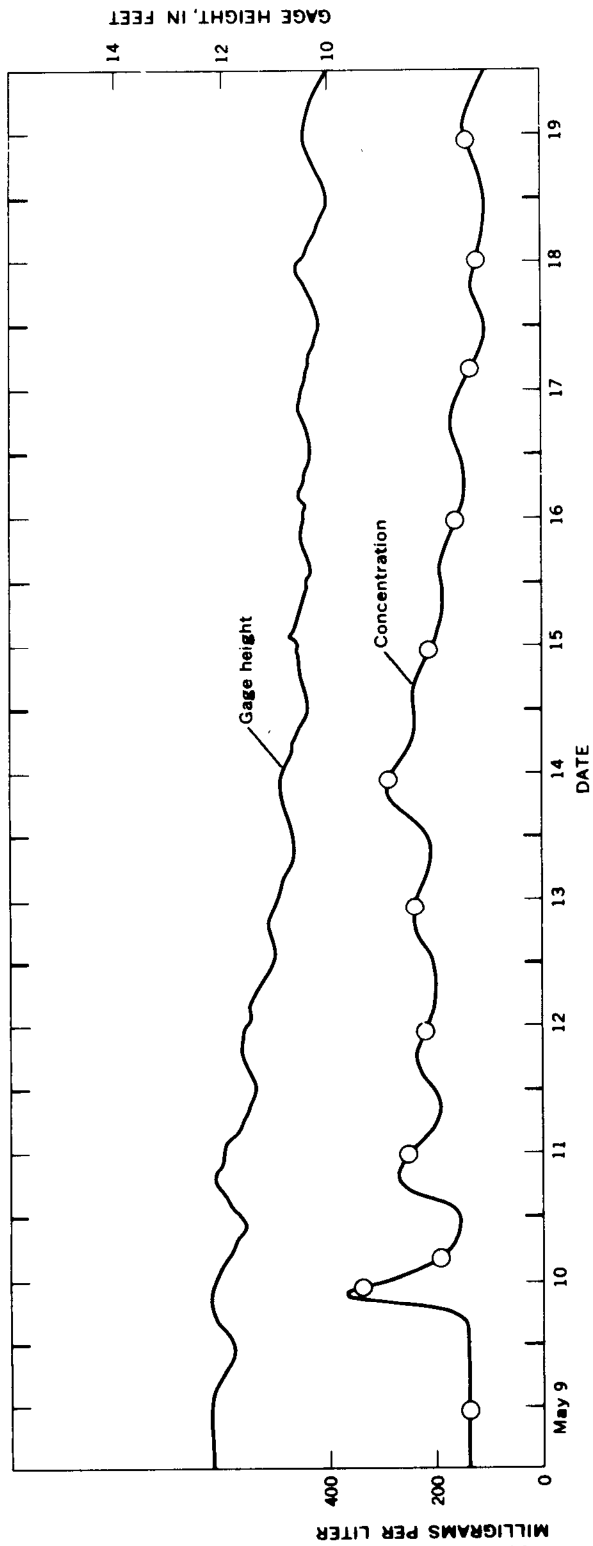

Figure 25.—Temporal relation of sediment concentration to water discharge during a snowmelt period.

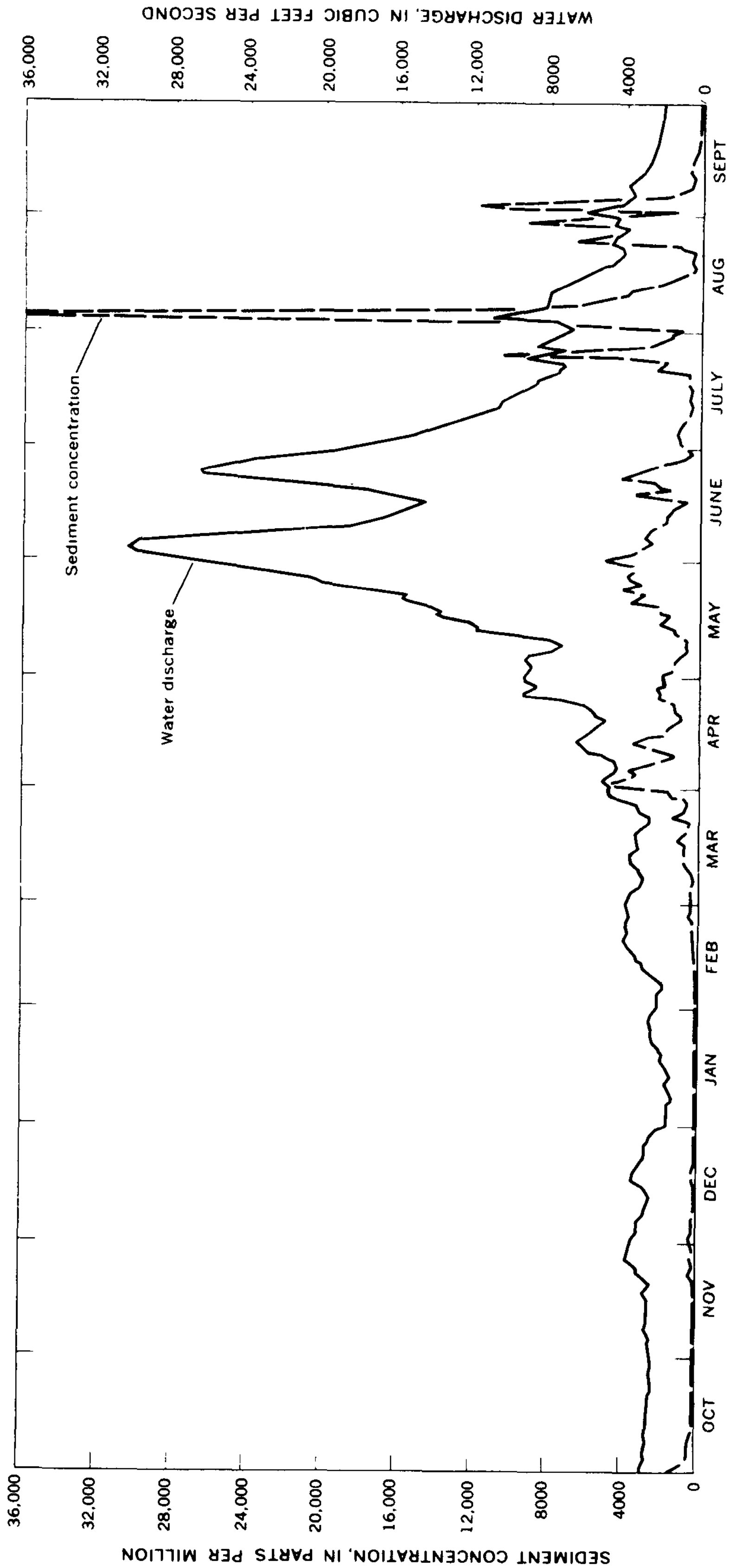

Figure 26.—Relation of water discharge to sediment concentration, Green River at Green River, Utah, 1951.

and June.

During the storm-runoff period July 22-September 1, sediment concentrations were considerably larger than those during the snowmelt period. The rainfall on August 1-2 caused an increase in discharge from 7,000 to 11,000 cfs (cubic feet per second), but the corresponding concentration increased from 1,000 to 39,000 mg/l. The maximum snowmelt runoff which started May 9 caused an increase in discharge from 7,000 to 30,000 cfs and an increase in concentration only from 500 to 5,000 mg/l.

Application of cross-section coefficient

Coefficients may be applied to concentration values in several ways. Two methods discussed here are (1) correction of the concentration value arithmetically after values have been computed from the concentration graph and (2) correction or adjustment graphically of the concentration graph prior to computing concentration values from the graph. The second method is needed especially in a subdivided period where the coefficient may change with stage and discharge.

In the first method, concentration for each day, or part of day, for the water year is computed from the concentration graph and tabulated on a copy of the recorder chart. When the coefficients are computed, as illustrated in figures 9 and 10, the appropriate correction to each concentration value is written below the daily concentration. The adjusted concentration value then as computed, entered below the other values, and underscored so no error will be made when the value is transferred to the sediment-discharge worksheet. If the subdivided-day method of computation is used and the coefficient values vary during the day, then the concentration value for each interval must be corrected. This is accomplished by tabulating coefficient values taken from a table similar to that given in figure 10 in an additional column in table 3 and by correcting each concentration value in column 5 prior to computing the sediment discharge.

In the second method, the correction is made graphically by adjusting the concentration graph. This method is useful particularly if the transported material is coarse and the ratio (a/b) of mean concentration in the cross section to mean concentration in the single vertical (col. 6, fig. 6) is correlative with gage height or discharge. The concentration graph in figure 27 was adjusted graphically by using the coefficient values determined in the plot in figure 10. The range in gage height affected by each coefficient value was marked on the trace of the gage-height graph. The concentration value determined from the sediment-concentration graph for each range was multiplied by the appropriate coefficient, and an × placed at the location of the corrected value. An adjusted sediment-concentration graph, following the trend of the original (unadjusted) concentration graph, was then drawn through the adjusted values. Computation of suspended-concentration values, either for daily values or for intervals of a day, may be made directly from the adjusted graph.

Because the reasons for the lateral variation of sediment concentration may differ from station to station and even at the same station, the application of corrections to concentration cannot be reduced to a few simple methods. Hence, as in the construction of the concentration graph, each application of coefficient requires imagination and ingenuity as well as a knowledge of the station and the fundamentals of sediment transport.

All coefficients and adjustments should be applied to the concentration graph, or values, prior to computation of sediment discharge. Any corrections not yet made, and specifically those which vary during a subdivided period, should be made while computing the subdivided period. Additional columns may be added to table 3 to show the coefficient and corrected concentration for each interval.

Adjustments are necessary also if the intervals of a subdivided period do not equal 24 because the recorder is operating too fast or too slow. If the divisor, d (footnote 1,

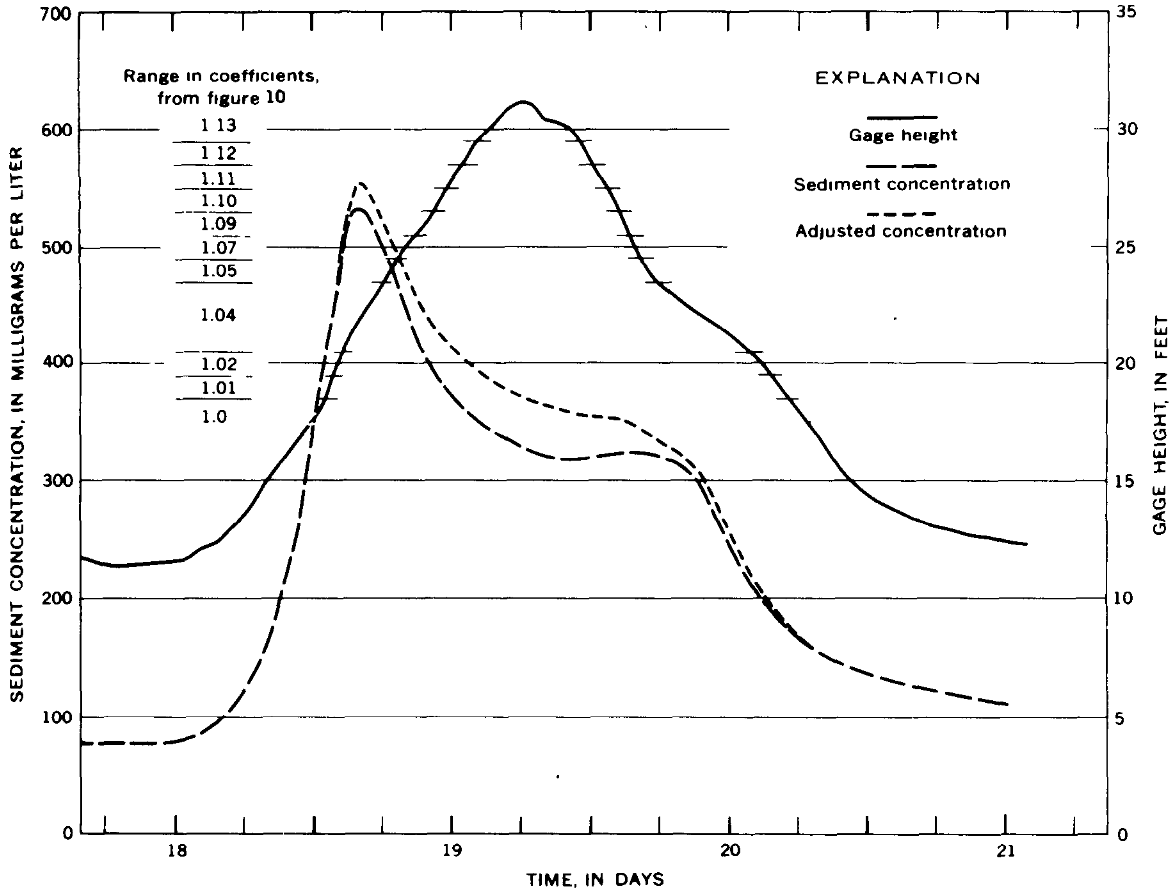

Figure 27.—Graphical adjustment of concentration.

table 3), based on 24 intervals per day, is used to compute the discharge per interval when the total interval, T, is different from 24, each interval must be corrected by $24/T$.

Computation of Daily Mean Concentration

The daily mean sediment concentration is the time-weighted mean value and is computed from the concentration graph described in previous sections. Each computed daily value is listed near the bottom of the chart at the midpoint (usually noon) of the day it represents.

Mean concentration values may be determined arithmetically or graphically. The arithmetic mean is obtained either by (1) selecting values from the concentration graph that represent uniform intervals of time and taking the arithmetic average or by (2) selecting values from the graph that represent unequal intervals of time and weighting these values by the time intervals represented by the concentrations. These methods or variations of these methods are also used to determine the average concentration for each interval of a subdivided period.

The mean concentration is determined graphically by use of an integrator—a simple device consisting of a thin sheet of clear plastic about 6 inches long and 3 inches high and with a fine visible line scribed through the center of the sheet parallel with the long axis. A clear plastic 45° or 30°-60° triangle also may be used. A small hole is drilled through the plastic near the center of the line to accommodate a pencil point. The average is determined by placing the line on the plastic over the concentration graph with the hole at the midpoint of the time interval. The line is adjusted vertically or rotated until half the area is above the graph and below the line and half the area is below the graph and above the line. The average concentration is the value where the line intersects the midpoint of the time interval and may be marked on the chart by placing a point of a pencil through the hole in the plastic. This graphical method is used to compute the daily mean concentration for days not subdivided as well as to determine mean concentrations for smaller intervals of time when the day is subdivided.

Because most personnel familiar with computations of water-discharge and sediment records are thoroughly familiar with the graphical method, only a brief discussion is included. A demonstration of the method by experienced personnel plus a little practice and ingenuity is sufficient to obtain acceptable values of mean concentration from the concentration graph.

Figure 28 illustrates ways to use the integrator. The line on the plastic, represented by the line *A-B,* is placed on the graph so that half the area is above the graph and below the line and half the area is below the graph and above the line. In figure 28*A* the line *A-B* is parallel to the base line and intersects the graph in two places. The area below the graph (designated 1) is equal to the sum of the two areas above the graph (designated 2). By placing the line on the integrator to intersect at the beginning of the 24-hour period (point *x* in fig. 28*B*), the graph is intersected only once. Thus, only two areas need be balanced, thereby sim-

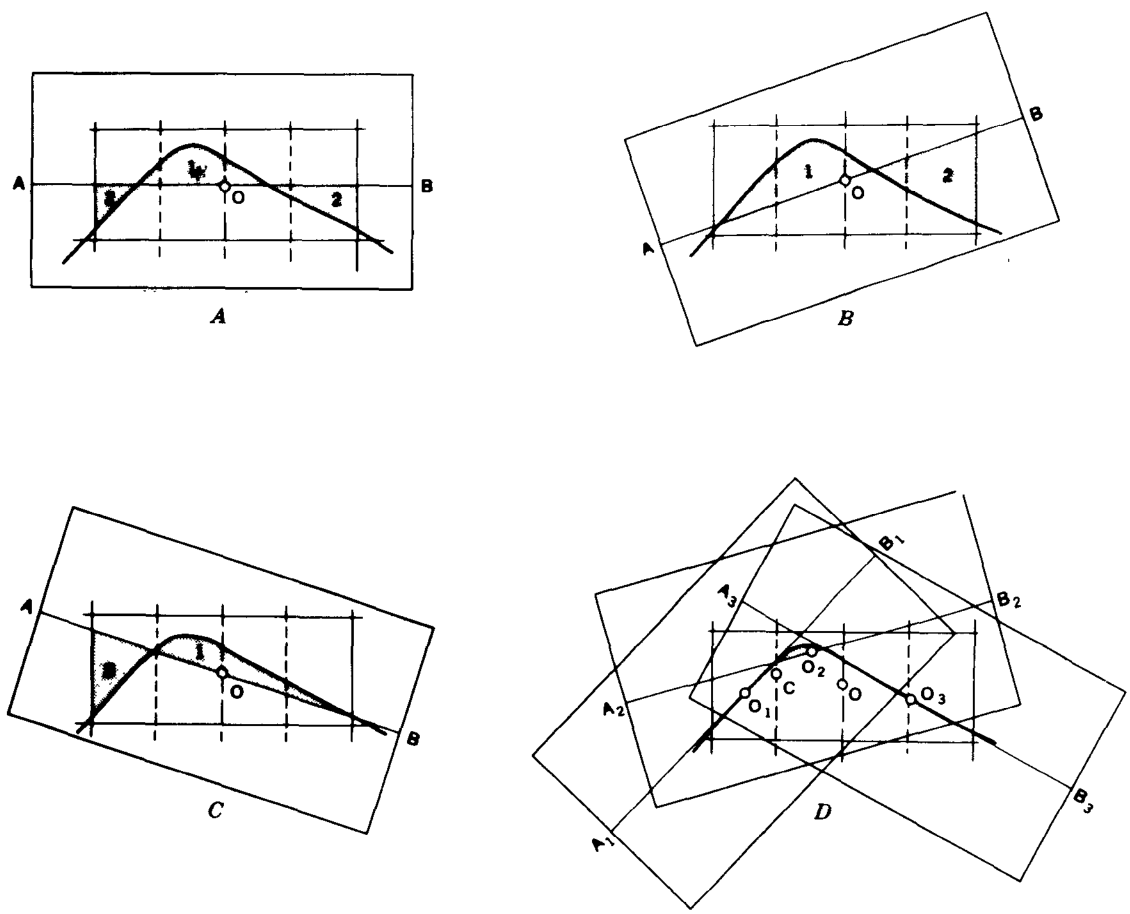

Figure 28.—Determination of mean concentration by graphical method.

plifying the visual balancing of the areas. The balancing of the areas can be further simplified by trial-and-error placing of the integrator to produce areas of uniform geometric appearance. Hence, in figure 28*C* the integrator line was placed on the end of the 24-hour-time period (point x) to test for uniformity of areas. As the graphs analyzed became more complex, a combination of the approaches in *A*, *B*, and *C* was used, and the time period (usually 24 hours) was divided into several parts, each representing nearly straight lines or small areas to be balanced. This approach is the one usually practiced by experienced personnel and is illustrated in figure 28*D*.

Figure 28*D* is divided for convenience into three time intervals—0-0600, 0600-1200, and 1200-2400. Line A_1-B_1 establishes the mean of the first 6-hour interval at O_1 at the midpoint of the interval. Likewise, A_2-B_2 establishes the mean of the interval 0600-1200 at O_2, and A_3-B_3 establishes the mean of the interval 1200-2400 at O_3. The mean of the first two intervals, which are equal in time, is found by placing the integrator line on O_1 and O_2 and marking the intersection (point C) of the line O_1-O_2 with the midpoint of the combined time interval, in this case 0600. The mean of the two 12-hour intervals is found at intersections of a line O_3-C and the midpoint of the combined time interval, O. In each of the examples, the mean is at point O on the midpoint of time intervals.

A value of mean concentration is determined for each day for which a graph has been constructed. For periods of constant, usually low, discharge and low constant concentration, the daily concentration sample will approach the daily mean concentration, and there will be no need to construct a graph to compute daily values. For these periods, sample values may be transferred directly to the sediment-discharge sheet with no intermediate calculation.

Footnotes

Footnotes are used to describe laboratory and computation procedures and to qualify estimated values. The appropriate footnote should be determined as each value is computed and entered after the concentration value on the gage-height graph. The footnote then can be transferred to the sediment-discharge worksheet simultaneously with copying of the concentration values on the worksheet.

Footnotes generally are not processed or stored by electronic computer; therefore, no footnotes will be listed on the tables of data processed by computer for publication. If footnotes are desired on these tables, they must be added manually by typewriter. Footnotes, however, should be limited to the minimum needed to explain and clarify the data or to describe unusual conditions that affected collection or quality of data.

Sediment footnotes and symbols do not follow the rules listed in the United States Government Printing Office "Style Manual," revised edition, January 1967; they are standardized here and have the same meaning regardless of their position in the table. The proper placement of footnotes in the table is described in the section on "Sediment-Discharge Worksheet."

Footnotes and references and the sequence in which they must appear if used on the sediment-discharge worksheet are listed as follows:

- E Estimated. (When there are 6 or more days in a year with the footnote E, delete E and insert the following headnote under the table title: "When no daily concentrations are reported, loads are estimated.")
- S Computed by subdividing day.
- A Computed from estimated-concentration graph.
- C Composite period.
- D Daily mean discharge.

Footnotes E and A are used to identify noteworthy estimated values, such as maximum and minimum values of concentration and sediment discharge, and to explain any missing values of concentration. Daily sediment-discharge values based on interpolation for short periods of low or uniform flow are not identified; hence, the sampling program must be scheduled to assure that samples are collected at some predetermined frequency, even during periods of low and uniform flow. Records that include long periods of estimated daily sediment discharges and contain the maximum sediment discharge of the year should be explained in the remarks paragraph of the station analysis. Also, conditions that influence sediment discharge such as unusual flow conditions, diversions, or construction activities should be described.

Footnote C is used to identify concentrations that are average values for a period. These average concentrations are obtained by compositing samples during periods of low concentration when fluctuations in concentration are assumed to be small. Daily values of concentration are more useful than average values for statistical treatment or interpretation of sediment trends. Daily values of concentration, therefore, should be published whenever available, and unless the analytical costs are prohibitive, the concentration of each sample should be determined in the laboratory.

Footnote D is used on tabulations of particle-size analyses to identify daily values of water discharge.

Significant Figures

Rounding of sediment-concentration and discharge values is standardized to accommodate and facilitate the computation, processing, and storage of data by electronic computer. Beginning with the 1968 water year, the number of significant figures reported in data releases is as follows:

Sediment concentration		*Sediment discharge*	
<0.5	report 0 mg/l or place leader (....) in column.	<0.005	report 0 tons.
0.5- 1	report 1 mg/l.	0.005-0.01	report 0.01 ton.
1 - 9	report one significant figure.	.01 - .09	report to nearest 0.01 ton.
10 -99	report two significant figures.	.10 -99	report two significant figures.
>100	report three significant figures.	>100	report three significant figures.

The monthly and annual sediment discharges are the unrounded sums of the daily values. No monthly or annual values will be shown for concentration.

The use of two significant figures below 1.0 is not intended to imply accuracy, but does make the published records of sediment compatible with those of water discharge and will facilitate computer processing of the data. A statement explaining the accuracy of published values may be included in the introductory text of the basic-data report.

Computer Programs

The description of the computation procedure thus far has been related entirely to manual preparation of records. Data-processing equipment has outmoded many manual procedures, and many additional changes undoubtedly will occur in the future. Automation, however, will not change the fundamental methods described for manual processing; therefore, each individual involved in the computation of sediment discharge should be familiar with and thoroughly understand the computation procedure and be able to compute records by the manual method.

A simplified computer program is now available for general use. This program performs the routine computations described in the sections on "Computation of Sediment Discharge," "Computation of Subdivided Days," and "Sediment-Discharge Worksheet" and lists the data for offset reproduction. The program does not eliminate the need to interpret concentration and water data and define a concentration graph.

Basic data needed for computer computation of sediment discharge are identical with those needed for manual processing and include the following:

1. Water discharge and sediment concentration for each day as described in the section on "Sediment-Discharge Worksheet."
2. Water discharge, concentration, and clock time or time interval as described in

the section on "Computation of Subdivided Days."

Format of Sediment Tables

Prior to October 1967 sediment data were typed or listed by automatic data-processing equipment on forms similar to those illustrated in figures 2, 38, and 45. Data published subsequent to October 1967 are processed and the results listed by electronic computer for publication in one or more of the methods in figures 29-35.

Computation of Sediment Discharge

Sediment discharge is determined by multiplying the water discharge, in cubic feet per second, by the concentration of suspended sediment, in milligrams per liter, and a coefficient:

$$Q_s = Q_w \times C_s \times k,$$

where

Q_s is the sediment discharge, in tons per day (tons/day),

Q_w is the water discharge, in cubic feet per second (cfs),

C_s is the concentration of suspended sediment, in milligrams per liter (mg/l),

and

k is a coefficient that is based on the unit of measurement of water discharge and that assumes a specific weight of 2.65 for sediment.

Units of measurement

The concentration of suspended sediment, C_s, is reported in milligrams of sediment per liter of water-sediment mixture. However, as a matter of convenience, it is determined in the laboratory in parts per million, which is the dry weight of suspended material per million equal weights of water-sediment mixture, or milligrams per kilogram, and is found by the formula

$$\text{parts per million} = \frac{\text{weight of sediment} \times 1{,}000{,}000}{\text{weight of water-sediment mixture}}$$

or

$$1 \text{ ppm} = \frac{0.0010 \text{ g}}{1{,}000 \text{ g}} = \frac{1 \text{ g}}{1{,}000{,}000 \text{ g}}$$

Concentration in milligrams per liter is the weight in milligrams (mg) of sediment per thousand milliliters (ml) of mixture and is the ratio of dry weight of sediment to the volume of mixture, or

$$\text{milligrams per liter} = \frac{0.0010 \text{ g}}{1{,}000 \text{ ml}} = \frac{1 \text{ mg}}{1{,}000 \text{ ml}}$$

The numerical values of parts per million and milligrams per liter are equal when the density of the mixture is equal to 1.00, and for all practical purposes, 1 liter weighs 1,000 g (grams). An increase in concentration increases the density of the mixture, and the laboratory value of concentration in parts per million must be corrected by the ratio, C, of the density of the water-sediment mixture to the density of water. Thus,

$$\text{milligrams per liter} = C \times \text{parts per million.}$$

The values of the conversion factor C, are given in table 2. These values are based on

Table 2.—Conversion factors, C, for sediment concentration: parts per million to milligrams per liter

[The factors are based on the assumption that the density of water is 1.000 (plus or minus 0.005), the range of temperature is 0°-29°C, the specific gravity of sediment is 2.65, and the dissolved-solids concentration is less than 10,000 ppm. This table supersedes table 1 in Guy (1969)]

Concentration range (ppm)	C	Concentration range (ppm)	C
0- 15,900	1.00	322,000-341,000	1.26
16,000- 46,800	1.02	342,000-361,000	1.28
46,900- 76,500	1.04	362,000-380,000	1.30
76,600-105,000	1.06	381,000-399,000	1.32
106,000-133,000	1.08	400,000-416,000	1.34
134,000-159,000	1.10	417,000-434,000	1.36
160,000-185,000	1.12	435,000-451,000	1.38
186,000-210,000	1.14	452,000-467,000	1.40
211,000-233,000	1.16	468,000-483,000	1.42
234,000-256,000	1.18	484,000-498,000	1.44
257,000-279,000	1.20	499,000-514,000	1.46
280,000-300,000	1.22	515,000-528,000	1.48
301,000-321,000	1.24	529,000-542,000	1.50

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SUSPENDED-SEDIMENT DISCHARGE, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

	OCTOBER			NOVEMBER			DECEMBER		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	.60	4	.01	66	247	87	1410	913	3820
2	.30	4	0	62	40	6.7	780	318	670
3	.30	4	0	58	22	3.4	470	140	-178
4	0	--	0	28	7	.53	345	70	65
5	0	--	0	19	4	.21	205	35	19
6	.30	2	0	14	4	.15	160	20	8.6
7	.30	2	0	18	3	.15	130	11	3.9
8	.60	1	0	80	100	45	117	9	2.8
9	.80	1	0	318	651	690	241	65	42
10	.80	1	0	459	542	1290	330	121	313
11	.80	1	0	254	326	388	1010	742	2430
12	.80	1	0	340	300	289	422	110	125
13	1.1	2	.01	148	65	26	275	40	30
14	1.4	4	.02	80	22	4.8	218	22	13
15	4.7	5	.06	55	8	1.2	196	20	11
16	6.1	4	.07	42	4	.45	163	17	7.5
17	6.1	4	.07	37	2	.20	134	10	3.6
18	6.1	3	.05	33	2	.18	117	10	3.2
19	6.1	2	.03	30	2	.16	134	15	5.4
20	6.1	2	.03	28	1	.08	500	249	461
21	6.1	1	.02	33	1	.09	8630	8100	258000
22	6.1	1	.02	42	1	.11	29800	57900	5070000
23	6.1	1	.02	39	1	.11	15600	46300	2110000
24	6.6	1	.02	42	1	.11	9300	36500	1020000
25	7.0	1	.02	378	369	561	5030	25500	346000
26	7.5	2	.04	232	65	41	4300	22300	259000
27	9.0	2	.05	148	22	8.8	3230	15500	135000
28	19	3	.15	486	541	1330	2050	11000	60900
29	80	226	60	595	360	723	1550	10700	44800
30	48	66	8.6	315	78	66	1340	9430	34100
31	22	10	.59	--	--	--	1070	7950	23000
TOTAL	260.70	--	69.88	4479	--	5563.43	89257	--	9369012.0

Figure 29.—Format table 1, suspended-sediment discharge.

SUSPENDED-SEDIMENT DISCHARGE FOR SELECTED DAYS, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	DATE	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
NOV 28, 1969..	4.4	519	13	MAY 7........	14	3670	265
JAN 27, 1970..	6.0	2180	213	MAY 8........	1.9	140	.72
JAN 28........	1.5	50	.20	JUN 22........	4.2	1410	122
MAR 6........	3.4	143	2.6	JUN 23........	.42	80	.09
MAR 7........	42	449	28	AUG 3........	2.0	1030	61
MAR 8........	1.5	70	.28	AUG 4........	5.7	3700	372
MAR 15........	6.6	795	26	AUG 5........	.98	490	4.0
MAR 16........	1.8	50	.24	AUG 24........	14	3950	968
APR 17........	1.5	326	3.5	AUG 25........	27	1270	640

Figure 30.—Format table 2, suspended-sediment discharge for selected days.

SUSPENDED-SEDIMENT DISCHARGE MEASUREMENTS, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DISCHARGE (CFS)	CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	DATE	TIME	DISCHARGE (CFS)	CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
DEC 6, 1969	0450	42	14	1.6	JUN 10......	1430	45	12	1.5
JAN 12, 1970	1700	126000	100	34000	JUN 22......	2300	219	69	41
JAN 14......	1830	1.3	8	.03	JUL 1......	1530	.80	12	.03
FEB 22......	1200	13	33	1.2	AUG 12......	1200	14	8	.30
FEB 28......	0100	770	212	441	AUG 15......	1845	108	15	4.4

Figure 31.—Format table 3, suspended-sediment discharge measurements.

SUSPENDED-SEDIMENT DISCHARGE DURING PERIODS OF HIGH FLOW, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME INTER-VAL (HRS)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	DATE	TIME INTER-VAL (HRS)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
JUL 27......	2	1340	41000	12400	JUL 28......	15	625	11600	12200
JUL 27......	2	944	30000	6370	JUL 28......	3	400	5700	770
JUL 28......	2	730	21000	3450	JUL 28......	4	278	3600	450

Figure 32.—Format table 4, suspended-sediment discharge during periods of high flow.

TOTAL SEDIMENT DISCHARGE, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	WATER TEM-PERA-TURE (°C)	DISCHARGE (CFS)	SUSPENDED SEDIMENT CONCEN-TRATION (MG/L)	SUSPENDED SEDIMENT DISCHARGF (TONS/DAY)	TOTAL SEDIMENT DISCHARGE (TONS/DAY)	STREAM CHARACTERISTICS WIDTH (FT)	MEAN DEPTH (FT)	MEAN VELOCITY (FPS)
DEC 10, 1969	1800	12.0	1400	1200	4540	4590	30.3	8.5	4.00
DEC 30......	1545	14.0	440	22	26	33	25	6.6	2.9
JUN 12, 1970	1430	26.5	120	200	65	70	10.2	5	3.2
JUN 14......	0900	28.0	1.6	25	.11	.17	1.8	.2	.45
JUN 15......	1200	28.5	12	30	.97	.17	2.0	.6	.50
JUN 16......	1300	28.0	.88	15	.04	.04	1.5	.1	.2

Figure 33.—Format table 5, total sediment discharge.

a water density of 1.00 g/cc and a sediment density of 2.65 g/cc. They are calculated to three significant figures in 2-percent steps. Computation errors from use of these factors will be less than 1 percent and will average zero.

Values of concentration determined in the laboratory as parts per million should be converted to milligrams per liter by laboratory personnel on the form, sediment-concentration notes (fig. 5). For concentrations under 16,000 ppm, the values of parts per million and milligrams per liter are assumed to be equal. For concentrations over 16,000 ppm, the corrected value in milligrams per liter should be penciled plainly below the concentration on the form as a reminder to the user that parts per million is different from milligrams per liter. In any event, personnel who transfer the data from the laboratory forms for other uses are responsible for the correct use of the data and should check the basic data to determine that the conversion was correctly made.

After the data are converted to milligrams per liter, the only coefficient needed to compute sediment discharge is k, which is equal to 0.0027 in the English system of units. The coefficient, k, includes the conversion of water discharge and is a constant for a given system of measurement. The derivation and value of k to determine tons per day in English and metric units follows.

If the weight of a cubic foot of water-sediment mixture is assumed to be 62.4 pounds, then

$$k=\frac{(60\times60\times24)\text{ seconds per day}\times62.4\text{ pounds per cubic foot}}{2{,}000\text{ pounds per ton}\times1{,}000{,}000}=0.0027,$$

and the computation of sediment discharge is

$$Q_s=Q_w\times C_s\times 0.0027\text{ tons per day (English short tons).}$$

A metric ton is 2,204.62 pounds avoirdupois, or 1.1023 English short tons, and a cubic meter is 35.31 cubic feet. To convert English short tons to metric tons multiply by 0.9072, or substitute factor 0.00245 in place of 0.0027 in the preceding equation.

PARTICLE-SIZE DISTRIBUTION OF SUSPENDED SEDIMENT, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970
(METHODS OF ANALYSIS: B, BOTTOM WITHDRAWAL TUBE; C, CHEMICALLY DISPERSED; N, IN NATIVE WATER; P, PIPET; S, SIEVE; V, VISUAL-ACCUMULATION TUBE; W, IN DISTILLED WATER)

DATE	TIME	WATER TEMPERATURE (°C)	DISCHARGE (CFS)	CONCENTRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	PARTICLE SIZE PERCENT FINER THAN THE SIZE (IN MILLIMETERS) INDICATED .002	.004	.008	.016	.031	.062	.125	.250	.500	1.00	2.00	METHOD OF ANALYSIS
MAR 27, 1970	1050	7.0	2020	254	1390		36		41		58	68	93	100			VPWC
MAY 24......	0550	11.5	603	11400	18600		78		99		100	--	--				PWC
MAY 26......	1255	16.5	800	10100	21800		71		96		100	--	--				PWC
JUN 10......	1700	14.0	2410	17900	116000		44		63		94	99	100				VPWC
AUG 10......	1615	19.0	784	39600	86900		59		78		97	100	--				VPWC
AUG 12......	1130	19.0	1470	46000	189000		50		67		93	99	100				VPWC
AUG 19......	1000	14.5	885	36000	89200		48		68		90	98	100				VPWC
AUG 23......	1355	21.0	8260	39900	92300		37		52		83	97	100				VPWC
AUG 24......	1235	17.5	3040	12600	103000		46		63		88	97	100				VPWC

Figure 34.—Format table 6, particle-size distribution of suspended sediment.

PARTICLE-SIZE DISTRIBUTION OF SURFACE BED MATERIAL, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970
(METHODS OF ANALYSIS: O, OPTICAL ANALYZER; P, PIPET; S, SIEVE; V, VISUAL-ACCUMULATION TUBE)

DATE	TIME	WATER TEMPERATURE (°C)	NUMBER OF SAMPLING POINTS	DISCHARGE (CFS)	PARTICLE SIZE: PERCENT FINER THAN THE SIZE (IN MILLIMETERS) INDICATED .004	.062	.125	.250	.500	1.00	2.00	4.00	8.00	16.00	32.00	METHOD OF ANALYSIS
NOV 29, 1969	1515	9.0		440	0	3	10	53	97	100	--	--	--			SV
JAN 30, 1970	1330	12.0		206	0	1	10	48	86	97	98	99	100			SV
MAR 22......	1240	16.5		143	0	1	10	51	86	98	99	99	100			SV

Figure 35.—Format table 7, particle-size distribution of surface bed material.

Water-discharge data in the metric system usually are reported in cubic meters per second, and sediment-discharge data in metric tons per day. If water data are in cubic meters per second, the weight of 1 cubic meter of water is 1 metric ton, and the time interval is 24 hours; thus

$$k=\frac{86{,}400 \text{ seconds per day} \times 1 \text{ ton per cubic meter}}{1{,}000{,}000}$$

$$=0.0864,$$

and the computation of sediment discharge becomes

$$Q_s=Q_w\times C_s\times 0.0864 \text{ (metric tons)}.$$

Computation of subdivided days

The term "subdivide" refers to the division of data for a calendar day into shorter periods of time to obtain correct daily mean values of water or sediment discharge when one or both change beyond certain limits during the day. The values for these periods are then summed to obtain values of water or sediment discharge.

The basic reasons for subdivision of data for a day to compute water discharge and the reasons for subdivision to compute sediment discharge are different. Computation of daily mean water discharge requires subdivision of the day when the gage height is changing because the relation between stage and discharge is curvilinear, and the daily discharge corresponding to a mean gage height will be less than the true mean discharge. Computation of a daily mean sediment discharge requires subdivision of the day when both water discharge and concentration are changing because the average of the products of two variable quantities is not the same as the product of the averages of the quantities. Subdivision is not required if either discharge or concentration is constant during the day.

Water-discharge values for subdivided days frequently are calculated in advance of sediment calculations and are listed on the recorder chart of the gage-height record. However, because the reasons for subdivision to determine water discharge and the reasons for a subdivision to compute sediment discharge are not the same, a subdivision for water discharge may not be adequate for sediment discharge. Colby (1956b) sums it thus:

> A common source of errors is incorrect division of the day into parts. An inept type of subdivision may be little better than no subdivision at all. Far too often the same separation of the day into parts is used for both the computation of water discharge and the computation of sediment discharge.

The concentration graph should be prepared prior to computation of water discharge, and the initial subdivision made on the basis of change in both water discharge and concentration. If subdivisions and computations of water discharge were made prior to preparation of the concentration graph, a new subdivision of water discharge may be necessary to compute sediment discharge. The new subdivision may divide the day into different parts and into a larger number of parts. Any new water-discharge values added to the subdivision should be carefully computed and checked. Usually when a period is subdivided into a larger number of intervals, the accuracy of the value of daily mean water discharge is improved, and the finite value of the daily water discharge is increased. If the increase in daily mean water discharge over the previously computed value is significant, the original value should be revised. This significant increase will not occur, however, if the original subdivision was adequate.

Figure 36 is a guide to indicate if subdivision is necessary to maintain computations within specified limits of error. The maximum and minimum discharge and the maximum and minimum concentration are determined for the day, or for a trial period, and the ratios of these values plotted on the guide. In practice, a precise computation and plotting of ratios is not necessary, and a quick mental calculation of the ratios and a visual location of these on the guide will suffice.

Subdivided days are computed primarily by two methods which are referred to herein as the mean-interval method and the mid-

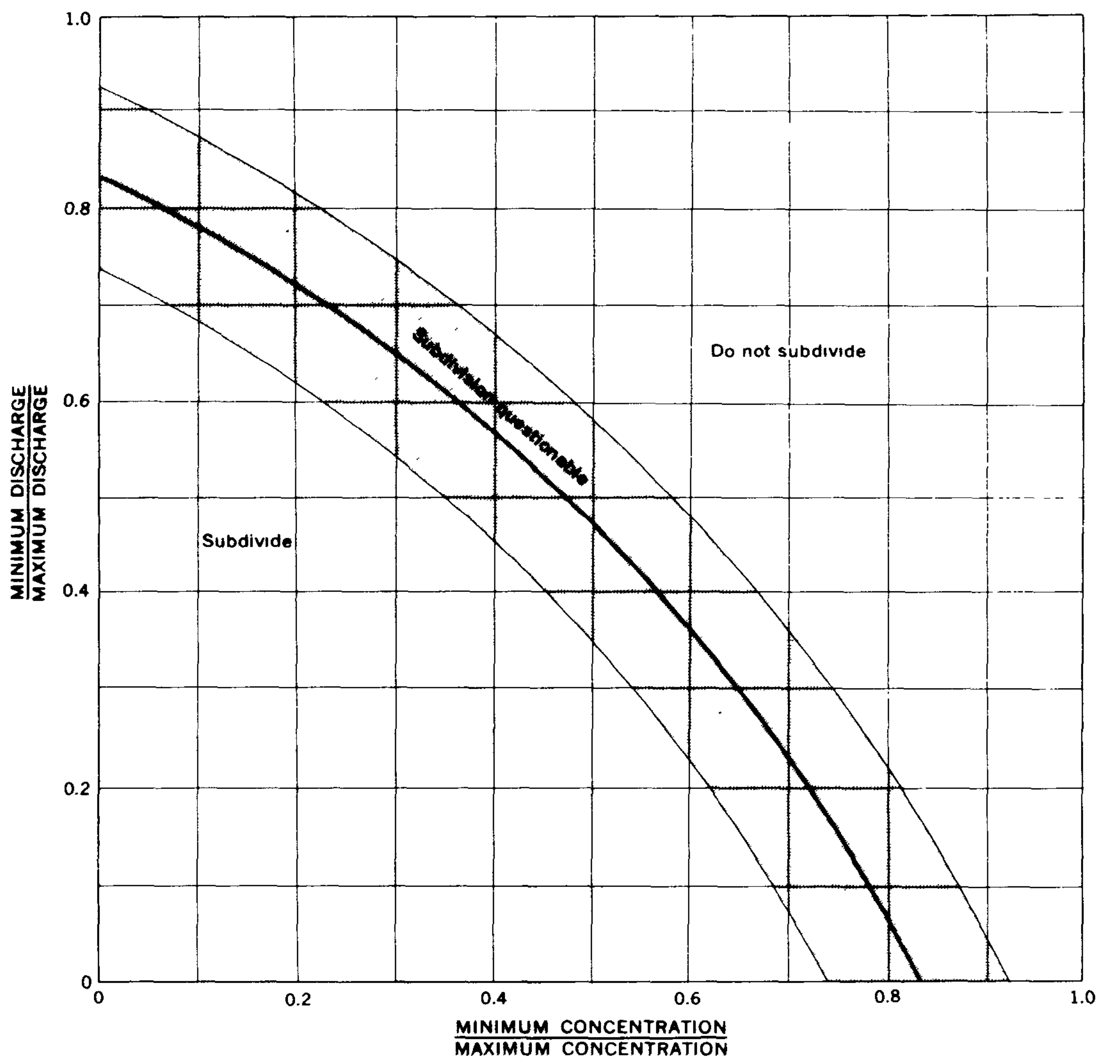

Figure 36.—Guide to subdivision, assuming accuracy about 5 percent (after Colby, 1956b).

interval method. These methods are analogous to the mean-section and midsection methods of computing streamflow from water-discharge measurements described by Buchanan and Somers (1965).

Mean-interval method

The mean-interval method of computation of sediment discharge requires the determination of the mean water discharge and mean sediment concentration for several short periods of time during a day. The products of the two variables for each interval are then time weighted and summed to obtain daily mean discharge. This method is convenient if an analog record of gage height is available and mean values of gage height (or water discharge) and concentration can be determined graphically. Graphical determination of these values for an interval of a day may be made in the manner described in the section on "Computation of daily mean concentration."

An example of the mean-interval method is given in table 3. The daily sediment-discharge data were computed by two procedures:

1. Sediment discharge computed for each time interval and summed to obtain daily discharge (col. 7).
2. Sediment discharge computed by summing the product of water discharge, time interval, and concentration in the calculator and multiplying the summation by k/T, where k is the coefficient, 0.0027, and T is the summation of hours in the time-interval column, or number of intervals used in subdividing the day. In this latter procedure, column 7 is not computed. This procedure is the one most commonly used.

An advantage resulting from use of the first procedure is the listing of actual sediment-discharge values or tonnage for each time interval (col. 7, table 3). This method is most convenient to use if the computations are made by slide rule or by a calculator that does not cumulatively multiply. These data are useful for direct application to special studies of water and sediment-discharge relations.

Midinterval method

The midinterval method of computation of sediment discharge assumes the values of water discharge and sediment concentration for a specific time represent the average values for the time interval that extends ahead and behind halfway to the preceding and following clock times. The term "midinterval" is not precisely descriptive because if the successive time intervals are unequal the values are not at the midpoint. However, if the time intervals are equal then the values are at the midpoint of the time interval. This method is usually used when the gage-height record is a printout of a digital record.

An example of the midinterval method is given in table 4. Values of gage height and concentration are tabulated for the clock time (col. 1), and the time interval and water discharge are computed. Sediment discharge is computed by summing the product of the water discharge, sediment concentration, and time interval in the calculator and multiplying the summation by k/T, where k is the coefficient, 0.0027, and T is the summation of hours in the time-interval column, or the number of intervals used in subdividing the day.

If subdivision was not used for the data in table 4, then the 24-hour sediment discharge would be

$$Q_s = Q_w \times C_s \times 0.0027 = 2{,}260 \times 1{,}830 \times 0.0027$$
$$= 11{,}200 \text{ tons per day.}$$

The error caused by not subdividing is

$$25{,}400 - 11{,}200 = 14{,}200 \text{ tons per day,}$$

and the ratio of Q_s computed from daily mean values to Q_s computed by the sub-

Table 3.—Computation of subdivided day, mean-interval method

Time interval (col. 1): Time during which there is insignificant change in water discharge and sediment concentration or during which the maximum change is within limits specified by the allowable range in stage and by the guide to subdivision (fig. 36). The number of intervals used will depend on the accuracy required.

Gage height (col. 2): The average gage height for the time interval corrected for any mechanical errors. It is usually determined graphically.

Shift correction (col. 3): The adjustment applied to gage height to account for variations in the rating. This column may be omitted if no shift is needed.

Water discharge (col. 4): The mean discharge for the interval; obtained from rating tables.

Sediment concentration (col. 5): The mean concentration for the interval; usually determined graphically from the concentration graph.

Interval × concentration (col. 6): The product of the time interval (col. 1) and concentration (col. 5). The daily mean concentration, published in the concentration column of the sediment-discharge sheet, is computed by dividing the sum of col. 6 by the sum of col. 1. Col. 6 can be omitted for simple computations; col. 1 × col. 5 may be accomplished mentally and entered directly in the calculator and multiplied by water discharge (col. 4).

Computer sediment discharge, procedure 1 (col. 7): The discharge for the interval is computed by multiplying the product of the qtc (col. 4 × col. 6) by 0.0027 and dividing by the time, or total length of the interval. The calculation for periods divided into 24 intervals may be simplified by using the divisor, d. If this is done, col. 6 may be omitted. Values of d, given in footnote 1, are T/tk, where t is the interval, k, is 0.0027, and T is 24. Tons per day is the numerical sum of interval values. An example of the computation of the first and last intervals, using d from footnote 1, is

$$\text{tons per interval} = \frac{\text{col. 4} \times \text{col. 5}}{d} = \frac{q \times c}{d} = \frac{174 \times 8}{1{,}481} = 0.94$$

$$= \frac{q \times c}{d} = \frac{4{,}920 \times 3{,}500}{8{,}889} = 1{,}940.$$

Computed sediment discharge, procedure 2:

Total interval $= T = \Sigma$ (col. 1) $= 24$

$$\text{Daily mean gage height} = \frac{\Sigma\,(\text{col. 1} \times \text{col. 2})}{T} = \frac{144.29}{24} = 6.01$$

$$\text{Daily mean water discharge, } Q_w = \frac{\Sigma\,(\text{col. 1} \times \text{col. 4})}{T} = \frac{54{,}286}{24} = 2{,}260$$

$$\text{Daily mean concentration, } C_s = \frac{\Sigma\,(\text{col. 1} \times \text{col. 5})}{T} = \frac{43{,}648}{24} = 1{,}820$$

$$\text{Tons per day, } Q_s = \frac{\Sigma q(tc)}{T}\,k = \frac{\Sigma\,(\text{col. 4} \times \text{col. 6})}{T} \times 0.0027$$

$$= \frac{225{,}767{,}432}{24} \times 0.0027 = 25{,}400$$

	Time interval, t (1)	Gage height (ft) (2)	Shift correction (ft) (3)	Water discharge, q (cfs) (4)	Sediment concentration, c (mg/l) (5)	Interval × concentration, tc (col. 1 × col. 5) (6)	Computed sediment discharge, procedure 1 (tons/interval) (7)
	6	4.17	0	174	8	48	1
	2	4.32	0	234	30	60	2
	2	4.57	0	355	80	160	6
	2	4.66	0	403	100	200	9
	1	4.83	0	498	180	180	10
	1	5.75	0	1,210	650	650	88
	1	6.80	0	2,520	1,350	1,350	383
	1	7.55	0	3,710	2,350	2,350	981
	1	8.10	0	4,760	3,350	3,350	1,790
	1	8.39	0	5,380	4,600	4,600	2,780
	1	8.53	0	5,690	6,200	6,200	3,970
	1	8.62	0	5,890	6,950	6,950	4,610
	1	8.58	0	5,800	5,500	5,500	3,590
	1	8.47	0	5,550	4,600	4,600	2,870
	1	8.37	0	5,330	3,950	3,950	2,370
	1	8.18	0	4,920	3,500	3,500	1,940
Total	24	144.29	—	54,286	—	43,648	25,400
Weighted mean		6.01	—	2,260	—	1,820	—

[1] Divisors used to compute sediment discharge in procedure 1 for a given time interval:

Time interval, t (hr)	Divisor, d	Time interval, t (hr)	Divisor, d
1	8,889	13	683.8
2	4,444	14	634.9
3	2,963	15	592.6
4	2,222	16	555.6
5	1,778	17	522.9
6	1,481	18	493.8
7	1,270	19	467.8
8	1,111	20	444.4
9	987.6	21	423.3
10	888.9	22	404.0
11	808.1	23	386.5
12	740.7	24	370.37

Table 4.—Computation of subdivided day, midinterval method

Clock time (col. 1): The actual time, given in 24-hour time, for which values are tabulated. Sufficient values must be chosen to assure that the maximum change in successive values of water discharge and sediment concentration is within the limits specified by the allowable range in stage and by the guide to subdivision (fig. 36).

Time interval (col. 2): The sum of one-half the time back to the preceding clock time and one-half the time to the following clock time. The first interval, of 2.5 hours, is one-half the time from midnight (0000 hrs) and 5 a.m. (0500 hrs). The second interval, of 3.5 hours, is one-half the time from midnight to 5 a.m. (2.5 hrs) plus one-half the time from 5 a.m. to 7 a.m. (1 hr). This may also be computed by taking one-half the difference of alternate hours (except the first and last) as follows:

First interval: $\frac{0500\text{-}0000}{2} = 2.5$

Second interval: $\frac{0700\text{-}0000}{2} = 3.5$

Third interval: $\frac{0900\text{-}0500}{2} = 2.0$

Cols. 3-6: See explanation for columns 2-5, table 3.

Interval × concentration (col. 7): See explanation for column 6, table 3.

	Clock time (hrs) (1)	Time interval, t (hrs) (2)	Gage height (ft) (3)	Shift correction (ft) (4)	Water discharge, q (cfs) (5)	Sediment concentration, c (mg/l) (6)	Interval × concentration, tc (col. 2 × col. 6) (7)
	0000	2.5	4.17	0	174	8	20
	0500	3.5	4.19	0	182	8	28
	0700	2.0	4.32	0	234	40	80
	0900	2.0	4.60	0	370	90	180
	1100	1.5	4.67	0	408	100	150
	1200	1.0	4.73	0	442	120	120
	1300	1.0	5.22	0	744	320	320
	1400	1.0	6.22	0	1,740	1,000	1,000
	1500	1.0	7.20	0	3,120	1,900	1,900
	1600	1.0	7.83	0	4,220	2,850	2,850
	1700	1.0	8.26	0	5,090	4,000	4,000
	1800	1.0	8.50	0	5,620	5.300	5,300
	1900	1.0	8.56	0	5,750	7,000	7,000
	2000	1.0	8.60	0	5,840	6,400	6,400
	2100	1.0	8.54	0	5,710	4,950	4,950
	2200	1.0	8.41	0	5,420	4,200	4,200
	2300	1.0	8.31	0	5,200	3,700	3,700
	2400	.5	8.10	0	4,760	3,300	1,650
Total	—	24	144.365	—	54,168	—	43,848
Weighted mean	—	—	6.02	—	2,260	—	1,830

Computed sediment-discharge procedure:

Total interval $= T = \Sigma$ (col. 2) $= 24$

Daily mean gage height $= \frac{\Sigma \text{ (col. 2} \times \text{col. 3)}}{T} = \frac{144{,}365}{24} = 6.02$

Daily mean water discharge, $Q_w = \frac{\Sigma \text{ (col. 2} \times \text{col. 5)}}{T} = \frac{54{,}168}{24} = 2{,}260$

Daily mean concentration, $C_s = \frac{\Sigma \text{ (col. 2} \times \text{col. 6)}}{T} = \frac{43{,}848}{24} = 1{,}830$

Tons per day, $Q_s = \frac{\Sigma q\ (tc)}{T}\ k = \frac{\Sigma \text{ (col. 5} \times \text{col. 7)}}{T} \times 0.0027$

$$= \frac{226{,}035{,}716}{24} \times 0.0027 = 25{,}400$$

divided-day method is

$$\frac{11{,}200}{25{,}400} = 0.44.$$

In practice, this ratio is computed for each subdivided day during the computation process because it gives an index to the value, or need, to subdivide. For large streams, it also provides an excellent basis for experienced personnel to estimate the need to subdivide the next day. As the flood peak recedes and concentration values decline, the ratio for each successive day will approach 1.00; subdivision is not necessary when the ratio for the preceding day is 0.95 or greater.

The excellent agreement between average values for corresponding variables in tables 3 and 4 is notable. Such close agreement indicates sufficient subdivision. A similar check also is possible when additional intervals are added to previously subdivided water-discharge values. If weighted gage-height values are the same, but water discharge increases significantly, then the original subdivision of water discharge was insufficient. This reasoning can be extended through computation of sediment discharge. If additional intervals fail to significantly change daily mean values of water discharge, concentration, or sediment discharge, then the period is subdivided into sufficient intervals.

Data for the examples in tables 3 and 4 are taken from the gage-height and the concentration graph in figure 37. Data may be recorded and computations made on a copy of the gage-height chart or on a separate sheet.

Sediment-Discharge Worksheet

At this point a continuous sediment-concentration graph has been drawn and reviewed. Concentration values for daily periods and subdivided periods have been computed, and all coefficients applied. Sediment discharge and time-weighted concentrations have been computed for each subdivided day. These values and computations now are ready for the next step—entering the data on the sediment-discharge worksheet (fig. 38).

The sediment-discharge worksheet and the tabulation of particle-size analyses (fig. 2) are the major products of the basic-data-collection program and are published annually. These are the forms from which copies are made to furnish preliminary information to the various data users and which are furnished to the records-processing center. These forms, therefore, should be filled out completely, neatly, and accurately—both in content and editorially. Editorial procedure and rules are based on the United States Government Printing Office "Style Manual," revised edition, January 1967. Specific rules are further explained in "Suggestions to Authors of the Reports of the United States Geological Survey," fifth edition, 1958.

If the electronic computer program is used, values of water discharge and sediment concentration are compiled and punched on data cards; sediment discharge is not computed by the method that follows. Part of the output of the computer program is a listing of sediment data in a form suitable for publication. Records computed manually on the worksheet also are sent to the records-processing center to be listed by computer for publication. An example of the offset copy—prepared from data on the worksheet (fig. 38)—produced by the automatic data-processing equipment is illustrated in figure 29.

The technical and editorial accuracy of the product depends on each individual who has a part in its preparation. Each value should be checked for accuracy, and each tabulation should be evaluated for editorial correctness. Data should not be listed with the intent of allowing the checker, or reviewer, to discover and correct errors. It is much easier to keep errors out of the tabulation than to correct them at a later date, if ever.

A list of the technical and editorial rules used in the preparation of the sediment-discharge worksheet (fig. 38) follows.

Heading of table:

1. Enter the number and name of station in capital letters.
2. Fill in the correct time period. If the period is not a complete water year, change the months to agree with period of record.
3. Fill in headnote, if applicable. See rules for footnote E in section on "Footnotes."

Body of table:

1. Mean discharge:
   - (a) Copy the water discharge from form 9-192 or printout. Use exact figures listed in surface-water data because perfect agreement must exist between data listed in surface-water and water-quality publications.
   - (b) Omit footnotes in this column.
   - (c) Omit explanation or qualifications concerning water discharge.
2. Mean concentration:

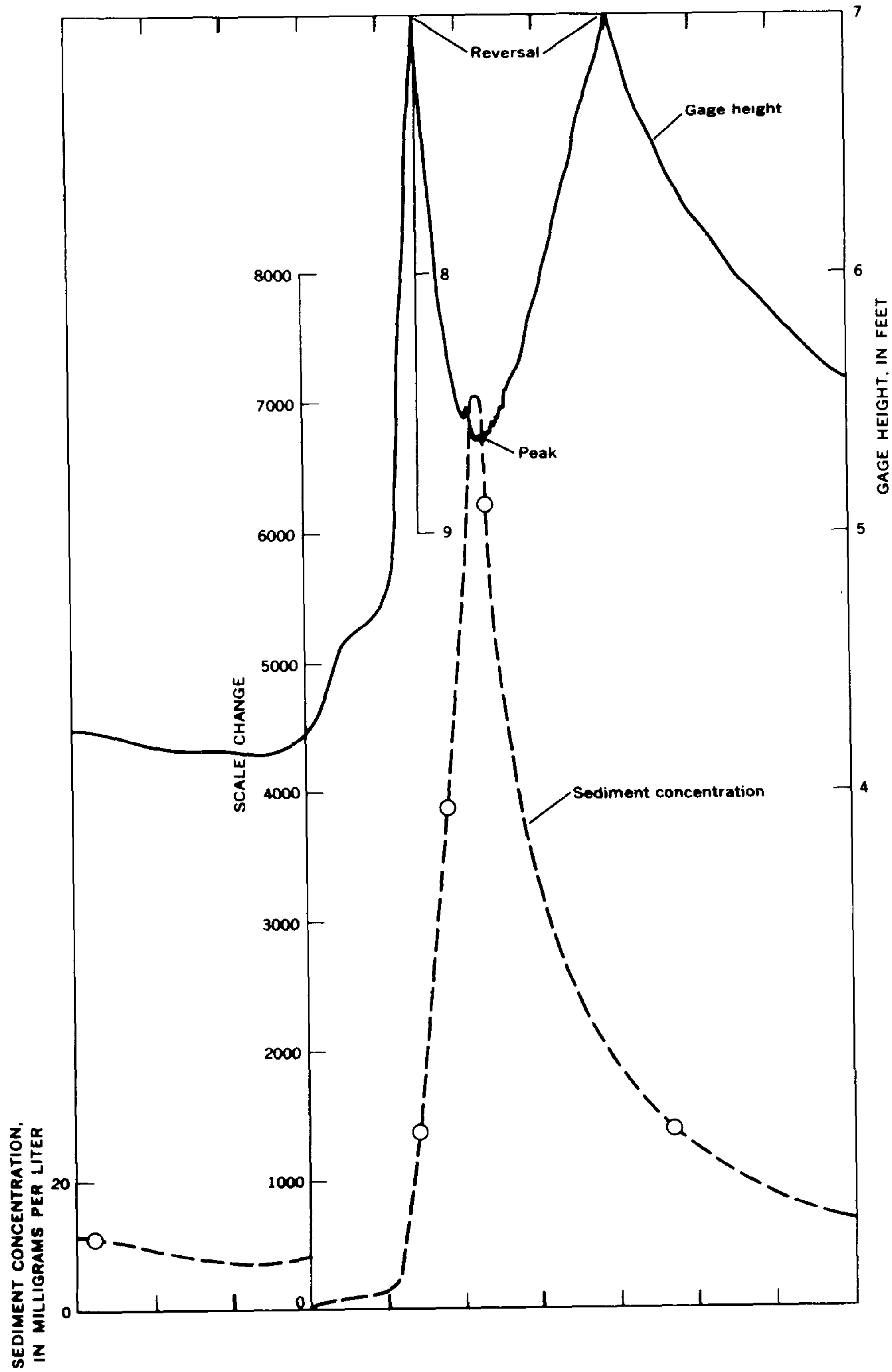

Figure 37.—Gage height and sediment concentration for a subdivided day.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY WATER RESOURCES DIVISION

11-582x SAMPLE CREEK NEAR SOMEWHERE, CALIF

Suspended sediment, water year October 1967 to September 1968

Day	October Mean discharge (cfs)	October Mean concentration (mg/l)	October Tons per day	November Mean discharge (cfs)	November Mean concentration (mg/l)	November Tons per day	December Mean discharge (cfs)	December Mean concentration (mg/l)	December Tons per day
1	0.60	4	0.01	66	247	S 87	1,410	913	S 3820
2	.30	4	0	42	40	67	780	318	670
3	.30	4	0	58	22	3.4	470	140	178
4	0	--	0	21	7	.53	345	70	65
5	0	--	0	19	4	.21	205	35	19
6	.30	2	0	14	4	.15	160	20	8.6
7	.30	2	0	18	3	.15	130	11	3.9
8	.60	1	0	20	100	S 46	117	9	2.8
9	.80	1	0	318	651	S 690	241	65	42
10	.80	1	0	459	542	S 1,390	330	121	S 812
11	.80	1	0	254	336	S 381	1,010	742	S 2430
12	.80	1	0	340	300	S 289	422	110	125
13	1.1	2	.01	148	65	26	275	40	30
14	1.4	4	.02	80	22	48	218	22	13
15	4.7	5	.06	55	8	12	196	20	11
16	6.1	4	.07	42	4	.45	163	17	7.5
17	6.1	4	.07	37	2	.20	134	10	3.6
18	6.1	3	.05	33	2	.18	117	10	3.2
19	6.1	2	.03	30	2	.16	134	15	5.4
20	6.1	2	.03	28	1	.08	500	249	S 461
21	6.1	1	.02	33	1	.09	8,630	8,100	S 258,000
22	6.1	1	.02	42	1	.11	29,800	57900	S 5,070,000
23	6.1	1	.02	39	1	.11	15,600	46300	S 2,110,000
24	6.6	1	.02	42	1	.11	9,300	36,500	1,020,000
25	7.0	1	.02	378	369	S 561	5,030	25,500	346,000
26	7.5	2	.04	232	65	41	4,300	22,300	259,000
27	9.0	2	.06	148	22	8.8	3,230	15,500	135,000
28	19	3	.15	486	541	S 1,330	2,050	11,000	60900
29	80	226	S 60	595	360	S 723	1,550	10700	44800
30	48	66	8.6	315	78	66	1,340	9430	34,100
31	22	10	.59				1,070	7950	23,000
Total	260.70		69.88	4,479		5,563.43	89,257		9,369,012.4

Day	January Mean discharge (cfs)	January Mean concentration (mg/l)	January Tons per day	February Mean discharge (cfs)	February Mean concentration (mg/l)	February Tons per day	March Mean discharge (cfs)	March Mean concentration (mg/l)	March Tons per day
1	860	7000	16,300	1,800	6200	16,300	490	850	1120
2	810	6700	16,500	1,070	5080	14,600	434	630	738
3	930	7000	17,600	920	4100	10,800	420	540	617
4	780	5200	11,000	880	3650	8670	371	515	516
5	2,080	11,900	S 78,600	1,060	4900	13,900	371	420	421
6	1,270	8620	S 29,800	962	3400	8830	437	600	692
7	951	6,900	17,700	810	2700	5,900	378	540	551
8	770	4,800	9,980	695	2400	4,500	344	486	450
9	780	4950	10,400	626	2050	3,460	326	418	368
10	951	4,550	11,800	562	1,660	2,530	332	410	368
11	1,150	8,800	A 27,300	522	1780	2,510	338	432	385
12	1,100	8,500	A 25,200	490	1600	2120	371	504	505
13	995	6,600	17,700	469	1220	1,540	350	350	331
14	973	5,650	14,600	462	1,080	1,310	302	275	224
15	1,150	6,500	20,200	434	910	1,070	284	288	221
16	1,220	7,100	23,400	413	920	1,030	264	296	226
17	1,270	6,950	23,800	379	880	948	279	300	226
18	1,430	8,150	31,200	406	780	855	257	255	177
19	1,580	8,450	36,000	427	880	1,010	252	276	187
20	1,500	7,250	29,400	462	1,000	1,250	235	330	209
21	1,260	5,980	20,300	490	1,000	1,320	240	315	204
22	1,030	5,500	15,300	490	990	1,310	240	435	341
23	2,120	15,400	S 156,000	448	850	1,030	246	410	328
24	2750	14,400	S 119,000	406	600	658	246	408	326
25	1,470	8,300	32,900	385	510	603	262	330	233
26	1,150	6,900	21,400	378	520	S 531	279	385	290
27	962	6,150	16,000	755	3,340	7,830	302	380	310
28	870	5,360	12,600	554	1600	2,390	257	268	186
29	900	5,160	12,500	617	1140	1690	240	297	168
30	1,170	5,960	18,800				257	282	196
31	1,290	5,960	20,700				274	302	223
Total	37,512		910,380	17,672		188,185	9,838		11,332

Day	April Mean discharge (cfs)	April Mean concentration (mg/l)	April Tons per day	May Mean discharge (cfs)	May Mean concentration (mg/l)	May Tons per day	June Mean discharge (cfs)	June Mean concentration (mg/l)	June Tons per day
1	284	880	253	594	1350	2170	246	110	73
2	320	456	393	506	1000	1370	223	98	59
3	279	690	294	462	860	1060	214	90	52
4	279	344	259	441	650	774	201	70	38
5	290	280	219	484	415	568	196	52	28
6	274	220	163	448	370	449	192	53	27
7	284	300	230	462	310	387	184	54	27
8	1,010	4,110	S 12,800	465	340	418	156	45	19
9	702	4,720	S 3,640	462	356	443	141	36	14
10	434	660	773	476	380	488	127	33	11
11	367	530	511	514	430	583	123	31	10
12	427	610	703	538	445	646	114	29	8.9
13	448	800	968	578	450	702	97	26	6.8
14	476	700	900	572	390	602	91	24	5.9
15	892	--	E 11,000	564	370	563	91	22	5.4
16	1,290	--	E 12,000	572	318	491	77	20	4.2
17	900	--	E 7800	580	300	470	72	17	3.3
18	4,910	--	E 53,000	519	266	373	77	16	3.1
19	3,560	10,700	103,000	498	250	336	72	13	2.5
20	2,530	7900	54,000	484	248	324	67	14	2.5
21	2,180	6700	39,400	488	220	290	69	16	3.0
22	1,360	4,600	16,900	404	178	194	69	25	4.7
23	1,080	3900	11,400	356	140	134	69	21	3.9
24	1,010	3300	9,000	325	117	103	67	17	3.1
25	995	3000	8,600	300	110	89	62	13	2.2
26	1,020	2850	7,850	285	119	92	60	11	1.8
27	1,020	3200	8,810	290	140	110	53	10	1.4
28	951	2600	6,680	295	180	143	51	10	1.4
29	830	2600	5,830	296	160	127	51	11	1.5
30	695	2200	4,180	285	130	100	53	11	1.6
31				270	110	80			
Total	28,087		386,606	13,721		14,668	3,365		425.2

Load max daily 5,070,000 tons Dec 22; min daily 0 tons many days
Conc max daily 57,900 mg/l Dec 22; min daily no flow many days

	Discharge			Concentration			Load		
Copied	RDB			DOB			RDB	DOB	RDB
Checked	DOB			RDB			DOB	RDB	DOB
Date									

Day	July Mean discharge (cfs)	July Mean concentration (mg/l)	July Tons per day	August Mean discharge (cfs)	August Mean concentration (mg/l)	August Tons per day	September Mean discharge (cfs)	September Mean concentration (mg/l)	September Tons per day
1	53	12	1.7	7.0	5	0.10			
2	48	10	1.3	5.9	4	.06			
3	46	7	.87	5.7	4	.06			
4	46	7	.87	6.1	4	.07			
5	42	8	.91	6.2	4	.06			
6	41	7	.77	4.1	4	.04			
7	33	6	.53	3.0	4	.03			
8	30	6	.49	2.4	4	.04			
9	28	7	.53	2.8	3	.02			
10	28	5	.38	2.2	2	.01			
11	28	4	.30	1.7	2	.01			
12	27	4	.29	1.1	2	.01			
13	28	4	.30	.91	3	.01			
14	30	3	.24	.80	2	0			
15	30	3	.24	.80	2	0			
16	28	3	.23	.72	2	0			
17	24	3	.19	.89	1	0			
18	19	3	.15	.54	1	0			
19	16	3	.13	.37	2	0			
20	15	3	.12	.31	1	0			
21	15	3	.12	.22	1	0			
22	14	3	.11	0	--	0			
23	13	3	.11	0	--	0			
24	12	3	.10	0	--	0			
25	10	4	.11	0	--	0			
26	11	5	.15	0	--	0			
27	9.8	7	.19	0	--	0			
28	9.0	5	.12	0	--	0			
29	8.2	3	.07	0	--	0			
30	9.1	4	.10	0	--	0			
31	7.4	6	.12	0	--	0			
Total	758.6		11.84	53.76		0.52	0		0

Total discharge for period/year (cfs-days) 205,073.96
Total load for period/year (tons) 10,818,153.87

E Estimated
S Computed by subdividing day
A Computed from estimated-concentration graph

[No footnotes will be published except E on Apr 15-18]

Figure 38.—Worksheet for annual suspended-sediment discharge.

(a) Copy values of concentration from graph.

(1) During low-flow periods, if samples are not collected daily, tabulate concentrations for days actually sampled, and estimate missing concentrations on basis of values for adjoining days and the water-discharge hydrograph. A concentration will be determined for each day of flow, if possible. On the worksheet the sampled concentrations are tabulated near the right-hand margin of the concentration column; the interpolated, or estimated, concentrations are tabulated near the left-hand margin of the column. Separation of the sampled and estimated values is for convenience only and aids in checking and reviewing the record. Punched cards for automatic data processing must contain both water discharge and concentration.

(2) During periods of changing concentration, a concentration graph may have been estimated on the basis of adjacent records and other data. The daily mean concentrations from the estimated graphs should be copied in the concentration column and the footnote A entered in the tons per day column. If a concentration graph cannot be estimated and sediment discharge is determined by indirect means such as a sediment-transport curve, then enter a leader (. .) in the concentration column and the footnote E in the tons per day column. If 6 or more days require the footnote E, then delete E and use a headnote.

(b) Show concentrations less than 0.5 mg/l either as a leader (. .) or as zero. If the water discharge is zero, a leader will be placed in the concentration column and a zero in the tons per day column:

Mean discharge (*cfs*)	*Suspended sediment* *Mean concentration* (mg/l)	*Tons per day*
3.7	1	0.01
1.8	1	0
.18	1	0
.18	....	0
0	....	0

(c) Report concentrations in whole numbers only. Values are rounded as instructed in the section on "Significant figures."

(d) Omit footnotes, with the exception of C, in the concentration column. Avoid the use of composite values. Daily values should be shown whenever possible.

(e) Copy footnotes recorded on gage-height chart that explain the concentration or sediment-discharge computation in the tons per day column.

(f) Copy sediment discharge (tons per day) and footnotes for subdivided days at the time concentration values are copied from chart.

3. Tons per day:

(a) Enter sediment discharge for subdivided days and footnotes at the time concentration values are copied from the chart.

(b) Compute sediment discharge for days where average concentration and water values are given. The daily sediment discharge is mean discharge × mean concentration × 0.0027.

(c) Round sediment-discharge values according to the instructions in the section on significant figures.

(d) Estimate sediment discharge for days where concentration is not shown.

(e) Plot all values of water and sediment discharge on logarithmic paper in the form of a sediment-transport curve (fig. 39). Check values that

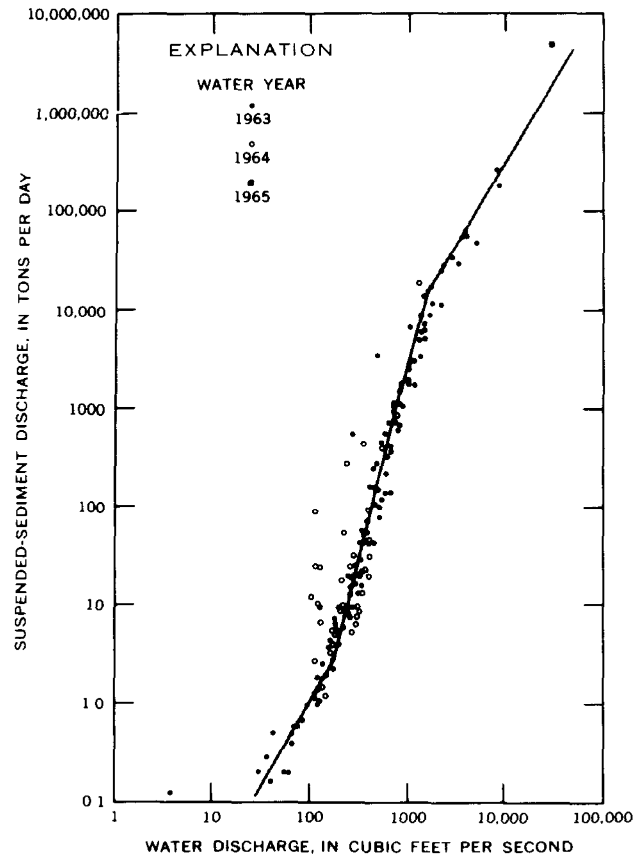

Figure 39.—Relation between daily suspended-sediment discharge and water discharge, Thomes Creek at Paskenta, Calif., 1963-65 water years.

deviate significantly from the average curve for decimal point error, incorrect concentration graph, error in computation, or error in water-discharge values. This plot is useful particularly on large streams having storm runoff events that last several days and where seasonal changes may be significant.

(f) Make revisions as necessary; however, do not try to revise a sediment-discharge value because the value is not consistent with an assumed pattern. The value may not agree because of unusual circumstances, which occur infrequently. These infrequent occurrences often may be verified by comparing them with log plots of water and sediment discharge made for previous years.

(g) Compute and check monthly and annual totals.

(h) Insert and check footnotes.

(i) Compute, record, and check maximum and minimum concentration and sediment discharge.

Station Analysis

A station analysis is a concise summary of (1) equipment used at the station, (2) stream conditions that may affect the quality of the sediment record with respect to particle-size distribution, concentration, and sediment transport, (3) the sampling procedures used, and (4) special methods used to compute sediment discharge.

The analysis of the sediment record may include a summary of chemical-quality sampling procedures and frequency, constituents determined, and special analytical methods. If the sediment records are prepared by the same office preparing the surface-water records, the analyses for the water records and sediment records may be combined. A consolidated analysis including all records collected at one station is preferred because the basic information concerning location, physiography, land use, and climate are common to each analysis. An individual analysis may be necessary when the records are not prepared by the same office or because of conflicts with local needs.

Items that should be considered in a consolidated analysis of sediment discharge, chemical quality, temperature, and rainfall records include:

Equipment type and location.

Equipment changes and date of change.

Important land-use changes that will probably affect the quantity and quality of runoff, such as burn areas, logging, construction, urbanization, and mining.

Temperature record: completeness, accuracy, and reliability.

Rainfall record: completeness, accuracy, and reliability, if obtained in connection with gaging station.

Sediment-sampling methods: regular or special techniques, number of sediment-discharge measurements made, and reliability of observer.

Gage-height record including the datum corrections.

Water-discharge record including the stage-discharge rating.

Concentration graph and sediment-discharge computations, and coefficients applied.

Particle-size analyses: number, methods of analysis, and average percentage of clay, silt, and sand.

Chemical quality: sampling procedures and frequency, constituents determined, and special analytical methods.

Remarks concerning other aspects that affect the record.

An example of a station analysis associated with water, sediment, temperature, and rainfall records is given in figure 40, an analysis for chemical quality and sediment records is given in figure 41, and an analysis for sediment records is given in figure 42.

Station Description Heading

A complete station description heading is prepared for each new station when a chemical or sediment data-collection program is started. It is revised when changes in location or operation warrant. Otherwise, no changes are made in the heading on an annual basis except the dates and figures for records available and extremes. A station description heading as published in the water-quality-data report is shown in figure 43.

Station headings may be updated and typed by the originating office or, once prepared, may be put on punched tape and filed at the records-processing center. This tape is used as input to an automatic typewriter which produces a final copy for offset printing. A major advantage of the taped heading is that the period of records and extremes can be updated without rewriting the remainder of the heading. This eliminates the need for copying, typing, checking, and reviewing the major part of the heading each year.

A copy of the heading (fig. 44) is furnished the office that computed the record. This copy will be used to update the heading for the next water year. The procedure is as follows:

1. Use red pencil to update heading.
2. Location should be changed only when major change occurs in sampling point or gaging station.
3. Drainage area is the value used in the surface-water-data report for the same water year.
4. Records available: Update the final data under "Sediment records" to include current records. Example: For 1968 records, line out 1967 in red, and write in 1968.
5. First "Extremes" paragraph lists extremes for current water year only. Thus, all dates and extremes probably will be changed.
6. Second "Extremes" paragraph shows extremes for period of record, including current year.

   The first date, 1961-67, is the period which includes all other dates in the paragraph. In the example, water-temperature records extend from 1961-67, thus the date is not repeated after water temperatures. Sediment-concentration record is 1962-67, which is included in, but different from, the first date; thus, it is placed after sediment concentrations and sediment loads. The last date must be lined out and updated, as shown in the example.

   Maximum and minimum values and the dates of occurrence may or may not need to be changed.

   Line out and update extremes and dates that change. Check all extremes and dates that remain the same. All dates and figures must be updated or checked.
7. Remarks: Revise this paragraph as required. This paragraph includes information regarding changes in sampling

NORTH FORK OF RED RIVER NEAR GLENWOOD, CALIF. 11-3789.00

STATION ANALYSIS
(Water, sediment, temperature, and rainfall)
1966 Water Year

Equipment.--Stevens A-35 recorder with manometer, and tipping bucket rain gage Weksler Thermograph, in steelox shelter. D-49 sediment sampler located on upstream side of bridge 1.2 miles downstream from gage. Measuring cable 0.3 mile below gage. Observer equipped with DH-48.

Hydrologic changes.--The area upstream varies in elevation from 900 ft to 7,600 ft. It is composed chiefly of sandstone, shale, and greenstones intruded by ultramafic rocks largely altered to serpentine. The combination of sheared rocks, steep slopes and heavy precipitation produces the landslides common to the area. The cover varies from pastures and sagebrush to heavy timber. The timber has been and is continuing to be heavily logged. Owing to the impermeability of the soil and mantle rock, base-flow is poorly sustained and the bulk of the runoff in both water and sediment is storm produced.

Temperature record.--Record complete except period November 12 to December 4 when Weksler clock stopped. Water temperature observations made at time of sediment samples were available for part of period.

Rainfall record.--Record complete for the year.

Sediment record.--Samples were taken about three times a week during low-flows, once a day during medium-flow, and one or more times a day during high-flows. All samples were depth-integrated and considered of fair to good quality.

Gage-height record.--Record complete except periods January 4-6, January 20 to February 2, and June 19 to July 1 when manometer malfunctioned. Observer's staff-gage readings were available for some of these periods.

Datum corrections.--Levels of June 20, 1966, found datum of gage to be 901.58 ft above mean sea level, datum of 1929, supplementary adjustment of 1956. The orifice elevation was found to be 3.26 ft and all outside staffs to be correct within 0.01 ft. No corrections applied.

Rating.--The streambed at the station is composed of sand, gravel, cobblestones, and a few large boulders. A gravel riffle just downstream forms the low-water control. The channel, with banks which are steep and of fairly stable base rock, forms the medium- and high-water control. There is extensive gravel mining 0.5 mile above the station which at times affects the discharge rating and concentration curve.

Sixteen discharge measurements, Nos. 115-130, were made during the current year. Measurement No. 123 made by an inexperienced hydrographer during a period of rapidly changing stage was not used in the analysis. Rating No. 4 in use at the close of the previous water year was continued in use until the high-water of January 12. Measurements after this date indicate an extensive scour and partial return to conditions similar to that existing prior to the December 1964 flood. Therefore, rating No. 5 was developed for use during the remainder of the year. This rating was based on measurements made after the January flood, is well defined and is the same as all previous ratings above 12,000 cfs.

Page 1 of 2

Discharge.--Rating No. 4 was used with small low-water shifts to the peak of January 12. Rating No. 5 was used direct for the remainder of the year. Discharge for periods of no gage height record were estimated on basis of observer's staff readings and hydrographic comparison with other stations in the basin.

Concentration graph and sediment load.--Eleven sediment measurements, depth-integrated at 3 to 5 verticals in the cross section, were made during the year.

Observer samples consisting mostly of two bottles were taken at the center of the stream cross section. The samples were analyzed separately and compared. In most cases the individual samples agreed fairly well. Several bottles differed considerably, and the unreasonable value was not used in this analysis.

Concentrations were plotted on a print of the gage height graph and the concentration curve developed. There were sufficient samples on the rises to adequately define the concentration curve. No coefficient was needed for the observer samples. Standard procedures were used to determine the daily sediment discharge.

Particle size.--Ten samples were analyzed. They ranged in concentration from 122 to 11,600 ppm and in discharge from 780 to 50,000 cfs. Average results of the analysis show 65 percent of material transported to be finer than 62 microns. All particle-size analyses in the silt-clay range were made using distilled water, with a dispersing agent added, as a settling medium.

Remarks.--Water discharge records are good. Suspended sediment records are fair.

James L. Cook
January 26, 1968

Page 2 of 2

Figure 40.—Station analysis (water, sediment, temperature, and rainfall) showing format and content.

RIO GRANDE BASIN
RIO CHAMA NEAR ABIQUIU, N. MEX. 8-2875.

STATION ANALYSIS
(Chemical Quality and Sediment)
1960 Water Year

Sampling program.--Collection of chemical quality and sediment samples on a daily basis was begun on January 15, 1959. Temperature observations are made on samples collected for chemical analyses only. The observer collects sediment samples twice daily from cable car at gaging station during normal flow periods and at more frequent intervals during periods of high flow. All samples are depth integrated and taken with either a D-43 or DH-48 sampler. (Estimate percentage of reported data collected by each.) Three samples were taken for each set, at 1/3, 1/2, and 2/3 of distance across the stream. An integrated sample for chemical analysis was collected at midsection about 0830 daily. No samples were obtained during several intervals in December and January. The collection of samples and records maintained by observer, John H. Jones, is satisfactory.

Equipment.--U.S. D-43 sediment sampler installed in metal shelter on bridge 100 yards upstream from gaging station. A cableway is available for sediment-discharge measurements at normal gaging section one quarter of a mile upstream from water-stage recorder.

Special sediment measurements.--Sixteen sediment discharge measurements were made during the year. Each measurement constituted a cross section, consisting of depth-integrated samples from five to seven verticals. No coefficients were applied as the three regular samples showed virtually no change with any discharge measurement.

Sediment-discharge computations.--The mean daily concentrations obtained at the station were plotted on a print of the gage-height chart and a smooth concentration curve drawn on a basin of the points. Daily mean concentrations were computed from the average of the cross-section sample. Daily sediment discharge was computed by multiplying product of adjusted daily mean discharge and mean concentration by factor 0.0027. On 7 days of rapidly changing water discharge and concentration the graphs were subdivided and total sediment discharge for the day was computed by summing the sediment discharge for appropriate intervals of the day.

Size analysis.--Thirty-three particle-size analyses were made on samples taken at this station during the year, of which 25 were tabulated for publication. The sample for April 10 was analyzed five times in different ways and at different concentrations. The bottom withdrawal results were unsatisfactory and only one decantation was listed for this date. Three bed material samples were taken August 12, September 10, and September 20. Analyses were made, but the data were not listed.

Page 1 of 2

Chemical quality methods.--The midsection samples collected at this station are considered to give a representation of quality as there is no inflow immediately above the station. The stream is quite uniform in composition both in depth and width as reflected in three sets of cross-section samples taken throughout the year. Conductance was run on all daily samples prior to compositing. Composite samples are made by discharge-weighted method. Composite analyses during the year are equivalent to a 1.1 adjusted complete analysis.

Remarks.--Sediment records at this station are considered fair during the year except during the period of December and January when many samples were missing and it was necessary to estimate sediment discharge guided by discharge variations or by interpolation. The records during those 2 months are considered poor. At times the observer was unable to make more than one trip a day though his instructions were to obtain two sets of samples. This station is on a regulated stream below El Vado Reservoir and all sediment originated downstream from this reservoir. The channel is sandy, but banks are fairly stable. No diversions or tributary inflow for several miles upstream from sampling site. The chemical quality was quite uniform throughout the year because of leveling effects of the reservoir.

Published and unpublished data for the 1960 water year are on file at the Albuquerque office.

John Doe
December 12, 1960

Page 2 of 2

Figure 41.—Station analysis (chemical quality and sediment) showing format and content.

SACRAMENTO RIVER BASIN

11-4525.00 CACHE CREEK AT YOLO, CALIF.

STATION ANALYSIS
(Sediment)
1959 Water Year

Equipment.--A U.S. D-49 sediment sampler is stored at the station and used from the cable provided for stream measuring. A Stevens A-35 water-stage recorder is located on the left bank upstream from U.S. Highway 99W bridge.

Sampling frequency.--Samples were collected once a day during low flow and two or more times a day on most days of discharge. All samples were depth integrated and were collected with a D-49 or USDH-48 sampler. The collection of samples and records maintained by the observer, Herman Gonzales, was fair to poor. Water-temperature observations were generally made at the time sediment samples were collected.

Concentration graph.--Most of the suspended-sediment samples consisted of three bottles, each taken at a separate vertical in the stream cross section. The samples were analyzed separately to facilitate comparison. If any one bottle seemed to be considerably different, more weight was given to the ones that seemed more reasonable. In most cases the individual bottles agreed fairly well with each other. All concentrations were plotted on a print of the gage-height graph, and a smooth graph was drawn on the basis of the plotted concentrations. The two major rises were sampled often enough to define adequately the concentration curve.

Suspended-sediment discharge computation.--The suspended-sediment discharge, in tons per day, was computed from the daily mean water discharge as determined at the stream-gaging station and the daily mean sediment concentration as determined at the sediment-measuring station. On days of rapidly changing flow conditions the graphs were subdivided and the total suspended-sediment discharge for the day was computed by averaging the suspended-sediment discharge for appropriate small intervals of the day. Streamflow data were furnished by the Sacramento Surface Water area office.

Particle size.--Twelve samples were analyzed for particle size resulting in 12 observations of particle-size gradation in the sand, silt, and clay range. The samples ranged in concentration from 12 to 7,970 ppm and water discharge from 122 to 14,000 cfs. Average results of the analyses show 16 percent of the material transported to be coarser than 62 microns and 41 percent to be finer than 4 microns. All particle-size analyses in the silt-clay range were made using distilled water, with a dispersing agent added, as the settling medium.

Remarks.--Suspended-sediment records for the year are considered fair. Water discharge records for the year are considered good. The streambed at the station is composed of sand, gravel, and cobblestones. The stream is leveed and has stable banks. Station is located on an intermittent stream.

Harry Mudboy
July 25, 1960

Figure 42.—Station analysis (sediment) showing format and content.

SACRAMENTO RIVER BASIN

11-3820. THOMES CREEK AT PASKENTA, CALIF.

LOCATION (revised).--Lat 39°52'57", long 122°33'03", in SW¼NW¼ sec.4, T.23 N., R.6 W., Tehama County, at gaging station 0.25 mile upstream from Digger Creek, and 0.3 mile upstream from highway bridge at Paskenta.
DRAINAGE AREA.--194 sq mi.
RECORDS AVAILABLE.--Chemical analyses: October 1958 to September 1967.
Water temperatures: October 1961 to September 1967.
Sediment records: October 1962 to September 1967.
EXTREMES, 1966-67.--Water temperatures: Maximum, 94°F Aug. 18, 23; minimum, freezing point Dec. 27, 28, Jan. 6.
Sediment concentrations: Maximum daily, 16,100 ppm Jan. 29; minimum daily, 1 ppm on several days.

CHEMICAL ANALYSES IN MILLIGRAMS PER LITER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	DIS-CHARGE (CFS)	SILICA (SIO2)	DIS-SOLVED IRON (FE)	CAL-CIUM (CA)	MAG-NE-SIUM (MG)	SODIUM (NA)	PO-TAS-SIUM (K)	BICAR-BONATE (HCO3)	CAR-BONATE (CO3)	SULFATE (SO4)	CHLO-RIDE (CL)
OCT.											
28...	2.2	19	.01	20	1.3	6.5	1.1	74	0	5.0	2.7
MAR.											
15...	3.1	18	.00	19	1.5	6.2	.7	70	0	7.0	1.9
APR.											
16...	7.2	18	--	18	1.5	6.1	.8	65	0	7.0	1.9
JUNE											
20...	8.8	20	--	11	1.0	4.8	.5	47	0	4.0	1.2
JULY											
23...	2.4	3.4	--	1.3	.1	1.1	.2	5	0	2.0	1.0
AUG.											
15...	3.1	--	--	--	--	--	--	--	--	--	--
SEPT.											
12...	1.2	21	--	18	1.5	6.8	.9	72	0	7.0	1.3

SACRAMENTO RIVER BASIN

11-3820. THOMES CREEK AT PASKENTA, CALIF.--Continued

EXTREMES, 1966-67--Continued
Sediment loads: Maximum daily, 273,000 tons Jan. 29; minimum daily, less than 0.05 ton on many days.
EXTREMES, 1961-67.--Water temperatures: Maximum, 94°F Aug. 18, 23, 1967; minimum, freezing point on several days in December and January of most years.
Sediment concentrations (1962-67): Maximum daily, 57,900 ppm Dec. 22, 1964; minimum daily, no flow Oct. 4, 1964.
Sediment loads (1962-67): Maximum daily, 5,070,000 tons Dec. 22, 1964; minimum daily, 0 ton Oct. 4, 1964.
REMARKS.--Clock stopped Apr. 14-12; temperature range, 38°F to 53°F.

CHEMICAL ANALYSES IN MILLIGRAMS PER LITER, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DATE	FLUO-RIDE (F)	NITRATE (NO3)	BORON (B)	DIS-SOLVED SOLIDS (RESI-DUE AT 180 C)	DIS-SOLVED SOLIDS (TONS PER AC-FT)	DIS-SOLVED SOLIDS (TONS PER DAY)	HARD-NESS (CA,MG)	NON-CAR-BONATE HARD-NESS	SODIUM AD-SORP-TION RATIO	SPECI-FIC COND-UCTANCE (MICRO-MHOS)	PH
OCT.											
28...	.2	.0	.02	97	.13	.58	56	0	.4	134	7.6
MAR.											
15...	.2	.1	.00	--	.12	.74	54	0	.4	137	7.9
APR.											
16...	.2	.4	.07	--	.12	1.67	51	0	.4	126	7.7
JUNE											
20...	.1	.1	.00	--	.09	1.57	32	0	.4	92	7.4
JULY											
23...	.0	--	.00	--	.01	.07	4	0	.3	14	6.4
AUG.											
15...	--	.0	--	--	--	--	--	--	--	--	--
SEPT.											
12...	.1	.5	.00	--	.13	.30	51	0	.4	133	7.5

Figure 43.—Heading and chemical-quality tabulation in annual water-quality-data report. (Heading and tabulation are on two pages that are published face to face or back to back.)

SACRAMENTO RIVER BASIN

11-3820. THOMES CREEK AT PASKENTA, CALIF.

LOCATION ~~(revised)~~.--Lat 39°52'57", long 122°33'03", in SW¼NW¼ sec.4, T.23 N., R.6 W., Tehama County, at gaging station 0.25 mile upstream from Digger Creek, and 0.3 mile upstream from highway bridge at Paskenta.

DRAINAGE AREA.--194 sq mi.

RECORDS AVAILABLE.--Chemical analyses: October 1958 to September ~~1967~~ 1968.

Water temperatures: October 1961 to September ~~1967~~ 1968.

Sediment records: October 1962 to September ~~1967~~ 1968.

EXTREMES, ~~1966-67~~ 1967-68.--Water temperatures: Maximum, ~~94°F~~ 30°C Aug. ~~18~~ 31, ~~28~~; minimum, freezing point on several days during December and January. ~~Dec. 27, 28, Jan. 6~~.

Sediment concentrations: Maximum daily, ~~16,100 ppm~~ 10,700 mg/l Jan. ~~20~~ 14; minimum daily, 1 ~~ppm~~ mg/l on ~~several~~ many days.

Sediment loads: Maximum daily, ~~272,000~~ 149,000 tons Jan. 29; minimum daily, ~~less than 0.05~~ 0.01 ton on ~~many~~ several days.

EXTREMES, 1961-~~67~~ 68.--Water temperatures: Maximum, ~~94°F~~ 34°C Aug. 18, 23, 1967; minimum, freezing point on several days in December and January of most years.

Sediment concentrations (1962-~~67~~ 68): Maximum daily, ~~67,000 ppm~~ 60,200 mg/l Dec. 22, 1964; minimum daily, no flow Oct. 4, 1964.

Sediment loads (1962-~~67~~ 68): Maximum daily, 5,070,000 tons Dec. 22, 1964; minimum daily, 0 ton Oct. 4, 1964.

REMARKS.--~~Clock stopped Apr. 14-12; temperature range, 38°F to 53°F.~~ Chemical-quality records furnished by California Department of Water Resources. Where no maximum or minimum is shown, temperature is once-daily observation.

(make updating in red)

Figure 44.—Updated station heading.

location during the water year, water temperatures, sampling procedures, and reference to discharge records if (1) sampling site and gaging stations were at different locations or (2) discharge records were furnished by other agencies. Reference may also be made to upstream factors affecting water and sediment movement and to periods of affected or estimated record.

Periodic Observations

Sediment samples are obtained at some stations on a periodic or infrequent basis, and at a few stations, samples are obtained monthly or more frequently during the periods of storm runoff. Data obtained on an infrequent basis that cannot be used to compute daily sediment-discharge records as described in the procedure used for daily stations are tabulated on form 9-1539D as illustrated in figure 45.

Periodic observations of suspended-sediment discharge are published as daily suspended sediment, illustrated in figure 30, or as instantaneous suspended sediment, illustrated in figure 31. They also may be combined with particle-size distribution and published as illustrated in figure 34.

The data for periodic observations may be tabulated on form 9-265b in the same format as that for particle-size distribution shown in figure 2 and described in the section on "Tabulation of Size Data."

Footnotes used for periodic tabulations are standard and are the same as those used for daily tabulations. (See section on "Footnotes.") Periodic or miscellaneous concentration and particle-size data are tabulated on form 9-1593D as described in the section on "Tabulation of Size Data" (fig. 2).

Checklist for periodic records

A checklist for tabulation of periodic samples follows. The editorial rules and computation procedures are the same as those described for the similar step for daily stations.

1. Size analysis: Compute and review for proper procedures and accuracy.
2. Concentration notes: Compute and evaluate for validity and sampling technique.

Form 9-1539D (10-69)

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION
Coding Form for Instantaneous Suspended Sediment and Particle Size

Type: 1 | Station ident number: 0 0 0 0 0 0 0 0 (1, 2 ... 9) | Stream and location: Sample Creek near Somewhere, U.S.A.

Methods of analysis (74-77): B, bottom withdrawal tube; C, chemically dispersed; D, decantation; N, in native water; P, pipet; S, sieve, W, in distilled water; V, visual accumulation tube.
Please do not punch the decimal point unless data appears in the field.

Date Yr	Date Mo	Date Day	Time (24 hour)	Temperature (°C)	Discharge (cfs)	Susp. sediment concentration (mg/l)	Particle size, percent finer (in millimeters) than size indicated 0.002	0.004	0.008	0.016	0.031	0.062	0.125	0.250	0.500	1.000	2.000	Method of analysis
10 11	12 13	14 15	16 17 18 19	20 21 22 23	24 25 26 27 28 29 30 31 32 33	34 35 36 37 38 39 40	41 42 43	44 45 46	47 48 49	50 51 52	53 54 55	56 57 58	59 60 61	62 63 64	65 66 67	68 69 70	71 72 73	74 75 76 77
69	10	11	1520	14.5	170.	95						70	74	77	96	100		S
	12	11	1400	4.0	142.	10						--	--	--	--	--	--	--
70	01	15	1000	.5	108.	12						--	--	--	--	--	--	--
	02	19	1440	7.0	224	14						--	--	--	--	--	--	--
	03	30	1105	6.0	995.	412	23	28	39	48	63	71	89	96	99	100		VPWC
	05	18	1300	11.0	595.	31						60	74	91	100			S
	07	16	1320	29.0	20.	39						--	--	--	--	--	--	--

Compiled by JP Date 10/9/70 Checked by RDB Date 10/12/70
Punched by ______ Date ______ Verified by ______ Date ______

Figure 45.—Tabulation of periodic sediment data.

3. Particle-size analyses: Compile in chronological order on form similar to that illustrated in figure 45.
4. Water discharge:
   (a) Report water discharge for time each sample was collected if instantaneous values are published (figs. 31-35).
   (b) Report daily mean discharge if daily mean concentrations are published (figs. 29, 30).
5. Sediment discharge: Compute sediment discharge, in tons per day. Sediment discharge is equal to water discharge, in cubic feet per second, × sediment concentration, in milligrams per liter, × 0.0027. Sediment discharge is not computed if data are punched for computer processing.
6. Review for editorial and technical correctness.
7. Station description heading is not prepared for periodic records.

Combined periodic and seasonal observations

A sediment record for a station where sediment samples were collected on a periodic basis for part of the year and on a daily or more frequent basis for the remainder of the year may be compiled in two parts. This type of record may occur because of a change in station operation or because of seasonal effect on the stream discharge and sediment concentration. The periodic part of the record consists of a tabulation of samples which are collected infrequently during routine visits and which do not provide sufficient information for computation of daily sediment discharge. These samples are combined with particle-size data on the form illustrated in figure 45.

The second part of the record consists of daily discharges computed by the same procedures described previously, and the sediment-discharge worksheet (fig. 38) is completed for as many complete, consecutive months as data are available. A station description and an analysis are prepared as described for computation of records for daily stations.

Transmittal of Completed Data

The completed compilation of water-quality data includes the following items:

1. Station heading (fig. 44).
2. Chemical analyses (fig. 43).
3. Temperature tabulation (figs. 3, 4).
4. Sediment discharge:
   - Daily records (fig. 38).
   - Periodic records (fig. 45).
5. Particle-size distribution of suspended sediment (fig. 2).
6. Particle-size distribution of bed material (fig. 35).

Each originating office should forward the records for which they are responsible through appropriate channels to be reviewed, consolidated, and forwarded to the records center for processing. Each record submitted for publication should be designated as to publication format desired (figs. 29-35).

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