CHAPTER 15—COMPUTATION OF DISCHARGE RECORDS

GENERAL

Streamflow records for each gaging station are computed and published annually. The 12-month period used, which is known as the water year, usually does not coincide with the calendar year. In the U.S.A. the water year runs from October 1 to September 30 and is designated by the calendar year of the last 9 months—for example, the 1975 water year runs from October 1, 1974 to September 30, 1975. The following considerations govern the choice of the 12 months that will constitute the water year. The 12-month record is essentially an inventory of the water supply. As with any inventory, it should be made when the stock on hand (available water resource) is at a minimum. That is the case in most of the U.S.A. on September 30, at which time the growing season is at an end. Not only are groundwater, soil-moisture, and surface storage at or near a minimum on that date as a result of heavy water use during the preceding summer, but the replenishing rains of autumn have not yet begun and streamflow is also near minimal. In short, the 12-month period to be used as the water year is determined by the climatic regime of the region.

A daily record of discharge, along with momentary values of peak discharge and minimum flow, is computed for the water year from the record of stage and the discharge rating for the gaging station. The type of stage recorder used determines whether the computations are performed manually or by an electronic computer. In either system, the engineer must study the data and prepare what is termed a station analysis before the actual computation of discharge is begun.

STATION ANALYSIS

A station analysis, which documents the results of the study of the data, is prepared for each station for each water year. The study includes the following items, all of which are needed as a preliminary to computing the discharge record.

1. A review of field surveys of gage datum and a determination of the datum corrections, if any, to be applied to stage observations or recordings during the year.
2. A listing and review of discharge-measurement notes
3. An analysis of the discharge rating and the determination of the rating (or shift) applicable during each period of the year.
4. The preparation of tables that express the discharge rating, using the rating curves derived in the above item 3.

Documentation of items in the station analysis is made as the various steps in the analysis and computation of the discharge record are completed. The station-analysis document is described in detail later in this chapter after all items in the analysis and computation of discharge have been discussed. Examples of the methods of analysis and computation are interspersed in the discussions of methodology for illustrative purposes.

DATUM CORRECTIONS

The datum of the gaging station is the elevation of the zero point of the base or reference gage, preferably referred to mean sea level. (For a discussion of reference and auxiliary gages see the section so-titled in chapter 4. The base gage or reference gage is the gage to which the recording instrument is set; at a nonrecording station it is the gage whose daily readings are recorded by the observer.) Levels are run periodically to all bench marks, reference marks, reference points, and gages at each station for the purpose of determining if any datum changes have occurred as a result of settlement or other movement of any of the gages or of the bubble orifice. If significant movement is indicated by the levels, the gage or bubble orifice is reset to its original datum.

Figure 261 is a typical set of level notes obtained in checking the datum of a recording stage-gage of the float-sensor type; the base gage is a vertical staff gage in the stilling well immediately below a reference point (RP1). Where a vertical staff gage consists of a number of standard USGS porcelain-enameled gage plates, each 3.4 ft long, the elevation of one of the central graduations on each plate should be checked. This is usually done by measuring to each plate with a steel tape whose zero end is held at a reference point of known elevation; the reference point, as mentioned, is established directly above the staff gage. The level notes in figure 261 for the inside staff gage (IG) show that the above procedure was followed.

The level notes are checked in the field for mathematical errors before the field party leaves the gaging station.

If a change in datum has occurred, it is necessary to determine the effective date of the change. In the absence of any evidence indicating the date when the datum change occurred, the change is assumed to have occurred gradually from the time the last levels were run, and the change is prorated with time. On the station-analysis document there would be entered the date(s) when levels were run, the period(s) and magnitude(s) of the datum correction(s) required, and the date and time when the original datum was restored to eliminate the need for corrections. If no datum corrections were required, as indicated, for example, in the level notes of figure 261, that fact would be entered in the station–analysis document.

File No. 10-2450

LEVEL NOTES
(First sheet, to be completed in the field)

Station Clear Creek near Utopia, Calif.

Date Oct 6, 1965 Party Patch π Sweet φ

Date level adjusted: Oct 6, 1965

Object of these levels:

To check gage datum

Conclusions

Elevations of RM's and RP checked within 0 002 ft.
Outside staff-gage datum checked within 0 01 ft.
Inside staff-gage datum checked within 0.003 ft

Changes made:
To inside staff gage, out staff gage, tape gage, or R.M.'s.
No changes required; none made.

Remarks

Data to be added to, or changed on, Station Description (9-197) as a result of these levels.
No changes or additions to be made.

Sheet No. 1 of 2 sheets. S.F. 2-45

9-276 (Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number 10-2450

LEVEL NOTES

Stream Clear Creek
Locality near Utopia, Calif
Party Patch π Sweet φ Date Oct 6, 1965

STATION	B S	HT INST	F S.	ELEVATION	REMARKS
RM 1				11.142	Given
RM 2				20.142	Given
RP 1				19.870	Given
RM 2	1.510	21 652		20 142	Bronze tablet, 40' DS
RP 1			1.781	19.871	Head of brass screw
RM 1	10.746	21.889	10.509	11 143	Bronze tablet, 20' DS
RP 1			2 017	19 872	
RM 2			1 746	20.143	
Levels to outside staff					
RM 1	0 657	11 799		11 142	
OG			10.19	1 61	1.60 ft graduation
OG			3 79	8 01	8 00 ft. "
OG			(-3 20)	15.00	15 00 ft "
Levels to inside staff - measured by steel tape from RP					
RP 1	0.000	19.870		19 870	
IG			18 268	1 602	1 60 ft. graduation
IG			14 869	5 001	5.00 " "
IG			11.572	8.298	8.30 " "
IG			8.271	11 599	11.00 " "
IG			4.873	14.997	15.00 " "
W.S. in well			18.850	1 020	Gage read 1.02

No. 2 of 2 sheets Comp. by MAP Chk. by GS

U S GOVERNMENT PRINTING OFFICE 1959 O—514175 895-172

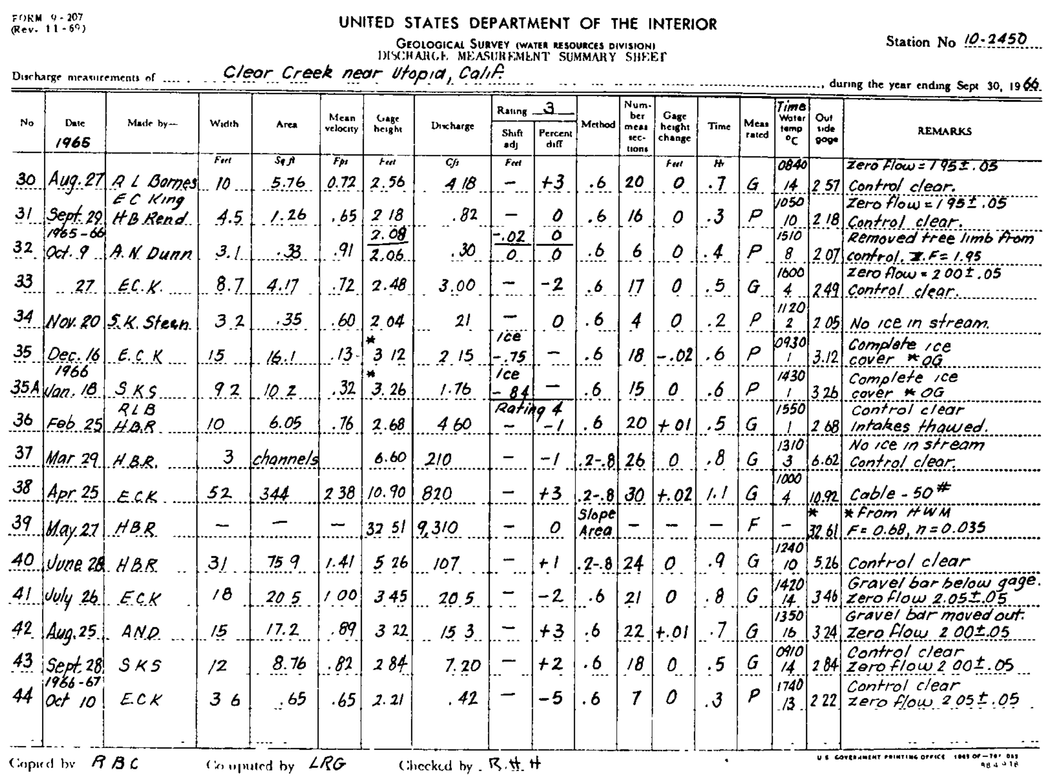
FIGURE 261.—Level notes for check of gage datum.

REVIEW OF DISCHARGE MEASUREMENTS

The first step in the review of discharge measurements is to check the mathematics of the measurements. It is usually considered expedient, however, to accept, without checking, the results of a discharge measurement made by an experienced hydrographer if the measurement checks the rating curve within ±5 percent and if the measured discharge does not exceed all previously measured discharges. The discharge measurements (fig. 42), including indirect determinations of discharge (chap. 9), are then arranged in chronological order and numbered consecutively. The measurements are next compared with the gage-height record to ensure that all discharge measurements are at hand—the inspection notes on the stage record should indicate whether or not a discharge measurement had been made—and also to check the gage heights shown on the measurement sheet. If a datum correction is applicable, it is applied to the mean gage height for the measurement.

The measurements are then tabulated on a special form (USGS form 9-207 in fig. 262). Most of the column headings in figure 262 are self-explanatory. Those on the right half of the table supply information that is helpful to the analyst in appraising the comparative accuracy of the discharge measurements, in case he should find it necessary to give more weight to one measurement than to another in developing the discharge rating. The hydrographer's field appraisal of the probable accuracy of his measurement is shown in the column headed "Meas. rated," where E is excellent, G is good, F is fair, and P is poor. For example, measurements nos. 31, 32, 34–35A, and 44 are rated "poor" because the depths were too shallow or the velocities too low to obtain reliable discharges. In addition, only a few sections (verticals) were used for measurement nos. 32, 34, and 44. The gage-height change during the time required for the measurement is also listed because a rapidly changing stage would adversely affect the adequacy of the measurement. The outside gage reading is listed to provide the analyst with information as to whether or not the gage-well intakes were functioning properly. (Small differences between the readings of the base gage and of the outside auxiliary gage are often the norm because of the difference in location between intakes and outside gage.) The two columns headed "Rating. . . ." are discussed in the section titled, "Rating-Curve Analysis."

The "Remarks" column is most important to the analyst. If a measurement was made by any means other than wading, the method and the sounding weight used are indicated. Measurements made from a bridge or cableway are directly comparable for studying changes in the measurement cross section because the same cross section is used for all discharge measurements. With regard to noting the



FORM 9-207
(Rev. 11-69)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)
DISCHARGE MEASUREMENT SUMMARY SHEET

Station No 10-2450

Discharge measurements of Clear Creek near Utopia, Calif. during the year ending Sept 30, 1966.

No	Date 1965	Made by—	Width	Area	Mean velocity	Gage height	Discharge	Rating 3: Shift adj	Rating 3: Percent diff	Method	Number meas sections	Gage height change	Time	Meas rated	Time / Water temp °C	Out side gage	REMARKS
			Feet	Sq ft	Fps	Feet	Cfs	Feet				Feet	Hr				
30	Aug. 27	A L Barnes E C King	10	5.76	0.72	2.56	4.18	—	+3	.6	20	0	.7	G	0840 14	2.57	Zero flow = 1.95 ± .05 Control clear.
31	Sept. 29	H B Rend	4.5	1.26	.65	2.18	.82	—	0	.6	16	0	.3	P	1050 10	2.18	Zero flow = 1.95 ± .05 Control clear.
32	1965-66 Oct. 9	A. N. Dunn	3.1	.33	.91	2.08 2.06	.30	-.02 0	0 0	.6	6	0	.4	P	1510 8	2.07	Removed tree limb from control. *F = 1.95
33	27	E.C.K.	8.7	4.17	.72	2.48	3.00	—	-2	.6	17	0	.5	G	1600 4	2.49	Zero flow = 2.00 ± .05 Control clear.
34	Nov. 20	S.K. Steen	3.2	.35	.60	2.04	.21	—	0	.6	4	0	.2	P	1120 2	2.05	No ice in stream.
35	Dec. 16	E.C.K	15	16.1	.13	*3.12	2.15	Ice -.75	—	.6	18	-.02	.6	P	0930 1	3.12	Complete ice cover *OG
35A	1966 Jan. 18	S K S	9.2	10.2	.32	*3.26	1.76	Ice -.84	—	.6	15	0	.6	P	1430 1	3.26	Complete ice cover *OG
36	Feb. 25	R L B H B R	10	6.05	.76	2.68	4.60	Rating 4 —	-1	.6	20	+.01	.5	G	1550 1	2.68	Control clear Intakes thawed.
37	Mar. 29	H.B.R.	3	channels		6.60	210	—	-1	.2-.8	26	0	.8	G	1310 3	6.62	No ice in stream Control clear.
38	Apr. 25	E.C.K	52	344	2.38	10.90	820	—	+3	.2-.8	30	+.02	1.1	G	1000 4	10.92	Cable - 50#
39	May 27	H.B.R	—	—	—	32.51	9,310	—	0	Slope Area	—	—	—	F	—	* 32.61	*From HWM F = 0.68, n = 0.035
40	June 28	H.B.R	31	75.9	1.41	5.26	107	—	+1	.2-.8	24	0	.9	G	1240 10	5.26	Control clear
41	July 26	E.C.K	18	20.5	1.00	3.45	20.5	—	-2	.6	21	0	.8	G	1420 14	3.46	Gravel bar below gage. Zero flow 2.05 ± .05
42	Aug. 25	A.N.D.	15	17.2	.89	3.22	15.3	—	+3	.6	22	+.01	.7	G	1350 16	3.24	Gravel bar moved out. Zero flow 2.00 ± .05
43	Sept. 28	S K S	12	8.76	.82	2.84	7.20	—	+2	.6	18	0	.5	G	0910 14	2.84	Control clear Zero flow 2.00 ± .05
44	1966-67 Oct 10	E.C.K	3.6	.65	.65	2.21	.42	—	-5	.6	7	0	.3	P	1740 13	2.22	Control clear zero flow 2.05 ± .05

Copied by R B C Computed by LRG Checked by R.H.H.

FIGURE 262.—List of discharge measurements.

sounding-weight size, the measured discharge tends to be greater than the true discharge if too light a weight is used in high-velocity flow because depth soundings tend to be erroneously high and the meter also tends to rise to a higher (and faster) level than intended when positioned at the desired depth for a velocity observation.

The condition of the control—whether clear, ice-covered, or debris-covered—is also noted in the "Remarks" column, along with the gage height of zero flow on the control at the time of low-flow measurements. (Zero flow equals gage-height minus depth of water over the lowest point on the control.) The stability of the rating is dependent on control conditions; the elevation of zero flow is highly important for extrapolating the low-water end of the rating.

In the case of an indirect discharge determination (no. 39), the gage-height of the outside high-water mark is noted in the "Remarks" column, along with the Froude number and roughness coefficient. The equation for computing the Froude number (F) is $F=V/\sqrt{gd}$, where V is mean velocity in the measurement section, g is the acceleration of gravity, and d is mean depth in the measurement section; d is computed by dividing the area of the measurement section by its width. A Froude number close to unity casts some doubt on the indirect determination because it indicates the probability of unstable flow conditions. As for the roughness coefficient, more reliability is generally attached to indirect determinations for smooth channels (low roughness coefficient) than to such measurements for rough channels (high roughness coefficient).

If the gaging station is on an intermittent stream—one that goes dry for periods during the year—the list of discharge measurements should also list chronologically the dates when the hydrographer actually observed that there was no flow in the stream.

STATION RATING—SIMPLE STAGE-DISCHARGE RELATION

The rating curve for a gaging station is a graphical depiction of the relation between stage and discharge. Additional parameters such as fall or velocity index may be required in the rating (see section titled, "Stage Rating—Three-Parameter Discharge Relation"), but this section of the manual deals only with simple stage-discharge relations. Each station rating curve presents individual problems based on the control characteristics for the station, a knowledge of which is a prerequisite for the rating analysis. The principles underlying simple stage-discharge relations were discussed in chapter 10; this section deals only with the mechanics of computing and preparing the station rating.

PLOTTING OF DISCHARGE MEASUREMENTS

Rating curves and discharge measurements should be plotted on logarithmic graph paper, and it is often advantageous to have an additional plot of the low-flow data on rectangular-coordinate graph paper so that the point of zero flow may be plotted. If a new station is being analyzed, the scales selected should be such as to accommodate the ranges of stage and discharge that are expected. If the station is not new, all measurements made since the analysis of the preceding year should be plotted on the prints of the last-used rating curve. Each plotted measurement is tagged with its identifying number, and if the "Remarks" column of the list of measurements indicates that a measurement was made under altered control conditions, that fact should be temporarily indicated alongside the measurement number. Measurements that are affected by ice (nos. 35 and 35A in fig. 262) are not plotted because they serve no purpose in defining the rating. (The use of ice-affected discharge measurements is discussed in the section titled "Rating-Curve Analysis" that follows.) The measurements listed in figure 262 are plotted on the logarithmic rating-curve sheet used during the preceding year (fig. 263). In actual practice, the rating-curve sheet that is used is large enough to accommodate both parts of the plot shown in figure 263. In figure 264, the low-water discharge measurements have been replotted on rectangular-coordinate graph paper that bears a copy of the last-used discharge rating. Logarithmic rating-curve sheets have been designed with a rectangular-coordinate scale in one corner, thereby permitting both logarithmic and rectangular plotting on the same sheet.

RATING-CURVE ANALYSIS

The principles involved in simple stage-discharge relations (chap. 10) are used in analyzing the rating. After reviewing and plotting the discharge measurements, the analyst must determine whether the last-used rating is applicable for part or all of the water year. To do that, he computes percentage departures of his measured discharges from the discharges for the measurement stages, as indicated by the last-used rating table (rating no. 3 on figs. 263 and 264). The percentages are tabulated on the list of discharge measurements (fig. 262). As long as the departures are random in sign (plus and minus) and within ±5 percent, the last-used rating is kept in effect. Aside from the two ice-affected measurements, nos. 35 and 35A, all measurements above a stage of 3.00 ft closely check rating no. 3. Sometime between measurements no. 35A (January 18) and no. 36 (February 25), the ice in Clear Creek went out. When the ice went out, it apparently moved bed material which built up the lower part of the low-water control by about 0.06 ft; the build-up is evident from the change in zero-flow elevation (see "Remarks" column of fig. 262) and from the plotting of the measurements on the low-water curves of figures 263 and 264. Inspection of the gage-height chart indicates that the ice

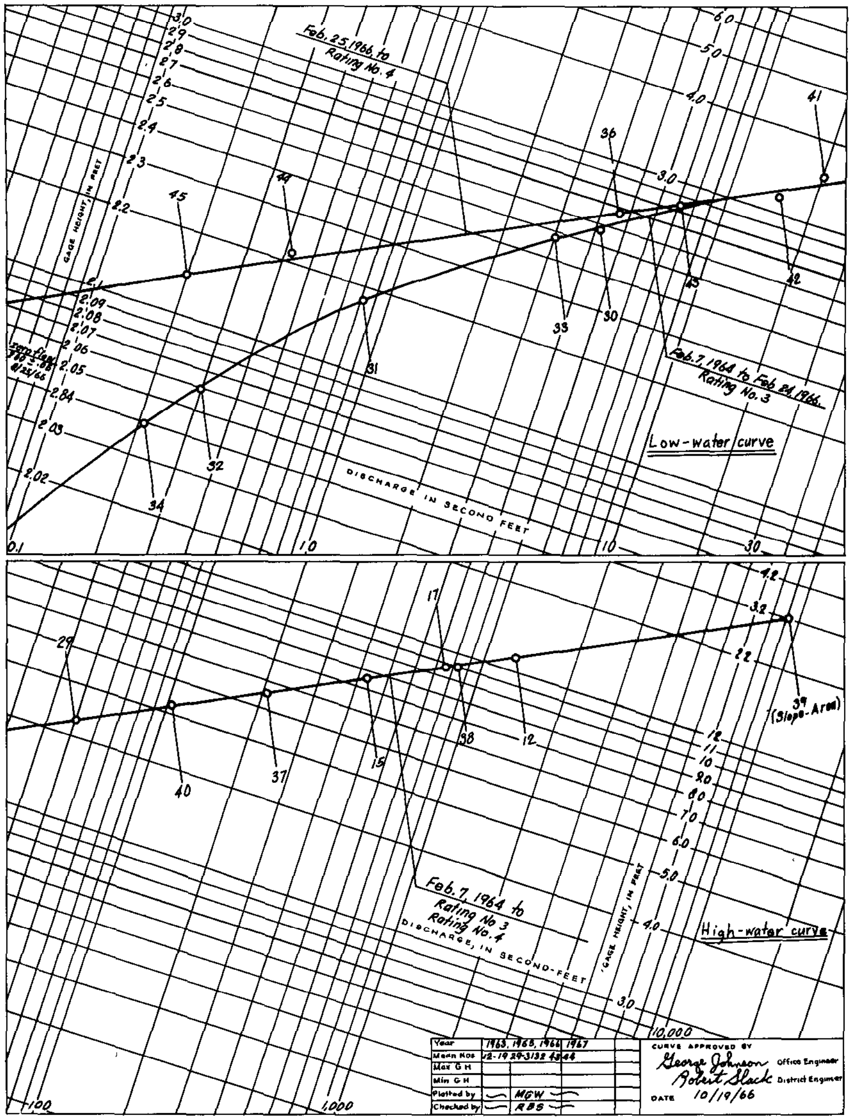


FIGURE 263.—Logarithmic plot of rating curve.

probably went out on a small rise in stage on February 24. Consequently a new rating curve (rating no. 4), based on measurements made after February 24, was developed for use starting February 25. Rating no. 4 is identical with rating no. 3 above a stage of 3.00 ft. One would expect the rating to change as a result of the major peak of May 27 (meas. no. 39), but no such change was evident from subsequent discharge measurements.

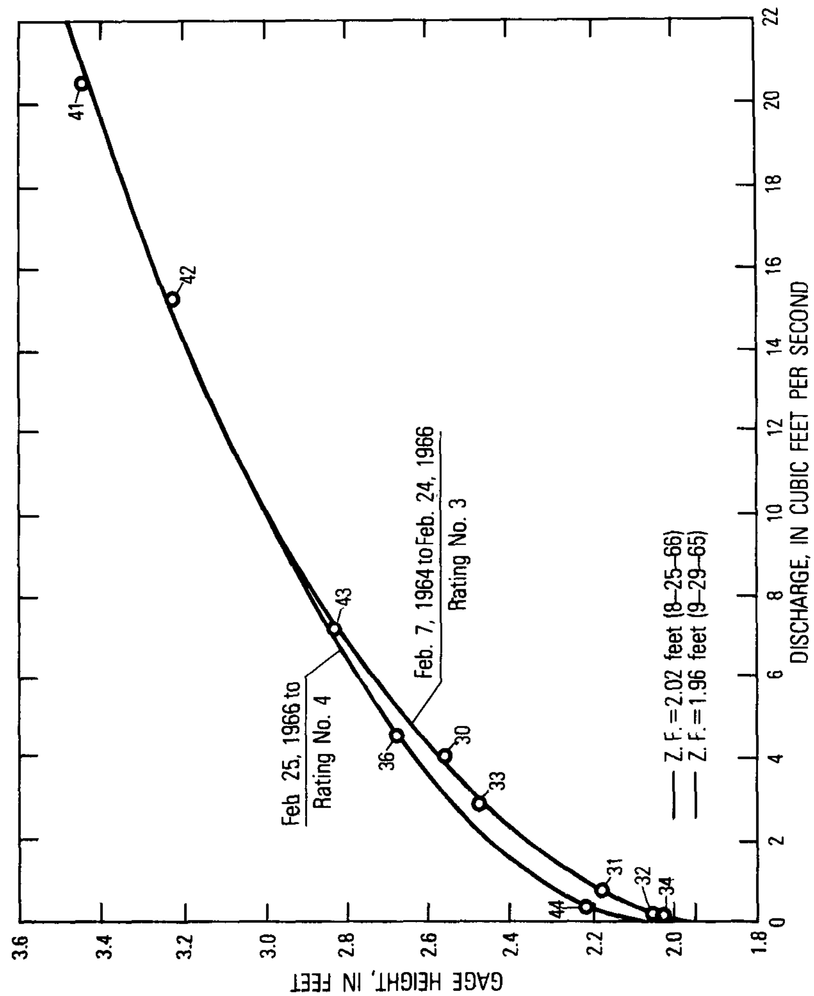


FIGURE 264.—Rectangular plot of low-water rating curve.

When discharge measurements depart from the rating curve by more than 5 percent, but the indicated change in rating is short-lived—less than a month or two—it is common practice not to establish a new rating curve, as such, for the short period. Instead, gage-height shifts (adjustments) are applied either to the rating in use prior to the period of shifting control or to a new rating, if one is later needed, that is established for use starting with the period of shifting control. (Shifts are discussed in detail in the section in chapter 10 titled, "Shifts in the Discharge Rating.") In our example for Clear Creek, aside from the period of ice effect shown by measurements nos. 35 and 35A, only one period of shifting control is in evidence. When the hydrographer visited the station on October 9, he found a heavy tree limb lodged on part of the control. He made his discharge measurement (no. 32) and then removed the limb. That is the proper sequence; had he removed the tree limb before the measurement, his results would be misleading unless he waited long enough for the surcharge storage to drain from the pool so that the stage and discharge became stabilized at the lower stage. That may take an hour or more, but if the measurement is made first, the drop in stage after removing the obstruction can be read later from the stage graph or punched tape. To get back to measurement no. 32, the stage dropped 0.02 ft after removal of the tree limb, and the measured discharge checked the rating curve at the lower gage height. The limb is believed to have lodged on the control on the recession following the minor rise of September 30. Consequently a shift of −0.02 ft is applied to all stages from October 1 to 1300h October 9 when the limb was removed. During that period 0.02 ft is subtracted from all recorded gage heights before obtaining the corresponding discharge from the rating table.

The period of rating shift that occurs as a result of ice effect is not classed as a period of shifting control because discharges are usually not computed by applying shifts to the gage-height record during an ice-affected period. The method of computing discharge for periods of ice effect is discussed in detail in chapter 10.

The basic rating curves to be used during the water year have now been defined and the next step is to transfer the ordinates of the rating curve to a rating table. That is done to refine the rating curve and to provide a more convenient way of obtaining the discharge corresponding to any given stage. The mechanics of preparing the rating table are described in the next section on "Rating Tables." At this point, we will assume that the rating table for rating no. 4 has been prepared, and the next task is to complete the forms that have been used up to now.

The first items to be considered are the two columns headed "Rating . . . ." in figure 262. A heavy line is drawn across the columns between the last measurement (no. 35A) for which rating no. 3 was used and the first measurement (no. 36) for which rating no. 4 was used, and above the latter measurement is inserted the heading "Rating 4." For measurement no. 32, the shift of −0.02 is inserted, as shown by the change in stage when the tree limb was removed from the control. Percentage differences are recomputed for measurements nos. 36–44, using discharges from rating table no. 4 as a base. The originally computed percentage differences for those measurements made at a stage greater than 3.00 ft will remain unchanged because the rating above the stage is unchanged. Shifts are computed and entered for the ice-affected measurements (nos. 35 and 35A), but no percentage differences are computed for ice-affected measurements because as mentioned earlier, shifting-control adjustments, as such, are not applied during the ice-affected periods. The shifts computed for ice-affected discharge measurements, therefore, are not an absolute requirement; they are shown solely for the purpose of giving the rating analyst a quick view of the magnitude of the backwater effect caused by ice. As an example of how shifts are computed, we consider measurement no. 35. The measured discharge of 2.15 ft^3/s corresponds to a gage height of 2.37 ft in rating table no. 3. The observed stage was 3.12 ft. The shift adjustment is −0.75 ft because that is the adjustment that must be applied to the observed stage (2.37 − 3.12) to obtain the stage corresponding to a discharge of 2.15 ft^3/s in rating table no. 3.

On figures 263 and 264 a closing date is added to rating curve no. 3. Rating curve no. 4 is replotted from the refined table for that rating—departures from the original plot of the rating should be very minor—and the new curve is tagged with its identifying number and the date on which it became effective.

To return to generalities about plotting discharge measurements and rating curves, the number of measurements and curves that have accumulated on a rating-curve sheet may in time be sufficient to clutter the sheet to the extent that the data are confusing. In that event a new rating curve should be drawn on a fresh sheet. Old high-water and extreme low-water measurements that are needed as supporting data for the new rating curve are transferred to the new curve sheet.

In the Clear Creek example that has been discussed, there was no need to extrapolate the rating curve. A slope-area determination of discharge had been made at the peak stage to define the high-water end of the curve, and current-meter discharge measurements defined the low-water end of the curve. Had extrapolation been required for either end of the curve, it would have been done by use of the methods discussed in the section in chapter 10 titled, "Extrapolation of Rating Curves."

RATING TABLES

The rating table is a tabular expression of the information that is graphically presented by the rating curve. A part of rating table no. 4 for the Clear Creek example is given in figures 265 and 266.

In preparing the rating table from the rating curve, it is important to transfer to the table the identifying number of the rating and its starting date or period of application. Then starting with the low-water curve, the discharge is read and tabulated at intervals of 0.1 ft of stage on the standard rating-table form (fig. 265). On reaching the stage where the rating curve is no longer strongly curvilinear, the discharge may be tabulated at intervals of 0.5 ft of stage, and when the curve becomes more linear, the discharge is tabulated at intervals of 1.0 ft or more. For those parts of the rating that are truly linear on a logarithmic plot, the discharge may be computed from the equation of the rating (chap. 10). The blank spaces in the discharge column of the rating curve are then filled with values that are interpolated between the discharges that were entered in the table.

Differences in discharge for each 0.1 foot of gage height are then computed and entered in the appropriate column of the rating table (fig. 265). The differences should increase uniformly with stage, but this will seldom result from the discharges first entered from the rating curve. It will be necessary to adjust the differences so that they do vary uniformly, which in turn will necessitate a recomputation of the discharge figures, starting with the lowest value whose difference has been adjusted. The adjustment of the rating table must be done judiciously so that the recomputed discharges do not depart significantly from the original rating curve values, particularly in the vicinity of the plotted discharge measurements. Because the rating curve usually has changes in slope, the variation of the difference values can seldom be perfectly uniform. The aim of the smoothing process is to eliminate abrupt changes in the progression of differences, because those abrupt changes would indicate sharp bends in the rating curve. The differences should never decrease with increasing stage unless there is an actual reversal in the shape of the rating curve. Such reversals can only occur where some impeding effect on the discharge (increased backwater) comes into play; for example, where an arch bridge is the high-water control, the increase in waterway area with stage slows and finally ceases at the stages where the archway becomes submerged.

If difficulty is encountered in smoothing the progression of difference values while still adhering to the rating curve, it is helpful to compute second differences, that is, the differences between the dif-

9-210
(Rev. 2-67)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 1 0 2 4 5 0 0 0
Table No. 0 4
Begin 6 6 0 2 2 5 0 0 (YR MO D HR)

Rating table for Clear Creek near Utopia, Calif.
from Feb. 25, 1966 to , from to , from to

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
2 00	0	Curvilinear	4 00	40	4	6 00	160	8	8 00	360	12	10 00	640	16	12 00	1,000	20	14 00	1430	25
10	.10		10	44		10	168	8	10	372		10	656	16	10	1,020		10	1455	
20	.40		20	48	4	20	176	9	20	384	12	20	672	17	20	1,040		20	1480	
30	.90		30	52	5	30	185		30	396	13	30	689		30	1,060		30	1505	
40	1.6		40	57		40	194		40	409		40	706		40	1,080		40	1530	
50	2.5	1.1	50	62	5	50	203		50	422		50	723		50	1,100		50	1555	
60	3.6	1.3	60	67	6	60	212		60	435	13	60	740		60	1,120		60	1580	
70	4.9	1.5	70	72		70	221	9	70	448	14	70	757	17	70	1,140		70	1605	
80	6.4	1.7	80	78		80	230	10	80	462		80	774	18	80	1,160		80	1630	
90	8.1	1.9	90	84		90	240		90	476		90	792		90	1,180		90	1655	
3 00	10.0	2.1	5 00	90		7 00	250		9 00	490		11 00	810		13 00	1,200		15 00	1680	
10	12.1	2.3	10	96		10	260		10	504		10	828		10	1,220		10	1705	
20	14.4	2.5	20	102	6	20	270	10	20	518	14	20	846	18	20	1,240		20	1730	
30	16.9	2.7	30	108	7	30	280	11	30	532	15	30	864	19	30	1,260	20	30	1755	25
40	19.6	2.9	40	115		40	291		40	547		40	883		40	1,280	25	40	1780	30
50	22.5	3.1	50	122		50	302		50	562		50	902		50	1,305		50	1810	
60	25.6	3.3	60	129	7	60	313	11	60	577	15	60	921	19	60	1,330		60	1840	
70	28.9	3.5	70	136	8	70	324	12	70	592	16	70	940	20	70	1,355		70	1870	
80	32.4	3.7	80	144		80	336		80	608		80	960		80	1,380		80	1900	
90	36.1	3.9	90	152	8	90	348	12	90	624	16	90	980	20	90	1,405	25	90	1930	30

This table is applicable for open channel conditions. It is based on 20 discharge measurements made during 1963, 65 and 66 water years and is well defined between 0 cfs and 1,500 cfs and extended to slope-area meas. at 9,300 cfs. Same as rating no. 3 above gage height 3.00 ft.

Comp by LRG date 10/18/67
Ckd by RHH date 10/18/67

U.S. GOVERNMENT PRINTING OFFICE 1967 OF—265-785

FIGURE 265.—Standard rating table.

9-210 b
(2-67)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta No 10245000
Table No 04
Begin 66 02 25 00 (YR MO D HR)

Rating table for Clear Creek near Utopia, Calif.
from Feb. 25, 1966 to . from to . from to

Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)	Gage height (Feet)	Discharge (Cfs)
2 00	0	2 20	0.40	40	1.60	60		80		00		20		40		60		80	
01	0	21	.44	41	1.68	61		81		01		21		41		61		81	
02	0	22	.48	42	1.76	62		82		02		22		42		62		82	
03	.01	23	.52	43	1.84	63		83		03		23		43		63		83	
04	.02	24	.56	44	1.92	64		84		04		24		44		64		84	
05	.03	25	.60	45	2.00	65		85		05		25		45		65		85	
06	.04	26	.66	46	2.10	66		86		06		26		46		66		86	
07	.05	27	.72	47	2.20	67		87		07		27		47		67		87	
08	.06	28	.78	48	2.30	68		88		08		28		48		68		88	
09	.08	29	.84	49	2.40	69		89		09		29		49		69		89	
2 10	.10	30	.90	50	2.50	70		90		10		30		50		70		90	
11	.12	31	.96	51		71		91		11		31		51		71		91	
12	.14	32	1.02	52		72		92		12		32		52		72		92	
13	.16	33	1.08	53		73		93		13		33		53		73		93	
14	.19	34	1.15	54		74		94		14		34		54		74		94	
15	.22	35	1.22	55		75		95		15		35		55		75		95	
16	.25	36	1.29	56		76		96		16		36		56		76		96	
17	.28	37	1.36	57		77		97		17		37		57		77		97	
18	.32	38	1.44	58		78		98		18		38		58		78		98	
19	.36	39	1.52	59		79		99		19		39		59		79		99	
	.40		1.60																

This table is applicable for open-channel conditions. It is based on 20 discharge measurements made during 1963, 65 and 66 water years and is well defined between 0 cfs and 9,300 cfs.

Comp by LRG date 10/18/67
Ckd by RHH date 10/18/67

GPO 1967 OF—269-764

FIGURE 266.—Expanded rating table.

ferences per tenth of a foot of stage. The second differences are then adjusted so that they form a uniform progression; second differences usually change quite slowly. After adjusting the second differences, the first differences are recomputed and finally the discharges are recomputed. As an aid in smoothing the second differences, it is often helpful to plot second differences against stage and then fit a smooth curve to the plotted points. It is highly desirable that a smooth rating table be obtained, but too great an effort to attain the ultimate in smoothness is unwarranted.

To obtain discharges from the rating table for gage heights that are expressed in hundredths of a foot, the discharges are computed by linear interpolation between the values shown for tenths of a foot of stage. Where sharp curvature occurs at the low-water end of the rating curve, such interpolation may be too crude. In that case the discharge for each hundredth of a foot of stage is picked from a large-scale plot of the low-water rating curve, and the discharge values are transferred to an expanded rating table (fig. 266).

Each rating table should be complete within itself for the entire range of stage through which it will be used so that it will not be necessary to refer to some other table that may be identical in part. For example, rating no.4 for Clear Creek is identical with the preceding rating no. 3 at stages above 3.0 feet. Nevertheless, rating no. 4 is completed in figure 265 for all stages above 3.0 ft so that there will be no shuffling back and forth between rating table sheets when applying discharges to recorded stages. By having each rating table complete in itself, the probability of error is reduced. If, as in the case of rating no. 4, the rating is identical with some former rating for some particular range of stage, that fact should be noted at the bottom of the rating table. The blank spaces below the rating table should also be filled to indicate the data on which the rating is based, the range of discharge that has actually been measured by current meter, and the basis of rating-curve extrapolation. As mentioned earlier, the completed rating table is used as the basis for computing the percentage differences for discharge measurements in figure 262, and it is also used to replot the rating curves in final form in figures 263 and 264. As a general rule, no more than three significant figures are used for discharge in the rating table.

STATION RATING—THREE-PARAMETER DISCHARGE RELATION

When a station rating involves three parameters—stage, discharge, and a third parameter such as fall or velocity index—the instructions given in the preceding sections will require some amending. The list of discharge measurements (fig. 262) will require an additional column for the third parameter. The additional column can be provided by reducing the width of the "Remarks" column or by using the column normally reserved for outside gage height.

The general principles concerning the plotting of the discharge measurements and rating curves remain unchanged, but additional curves are required as shown, for example, in figures 190–195. The curves may be plotted on rectangular-coordinate graph paper, as shown in figures 190–195, but logarithmic graph paper may be preferable because then the principles of rating analysis are more easily followed. It may also be advantageous to use more than one sheet of graph paper for the curves to avoid clutter and attendant confusion in working with the graphs.

Because a 3-parameter discharge relation requires more than one relation curve—for example; a rating-fall curve, a fall-ratio curve, and a Q_r rating curve—more than one rating or relation table is required. The general principles discussed on the preceding pages for transferring curve ordinates to a table are applicable for any table.

COMPUTATION OF DISCHARGE RECORDS FOR A NONRECORDING GAGING STATION

The computation of discharge records for a nonrecording gaging station is identical with that for a recording station equipped with a graphic recorder, except for the early steps in computing the gage-height record. Consequently only those early steps will be discussed in this section of the manual. The remaining steps in the computation of the discharge record are discussed on those pages of this chapter that deal with stations equipped with graphic stage recorders.

COMPUTATION OF GAGE-HEIGHT RECORD

The first step in computing the record for a nonrecording gage is to compare the readings on the weekly gage cards mailed in by the observer with those he has entered in his quarterly book of gage height observations. (See introductory pages of the section in chapter 4 titled, "Nonrecording Stream-Gaging Stations.") The observer's readings should also be compared with readings made by the hydrographer on his regular visits. After reconciling any differences, the next step is to apply datum corrections, if any, to the observed gage heights. Both the corrections applied and the corrected gage-height values are entered in the book of gage observations (fig. 8). The corrected gage-heights are plotted at the appropriate time ordinates on fragments of unused recorder chart that are excess when a new roll of recorder paper is installed in a graphic stage-recorder. It is not necessary to plot gage heights for the long periods of gradually receding flows that follow stream rises. For the days during such periods, the daily mean gage heights are computed as the mean of the two observed readings for each day.

A stage hydrograph is sketched through the plotted gage heights, using the graphic stage record from a nearby recording gaging station as a guide to the probable shape of the stage hydrograph. Observed high-water marks, for each of which the gage-height has been determined, and crest-stage gage readings are used where available, to give the peak stage of major rises. (Crest-stage gages are discussed in the last section of chapter 4.) The result is a stage hydrograph which, from the standpoint of discharge-computation methodology, is equivalent to the stage record from a graphic recorder after the recorder chart has had time and gage-height corrections applied to it.

Consequently, the remaining steps in computing the discharge record are, in effect, continued on the pages that follow the discussion of time and gage-height corrections for graphic-recorder charts. As mentioned above, from that point on the computation procedures are identical for nonrecording and graphic stage-recorder stations.

COMPUTATION OF DISCHARGE RECORDS FOR A RECORDING STATION EQUIPPED WITH A GRAPHIC RECORDER

COMPUTATION OF GAGE-HEIGHT RECORD

At a station visit when the recorded segment of the gage-height chart is removed and a fresh segment of chart is started, the hydrographer makes note of all information that will be needed in computing daily gage heights. His notations are made both on the end of the recorded chart and on the beginning of the fresh segment of chart. Those notations include name of the station, date, readings on all gages and the time of those readings, the instrument stage ratio, and notes explaining any unusual appearance of the pen trace. In addition to making a pen "tick" at the point where the pen rests at the time of chart removal and again at the time the fresh segment of chart is started, the hydrographer also rotates the float wheel to indicate the pen-reversal points on the chart. If the float wheel of the recorder is equipped with a tape, the step method of checking pen reversal is used. (See fig. 267.) The step method is used in making gage-height corrections to the pen trace and is explained in the section on "Determination of Gage-Height Corrections."

DETERMINATION OF TIME CORRECTIONS

Before determining the time corrections to be applied to the gage-height record, the chart should be dated. Each day is numbered on

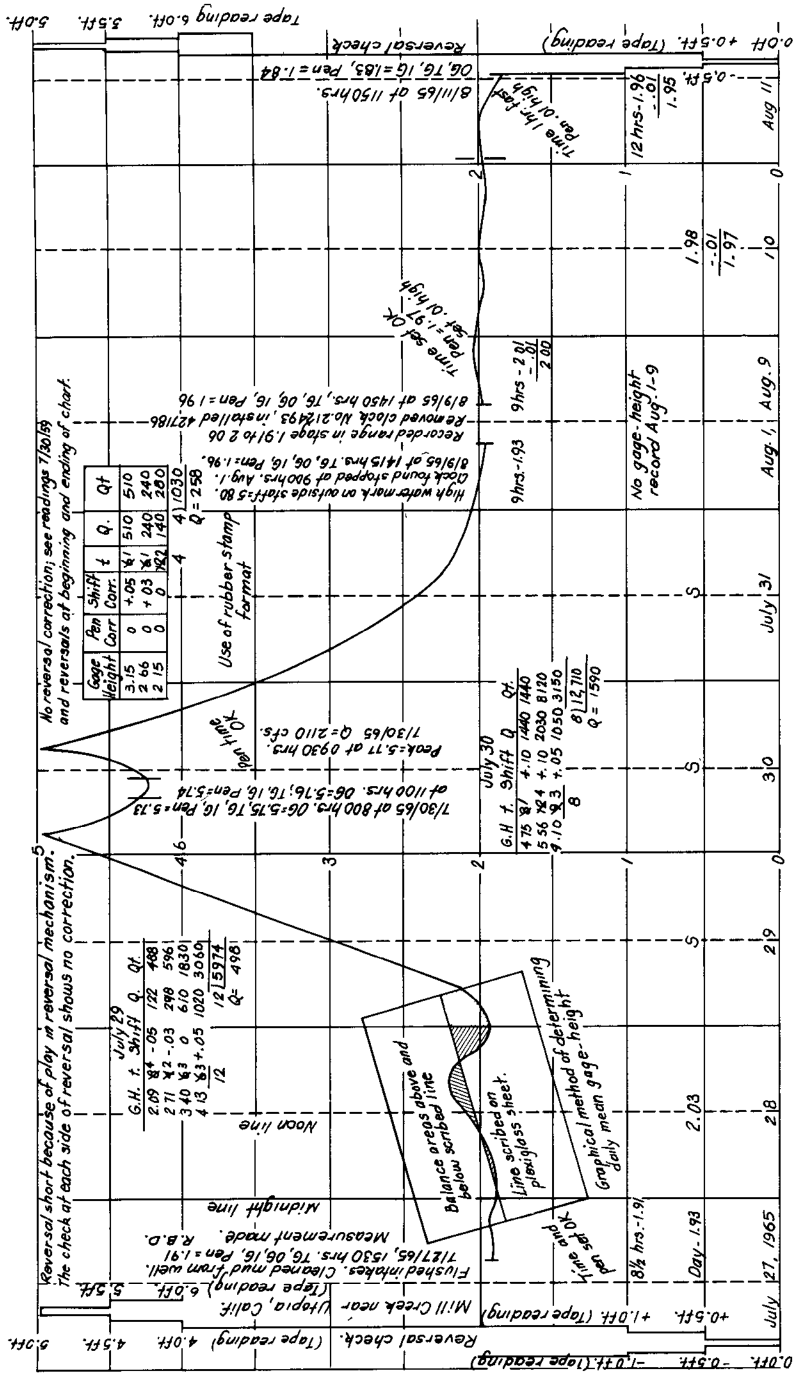


FIGURE 267.—Computation of daily mean gage height on graphic-recorder chart.

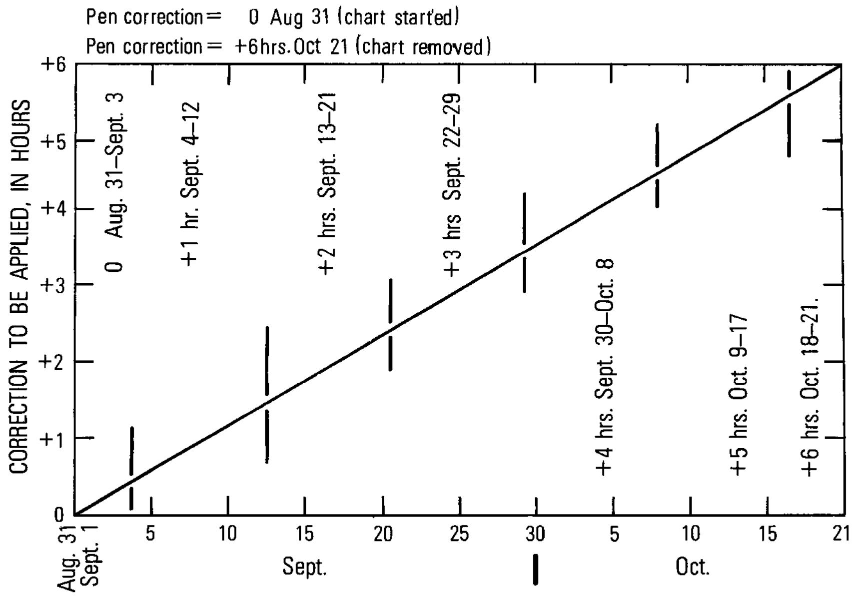


FIGURE 268.—Example of graphical interpolation to determine time corrections.

the lower base line at the noon line. The month is shown about every fifth day, and the year is shown about once a month.

The first step in computing time corrections for a segment of chart is to list the time corrections needed at each of the two or more days when the chart was field inspected. If the time correction at the end of the chart is large, the record should be inspected for evidence of large abrupt timing error—for example, clocks have been known to stop and then restart some hours later. If no abrupt timing errors are found, the time corrections are prorated by straight-line interpolation in which corrections are determined to the nearest hour. Figure 268 is an example of such an interpolation. The graph in figure 268, which is self-explanatory, would normally be drawn on the recorder chart near the beginning of the chart segment being studied. If the total time correction for the chart segment is small, the interpolated distribution of time corrections may be computed arithmetically without the use of a graph.

The computed time corrections are applied by changing the positions of the midnight lines for the affected days. Heavy vertical lines are drawn to indicate the new midnight lines, using care to ensure that the time adjustments are applied in the correct direction. It is advisable to make all interpretive notes, figures, and time corrections in colored pencil on the gage-height chart to differentiate them from the original notes.

DETERMINATION OF GAGE-HEIGHT CORRECTIONS

Gage-height corrections to the recorder trace are next determined. They are based on differences in readings of the recorder pen and the base gage, usually the inside staff, at station inspections. These corrections are also prorated with time unless there is evidence of abrupt instrumental error, such as would occur as a result of float-wheel slippage, or unless a systematic error with stage is shown to exist when the reversal points are checked by the step method at station inspections. An error in setting the pen at the start of a segment of strip chart will be carried throughout the length of that segment, but the original error may be increased or decreased by the above-mentioned errors. Gage-height corrections should be noted on the chart in such a manner that they can be easily applied to the gage-height values that are determined later.

Reversal errors, that is, errors that occur when the pen reverses direction at or near the upper or lower base lines, and systematic errors that vary with stage are usually caused by expansion or contraction of the chart, but they may also be caused by skewed travel of the chart. Reversal errors may also result from wear or maladjustment of the reversal mechanism of the stage recorder.

The step method of checking reversal points when changing the chart in the field provides a means of determining the gage-height corrections that vary with stage. The method requires that the recorder float wheel be equipped with a tape. The procedure used by the hydrographer is as follows:

1. Before removing the chart, raise the float tape to a value that is exactly 1 foot less than the foot mark at which the pen reverses; pull the chart forward a short distance to put an identifying "step" on the chart at that stage (fig. 267). Enter the tape reading on the chart.
2. Raise the float tape an additional half-foot and repeat the procedure.
3. Raise the float tape to the reversal point and repeat the procedure.
4. Repeat the above procedure, first with the tape reading 0.5 ft more than the foot mark at which the pen reverses, and again with the tape reading 1.00 ft more than the reversal foot mark.
5. Continue to raise the float tape and repeat steps 1 to 4 for the other base line reversal.
6. After the recorded segment of chart has been removed and the fresh segment of chart has been engaged, the pen is set to the correct gage height and steps 1 to 5 are repeated.

An example of the step method of checking reversal points is shown in figure 267. The step method in figure 267 actually indicates the need for a correction of +0.01 foot at a recorded stage of 4.99 ft and a correction of −0.01 foot at a recorded stage of 5.01 ft. In other words a true stage of 5.00 ft is recorded as 4.99 ft on one side of the reversal and 5.01 ft on the other side. However, the gage inspections at 5.73 ft and 5.74 ft indicate that no corrections are needed and none were applied.

As a final step, datum corrections (see section on "Datum Corrections"), if required, are noted for each affected day. The recorder chart is now ready for the determination of daily gage heights.

DETERMINATION OF DAILY MEAN GAGE HEIGHT

Daily mean gage heights are usually determined graphically by the use of a thin rectangular piece of clear plastic whose dimensions are approximately 2 by 4 inches; a centerline is scribed on the plastic parallel to the long edge. The plastic is placed over a 24-hour segment of the recorder chart with the scribed line approximately over the pen trace. The plastic is then maneuvered into a position where the areas bounded by the midnight lines and lying above the scribed line but below the pen trace are equal in size to the areas lying below the scribed line but above the pen trace. When the areas above and below the scribed line are so balanced, the gage height of the point at which the scribed line intersects the noon line is the uncorrected mean gage height for the day. An example of the graphical method of determining daily mean gage height is shown for July 28 in figure 267.

A gage-height correction and (or) a datum correction, if applicable, will have been entered on the chart at about the noon line and about 1½ inches above the base line. The uncorrected daily mean gage height determined by the graphical method is then entered above the correction(s), the required addition or subtraction is performed to obtain the corrected daily mean gage height, and the corrected value is written below the correction as shown for August 10 in figure 267.

SUBDIVISION OF DAILY GAGE HEIGHTS

When there is large variation in stage during the day, it is necessary to: subdivide the day into smaller increments of time, determine the mean gage height for each time increment, apply the corresponding discharge from the rating table to each incremental mean gage height, and compute a time-weighted mean discharge for the day. That procedure is necessary because the stage-discharge relation is curvilinear; consequently the discharge corresponding to the mean gage height for a segment of stage of large range will differ significantly from the true discharge, which is the discharge integrated over that range of stage. The allowable range of stage, for which the use of a mean gage height introduces no significant error in discharge, depends on the curvature of the stage-discharge relation; the more nearly linear the rating is, the larger the allowable range in stage.

The rule generally followed in the U.S.A. is to subdivide the gage-height graph for the day if the discharge corresponding to the daily mean gage height differs by 4 percent or more from the average of the two discharges corresponding to the maximum and minimum gage heights in the day. For any normal rating table, the average of the two discharges will be the larger figure. A simple method of computing a table of allowable range of stage for a rating is outlined below, using the rating table in figures 265 and 266 as an example.

First, a gage height G is selected near the lower end of the rating. Because the allowable difference in discharge is 4 percent, the average of the two extreme discharges in the allowable range of stage is 1.04 Q_G where Q_G is the discharge from the rating table corresponding to gage height G. That means that 2.08 Q_G equals the sum of the two extreme discharges in the allowable range of stage. (A definition sketch is given in fig. 269.) The analyst using the rating table moves small equal distances in stage up and down from gage height G until he obtains a pair of stages whose discharges total 2.08 Q_G. The range,

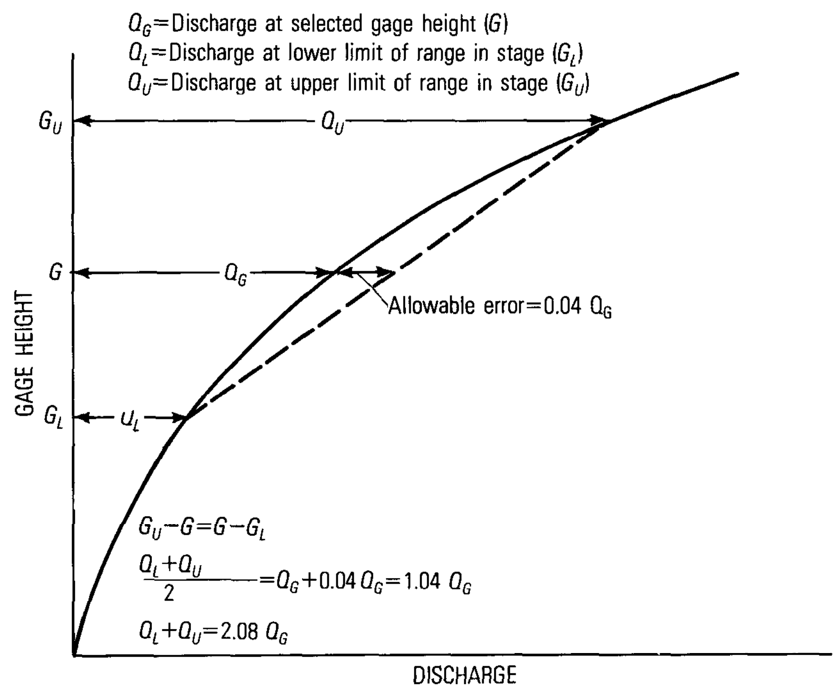


FIGURE 269.—Definition sketch illustrating computation of stage limits for application of discharge.

Mean gage height (ft)	Q (ft³/s)	Q x 2.08 (ft³/s)	Allowable limits of stage (ft) / Corresponding discharge (ft³/s)	Allowable range of stage (ft)
2.2	0 4	0.83	2.15–2.25 (0.22+0.60=0.82)	0.10
2.4	1.6	3.30	2.32–2.48 (1.02+2.30=3.32)	.16
2.8	6.4	13 3	2.65–2.95 (4 25+9.05=13.3)	.30
3.4	19.6	40.8	3.1–3.7 (12.1+28.9=41.0)	.6
4.0	40	83.2	3.6–4.4 (25.6+57.0=82.6)	.8
4.8	78	162	4.2–5.4 (48+115=163)	1.2
6.0	160	333	5.2–6.8 (122+203=325)	1.6
7.5	302	628	6.4–8.6 (194+435=629)	2.2
9.0	490	1020	7.6–10.4 (313+706=1019)	2.8

FIGURE 270.—Results of computation of allowable limits of stage for Rating No. 4, Clear Creek near Utopia, Calif.

in feet, between the pair of stages is the allowable range in stage for a mean gage height of G. The procedure just described is then used to obtain the allowable range in stage for other values of gage height. The results of such computations for the rating table in figures 265 and 266 are shown in figure 270. The information given by the table in figure 270 is reorganized to provide the table of allowable rise shown in figure 271, which is more convenient for use in subdividing days. For days that are subdivided it is not necessary to compute the daily mean gage height.

The table of allowable ranges for subdivision may require some revision for periods when shifting-control adjustments are used.

Gage height (ft)	Allowable rise (ft)	Gage height (ft)	Allowable rise (ft)
2.15	0.10	4.2	1.2
2 32	.16	5.2	1.6
2.65	.3	6.4	2.2
3.1	.6	7.6	2.8
3.6	.8		

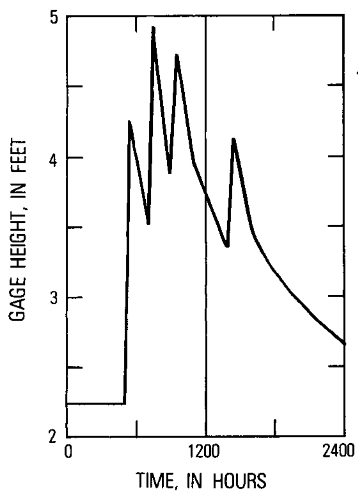
FIGURE 271.—Table of allowable rise for use with Rating No. 4, Clear Creek near Utopia, Calif.

However, revision will usually be necessary only in the unusual situation where the shifts to be applied are so extreme that they radically change the shape of the stage-discharge relation.

Either of two methods are used for computing discharge for subdivided days, and the procedure for subdividing the day varies with the method used. The first method is the increment-mean method. In that method the mean gage height is determined for each increment of the day by using the graphical process of balancing areas that was described earlier. Shifts, if appropriate, are applied to the mean gage heights, corresponding values of incremental mean discharge are obtained from the rating table, and a time-weighted daily mean discharge is computed. The time-weighting is done by first multiplying each incremental mean discharge by the number of hours in the increment, then adding the products, and finally dividing the sum of the products by 24 (number of hours in the day). The arithmetic is simplified if the increments of the day are all multiples of either 2, 3, 4, 6, 8, or 12 hours, because then the numerical values of the hours used can be reduced by factoring. For example, if the day had been subdivided into three increments of 6, 6, and 12 hours, those time periods could be expressed as multiples of 6. For weighting purposes, the hour values would be factored to give 1, 1, and 2, and the sum of the products would be divided by 4 rather than 24. (See subdivision for July 31 in fig. 267.)

The procedure for subdividing a day by the increment-mean method is as follows. The analyst starts at the lowest point of the pen trace and moves upward as far as the table of allowable rises will permit. That upper value of stage then becomes the starting point for the next increment of the day, whose upper limit is also determined from the table of allowable rises. The process is continued until the entire day has been subdivided. The ends of the time increments are adjusted to coincide with the nearest hour lines, but the adjustment should, if anything, decrease the range in stage for an increment from that indicated by the table of allowable rises. If feasible, the time increments are further adjusted to permit the factoring discussed in the preceding paragraph.

The second method of computing discharge for subdivided days is the point-intercept method. In that method, gage heights are noted along with the clock hour of occurrence, at the beginning of the day, the end of the day, and at all "breaks" in slope of the stage hydrograph during the 24 hours. It is important, however, not to permit the difference in stage between consecutive recorded gage heights to exceed values given by the table of allowable rises. If the stage difference for a time increment does exceed the allowable rise, one or more additional intermediate points on the hydrograph must be selected



JULY 1

(1) Time	(2) Corrected gate height	(3) Shift	(4) Time increase (hrs)	(5) Discharge (ft³/s)
0000	2 25	0	2½	24
0500	2.22	0	2¾	22
0530	4 28	0	½	464
0600	4.04	0	¾	392
0700	3.50	0	¾	250
0730	4.94	0	½	716
0800	4 55	0	¾	560
0900	3 87	0	¾	342
0930	4 77	0	½	648
1000	4.49	0	¾	536
1100	3.97	0	2	371
1400	3 34	0	1¾	213
1430	4.16	0	½	428
1500	3 88	0	¾	345
1600	3.48	0	2½	245
2000	2 94	0	4	133
2400	2 66	0	2	79
			24	*5484 5
				229.0=Mean Q

*Summation of individual products of column 4 times column 5

FIGURE 272.—Sample computation of daily mean discharge for a subdivided day by point-intercept method.

for use. The end result is a tabulation such as that shown in the example in figure 272 where the gage heights are tabulated at the nonuniform hours associated with breaks in slope of the stage hydrograph.

Computation of the daily mean discharge by the point-intercept method is similar to that for the increment-mean method except for the manner of determining the number of hours (col. 4 of fig. 272) associated with each tabulated gage height. Each of the gage heights is assumed to represent the mean gage height for a time interval that extends from (a) the clock time midway to the preceding tabulated gage height to (b) the clock time midway to the following tabulated gage height. The discharges in column 5 of figure 272 correspond to the tabulated gage heights in column 2 after those gage heights have been adjusted for the shifts, if any, shown in column 3. The time-weighting of the discharge is then done by first multiplying each discharge (col. 5) by the correspnding number of incremental hours (col. 4). The individual products, which are not shown in figure 272, are then added, and finally the sum of the products is divided by 24 (number of hours in the day).

The advantage of the point-intercept method over the increment-mean method of computing daily mean discharge for subdivided days lies in the fact that the point-intercept method provides the data for reproducing the stage or discharge hydrograph for storm runoff. Consequently, the point-intercept method is always used in flood reports. Because daily mean discharges computed by the two methods will seldom agree exactly, it is best to use the point-intercept method, at least for major runoff events. Then if the major runoff event is made the subject of a later flood report, daily mean discharge in the flood report and in the routine annual streamflow report will agree. For complex flood events, such as that shown in figure 272, the point-intercept method will usually give somewhat more accurate daily mean discharges than will the increment-mean method, but only because more gage heights per day are usually used in the point-intercept method for such events. Subdivision is really a crude form of mathematical integration of the hydrograph. Mathematical integration gives the only truly accurate value of mean discharge, and the more points that are used in the subdivision, the more closely the subdivision will resemble integration. The difference in results between mathematical integration and subdivision rapidly dwindles to insignificance when sufficient points are used in the subdivision. Mechanical integrators, now largely superseded by digital recording and computation, are available to compute daily mean discharge for stations having large and frequent stage fluctuations, such as those that occur downstream from hydroelectric power plants.

COMPUTATION OF DAILY DISCHARGE

PREPARATION OF FORM FOR COMPUTING AND TABULATING DISCHARGE

The first step in the computation of daily discharge for a nonrecording station or a recording station equipped with a graphic recorder is to prepare a form, such as USGS form 9–192a which is shown in figure 273, to receive the computed values. The form in figure 273 provides columns for daily mean gage height and discharge for the 12 months in the water year, as well as spaces for monthly and annual summaries which will be discussed in the section on "Completion of the Discharge Form." The analyst fills in the blanks at the top of the form that supply general information such as name of station, drainage area, type of recorder, water-year date, numbers of the rating tables used, and so on. It is important that the form be prepared carefully because the data are copied from this form on to offset sheets used for publication of the data. In addition, prints of the form are often furnished to water users as preliminary data in advance of the published data.

Daily mean gage heights from the original water-stage recorder chart are copied in the columns headed "Gage height." In addition, the maximum and minimum gage heights that occurred during the year are listed in the spaces provided at the left margin. For those days that are subdivided for the computation of daily discharge, no

9-192-a. July 1937

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Clear Cr nr. Utopia, Calif 1965-66

File Number { Washington 10-2450 District

Used rating table Nos. 3, 4

Gage heights used to half tenths between ... and ... feet hundredths below and tenths above these limits.

Daily Gage Height, in Feet, and Discharge, in Second-Feet, of Clear Creek

Near Utopia, Calif. for the Year Ending September 30, 1966.

Drainage Area 160 Square Miles. Water-Stage Recorder Stevens A-35 Ratio ...

Gage Read to ... Once/Twice a Day by ...

Max Disch. 9,310 Sec-ft at 1500 h on May 27 (G H 32.51 ft) Max G H 32.51 ft at 1500 h on May 27

daily Min Disch. 0.25 Sec-ft on Nov. 20 (G H ... ft) Min G H ... ft on ...

Note.-- Stage-discharge relation affected by ice Nov. 27 to Dec. 25.
No gage-height record Dec. 26 to Feb 24, Aug. 20, 21, Sept. 2-10.
S - subdivided day; V - variable shift.

Day	October Gage height	October Discharge	November Gage height	November Discharge	December Gage height	December Discharge	January Gage height	January Discharge	February Gage height	February Discharge	March Gage height	March Discharge
1	2.35	1.8	2.56	3.8	2.53	3.3		2.0		2.0	2.80	6.4
2	2.36	1.9	2.54	3.7	2.55	3.6		2.0		2.1	2.78	6.1
3	2.36	1.9	2.55	3.8	2.54	3.4		1.8		2.2	2.81	6.6
4	2.38	2.1	2.56	4.0	2.56	3.6		1.0		2.3	2.84	7.1
5	2.37	2.0	2.54	3.7	2.58	3.8		1.6		2.4	2.82	6.7
6	2.39	2.1	2.53	3.6	2.95	3.6		2.2		2.5	2.86	7.4
7	2.40	2.2	2.55	3.8	3.10	3.4		2.4		2.6	2.89	7.9
8	2.41	2.3	2.54	3.7	3.18	3.2		2.4		2.7	2.91	8.3
9	2.42-13 / 2.40-11	2.4	2.57	4.1	3.16	2.6		2.2		2.8	2.94	8.9
10	2.41	2.5	2.55	3.8	3.17	2.5		2.2		2.9	2.95	9.0
11	2.40	2.4	2.56	4.0	3.15	2.4		2.2		3.1	2.97	9.4
12	2.42	2.6	2.58	4.2	3.19	2.5		2.1		3.2	2.99	9.8
13	2.45	2.9	2.59	4.3	3.21	2.6		2.0		2.8	3.00	10
14	2.43	2.6	2.62	4.6	3.18	2.5		2.0		2.9	3.03	11
15	2.46	2.9	2.60	4.5	3.20	2.4		2.0		3.0	3.05	11
16	2.49	3.2	2.45	2.9	3.15	2.2		1.9		3.1	3.08	12
17	2.48	3.1	2.30	1.6	3.18	2.3		1.8		3.2	3.16	14
18	2.51	3.4	2.20	.94	3.16	2.2		1.8		3.3	3.27	16
19	2.49	3.2	2.12	.54	3.17	2.1		1.8		3.4	3.40	20
20	2.48	3.1	2.05	.25	3.20	2.1		1.9		3.5	3.52	23
21	2.52	3.5	2.12	.54	3.22	2.0		2.0		3.5	3.61	26
22	2.53	3.6	2.21	1.0	3.26	2.1		2.0		3.5	3.83	34
23	2.51	3.3	2.30	1.6	3.30	2.0		2.0		3.7	4.15	46
24	2.54	3.6	2.40	2.4	3.40	2.0		2.2		15	4.40	57
25	2.57	4.0	2.45	2.9	3.45	2.0		2.2	2.70	4.9	4.77	76
26	2.56	3.8	2.48	3.2		2.0		2.2	2.68	4.6	5.02	91
27	2.57	4.0	2.62	3.0		2.0		2.1	2.71	5.0	5.41	116
28	2.55	3.7	2.58	2.8		2.0		2.0	2.75	5.6	5.92	156
29	2.55	3.7	2.66	2.9		2.0		2.0	—	—	6.65	216
30	2.55	3.7	2.62	3.1		2.0		2.0			6.70	221
31	2.53	3.5				2.0		2.0			6.68	219

Day	April Gage height	April Discharge	May Gage height	May Discharge	June Gage height	June Discharge	July Gage height	July Discharge	August Gage height	August Discharge	September Gage height	September Discharge
1	6.65	216	9.41	548	10.02	643	5.10	96	3.39	16	3.09	13
2	6.70	221	9.28	529	9.96	634	5.03	92	3.36	15		13
3	6.73	224	9.13	508	9.91	626	4.96	88	3.37	16		13
4	6.77	227	8.97	486	9.79	606	4.88	83	3.35	15		12
5	6.81	231	8.84	468	9.66	586	4.81	79	3.33	15		12
6	6.74	225	8.79	461	9.51	564	4.72	73	3.50	20		11
7	6.69	220	8.65	442	9.30	532	4.66	70	S	287		11
8	6.62	214	8.51	423	9.08	501	4.57	66	S	154		10
9	6.58	210	8.30	396	8.84	468	4.51	62	S	49		10
10	6.55	208	8.16	379	8.61	436	4.43	58	3.61	28		10
11	6.50	203	8.01	361	8.39	408	4.35	54	3.42	22	2.98	10
12	6.46	199	7.95	354	8.16	379	4.22	49	3.37	21	2.96	10
13	6.51	204	7.93	352	7.94	353	4.05	42	3.34	20	2.94	9.6
14	6.56	208	7.98	358	7.71	325	3.96	38	3.31	19	2.96	9.8
15	6.60	212	8.04	365	7.53	305	S	243	3.27	18	2.97	10
16	6.64	216	8.10	372	7.35	286	S	112	3.25	17	2.95	9.6
17	6.67	218	8.17	380	7.16	266	4.02	38	3.24	17	2.96	9.8
18	6.71	222	8.40	409	7.01	251	3.81	29	3.21	16	2.94	9.2
19	6.73	224	8.75	455	6.84	234	3.66	24	3.18	16	2.95	9.4
20	6.80	230	9.02	493	6.71	222	3.62	22		16	2.95	9.4
21	7.15	265	9.30	532	6.56	208	3.55	20		15	2.92	8.9
22	7.60	313	9.57	572	6.35	190	3.57	21	3.17	15	2.93	9.0
23	8.10	372	9.93	629	6.07	166	3.53	20	3.15	15	2.91	8.6
24	S	543	10.12	659	5.83	146	3.50	19	3.17	15	2.90	8.3
25	S	802	S	820	5.60	129	3.51	19	3.16	15	2.87	7.8
26	S	850	S	1,120	5.42	116	3.54	20	3.14	15	2.88	7.9
27	10.15	766	S	1,460	5.35	112	3.50	19	3.15	15	2.85	7.4
28	10.10	656	S	1,380	5.28	107	3.46	18	3.13	14	2.83	7.1
29	9.72	595	S	850	5.21	103	3.47	18	3.14	15	2.82	6.9
30	9.53	566	10.50	723	5.16	100	3.44	17	3.12	14	2.79	6.4
31			10.16	650			3.42	17	3.11	14		

Recorded range in stage was 2.97 to 3.09 ft (Sept. 2-10)

Calendar Year 1965		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year 1966
45,268.37	Total	91.0	89.27	78.4	62.0	101.8	1,466.6	10,060	17,934	10,002	1,626	959	290.0	42,760.07
.124	Mean	2.94	2.98	2.53	2.00	3.51	47.3	335	579	333	52.5	30.9	9.67	117
	Second-feet per square mile													
	Run-off in inches													
89,790	Run-off in acre-feet	198	198	156	123	202	2,910	19,950	35,570	19,840	3,230	1,900	575	84,810
1,520	Maximum	4.0	4.6	3.8	2.4	15	221	850	1,460	643	243	287	13	1,460
.25	Minimum	1.8	.25	2.0	1.0	2.0	6.1	199	352	100	17	14	6.4	.25

Peak discharge (base 800 cfs) -- Apr. 26 (1800 h) 1,080 cfs (12.40 ft); May 27 (1500 h) 9,310 cfs (32.51 ft); Aug. 7 (1830 h) 810 cfs (11.00 ft).

Computed LRM, Checked JRC 11/21/66; Disch. applied LRM, Disch. checked RCL 11/18/66; G.H. copied RCL, G.H. checked LRM 11/17/66

FIGURE 273.—Computation of daily discharge.

figures of daily mean gage height will be computed; for those days an uppercase letter "*S*" is entered in the gage-height columns. That symbol, as well as any others that are used, is explained by a footnote in the left margin; for example "*S*—subdivided day." For days of recorder malfunction, if the daily mean gage height is computed from a graph based on the observer's gage readings, the symbol "*g*" is added to the left of the gage-height value.

In a last step before applying discharges from the rating table to the gage heights, values of shifts to be applied are entered in columns constructed on the left side of the wide columns headed "Discharge" in figure 273. Little has been said about shifts in this chapter of the manual because they have been discussed in detail in the section in chapter 10 titled, "Shifts in the Discharge Rating." Shifts, it will be recalled, may vary with stage. If, during a subdivided day, shifts of varying magnitude are to be used because of the varying stage during the day, the symbol "v" is used in place of a numerical value in the shift column. The application of discharges to gage heights for subdivided days has been discussed in the section on "Subdivision of Daily Gage Heights." The reader is warned at this point that the shifts shown in figure 273 have no relation to the rating-curve analysis discussed in the section on "Rating-Curve Analysis." That analysis for Clear Creek indicated only a short period of shifting control in early October. Shifts have been scattered throughout figure 273 for the purpose of illustrating various conditions in applying discharge.

DETERMINATION OF DISCHARGE FROM THE GAGE-HEIGHT RECORD

Discharges are determined by applying the appropriate rating tables to the gage heights tabulated in figure 273. The rating analysis indicated a change in the rating after February 24, rating no. 3 being used up to and including that date and rating no. 4 thereafter. Consequently, before applying discharges a heavy horizontal line is drawn in the discharge column of figure 273 between February 24 and February 25 to warn the analyst of the change in rating on February 25. The daily mean discharges, in cubic feet per second, are entered in the discharge columns of figure 273. Daily discharges are shown to the nearest hundredth from 0.01 to 0.99 ft^3/s, to the nearest tenth from 1.0 to 9.99 ft^3/s, to the nearest unit from 10 to 999 ft^3/s, and to three significant figures above 1,000 ft^3/s. Where shifts are indicated, the amount of the shift is added algebraically to the tabulated gage height, and the discharge corresponding to the shift-adjusted gage height is determined from the appropriate rating table. It is important that there be no discontinuity between the discharge on the last day of the preceding water year and the first day of the current water year. That can easily occur if a new rating table is placed in effect on the first day of the current water year, or if shift adjustments to the gage height are used on either or both the first and last days of the two water years. Consequently the discharge for the last day of the preceding water year should be examined to ensure consistency.

To facilitate the determination of discharges from the rating table, it is advisable to expand the rating table to show the discharge for each one-hundredth of a foot of stage, as in figure 266, to cover the frequently occurring stages. For example, if the rating table were expanded to a stage of 7.0 ft, it would cover most of the gage heights tabulated in figure 273, thereby reducing the probability of error in mentally interpolating discharge values between the tenths of a foot of stage given in the standard rating table (fig. 265).

At this point all boxes for daily mean discharge in figure 273 will have been filled, except those opposite gage-height boxes that are blank for lack of record because of instrument malfunction, or those opposite gage-height boxes that carry the symbol "S" for subdivided day. The discharges for subdivided days are next computed. The method of computation was explained in the section on "Subdivision of Daily Gage Heights." The daily mean discharges are computed on the gage-height chart, as shown in figure 267, where the increment-mean method of computation was used. The computed discharges are then transferred to the discharge columns in figure 273.

ESTIMATION OF DAILY DISCHARGE FOR PERIODS OF INDETERMINATE STAGE-DISCHARGE RELATION

After the mean discharge has been computed for each day of the water year for which there is a gage-height record, a hydrograph of daily mean discharge is prepared on a form that has a logarithmic discharge scale. Discharge measurements are also plotted on the hydrograph sheet. The hydrograph is used for comparison with similar hydrographs of daily discharge for nearby stations as a test for consistency of the computed record. Obviously such comparison is only valid for streams whose daily flow is essentially natural, that is, not controlled significantly by the works of man. Hydrographic comparison usually brings to light any serious errors in the basic data computations and interpretations; it also provides a means of estimating discharge for days of no gage-height record and for days of indeterminate stage-discharge relation. A period of indeterminate stage-discharge relation does not refer to one in which the gage-height record is faulty; if the recorded gage-heights do not reflect the true stage of the stream, the period affected is considered to be one of no gage-height record. A period of indeterminate stage-discharge relation is one for which a satisfactory gage-height record is available, but one for which no stage-discharge relation can be determined. The most common situation of that kind occurs during an ice-affected period, and it may also occur during the passage of sand waves in an alluvial channel. Sometimes ephemeral backwater effect occurs when a channel is choked by debris for a few days, but in that situation the stage-discharge relation is not really indeterminate but is merely undefined because of the limited opportunity to define it by discharge measurements.

A period of indeterminate or undefined stage-discharge relation is indicated on the discharge tabulation form (fig. 273) by a heavy vertical line drawn between the gage-height and discharge columns. Such a line appears in November and December in figure 273 to indicate that the ice-affected discharges during those months bear no relation to the recorded stages. Where preliminary discharge values from the rating table have been entered for such days in figure 273 and are then shown by hydrographic comparison to be in error, they are replaced in figure 273 by the revised discharge figures.

Periods of ice effect.—The method of estimating discharge during periods of ice effect was discussed in detail in chapter 10 and will not be repeated here. Measurements nos. 35 and 35A (fig. 262) clearly indicated, by the magnitude of the backwater effect (shift values), that ice affected the stage-discharge relation.

Other periods of indeterminate stage-discharge relation.—For periods of indeterminate stage-discharge relation other than ice effect, discharges are estimated as though they occurred during periods of no gage-height record. Methods of treating periods of no gage-height record are described on the pages that follow; hydrographic comparison is one of those methods.

ESTIMATION OF DAILY DISCHARGE FOR PERIODS OF NO GAGE-HEIGHT RECORD

The analyst is often required to estimate discharge for periods of no gage-height record resulting from recorder malfunction, or a frozen well, or a plugged intake. Such periods are shown in figure 273 for periods December 26 to February 24, August 20–21, and September 2–10. The task of the analyst is greatly facilitated if the fieldman who finds the gage-height record incomplete makes an effort to collect as much supplementary information as possible. An attempt should be made to get the range in stage during the period of no gage-height record because that information indicates the limits of discharge within which any estimates made may vary. If the clock has stopped but the pen continues to function, the vertical line recorded on the chart will give the range in stage. Because of the possibility of the pen reversing during the period of no record, when the pen was scribing a vertical line, there may be some doubt as to the maximum gage-height reached during that period. If the tape gage is equipped with either a magnet or wire clip for indicating peak stage (see the section in chapter 10 titled, "Operation of a Recording Stream-Gaging Station"), the peak indicated by either of those devices should be noted. High-water marks should be sought both in the well and outside the gage structure. If the intakes have been plugged or the well frozen and a high stage had occurred during the period of no record, again an outside high-water mark should be sought. Local residents should be interviewed in an attempt to determine the time the peak occurred.

The previously mentioned annual hydrograph of daily mean discharge, with gaps left for periods of no gage-height record, along with the annual hydrograph of daily discharge for nearby stations, are prerequisites for estimating the discharges sought. Each of the station hydrographs should be plotted on a separate graph sheet, but the logarithmic discharge scales and time scales on the individual sheets should be identical. It is particularly helpful if one or more of the stations used is on the same stream as the station being studied. The hydrographs for uncontrolled streams in the same vicinity will usually have similar patterns of discharge.

In the discussion that follows, the procedure for estimating discharge for periods of no gage-height record is described under the following subheadings:

1. No gage-height record during a low- or medium-flow recession on an uncontrolled stream.
2. No gage-height record during periods of fluctuating discharge on an uncontrolled stream.
3. No gage-height record for a station on a hydroelectric powerplant canal.
4. No gage-height record for a station immediately downstream from a reservoir.
5. No gage-height record for a station on a controlled stream where the station is far downstream from the known controlled release.

CASE A. NO GAGE-HEIGHT RECORD DURING A LOW- OR MEDIUM-FLOW RECESSION ON AN UNCONTROLLED STREAM

If the vertical trace left by the inoperative recorder indicates no stages higher than that when the clock stopped nor any stages lower than that when the stoppage was discovered, there may well have been an unbroken recession from the time the clock first stopped. The hydrographs plotted for other nearby stations, particularly those on the stream being studied, should then be examined. If there is no evidence of anything but an unbroken recession, the discharge should be estimated by semilogarithmic interpolation. That is, the gap in the logarithmically plotted hydrograph for the station being studied should be filled by either a straight line or a smooth flat curve, depending on which best merges with the graph on either side of the dates of no gage-height record. The daily discharges that are estimated on the hydrograph are then transferred to the discharge-tabulation form with appropriate notation. (See record for September 2–10 in fig. 273.) If the period of no gage-height record involves only a few days, it is permissible to interpolate gage heights graphically on the recorder chart and then obtain the corresponding discharges from the rating table. That was actually done for August 20, 21 in figure 273.

CASE B. NO GAGE-HEIGHT RECORD DURING PERIODS OF FLUCTUATING DISCHARGE ON AN UNCONTROLLED STREAM

If a short period of recorder stoppage occurred near the peak of a stream rise, such as might occur if the float could not operate freely, knowing the peak stage of a stream makes it possible to sketch in the missing portion of gage-height record on the recorder chart. An even better estimate can be made on the recorder chart if the time of the peak is also known.

If long periods of no gage-height record are involved, the best method of making discharge estimates is by hydrographic comparison. A "light table" is used for the purpose in the manner described in the section in chapter 10 titled, "Hydrographic- and Climatic-Comparison Method." The logarithmic hydrograph of daily discharge for the study station is superposed on the logarithmic hydrograph for the reference station, and the date lines for the two sheets are matched. If the two stations are comparable, the two hydrographs should show similar runoff patterns. The study hydrograph is moved vertically until the hydrographs on either side of the period of no gage-height record match closely, making sure that the date lines match perfectly. An exception, to the perfect matching of date lines occurs, for example, where the two stations are on the same stream, but so distant from each other that the travel time between stations is approximately 24 hours. It would then be necessary to lag the hydrographs by a day. After matching the hydrographs, the missing portion of the study hydrograph is sketched by tracing the underlying reference hydrograph.

The hydrographic comparison also provides a simple means of comparing the runoff yield per square mile (unit yield) for the two stream basins. To make that comparison a short horizontal line, showing drainage-area size is marked on the logarithmic ordinate of each hydrograph. If, when the two hydrographs are matched vertically, the drainage-area lines also match, the two basins have equal unit yield. If the drainage area lines do not match, the basin whose drainage-area line is the lower of the two has the greater unit yield.

More often than not, it will be found that when the low-water part of the study hydrograph is matched with the low-water part of the reference hyrograph, the high-water parts of the two hydrographs do not match, and vice versa. When that occurs, the low-water parts of the two hydrographs are matched for sketching the low-water estimates, and the high-water parts of the two hydrographs are matched for sketching the high-water estimates of discharge. The discharge estimates for the medium-flow part of the study hydrograph is sketched while gradually sliding that hydrograph up or down, as required. Any discharge measurements made at the study station during the period of no gage-height record are especially valuable in positioning the two hydrographs, and unless it is known that the discharge measurement was made at a time of rapidly changing stage and is not representative of daily mean discharge, the sketched discharge on the study hydrograph should pass through the discharge measurement. If the range of stage for the period of no gage-height record is known, no estimated daily mean discharge should be smaller than the discharge corresponding to the minimum gage height for the period; no estimated daily mean discharge should equal or be greater than the discharge corresponding to the maximum gage height for the period, because the maximum daily discharge is seldom as great as the maximum momentary peak discharge. In figure 273 the daily mean discharges for the period of no gage-height record, December 26 to February 24, were estimated by hydrographic comparison with discharges for a nearby station.

It is desirable that hydrographic comparisons be made with more than a single reference station. The different comparisons will give estimates of daily discharge that differ from each other to some degree. In averaging the estimates, the greatest weight should be given to the results obtained from: reference hydrographs that show the closest fit with the study hydrograph; reference hydrographs on the same stream as the study station; and reference hydrographs for stations whose drainage areas approximate that of the study station.

If the period of no gage-height record involves a snowmelt period and the maximum stage is known, the maximum daily mean discharge can often be estimated fairly closely. Discharge has a diurnal fluctuation during snowmelt periods, and the ratio of maximum daily mean to maximum momentary discharge will vary with such factors as air temperature and date. However, examination of discharge records for the study station and for a snowmelt reference station may show how concurrent ratios vary at the two stations, and thereby give a strong clue to the ratio to be used to estimate maximum daily mean discharge during the period of no gage-height record.

On occasion, the station that has a period of no gage-height record may be located immediately upstream from a reservoir for the purpose of measuring inflow to the reservoir. If reliable records are available showing daily change in reservoir contents and daily spill and release from the reservoir, it is then a simple matter to compute the daily discharge (Q) at the gaging station from the formula:

$$Q = \text{Daily spill} + \text{daily release} \pm \text{daily change in reservoir contents.}$$

There may be times when record for a flood period is lacking and there is no nearby gaging station with which to compare runoff records. Under those circumstances, daily discharges for the flood period may be estimated from a model study of rainfall-runoff relations. It is beyond the scope of this manual to detail the development of such hydrologic models. A simpler task is to estimate the total volume of storm runoff from precipitation records. For general storms in the past at the study station, tabulate the total storm precipitation, its duration in days, and the total volume of storm runoff in inches or millimeters. Compute the value (infiltration index) that must be subtracted from each daily increment of precipitation during a storm to give the total volume of runoff from that storm. The infiltration index will vary with storms, but it can often be related to antecedent precipitation and month of the year. Apply the appropriate infiltration index to the storm precipitation during the period of no gage-height record to obtain the total volume of storm runoff during that period. This simple method provides only an approximate result; it should be used sparingly for general storms, and not at all for thunderstorms, which usually occur over limited areas.

CASE C. NO GAGE-HEIGHT RECORD FOR A STATION ON A HYDROELECTRIC-POWERPLANT CANAL

For a period of no gage-height record for a station on a powerplant canal, it is generally possible to use the powerplant record of daily kilowatt output to estimate reliably the daily mean discharges. That is done by means of a relation of daily discharge to daily power output that is developed for periods preceding and following the period of no gage-height record.

CASE D. NO GAGE-HEIGHT RECORD FOR A STATION IMMEDIATELY DOWNSTREAM FROM A RESERVOIR

Ratings are often available, or may be computed, for a reservoir spillway, gates, valves, and turbines (see the section in chapter 14 titled, "Pressure Conduits"). Ratings of those types will enable the engineer to estimate the discharge for a period of no gage-height record at a station immediately downstream from a reservoir.

Another method may be used if the reservoir itself is equipped with a stage gage so that a reliable record of daily change in reservoir contents is available. Daily changes in reservoir contents may be added algebraically to the daily mean discharge at the study station downstream from the reservoir to provide daily mean values of reservoir inflow during periods of record at the study station. An annual hydrograph of daily mean reservoir inflow is prepared and is compared with the hydrograph for a nearby natural-flow station. Using the technique described for Case B, the daily mean values of reservoir inflow are estimated for the period of no gage-height record at the study station. The known daily changes of reservoir contents are then subtracted algebraically from those estimated daily values of reservoir inflow to give the required daily discharge at the study station.

CASE E. NO GAGE-HEIGHT RECORD FOR A STATION ON A CONTROLLED STREAM WHERE THE STATION IS FAR DOWNSTREAM FROM THE KNOWN CONTROLLED RELEASE

Case E is a situation somewhat similar to Case D, except that the study station is so far downstream from the reservoir that tributary inflow between the reservoir and the study station cannot be ignored. Outflow from the reservoir cannot be compared directly with the discharge at the study station because the reservoir outflow is completely controlled and the discharge at the study station is partially controlled. The method of attacking the problem is to estimate daily tributary inflow during the period of no gage-height record at the study station, and then to add the estimated daily tributary inflow to the known upstream reservoir releases to obtain the required daily discharges at the study station. What is needed, therefore, is a means of estimating tributary inflow.

Daily releases from the reservoir are subtracted from the daily mean discharge at the study station to provide daily mean values of tributary inflow during periods of record at the study station. An annual hydrograph of daily mean tributary inflow is prepared and is compared with the hydrograph for a nearby natural-flow station. Using the technique described for Case B, the daily mean values of tributary inflow are estimated for the period of no gage-height record at the study station. As mentioned above, those estimated values of tributary inflow, when added to the concurrent reservoir releases, give the required discharges at the study station.

The above computational procedure may also be used for study reaches of channel that have diversions as well as tributary inflow, provided that the diverted discharges are measured. In that situation, the diversions must be subtracted from the reservoir releases. In other words, for reservoir release or outflow in the above description, we substitute reservoir outflow minus diverted flow.

COMPLETION OF THE DISCHARGE FORM

After all daily mean discharges have been entered on the discharge form (fig. 273), little is required to complete the form. Discharges from the appropriate rating table are entered in the left margin for the maximum and minimum stages of the water year that were previously recorded there. The summary discharge values at the bottom of figure 273 for each month, the water year, and the calendar year, are next computed. The mechanics of computing those total and average values are self-evident. The remaining entry in figure 273—peak discharges above a stated base—requires some explanation.

For stations whose high flows are not significantly regulated, peak discharges are shown for all peaks whose discharge equals or exceeds a chosen peak discharge, regardless of the number of peaks that occur in any given water year. A properly chosen base discharge is one that is exceeded, on the average, three times a year. The following suggestions are offered for selecting the base discharge:

1. For stations having records of more than 5 years, list the annual flood peaks, compute their recurrence intervals (R) in years by the formula, $R = (N + 1)/M$, and select as a base the discharge (rounded upward to two significant figures) whose value of R is 1.15 years. (In the formula, N is the number of years of record; M is the order number of the peak discharge after the peaks have been ranked in order of magnitude starting with 1 for the greatest peak.)
2. For stations having records of 5 years or less, select a base discharge, guided by judgment and by comparison with nearby stations having records of longer duration. The selected base can be modified as more data become available. It is, therefore, better to select a base discharge originally that is on the low side; if the base is later raised, it is a simple matter to drop originally selected peak discharges that do not exceed the new base value. If it is desirable later to lower the base discharge, it becomes necessary to search the earlier re-

corder charts for peak discharges that are smaller than the original base discharge but greater than the new base.

If two peak discharges that exceed the base discharge occur within 48 hours of each other, it is likely that the two peaks are not independent; only the larger of the two, or the earlier of the two if they are both equal, should be listed. If two adjacent peak discharges, both larger than the base, are separated by more than 48 hours, the lower of the two peaks is shown only if it is at least 1.33 times as large as the discharge of the trough between the adjacent peaks. For periods of diurnal peak discharges caused by snowmelt, only the highest peak that occurred during each distinct period of melting is shown regardless of the fact that other peaks may meet the criterion stated in the preceding sentence.

RECORD OF PROGRESS OF DISCHARGE COMPUTATIONS

Completion of the discharge form (fig. 273) marks the end of the actual computation of discharge for the water year. It is necessary, of course, that all computations be checked before the discharge figures are considered final. Furthermore, it is customary for the checker to initial and date any graphs or computation forms that he checks.

In the interest of efficiency it is advantageous to have a progress check list (fig. 274) attached to the folder in which the station computation forms are kept. The items on the check list are shown in the order in which they should be completed for maximum efficiency. Each item on the list has two boxes on the left margin. A checkmark is placed in the box at the extreme left when the item is completed; a checkmark is placed in the other box when the item has been checked. The supervisor of the discharge computations need only glance at the set of boxes to inform himself of the progress of the computations at a station.

STATION-ANALYSIS DOCUMENT

A complete analysis of data collected, procedures used in processing the data, and the logic upon which the computations were based must be recorded for each year of record to provide a basis for review and to serve as a reference in the event that questions arise about the records at some future date. Such a report is called the "Station Analysis." A record of any changes in: records collected, equipment, location, or other physical features should be included. The document should be written clearly and concisely and should contain sufficient information so that those who are totally unfamiliar with the station will be able to follow the reasoning used in computing the records. A

PROGRESS CHECK LIST
COMPUTATION OF GRAPHIC RECORDER RECORD

Station______________________________ Water Year__________

Index Number______________________________

Check work done. Complete in order. Initial when finished.

☐☐ Review chart for continuity, errors, peaks, faulty record.
☐☐ Check level notes. Apply datum corrections to chart and measurements.
☐☐ Check measurements, field notes, level notes for peak data. Enter on chart.
☐☐ Check mean gage heights of measurements. Compare with chart.
☐☐ List measurements and observations of no flow chronologically on 9-207 (fig. 262).
☐☐ Plot measurements on rating curve. Develop new curve and table, if necessary.
☐☐ Copy gage heights on 9-192 (fig. 273).
☐☐ Compute shifts, percentage differences on 9-207 (fig. 262).
☐☐ Enter shift corrections on 9-192 (fig. 273). "S" days on chart.
☐☐ Write station analysis.

Computed__________________ Checked__________________

....

☐☐ Apply discharge to 9-192 (fig. 273) and "S" days.

Computed__________________ Checked__________________

....

☐☐ Plot hydrograph. Enter measurements. Show drainage area size and discharge from rating tables.

....

☐☐ Estimate discharge for ice, missing, doubtful or backwater periods.
☐☐ Revise and complete daily discharges on 9-192 (fig. 273).
☐☐ Review and complete station analysis.

Computed__________________ Checked__________________

....

☐☐ Make monthly and yearly computations on 9-192 (fig. 273).
☐☐ Enter notes, maximum, minimum and peaks on 9-192 (fig. 273).
☐☐ Revise manuscript from previous year.

Computed__________________ Checked__________________

....

Final Review______________________________

FIGURE 274.—Form showing progress of computation of graphic-recorder record.

station analysis should be prepared for each station, including those for which records are furnished by other agencies.

The introductory paragraphs of the station analysis describe the equipment installed and the hydrologic characteristics of the drainage basin above the station. The remaining sections of the analysis outline the quality of the base data collected and the methods used to convert those data into the final discharge figures. The discussions are organized under the headings that follow.

(Station name and number)
STATION ANALYSIS
(WATER YEAR)

Equipment.—
Hydrologic conditions.—
Gage-height record.—
Datum corrections.—
Rating.—
Discharge.—
Special computations.—
Remarks.—
Recommendations.—

The following detailed discussion of each of the above items describes the type of information to be presented. As mentioned in the introductory pages of this chapter, documentation of that information is made as the various steps in the analysis and computation of the discharge record are completed.

STATION ANALYSIS

Equipment.—Provide a short statement that describes the equipment at the site. Designate the type of gage (float sensor or bubble-gage sensor); type of recorder; measurement facilities; artificial control, if any. Report any changes in equipment that may affect the accuracy of the record. Review the station description, revise it if necessary and include the statement, "Equipment conforms to station description dated. . . ."

Hydrologic conditions.—A brief description of the hydrologic characteristics of the basin should be carried forward in the station analysis from year to year. Review this paragraph and briefly describe any changes that might affect the runoff regime. These changes may result from fire (give date and percentage of basin area affected), or urban development (describe type and extent of development and give approximate dates), or from logging or road building operations. Usually several years elapse before the effects of these hydrologic changes become stabilized. Therefore, even if no changes occur in the current year, this paragraph should carry a statement referring to changes in the recent past such as: "No changes since the fire of August 21, 1961, which burned 6,000 acres of woodland;" or "No increase in urban development since September 1962."

Gage-height record.—Tabulate periods of faulty or no gage-height record and reasons for those problems. Discuss briefly any large instrument errors that affect the accuracy of the gage-height record. If portions of the gage-height record have been synthesized or adjusted on the basis of observers' readings and other data, this should be explained. Do *not* discuss in this paragraph how discharge was computed during periods of no gage-height record. That should be explained in the "Special Computations" paragraph.
Datum corrections.—Confusion frequently exists as to what should be included in this paragraph. Datum errors result from settlement of the base or reference gage to which the recording instrument is set or from movement of the bubble-gage orifice. Care should be taken, particularly with manometer and digital recorder combinations to differentiate between datum corrections and shift corrections. If datum corrections are necessary, the reasons should be explained and corrections listed in tabular form such as:

Period	*Correction applied*
Oct. 1–Jan. 15	+0.04
Jan. 16–Apr. 15	+0.05
Apr. 16–Aug. 3	+0.06
Aug. 4–Sept. 30	0

If applicable use a simple statement such as "None applied, last levels run on (date) ."
Rating.—Start this section with a description of the channel and the control, and provide sufficient detail to give anyone unfamiliar with the site a fairly good picture of the dominant features. Items discussed should include the size of the channel, composition of the bed (sand, gravel, boulders, or bedrock), location of the gage relative to the control, and the approximate elevation of any overflow areas.

Example: "The controlling reach of channel is sharply incised in the flood plain. Bed material is predominantly sand and gravel. The low-water control is generally a gravel riffle which moves up and down the channel in response to flood flows. At bankfull stage (about 21 feet), the channel is about 150 feet wide. At higher stages, it spreads out rapidly to a width of about 300 feet at a stage of 25 feet."

The remainder of the rating paragraph should be a chronological narrative of what occurred, hydraulically, during the year. Begin with a statement as to the number of measurements made and how they plot in relation to the rating curve in use at the end of the previous year. If new ratings are required, explain how this conclusion was reached and what caused the shift from one rating to the other. State exact time and date when rating changes were made. If ratings are modified during periods of significant flow by use of the shifting-control method, document these rating changes with shift tables or shift curves. These are rating changes too, and require the same explanations that a new table does. Because the reviewer does not always have access to the basic data, it is most important that the distribution of shifts be explained in detail, particularly if any unusual methods were used.

The statement "Shifts were distributed on basis of stage and (or) time" does not constitute a detailed explanation. The reviewer needs sufficient detail so that he can at least determine if a shift must be applied to the maximum and secondary peak stages and know its magnitude. For example, discharge measurements were obtained before and after a peak of 12.55 ft; the measurement preceding the peak shows a shift of −0.26 ft at gage height 2.56 ft, and the one following the peak shows a shift of + 0.06 ft at gage height 9.63 ft. One might reason that the rise scoured out the channel gradually, and the shift was zero at the peak. In the analysis, one might state "It was assumed that the shift of −0.26 ft indicated by measurement No. xx was gradually reduced during rise, and there was no shift at the peak; therefore, the shift between measurements No. xx and xxx was distributed on basis of stage." Or, one might have basis for this statement: "On the basis of shifts indicated by measurements No. xx and xxx and succeeding measurements, shift distribution was made on the assumption that the shift varied during the rise from −0.26 ft at gage height 2.50 ft to +0.06 ft at the peak and remained at +0.06 ft through the date of measurement No. xxx." Those two statements would indicate to the reviewer the shift needed for the peak stage and would give him a better idea of the distribution of shifts that was made. If a shift distribution were made on the basis of time, the statement "Shifts were distributed on the basis of time" is sufficient. However, if a peak discharge occurred during that shifting-control period, a statement should be added giving the shift used for the peak.

Discuss also the adequacy of the high-water rating. Is it defined to within 50 percent of the maximum discharge for the current year on the basis of measurements made during the year? (The 50 percent criterion is discussed early in the section in chapter 10 titled, "High-Flow Extrapolation.") If the extension has been made on the basis of older measurements or on the basis of a slope-area determination (chap. 9), give the date of those measurements or of the slope-area determination and state whether or not significant channel changes might have occurred within the intervening period.

Discharge.—This paragraph is a summary explaining how the stage records and rating data were combined to produce the discharge record. The information can best be presented in tabular form; an example for a station equipped with a graphic stage-recorder follows. (The table would be more complex for a station equipped with a digital stage-recorder; see page 599.)

Period	*Rating table used*	*Periods of shifting control*
Oct. 1 to Feb. 24	No. 3	Oct. 1–9, Oct. 14 to Nov. 14
Feb. 25 to Sept. 30	No. 4	July 15 to Sept. 1, Sept. 11–30

Special computations.—Describe the methods used for determining discharges during the periods of no gage-height record, ice effect, backwater, or other special conditions. Explain any unusual method for determining shifts. If daily discharges were estimated on the basis of hydrographic comparison with records for nearby stations, state the name of the stations used and how closely the station records compared. If weather records were used in the analysis, give the name or names of the weather stations used.

Remarks.—A statement should be made concerning the general accuracy of the daily records along with special accuracy statements regarding periods of ice effect, no gage-height record, high water, low water, backwater, shifting control, or other unusual conditions. A statement should be made here indicating that a hydrographic comparison was made. Identify station or stations used for comparison and state how well the hydrographs compared. Although the statement concerning hydrographic comparison duplicates some of the material given above under the heading "Special computations," the duplication is warranted because it will expedite the preparation of the "Remarks" paragraph of the manuscript station description. (See figs. 286*H* and 289.) It is helpful if all statements to be included in that manuscript paragraph can be drawn from material in the "Remarks" section of the station-analysis document. The "Remarks" section of the station-analysis document should also include any additional comments pertinent to the analysis of the record.

Recommendations.—A sample recommendation might read, "Flood schedule for next year should place high priority on high water measurements at this site. No measurements greater than 8,000 ft^3/s have been made since 1967. There have been several major peaks since that date."

(Authors) W. W. Smith (date)
A. R. Brown (date)

COMPUTATION OF DISCHARGE RECORDS WHEN A THREE-PARAMETER DISCHARGE RELATION IS USED

The section of this chapter titled, "Station Analysis," ended with a brief discussion of the preparation of the station rating when three parameters are involved—stage, discharge, and a third parameter such as fall or velocity index.

The first step that follows completion of the station rating is the computation of the gage-height record for the base-gage recorder, and for the auxiliary-gage recorder if fall is the third parameter. The daily mean gage heights are determined by the procedures explained for the graphic recorder in the section titled, "Computation of Gage–Height Record." Where subdivision of the day is required, the same time increments are used for both recorder charts. The daily mean fall, or mean fall for a time increment in a subdivided day, is computed by subtracting the downstream stage from the upstream stage. If a velocity index is the third parameter, as for example, where a deflection meter is used, the velocity-index record is used to determine daily mean values of the index or mean values for the time increments used in subdivided days. Gage-heights and velocity-index values are entered on a form similar to, but larger than, the form shown in figure 273. The expansion of the form is to accommodate an additional column each month for recording daily values of the third parameter; the additional column lies between the gage-height and discharge columns that are shown in figure 273.

The mechanics of computing discharge from stage and concurrent values of the third parameter were discussed in chapters 11 and 12. In chapter 11 slope (fall) is the third parameter; in chapter 12 a velocity index is the third parameter. Computed values of daily discharge are entered on the form bearing the daily values of stage and the third parameter. The daily discharges for periods of no record or of indeterminate discharge rating, such as ice-affected periods, are computed precisely as explained in a preceding section titled, "Computation of Daily Discharge;" hydrographic comparison is the principal method used. After all boxes for daily mean discharge on the discharge form are filled, the form is completed as shown in figure 273 and explained in the section on "Completion of the Discharge Form."

Throughout the computation procedure, a record of progress is kept, similar to that shown in figure 274 but modified to accommodate the additional steps needed to compute discharge when a 3-parameter discharge relation is used. A station-analysis document is prepared, similar to that described in the section immediately preceding this discussion of 3-parameter relations; the various items that are included are documented as corresponding steps in the analysis and computation of the discharge record are completed.

COMPUTATION OF DISCHARGE RECORDS FOR A RECORDING STATION EQUIPPED WITH A DIGITAL RECORDER

GENERAL

The fact that a gaging station is equipped with a digital stage-recorder does not affect the preparation of the station analysis (see the section on "Station Analysis"). Datum corrections are determined, discharge measurements are listed and reviewed, and graphical ratings are prepared and then converted to rating tables. The computations that follow the station analysis are similar to those described for a station equipped with a graphic stage-recorder, but instead of being performed manually they are performed by an electronic computer; the principal output forms are machine adaptations of the manual computation forms. The field offices generally send their input data to a central computer center where the computations are performed. The processing between field office and computer center may be accomplished by a combination of two or more of the following: mail, 16-channel paper-tape reader-transmitter, telephone line, and computer terminal.

The sequence and operation of an automated computing system is described in general terms in the last section of this chapter. It is not practicable to include a more detailed description of each step in the sequence because although the system of automated computation is well established, the particulars of each step are somewhat in a state of flux in response to continual improvement in storage and access procedures. Space limitations in this manual are also a factor in the treatment given to the subject. Additional pertinent information for the interested reader can be found in the following references that are listed at the end of this chapter: Carter and others, 1963; Edwards and others, 1974; WMO Technical Note No. 115, 1971 (contains a noteworthy bibliography).

The automated computation of discharge records from digital stage records is now (1980) more common in the U.S.A. than the manual computation of discharge records from graphic stage records. It may therefore seem incongruous to devote more space in this manual to manual computation than to automated computation. The two types of computation, however, are essentially similar, and a description of the manual method provides a far superior vehicle for explaining the computational technique.

INPUT TO COMPUTER

The input to the computer for a routine gaging station consists of: (1) the digital record of stage, accompanied by a list of corrections, if needed, for instrumental error in recording time and (or) gage height (any necessary datum corrections are included with the gage-height corrections); and (2) the discharge ratings accompanied by a list of any necessary shift adjustments. (See USGS form 9–1536 in fig. 275.) Stations for which the stage-fall-discharge type of rating is applicable require that the digital-tape records of stage for both the primary and auxiliary gages be furnished to the computer. Also required are the stage-discharge relation and such supplementary information as the stage-fall relation and the relation of fall ratio to discharge ratio. For stations at which velocity index is a third parameter—for example, a station equipped with a deflection meter—input requirements include the digital stage record, the digital record of deflection units, the stage-area relation, and the relation of deflection units to mean velocity, along with any necessary shift adjustments to those two relations.

OUTPUT FROM COMPUTER

The principal output from the computer consists of two forms—the primary computation sheet and the print-out of daily discharge. The primary computation sheet presents the initial or preliminary discharge computations. Normally, the computation sheet is edited, discharges are corrected or revised where necessary, and the corrections are fed back to the computer before the print-out of daily discharge is produced. Computer-produced hydrographs of daily mean discharge may be obtained for both preliminary and final discharge values. The discharge hydrograph of daily mean discharge based on preliminary values of discharge is very helpful for correcting the preliminary values; the method used is that of hydrographic comparison with final records for a nearby station, as explained in the section titled, "Computation of Daily Discharge." (Hydrographic comparison of discharge records is discussed in the two subsections that deal with the estimation of daily discharge.)

The primary computation sheet for a routine gaging station includes a listing for each day of: the maximum, minimum, hourly, and mean gage heights; mean discharge; the gage height equivalent to the mean discharge; the shift adjustment; and the datum correction. Figure 276 is an example of a primary computation sheet for a routine gaging station. The primary computation sheet for a slope station, shown in figure 277, differs somewhat. Listed for each day are: the maximum, minimum, and mean gage heights, mean fall, and mean and hourly discharge. For a deflection-meter station, the primary computation sheet (fig. 278) lists for each day maximum,

Form 9-1536
(Rev 10-69)

UNITED STATES DEPARTMENT OF THE INTERIOR—GEOLOGICAL SURVEY—WATER RESOURCES DIVISION
Correction Sheet For Water Data

Sta No ....

3 Shift 6 Discharge
4 Datum 7 Gage Height
5 Aux Datum 8 Sediment Conc
9 Susp Sediment

Corrections for ______________________ for year ending Sept 30, 19.......

DAY	OCT (10)	NOV (11)	DEC (12)	JAN (01)	FEB (02)	MAR (03)	DAY	APR (04)	MAY (05)	JUNE (06)	JULY (07)	AUG (08)	SEPT (09)	DAY
1							1							1
2							2							2
3							3							3
4							4							4
5							5							5
6							6							6
7							7							7
8							8							8
9							9							9
10							10							10
11							11							11
12							12							12
13							13							13
14							14							14
15							15							15
16							16							16
17							17							17
18							18							18
19							19							19
20							20							20
21							21							21
22							22							22
23							23							23
24							24							24
25							25							25
26							26							26
27							27							27
28							28							28
29							29							29
30							30							30
31							31							31

Remarks *Return to Boise, Idaho*
OCR PROCESSING

U. S. Geological Survey
Water Resources Division
Room 365, Federal Building
550 West Fort Street
Boise, Idaho 83702

Monthly Summary Code ....
Gage Height Code ....
Drainage Area ....
Cfs-Day Total (Jan-Sept) ....
Max Daily (Jan-Sept) ....
Min Daily (Jan-Sept) ....
Skip Code ....

U S GOVERNMENT PRINTING OFFICE 1969 OF—360-372

FIGURE 275.—Correction and update form for daily values of discharge.

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION DIST 25
PRIMARY COMPUTATION OF GAGE HEIGHTS AND DISCHARGE
01103500 DATA PROCESSED 01-14-74
CHARLES RIVER AT CHARLES RIVER VILLAGE, MASS. USE RT 32

PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1973 TEST DIFF 0.2 PUNCH INT 15 MIN STORE PARM 00060, STATISTIC 00003
PARM 00065, STATISTIC 00003

DATE	MAX GH (TIME)	MIN GH (TIME)	MEAN GH	EQUIV GH	MEAN DISCH	SHIFT ADJ	AT HR	DATUM CORR	AT HR		STAGE, IN HUNDREDTHS OF FEET, AT INDICATED HOURS 1	2	3	4	5	6	7	8	9	10	11	12
9-18	1.07	0.92	0.98	.98	113					AM	93	93	93	93	93	93	93	93	92	93	93	93
	(1630)	(0715)								PM	96	99	104	106	107	106	105	104	104	103	102	102
9-19	1.02	1.00	1.00	1.01	122					AM	101	101	101	100	100	100	100	100	100	101	101	101
	(0015)	(0315)								PM	101	101	101	101	101	101	101	102	101	101	101	101
9-20	1.04	1.01	1.02	1.03	131					AM	101	102	102	102	102	103	103	103	103	103	103	103
	(1215)	(0015)								PM	104	104	104	104	104	104	104	103	104	104	104	104
9-21	1.04	1.00	1.02	1.02	127					AM	103	103	103	103	103	103	103	102	103	102	102	102
	(0015)	(2230)								PM	102	102	102	101	101	101	101	101	101	101	100	100
9-22	1.00	0.98	0.98	.99	116					AM	100	100	100	100	100	100	100	99	99	99	99	98
	(0015)	(1200)								PM	98	98	98	98	98	98	98	98	98	98	98	98
9-23	0.98	0.96	0.97	.97	110					AM	98	98	98	97	97	97	97	97	97	97	97	97
	(0100)	(1315)								PM	97	97	97	97	97	97	97	97	97	98	98	98
9-24	1.06	0.98	1.01	1.02	125					AM	98	99	99	99	99	100	100	100	101	101	101	101
	(2230)	(0015)								PM	101	101	102	102	103	103	104	105	105	105	106	106
9-25	1.14	1.06	1.09	1.10	155					AM	106	106	107	107	107	107	108	108	109	110	110	110
	(2030)	(0015)								PM	110	110	111	111	112	112	113	113	114	114	114	114
9-26	1.17	1.14	1.16	1.16	177					AM	115	115	115	115	116	116	116	116	117	117	117	117
	(0845)	(0015)								PM	117	117	117	117	117	117	117	117	117	117	117	117
9-27	1.17	1.14	1.16	1.16	175					AM	117	117	117	117	117	117	117	117	117	116	117	116
	(0015)	(1945)								PM	116	116	116	116	115	115	115	114	114	114	114	114
9-28	1.14	1.07	1.10	1.10	156					AM	113	113	113	113	113	112	112	112	112	111	111	111
	(0015)	(2015)								PM	110	110	109	109	108	108	108	108	107	107	107	107
9-29	1.07	1.00	1.03	1.04	133					AM	107	105	106	106	105	105	105	105	105	104	104	105
	(0015)	(2030)								PM	104	104	103	103	102	102	101	101	100	100	100	100
9-30	1.00	0.94	0.96	.97	109					AM	99	99	99	99	98	98	98	98	98	98	98	98
	(0015)	(1945)								PM	97	95	96	96	95	95	95	94	94	94	94	94
MONTH					116																	
PERIOD	1.17	0.83																				

RECORDER CLOCK RUNNING 3.1 MINUTES PER DAY FAST. RECORD ADJUSTED.

NOTE. SYMBOLS USED ABOVE HAVE THE FOLLOWING MEANINGS
A - SUCCESSIVE ADJUSTED PUNCH READINGS DIFFER BY MORE THAN THE SPECIFIED ALLOWABLE TEST DIFFERENCE
P - DAILY SUMMARY IS FOR AN INCOMPLETE DAY
R - ONE OR MORE INPUT VALUE IS OUTSIDE THE RANGE OF THE RATING IN USE
W - SHIFT IS A VALUE WEIGHTED BY DISCHARGE WHERE SHIFT VARYS WITH STAGE DURING THE DAY

FIGURE 276.—Primary computation sheet for routine gaging station.

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION DIST 36
PRIMARY COMPUTATION OF DISCHARGE WHERE SLOPE OF THE WATER SURFACE IS A FACTOR
DATA PROCESSED 02-11-74

04246500
ONEIDA RIVER AT CAUGHDENOY NY DISCH RT 3 FALL RT 2 RATIO RT 1

PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1974
BASE GAGE IS UPSTREAM DATUM DIFFERENCE BETWEEN GAGES 0.00 TEST DIFF 0.1 STORE PARM 00060, STATISTIC 00003
SLOPE IS NOT A FACTOR BELOW OR ABOVE PUNCH INTERVAL 60 MIN

S	DATE	MAX GH (TIME)	MIN GH (TIME)	MAX DISCH (TIME)	MEAN GH	MEAN FALL	MEAN DISCH	1	2	3	4	5	6	7	8	9	10	11	12
								DISCHARGE AT INDICATED HOURS (1ST LINE A.M., 2ND LINE P.M.)											
	12-26	8.22	7.98	4560	8.06	3.08	4310	4180	4100	4230	4230	4260	4250	4260	4260	4220	4220	4230	4280
		(2300)	(0100)	(2300)				4310	4310	4330	4310	4340	4330	4390	4410	4420	4500	4560	4450
B	12-27*	8.62	8.19	5220	8.40	3.42	4850	4520	4650	4660	4640	4710	4630	4710	4630	4820	4740	4870	4750
		(2400)	(0100)	(2400)				4930	4830	4970	4930	5050	5000	5080	5080	5150	5140	5200	5220
	12-28	9.00	8.60	5860	8.82	3.84	5550	5190	5240	5300	5400	5350	5460	5390	5420	5390	5460	5520	5590
		(2400)	(0100)	(2400)				5620	5610	5640	5660	5690	5740	5740	5780	5790	5810	5840	5860
	12-29	9.17	9.00	6150	9.09	4.11	6010	5860	5910	5860	5940	5930	5940	5940	5960	6000	5980	6030	6000
		(2100)	(0100)	(2100)				6950	6010	6050	6060	6080	6060	6130	6100	6150	6100	6130	6050
	12-30	9.23	9.05	6250	9.17	4.29	6150	6110	6080	6000	5940	6050	6080	6230	6080	6210	6130	6160	6100
		(1700)	(0400)	(1700)				6160	6110	6230	6150	6250	6200	6230	6210	6210	6210	6230	6250
	12-31	9.27	9.21	6320	9.24	4.23	6260	6270	6250	6270	6230	6280	6230	6300	6280	6320	6270	6300	6270
		(0900)	(2100)	(0900)				6300	6250	6270	6250	6280	6270	6250	6270	6210	6270	6210	6210
	MONTH						4927												
	1-01	9.24	9.11	6270	9.19	4.16	6170	6230	6230	6250	6270	6200	6210	6200	6200	6230	6210	6210	6200
		(0400)	(1400)	(0400)				6160	6050	6180	6100	6160	6080	6180	6080	6150	6100	6130	6100
	1-02	9.15	9.07	6110	9.12	4.10	6060	6100	6110	6100	6110	6100	6100	6100	6100	6100	6080	6060	6100
		(0200)	(2300)	(0200)				6060	6050	6050	6050	6050	6030	6010	6010	6030	6010	5980	6030
	1-03	9.08	8.97	6000	9.03	4.02	5920	5980	6000	5960	6000	5940	5980	5920	5980	5930	5950	5890	5940
		(0200)	(2200)	(0200)				5890	5910	5860	5890	5890	5840	5880	5630	5880	5810	5880	5830
	1-04	8.99	8.93	5840	8.95	3.91	5780	5840	5790	5810	5780	5760	5760	5790	5760	5740			
		(0100)	(0900)	(0100)															

PERIOD MAX GH 9.27 (0900) 12-31 MIN GH 7.76 (0700) 12-21 MAX DISCH 6320 (0900) 12-31 MIN DISCH 1470.00 ON 11-16

NOTE.- SYMBOLS USED ABOVE HAVE THE FOLLOWING MEANINGS
A - SUCCESSIVE RECORDED GAGE HEIGHTS AT AUXILIARY GAGE DIFFER BY MORE THAN THE SPECIFIED ALLOWABLE TEST DIFFERENCE
B - SUCCESSIVE RECORDED GAGE HEIGHTS AT BASE GAGE DIFFER BY MORE THAN THE SPECIFIED ALLOWABLE TEST DIFFERENCE
R - ONE OR MORE INPUT VALUE IS OUTSIDE THE RANGE OF THE RATING TABLE
* - OBSERVED FALL IS ZERO OR NEGATIVE FOR ONE OR MORE SETS OF OBSERVATIONS

FIGURE 277.—Primary computation sheet for slope station.

minimum, and mean gage heights; maximum, minimum, hourly, and mean discharges; maximum and minimum velocities; volume and direction of flow (for a tidal stream whose flow reverses direction); and shift adjustments to the area and velocity relations.

The printout of daily discharge is virtually the same for all types of gaging stations. In addition to daily mean discharges, the printout includes monthly and yearly summaries in the same format that is used for publication (fig. 279). Besides being published, the figures on the printout are stored on a magnetic tape or disk. If, for some reason, it is found necessary to revise the computed records at some later date, corrections are made on the stored tape or disk.

SEQUENCE OF OPERATION OF AN AUTOMATED COMPUTING SYSTEM

The sequence of operation of the automated computing system used by the Geological Survey is as follows:

1. River stage is punched on 16-channel tape by the digital recorder in the gage house. When a segment of the tape is started by the hydrographer, he leaves a fresh inspection form (USGS form 9–176D in fig. 280) in the instrument shelter. On that form he fills out the box headed "Started by".
2. Tape is removed by field personnel at intervals of 30 to 60 days. Upon removal, the tape is checked for continuity and quality of record, and appropriate notes concerning identity of the station and quality of the record are made on the tape. The boxes headed "Removed by" and "Battery voltage" on inspection form 9–176D (fig. 280) are also filled out by the hydrographer, and the form accompanies the segment of 16-channel tape to the field office. If the hydrographer merely inspects the recorder without removing the punched segment of tape, he fills out the box headed "Insp'd by" on the inspection form and leaves the inspection form in the instrument shelter.
3. The tape, rating table, datum correction, and table of shifts are forwarded from the field office to the Automatic Data Processing Unit. Ratings may be submitted in one of three alternate forms. Discharge may be tabulated for each 0.01 foot of gage height for the part where curvilinear expansion between tenths of feet is necessary; it may be tabulated for each 0.1 foot; or, preferably, it may be defined by a series of coordinate values at the ends of straight-line segments on a logarithmic plot of the rating curve. The entry of ratings directly from the logarithmic plot eliminates the preparation of a rating table in the usual form. Shift adjustments are prorated with time to give a shift for each day between the days for which values of shift are submitted. A new rating may be put in use at any

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION DIST 21
COMPUTATION OF DISCHARGE AT DEFLECTION METER STATION
DATA PROCESSED 02-26-74

03438192
BARKLEY-KENTUCKY CANAL NEAR GRAND RIVERS, KY. STANDARD DATUM CORR 0.00 FEET

PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1974 PUNCH INTERVAL 15 MIN STORE PARM 00060, STATISTIC 00003

DATE	GAGE HEIGHT IN FEET		DISCHARGE IN CFS		TIME	VELOCITY IN FT/SEC		VOLUMES IN MCF			HOURLY DISCHARGE (6 HOURS PER LINE, BEGINNING AT 1 A.M.) 1	2	3	4	5	6
1-23	MAX	62.87	MAX	35000.00	AT 0600	MAX	2.90	DOWN	1299.45	AM	10500.00	9840.00	8730.00	16200.00	24800.00	35000.00
	MIN	62.29	MIN	729.00	AT 0130	MIN	.06	UP		AM	26100.00	2420.00	15908.00	7280.00	12200.00	6440.00
	MEAN	62.54	MEAN	15000.00						PM	11800.00	3170.00	21900.00	1590.00	18400.00	5640.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	22500.00	21300.00	22000.00	11300.00	22600.00	21100.00
1-24	MAX	63.17	MAX	23400.00	AT 0030	MAX	1.90	DOWN	1115.41	AM	19100.00	6530.00	13000.00	21700.00	21700.00	10300.00
	MIN	62.83	MIN	1620.00	AT 1430	MIN	.13	UP		AM	17200.00	12400.00	22800.00	17200.00	15600.00	18200.00
	MEAN	62.99	MEAN	13000.00						PM	11100.00	11100.00	2490.00	8960.00	10700.00	8560.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	7470.00	10700.00	6510.00	9720.00	9350.00	4990.00
1-25	MAX	63.44	MAX	12500.00	AT 0545	MAX	1.00	DOWN	370.17	AM	6620.00	5000.00	12100.00	8370.00	12100.00	9010.00
	MIN	63.16	MIN		AT 0930	MIN		UP		AM	3250.00	8640.00	4130.00	2510.00		4140.00
	MEAN	63.31	MEAN	4310.00						PM	10300.00	4150.00	3270.00	3270.00	4150.00	2520.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	755.00	756.00			1640.00	756.00
1-26	MAX	63.84	MAX	31900.00	AT 1545	MAX	2.50	DOW	475.20	AM	756.00	7550.00	1640.00	758.00		758.00
	MIN	63.40	MIN		AT 0030	MIN		UP		AM	1640.00	758.00	759.00	760.00	760.00	760.00
	MEAN	63.61	MEAN	5500.00						PM	6720.00	8520.00	14800.00	28000.00	13400.00	14100.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	15100.00	5110.00	4200.00	1660.00	3320.00	1660.00
1-27	MAX	63.78	MAX	10500.00	AT 2145	MAX	1.47	DOWN	578.32	AM	6750.00		2550.00	2550.00	764.00	764.00
	MIN	63.39	MIN		AT 0015	MIN		UP		AM	764.00	763.00	764.00	1660.00	763.00	10900.00
	MEAN	63.62	MEAN	6640.00						PM	762.00	762.00	2540.00	9510.00	15700.00	10900.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	18100.00	16300.00	12600.00	9070.00	17200.00	13600.00
1-28	MAX	63.41	MAX	28700.00	AT 1100	MAX	2.29	DOWN	971.55	AM	16500.00	17500.00	16800.00	10200.00	12500.00	10100.00
	MIN	62.97	MIN	4090.00	AT 2300	MIN	.33	UP		AM	18800.00	13600.00	28100.00	17400.00	28700.00	16400.00
	MEAN	63.20	MEAN	11300.00						PM	13500.00	10100.00	6600.00	5730.00	4110.00	4100.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	4100.00	4100.00	4090.00	4090.00	4090.00	5700.00
1-29	MAX	62.97	MAX	20700.00	AT 1445	MAX	1.68	DOWN	819.42	AM	5640.00	5690.00	5590.00	5690.00	4940.00	4940.00
	MIN	62.80	MIN	4940.00	AT 0600	MIN	.40	UP		AM	5540.00	5580.00	5670.00	5670.00	5570.00	5670.00
	MEAN	62.87	MEAN	9440.00						PM	8500.00	16200.00	11400.00	17100.00	15900.00	9960.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	12000.00	11700.00	6510.00	15900.00	13900.00	15900.00
1-30	MAX	63.37	MAX	20600.00	AT 1215	MAX	1.66	DOWN	9''.41	AM	15540.00	15300.00	15300.00	14900.00	10600.00	8510.00
	MIN	62.84	MIN	5680.00	AT 0900	MIN	.46	UP		AM	6810.00	8270.00	5680.00	18900.00	16200.00	10600.00
	MEAN	63.03	MEAN	10600.00						PM	11400.00	6580.00	5600.00	8350.00	6620.00	7500.00
	(DATUM	0.00)	(SHIFT TO AREA		0.00)	(SHIFT TO VEL			0.00)	PM	6520.00	5760.00	6760.00	5780.00	5780.00	8420.00
PERIOD	MAX	64.16	MAX	60973.47		MAX	5.43									
	MIN	57.28	MIN			MIN										

FIGURE 278.—Primary computation sheet for deflection-meter station.

PROCESS DATE IS 02-27-7

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY

STATION NUMBER 11183600 WALNUT CREEK AT CONCORD, CALIF. STREAM SOURCE AGENCY USGS
LATITUDE 375643 LONGITUDE 1220255 DRAINAGE AREA 85.10 DATUM 35.44 STATE 06 COUNTY 013

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	12	16	9.2	9.7	116	27	45	30	18	13	12	9.8
2	12	17	23	10	170	32	40	29	19	12	13	9.8
3	11	9.2	98	9.7	121	25	44	31	20	13	13	9.9
4	9.7	17	44	10	170	24	184	30	21	13	13	11
5	9.7	8.6	14	10	32	38	272	26	19	14	13	11
6	9.2	8.1	12	86	23	42	130	26	19	13	11	11
7	9.2	20	11	23	61	177	170	24	18	14	13	10
8	9.7	18	10	90	55	127	354	24	18	13	13	11
9	9.7	10	11	19	293	44	110	23	17	13	13	11
10	9.2	17	10	15	201	133	81	23	17	13	12	10
11	10	9.7	11	14	48	52	71	22	16	13	13	11
12	10	10	11	12	71	35	65	23	16	12	13	9.3
13	9.2	9.7	11	12	574	439	59	23	16	13	13	9.3
14	9.2	8.1	11	12	84	157	57	22	15	12	13	10
15	9.7	8.1	10	12	45	142	71	23	14	17	13	9.6
16	10	8.1	11	12	34	227	59	23	17	14	12	9.9
17	10	8.1	10	12	27	81	50	21	16	14	12	10
18	27	8.6	9.2	12	25	63	45	22	15	14	15	9.6
19	11	8.6	9.2	12	47	55	44	22	14	13	14	9.5
20	14	8.1	9.2	12	48	50	42	19	14	13	13	12
21	19	32	9.2	12	25	1370	42	18	14	13	12	12
22	11	14	9.2	13	23	486	39	19	16	14	12	10
23	10	9.7	9.2	12	21	145	36	19	15	13	12	9.5
24	10	8.6	9.2	13	21	119	71	19	16	14	11	9.6
25	11	12	9.2	13	21	733	81	18	16	14	11	9.0
26	10	9.2	9.2	12	22	145	36	17	14	14	11	8.3
27	15	9.2	79	10	24	90	31	18	14	12	11	7.8
28	69	9.2	88	12	25	70	36	18	13	12	11	7.9
29	19	9.2	17	12	---	60	39	19	13	12	11	8.0
30	14	9.2	12	11	---	55	31	20	13	12	10	7.8
31	30	---	10	139	---	50	---	20	---	12	10	---
TOTAL	438.5	350.3	606.0	663.4	2427	5293	2435	691	483	408	381	294.6
MEAN	14.1	11.7	19.5	21.4	86.7	171	81.2	22.3	16.1	13.2	12.3	9.82
MAX	69	32	98	139	574	1370	354	31	21	17	15	12
MIN	9.2	8.1	9.2	9.7	21	24	31	17	13	12	10	7.8
AC-FT	870	695	1200	1320	4810	10500	4830	1370	958	809	756	584

CAL YR 1974 TOTAL 17259.8 MEAN 47.3 MAX 1450 MIN 8.1 AC-FT 34230
WTR YR 1975 TOTAL 14470.8 MEAN 39.6 MAX 1370 MIN 7.8 AC-FT 28700

FIGURE 279.—Printout of daily discharge.

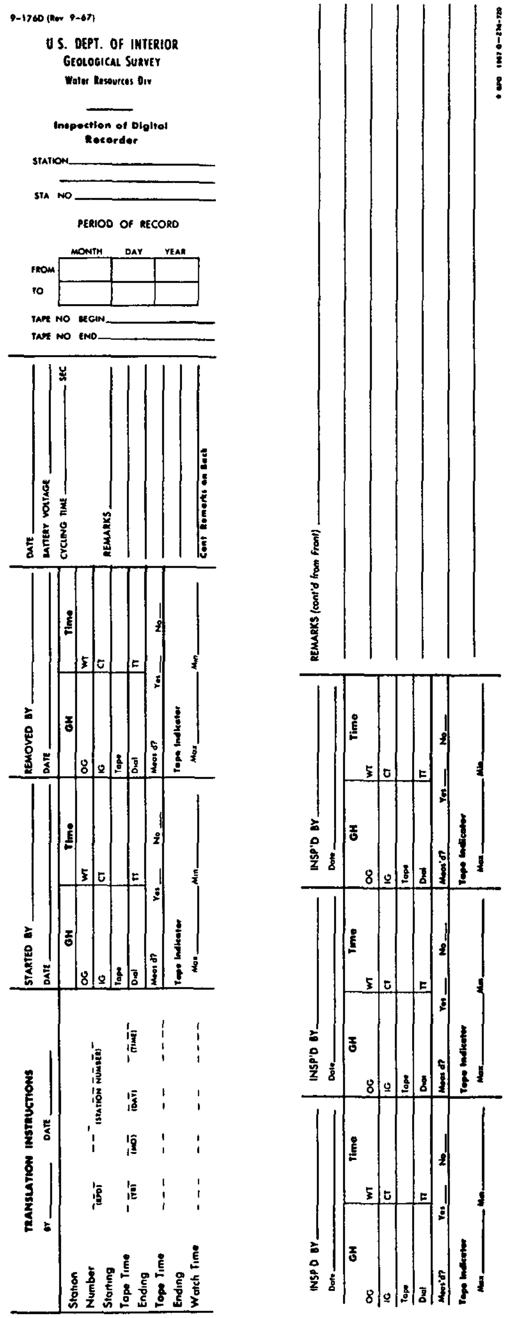


FIGURE 280.—Digital-recorder inspection form.

time during a day, and any shift applicable to the old rating on the same day will be dropped when the new rating takes effect.

The refinement considered in ratings for the initial run through the computer depends upon the complexity of the rating problem and the completeness of the data available. Sometimes final ratings can be prepared at the outset, at other times the output from the first run will be needed to complete the analysis. In the latter situation, only base ratings and approximate shift corrections are supplied.

Data from the 16-channel tape are translated by the central processing unit onto magnetic tape. The information on ratings is manually punched on cards. The magnetic tape and punch cards comprise the input to the digital computer. The rating table is stored on magnetic disk or tape at the computer center after the initial run.

4. The computer converts each instantaneous reading of river stage into a discharge value. Both daily mean discharge and daily mean gage height are computed as an average of instantaneous values. An equivalent daily mean gage height (the gage height corresponding to the daily mean discharge) is computed for each day so that recomputation, if necessary, can be made at a later date without reference to the individual items of the original base data. Daily mean values of gage height, discharge, and equivalent gage height are stored on a magnetic tape or disk. The printed output from the first computer pass consists of two items; a primary computation sheet, which is standard, and a daily discharge sheet, which is optional.

   The primary computation sheet (fig. 276) gives for each day the maximum, minimum, and mean gage heights, equivalent mean gage height, the datum and shift corrections applied, and the daily mean discharge. In addition, hourly gage heights and the time when maximums occurred are printed out.

   The printout of daily discharges (fig. 279), which is suitable for outside distribution, lists daily mean discharges for the period from the beginning of the water year to the end of the record being computed.

5. The field offices use the primary computation sheet in quality checks of the original and computed data, in further analysis of the stage-discharge relation, and in selecting instantaneous peak discharges to be published. Daily discharges from this sheet can be plotted for comparison with adjacent streams, and the usual studies can be made for periods of ice effect, no gage-height record, or backwater from various sources. Estimates can be made for all anomalous periods, and ratings can be revised, if

necessary, so that daily discharge can be recomputed from the effective mean gage heights on the second pass through the computer. The information necessary for revision or recomputation is forwarded to the Automatic Data Processing Unit.

6. The final tabulation is the same as figure 279 except that it is complete for the year and is produced on the second pass (update) through the computer. Where rating changes have been made as a result of the quality control analysis or where individual discharge figures have been estimated, the recomputation will involve substituting the estimated figures on the magnetic storage record, recomputing other discharge figures from revised ratings and the equivalent daily mean gage height, and printing out of the final discharge figures. (A printout from the subprogram for updating the primary computation sheet is shown in figure 281.) The printout from the final computer update is for the complete year. The format of the output is suitable for direct offset reproduction. The data on this form are also stored on magnetic tape for permanent storage.
7. A tabulation of daily mean gage heights may also be printed out during the second computer pass for stations designated by the field offices. That tabulation is prepared only for those stations for which there is a specific need.
8. The documentation file in the field offices consists of the original measurement notes, the 16-channel tapes, a station analysis, a list of discharge measurements, a rating curve, the primary computation sheet, a table of daily mean discharges from the final computer run, and possibly a rating table.

A record of progress of the discharge computations is kept in the field office on a check list such as that shown in figure 282. That form or perhaps a more detailed one, such as figure 283, is especially necessary because of the complication caused by records being shuttled back and forth between the field office and the computer center.

It is also necessary that a station-analysis document be prepared in the field office, as described for the graphic recorder in the section titled, "Station-Analysis Document." In that description it was mentioned that the "Discharge" paragraph showing the ratings used during the water year would be more complex for a digital-recorder station than for a graphic-recorder station. For a digital-recorder station, it is necessary to explain the origin of figures shown on the primary computation sheet as well as those on the final print-out. Documentation received on updating computer runs should therefore be referred to in the "Discharge" paragraph. A sample table of ratings used for a digital-recorder station having a somewhat complicated rating problem follows:

```
            UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION            DIST 17
                         UPDATE BY SUBSTITUTION OR RECOMPUTATION OF DAILY VALUES
03337000                                DATA PROCESSED 02-11-74
BONEYARD CREEK AT URBANA, ILL
PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1973                          STORE PARM 00065, STATISTIC 00003

                         DAILY GAGE HEIGHTS SUBSTITUTED(EQUIV GH SET THE SAME)
                                   9-20-73 TO  9-22-73
                                   9-25-73 TO  9-27-73

                              STAGE-SHIFT VARIATION DIAGRAM
                         HIGH POINT     2.00 SHIFT AT GH  5.00
                         BASE           1.00 SHIFT AT GH  2.00
                         LOW POINT      0.10 SHIFT AT GH  0.20

                                  SHIFT ADJUSTMENTS
                                    ADJ     DATE
                                    .09  09-13-73  AT GH   .55 PROJECTED TO   0.33 AT BASE GH
                                   -.02  10-01-73  AT GH   .65 PROJECTED TO  -0.06 AT BASE GH

                              DAILY DISCHARGE RECOMPUTED
                                    USE RT 07
                               09-18-73 TO 09-30-73
                              (SHIFTS VARIED WITH STAGE)
```

FIGURE 281.—Printout from subprogram for updating primary computation sheet.

PROGRESS CHECK LIST
COMPUTATION OF DIGITAL RECORDER RECORD

Station________________________________ Water Year________.

Index Number______________________

1 2 4 4 — Check work done. Complete in order. Initial when finished.

Examine and prepare tapes for transmittal.
List measurements on 9-207 (fig. 262).
Plot measurements on rating curve. Develop new curve and table, if needed.
Compute shift corrections, percentage difference on 9-207 (fig. 262).
Enter shift or datum corrections on 9-1536 (fig. 275).
Write preliminary rating analysis.

Computed______________ Checked______________

....

Tape transmitted.
Ratings transmitted.
9-1536 transmitted (fig. 275)

....

Inspect primary computation sheet.
Check measurements and field notes for peak data. Enter on PC sheets.
Revise shifts and recompute daily discharges on primary computation sheet.
Plot hydrograph.
Estimate discharge for ice, missing, doubtful or backwater periods.
Complete daily discharges monthly totals on primary computation sheets.
Complete station analysis.

Computed______________ Checked______________

....

Transmit updating corrections.

....

Enter notes, maximum, minimum and peaks on 9-211m (fig. 279).
Revise manuscript from previous year.

Computed______________ Checked______________

FIGURE 282.—Form showing progress of computation of digital-recorder record (sample 1).

"*Discharge*.—Computed as follows:

Ratings Used

Period	*Primary*	*Final*	*Update*
Oct. 1 to Jan. 4	No. 4	No change	None
Jan. 5 to Jan. 20	———	Special	May 12, 1973
Jan. 21 to Jan. 29	No. 4	No. 5	May 12, 1973
Jan. 30 to Feb 20	No. 4	Special	May 12, 1973
Feb. 21 to Aug. 10	No. 5	No. 5	None
Aug. 11 to Sept. 30	———	Special	Oct. 20, 1973"

All other instructions on the preparation of the station-analysis documents (p. 580–585) are applicable for a digital-recorder station.

SELECTED REFERENCES

Carter, R. W., and Davidian, Jacob, 1968, General procedure for gaging streams: U.S. Geol. Survey Techniques Water Resources Inv., book 3, chap. A6, p. 12–13.

WRD-ID-11
Jan 76

19__ water year A.D.P. check list

Station No.____________
Station Name____

List of measurements:
Gage-heights . . . . checked (_____)
Original list of measurements. . checked (_____)
List of measurements . . . . . . checked (_____)
Shifts O.K. as submitted . . . . yes ( ) no ( )
Shifts . . . . updated (_____ checked (_____)

Rating curve:
Measurements . . . . plotted (_____) checked (_____)
New curve needed . . . . yes ( ) no ( )
Measurements . . . . plotted (_____) checked (_____)
Curve. . . . . drawn (_____) checked (_____)
Rating table . . . . computed (_____) checked (_____)

Primary sheets:
Record complete. . . . . yes ( ) no ( )
Primary shifts O.K. . . . . yes ( ) no ( )
Primary datum corr. O.K. . . . . yes ( ) no ( )
Correct rating in use. . . . . . yes ( ) no ( )
Rating changed during year . . . yes ( ) no ( )
Missing record . . . . estimated (_____) checked (_____)
Ice period . . . . estimated (_____) checked (_____)
Shift. . . . . update (_____) checked (_____)
Datum. . . . . update (_____) checked (_____)
Discharge. . . . . update (_____) checked (_____)
Re-update. . . . . yes ( ) checked (_____)
Re-update. . . . . yes ( ) checked (_____)

Station analysis:
Written by______________ checked by____________
Reviewed by______________

Discharge table:
Two copies . . . . yes ( ) no ( )
Left margin attached . . . . . . yes ( ) no ( )
Extremes . . . . computed (_____) checked (_____)
Supplemental peaks . . . . . . (_____) checked (_____)
Footnotes. . . . . (_____) checked (_____)
Table annotated. . . . . (_____) checked (_____)

Manuscript:
Mean flow. . . . . computed (_____) checked (_____)
Sheet updated with current data. (_____) checked (_____)
Historical data changed. . . . . yes ( ) no ( )
Footnotes. . . . . updated (_____) checked (_____)
Skeleton rating. . . . . (_____) checked (_____)

FIGURE 283.—Form showing progress of computation of digital-recorder record (sample 2).

Carter, R. W., and others, 1963, Automation of streamflow records: U.S. Geol. Survey Circular 474, 18 p.

Corbett, D. M., and others, 1943, Stream-gaging procedure: U.S. Geol. Survey Water-Supply Paper 888, 245 p.

Edwards, M. D., and others, 1974, National water data storage and retrieval system; processing digital recorder records: U.S. Geol. Survey open-file report, 139 p.

World Meteorological Organization, 1971, Machine processing of hydrometeorological data: WMO–no. 275, Technical Note no. 115, 79 p.