QUALITY OF WATER

UPPER COLORADO RIVER BASIN

PROGRESS REPORT No. 1

January 1963

UNITED STATES
DEPARTMENT OF THE INTERIOR
Stewart L. Udall, Secretary

SURVEY
n, Director

BUREAU OF RECLAMATION
Floyd E. Dominy, Commissioner

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QUALITY OF WATER
UPPER COLORADO RIVER BASIN
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LEGISLATIVE DIRECTIVES AND RESPONSE

Public Law 485, 84th Congress, Second Session, the authorizing legislation for the Colorado River Storage project and participating projects, was signed by the President on April 11, 1956. Section 15 of the Act states, "The Secretary of the Interior is directed to continue studies and make a report to the Congress and to the States of the Colorado River Basin on the quality of water of the Colorado River."

Authorizing legislation (PL 87-483) for the San Juan-Chama project and the Navajo Indian Irrigation project became effective on June 13, 1962. Section 15 of this Act states, "The Secretary of the Interior is directed to continue his studies of the quality of water of the Colorado River system, to appraise its suitability for municipal, domestic, and industrial use and for irrigation in the various areas in the United States in which it is used or proposed to be used, to estimate the effect of additional developments involving its storage and use (whether heretofore authorized or contemplated for authorization) on the remaining water available for use in the United States, to study all possible means of improving the quality of such water and of alleviating the ill effects of water of poor quality, and to report the results of his studies and estimates to the Eighty-seventh Congress and every two years thereafter."

Similar reports are required by P. L. 590, 87th Congress, Second Session which authorized the Fryingpan-Arkansas project. January 3, 1963, is stipulated as the submission date for the initial report.

Response to these directives by the Department of the Interior comprises two parts that are reported here: (1) an assessment of the water-quality situation in the part of the Colorado River basin above Lee Ferry, Ariz., as of 1957, by the Geological Survey; and (2) a projection of water-quality effects to be expected from additional developments that involve storage and use of river waters above Lee Ferry, by the Bureau of Reclamation. Current studies that concern the lower part of the Colorado River basin, below Lee Ferry, have not reached a definitive stage and are not reported here.

Determination of the effects of man and nature on the quality of water in any area is dependent upon many factors, the most important of which is the availability of adequate streamflow and salinity records of long standing. Although quantitative streamflow records on the Colorado River and its major tributaries meet this requirement, the quality-of-water records do not. Paucity of water quality records precludes conclusive determination of the dissolved-solids yields caused by irrigation. Therefore, any of the determinations included in this report are subject to substantial revision as more adequate basic data are accumulated and as such determinations are applied to future conditions of precipitation and runoff.

Drought conditions which cause months or years of minimum flow greatly reduce the dilution potential of any stream, with a consequent increase in salinity, regardless of external causes. Conversely, months or years of high stream flow will decrease the salinity of any stream. Any determination of the effects of irrigation on water quality, to be of a conclusive nature, will require many years of record which include both wet and dry cycles as well as adequately documented storage releases and water deliveries to projects within the basin. Variations in the cropping pattern, with its accompanying variation in water requirements, will produce different salinity patterns.

All of the salinity estimates in this report should be judged merely as credible interim indicators associated with the general order of magnitude of the results shown.

The continuing requirements of the cited legislative directives will be the subject of future reports which will incorporate additional data as they become available.

PART I

THE WATER-QUALITY SITUATION AS OF 1957

GEOLOGICAL SURVEY

PART I

THE WATER-QUALITY SITUATION AS OF 1957

OBJECTIVE OF THE INVESTIGATION

Assessment of the water-quality situation in the Colorado River basin above Lee Ferry, by the Geological Survey, began in 1957. The principal specific objective has been--so far as was practicable from information at hand or obtainable within the span of a few years under a modest budget--to discriminate natural and man-caused components of the dissolved-solids load that was in the stream system as of 1957 and to scale the size of each major component. The components having been identified and scaled, an informative hypothetical model of the virgin water-quality situation can be computed readily, although this was not a basic purpose of the investigation.

Two reports on this investigation have been completed in manuscript form by the Geological Survey. Both carry the general title, "Water resources of the Upper Colorado River basin, Colorado, Wyoming, Utah, New Mexico, and Arizona." One, a "Basic data report" of 1,305 pages, collects and summarizes statistical water information; it has been released as of December 1961 and awaits publication as Professional Paper 442. The other, a "Technical report" of 758 pages, including numerous figures and tables, awaits release and publication. It does not undertake to assess the effects of water-management measures begun or contemplated after 1957. General and specific summaries of this technical report follow.

THE SITUATION IN SUMMARY

As of 1957--with then-existing facilities for storage, withdrawal, and use of the waters--average yield of water from the upper part of the Colorado River basin, as measured at Lee Ferry, Ariz., was 12.733 million acre-feet yearly. Average dissolved-solids discharge and concentration were 8.676 million tons and 501 ppm (parts per million), respectively.

Components of the development as of 1957, and their effects on water yield and water quality at Lee Ferry, were about as follows, assuming that they could have been accomplished separately and in the sequence to be listed: (1) Reservoirs and canals, owing to evaporation, average yearly water yield diminished about 200,000 acre-feet, concentration increased about 4 ppm, and dissolved-solids discharge unchanged; (2) transmountain diversions, water yield and dissolved-solids discharge diminished by 465,800 acre-feet and 37,500 tons, respectively, and concentration increased 6 ppm; (3) domestic and industrial uses, water yield diminished 22,600 acre-feet, dissolved-solids concentration and discharge increased 2 ppm and 33,600 tons, respectively; (4) irrigation, owing to consumptive use only, water yield diminished 1.769 million acre-feet, concentration increased 37 ppm, dissolved-solids discharge unchanged; and (5) irrigation, owing to leaching of the watered lands, water yield unchanged, dissolved-solids concentration and discharge increased 199 ppm and 3.45 million tons, respectively. Here and elsewhere in this report, "leaching" is used in a very broad sense, to include all physical and chemical processes by which water, flowing or percolating, picks up dissolved solids from soil. Had transmountain diversions been the "last-added" component, they would have increased dissolved-solids concentration by 16 ppm, rather than by 6 ppm as indicated above.

Thus, had the developments of 1957 not been in existence, the hypothetical average yearly water yield at Lee Ferry would have been about 15.2 million acre-feet rather than the 12.733 million measured; hypothetical average concentration would have been 253 ppm rather than 501 ppm, and hypothetical average dissolved-solids discharge would have been about 5.2 rather than 8.676 million tons. In other words, in relation to a hypothetical virgin situation, man's developments in the upper basin of the Colorado River appear to have diminished water yield about 16 percent, nearly doubled dissolved-solids concentration, and increased dissolved-solids discharge about 66 percent.

Substantially all the increase in dissolved-solids discharge is construed as an effect of irrigation on 1.4 million acres of land--that is, an average increase of 2.4 tons per irrigated acre per year. From one part of the area to another, this average ranges about from 0.1 ton to 5.6 tons.

LOCATION AND GEOGRAPHIC FEATURES

The area covered by this statement is the drainage basin of the Colorado River above "Lee Ferry," Arizona--that is, above the so-called compact point which separates the "upper" and "lower" basins of the Colorado River. It is defined by the Colorado River Compact as "a point in the main stem of the Colorado River one mile below the mouth of the Paria River."

The Upper Colorado River Basin (Fig. 1) comprises about 109,500 square miles: in western Colorado (38,670 sq. mi.), southwestern Wyoming (17,430 sq. mi.), eastern Utah (37,310 sq. mi.), northwestern New Mexico (9,580 sq. mi.), and northeastern Arizona (6,510 sq. mi.). The basin is within parts of two principal physical divisions of the United States--the Rocky Mountain system and the Intermontane Plateaus (Fenneman and Johnson, 1946).1/ The basin extends from latitude 35° 34' north to 43° 27' north, about 550 miles, and from longitude 105° 38' west to 112° 19' west, about 350 miles.

Northward from Lee Ferry, the boundary of the basin follows the crests of the Paria, Aquarius, and Wasatch Plateaus and of the Wasatch Range to merge finally with the Continental Divide at the northern end of the Wind River Range. Southward and eastward from Lee Ferry, the boundary trends first across the Kaibito Plateau, along the north and east rim of Black Mesa, then across the southern end of the Chuska Mountains to merge with the Continental Divide a few miles northeast of Gallup, N. Mex. From here northward, the east boundary of the basin follows the Continental Divide almost 1,000 miles to the northern end of the Wind River Range in Wyoming.

The Colorado River rises in the extreme eastern part of the basin on the east slope of Mount Richthofen, a 13,000-foot peak on the Continental Divide, and flows southwestward across all the upper basin to Lee Ferry. Green River, the largest tributary, rises in the Wind River Range at the north tip of the basin and flows southward to its junction with the Colorado River about 60 miles south of Green River, Utah. The San Juan River, the next largest tributary of the Colorado River, rises on the western slope of the Continental Divide in the southeast part of the basin and flows west to its junction with the Colorado River about 75 miles west of Bluff, Utah.

Principal tributaries of the Colorado River above the Green River are the Eagle River, Roaring Fork, Gunnison River, and the Dolores River. Those of the Green River are New Fork River, Big Sandy Creek, Blacks Fork, Henrys Fork, and Yampa, White, Duchesne, Price, and San Rafael Rivers. Principal tributaries of the San Juan River are the Navajo, Los Pinos, Animas, and La Plata Rivers. Other tributaries that enter the Colorado River below the Green River are the Dirty Devil, Escalante, and Paria Rivers.

1/ Fenneman, Nevin M., and Johnson, D. W., 1946, Physical divisions of the United States: U.S. Geol. Survey Misc. Maps and Charts.

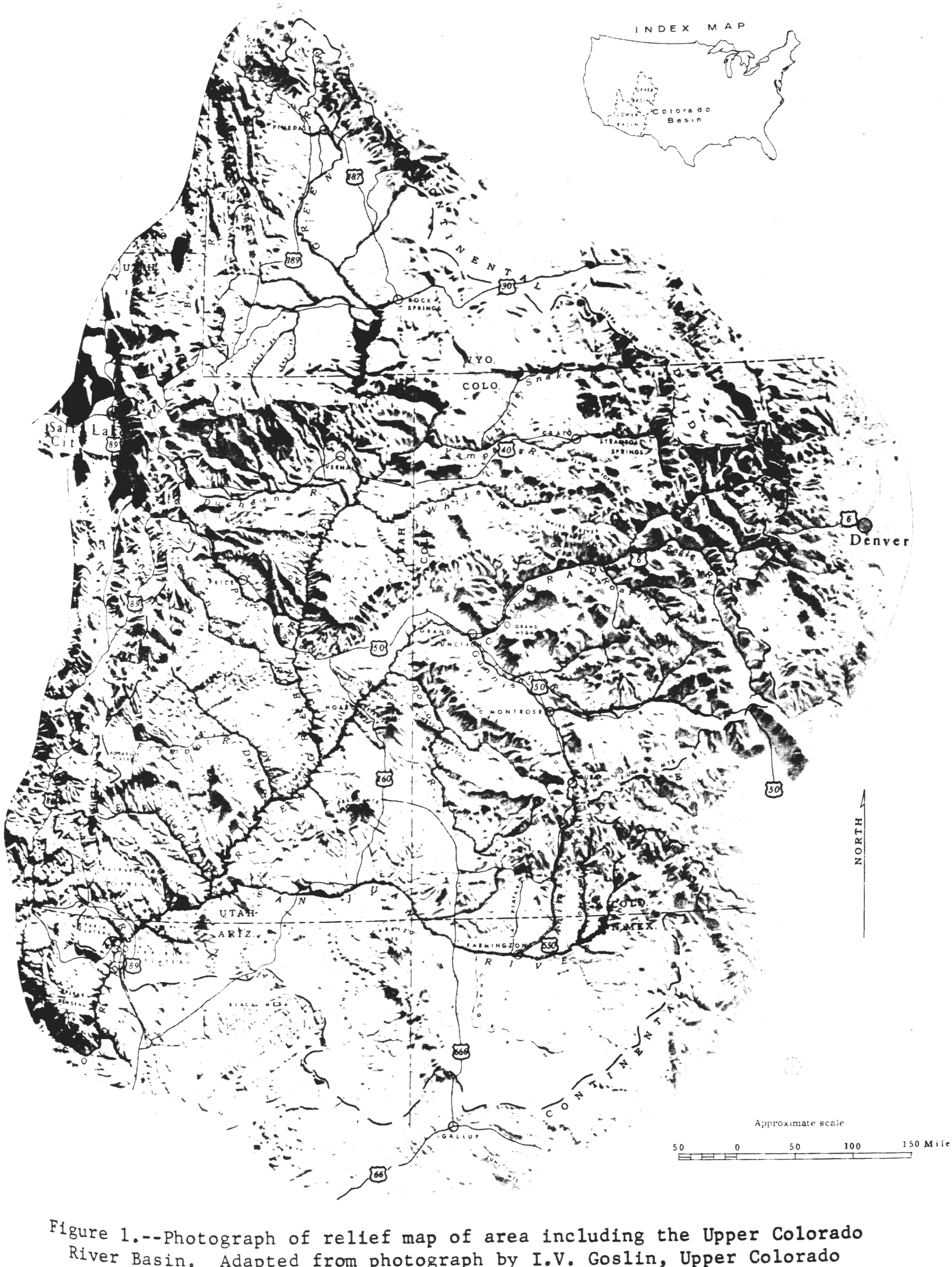
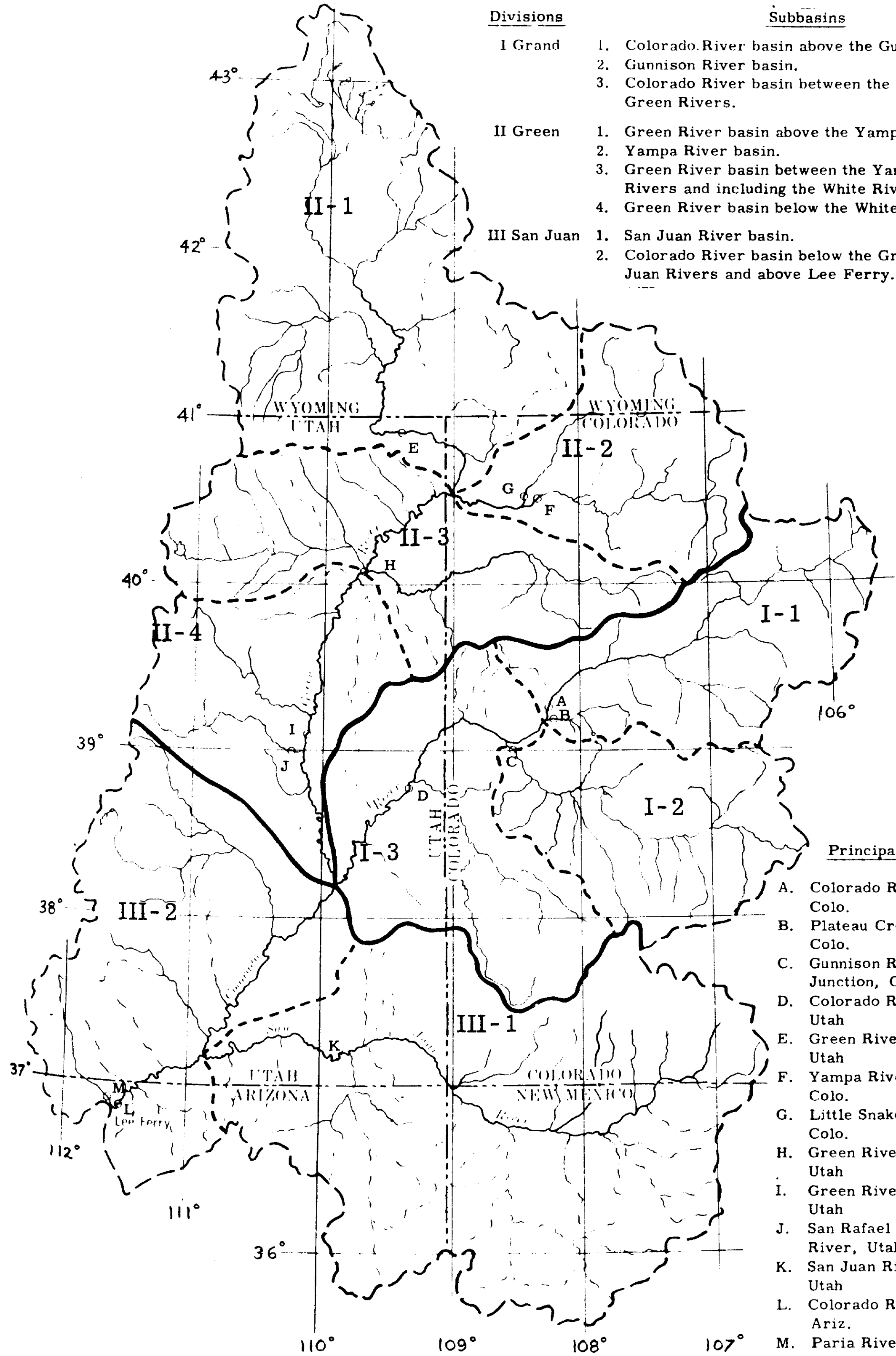


Figure 1.--Photograph of relief map of area including the Upper Colorado River Basin. Adapted from photograph by I.V. Goslin, Upper Colorado River Commission.

LOCATION AND GEOGRAPHIC FEATURES

Topographic features and the stream system divide the upper basin into three convenient major parts or "divisions." These are: (1) the Grand division, the drainage basin of the Colorado River above the Green River; (2) the Green division, the drainage basin of the river of that name; and (3) the San Juan division, the drainage basin of the Colorado River between the mouth of the Green River and Lee Ferry, Ariz. (Fig. 2)



EXPLANATION

Divisions		Subbasins
I Grand	1.	Colorado River basin above the Gunnison River.
	2.	Gunnison River basin.
	3.	Colorado River basin between the Gunnison and Green Rivers.
II Green	1.	Green River basin above the Yampa River.
	2.	Yampa River basin.
	3.	Green River basin between the Yampa and White Rivers and including the White River basin.
	4.	Green River basin below the White River.
III San Juan	1.	San Juan River basin.
	2.	Colorado River basin below the Green and San Juan Rivers and above Lee Ferry.

Principal Gaging Stations

A. Colorado River near Cameo, Colo.
B. Plateau Creek near Cameo, Colo.
C. Gunnison River near Grand Junction, Colo.
D. Colorado River near Cisco, Utah
E. Green River near Greendale, Utah
F. Yampa River near Maybell, Colo.
G. Little Snake River near Lily, Colo.
H. Green River near Ouray, Utah
I. Green River at Green River, Utah
J. San Rafael River near Green River, Utah
K. San Juan River near Bluff, Utah
L. Colorado River at Lees Ferry, Ariz.
M. Paria River at Lees Ferry, Ariz.

Figure 2.--Divisions and subbasins in the Upper Colorado River Basin.

CLIMATE

The climate of the Upper Colorado River Basin is due principally to the influence of mountain ranges on the movement of air masses. The high mountains are comparatively wet and cool, while the plateaus and lower mountains are dryer and subject to wide ranges of temperature. The interior valleys at the lower elevations are hot and dry in summer and cold in winter.

Masses of moist Pacific air which approach from the west commonly move entirely across the basin. Dry polar air from the north and moist tropical air from the south penetrate the basin at times, but rarely all the way across. All these types of air masses are obstructed and deflected by the encircling mountains so that within the basin their effects are weaker and more erratic than in most other parts of the United States.

Most of the moisture for precipitation on the upper basin is derived from the Pacific Ocean and the Gulf of Mexico, whose nearest coasts are 600 and 1,000 miles away, respectively. The Pacific source predominates generally from about October through April; the Gulf source, during the late spring and early summer.

Figure 3 shows monthly precipitation and average monthly temperature at 11 weather stations in the upper basin. Except in the southern part of the basin, the monthly precipitation is greater in winter. The altitude, as well as the latitude of the climatologic station, noticeably influences the average yearly temperature.

The average yearly precipitation ranges from less than 6 inches on certain lowland areas to more than 60 inches in parts of the Wind River Range and San Juan Mountains. Areal distribution of this yearly average (calendar years 1921-1950) is shown by Table 1; this table indicates that the mean yearly precipitation on the upper basin is 15.97 inches. For the water years 1914-1957, a period which this statement takes as a standard, the mean yearly precipitation is computed to have been 15.83 inches. Precipitation of the latter amount on the 109,500 square miles in the upper basin would be equivalent to 92,740,000 acre-feet of water. Average yearly evaporation from lakes and other open-water surfaces in the upper basin ranges about from 28 to 60 inches; the yearly volume is about 575,000 acre-feet (Table 2).

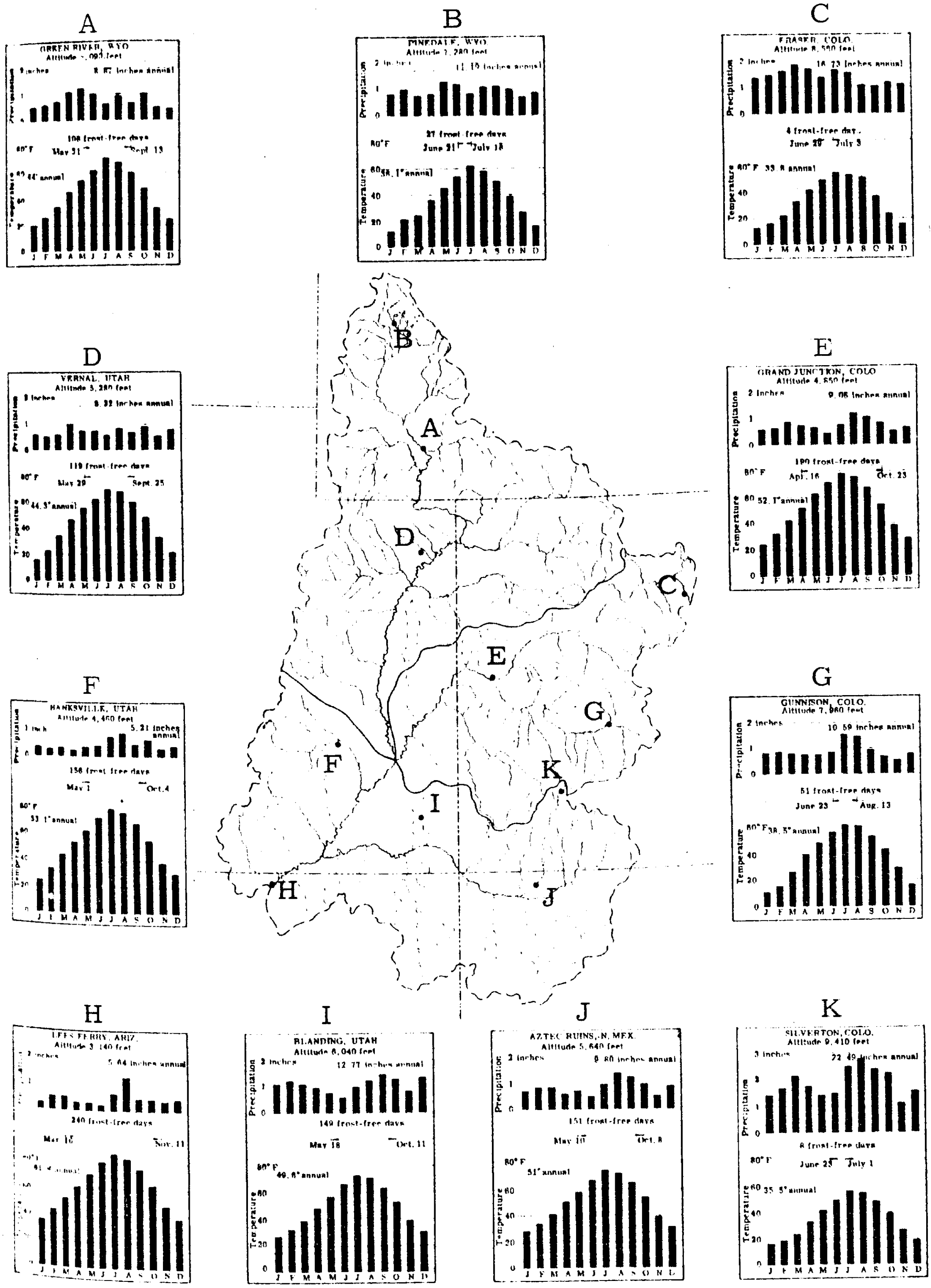


Figure 3. --Normal precipitation and temperature, and frost-free seasons at representative stations in the Upper Colorado River Basin. Data from U.S. Weather Bureau Normals (average 1921-50 calendar year).

CLIMATE

Table 1
Areal distribution of mean yearly precipitation in the Upper Colorado River Basin, calendar years 1921-1950 1/

Precipitation range (inches)	Area	
	Square miles	Percent of total area
60-70	46	0.04
50-60	374	.34
40-50	1,815	1.66
30-40	7,271	6.64
25-30	6,906	6.31
20-25	9,071	8.28
16-20	13,911	12.70
12-16	23,634	21.59
10-12	15,201	13.88
8-10	15,417	14.08
6-8	14,126	12.90
4-6	1,728	1.58
Total	109,500	100.00

1/ From a map and data prepared by the U. S. Weather Bureau especially for the investigation by the Geological Survey. Basinwide mean precipitation derived from this table is about a third more than has been estimated previously, largely because greater (and more appropriate) weight is ascribed to records from certain remote, high-altitude climatologic stations.

Table 2
Estimated average yearly evaporation, in acre-feet, from water surfaces in the Upper Colorado River Basin (After Meyers, 1962) 1/

Principal reservoirs and regulated lakes	83,000
Other lakes over 500 acres	16,000
Principal streams and canals	156,000
Small ponds and reservoirs	217,000
Small streams	103,000
Total	575,000

1/ Meyers, J. S., 1962, Evaporation from the 17 Western States: U.S. Geol. Survey Prof. Paper 272-D, p. 71-97, 1 pl., 5 figs.

WATER UTILIZATION

In the Upper Colorado River Basin, the surface waters are used for domestic, industrial, and municipal purposes, including the dilution of sewage and industrial wastes; for irrigating land to produce food and fiber; for watering livestock; for producing hydroelectric power; for conserving fish and wildlife; and for recreation. Also, water is exported out of the basin for use elsewhere. These uses of water by man have changed the natural regimen of many of the streams. Table 3 summarizes the magnitude of these uses and the water-management facilities involved.

The greatest use of water in the Upper Colorado River Basin is for irrigation, which in 1957 served about 1,413,000 acres of land. Most of these irrigated lands have been developed by private enterprise; however, Bureau of Reclamation projects furnish water for about 270,000 acres. In addition, the Bureau of Indian Affairs operates five projects involving about 93,000 acres of Indian reservations (President's Water Resources Policy Commission, 1950, p. 365).1/

In this irrigation, average yearly consumptive use of water has been estimated to be 1,769,100 acre-feet (Upper Colorado River Basin Compact Commission, 1948).2/ Several times this volume is diverted from the streams, applied to the lands, and returned to the streams minus the amount consumed. Ninety-two reservoirs with storage capacities greater than 1,000 acre-feet had been constructed in the basin by 1957. Their combined capacity is about 1,635,000 acre-feet, of which about 738,000 acre-feet is primarily to provide water for irrigation, domestic, and industrial uses within the Upper Colorado River Basin. The remainder of the stored water is primarily for export.

On the average as of 1957 about 468,400 acre-feet of water was being exported from the basin yearly in 42 transmountain canals and tunnels. Part of this water was used east of the Continental Divide in Colorado and Wyoming, and part in the Great Basin of Utah. One diversion imports an average of about 2,600 acre-feet yearly into the Colorado River Basin from the Great Basin. Figure 4 shows the increase in transmountain diversions from 1914 to 1957.

Yearly consumption of water by domestic and industrial uses in the basin is estimated to average about 22,600 acre-feet for the 1957 level of development. The volume of water withdrawn for these purposes is several times the amount consumed.

In the basin, 25 hydroelectric powerplants have a total installed capacity of about 55,410 kilowatts. No data are available on the amount of water passed through the turbines of these plants. Their consumptive use is essentially zero.

1/ President's Water Resources Policy Comm., 1950, Ten rivers in America's future: U.S. Govt. Printing Off., Washington, D.C., p. 365.

2/ Upper Colorado River Basin Compact Commission, 1948, Final Report of Engineering Advisory Committee to Upper Colorado River Basin Compact Comm.: Upper Colorado Commission, 1948, 203 p., 18 figs.

Table 3
Water-management facilities and surface-water utilization in the Upper Colorado River Basin, as of 1957.

Facility or use	Grand division	Green division	San Juan division	The basin
Storage reservoirs with usable capacities greater than 1,000 acre-feet				
Number	33	41	18	92
Total usable capacity, acre-feet	831,600	575,400	228,160	1,635,160
Transmountain diversions				
Number	17	20	7	1/44
Acre-feet exported, average yearly	2/453,400	112,200	2,800	2/568,400
Acre-feet imported, average yearly	0	0	3/102,600	3/102,600
Irrigation				
Acres irrigated	583,200	590,100	239,700	1,413,000
Estimated consumptive use, average yearly, acre-feet	739,100	728,900	301,100	1,769,100
Domestic and industrial uses				
Population (1960)	130,200	99,400	106,000	335,600
Estimated consumptive use, average yearly, acre-feet	8,800	6,700	7,100	22,600
Hydroelectric power plants				
Number	15	5	5	25
Installed capacity, kw . .	47,610	2,730	5,070	55,410

1/ Of the 44 transmountain diversions, 42 exported water out of the basin, one imported water into the basin, and one transported water between divisions of the basin.

2/ Includes 100,000 acre-feet diverted from the Grand division to the San Juan division.

3/ Includes 100,000 acre-feet imported from the Grand division and 2,600 acre-feet imported from the Sevier River basin, Utah.

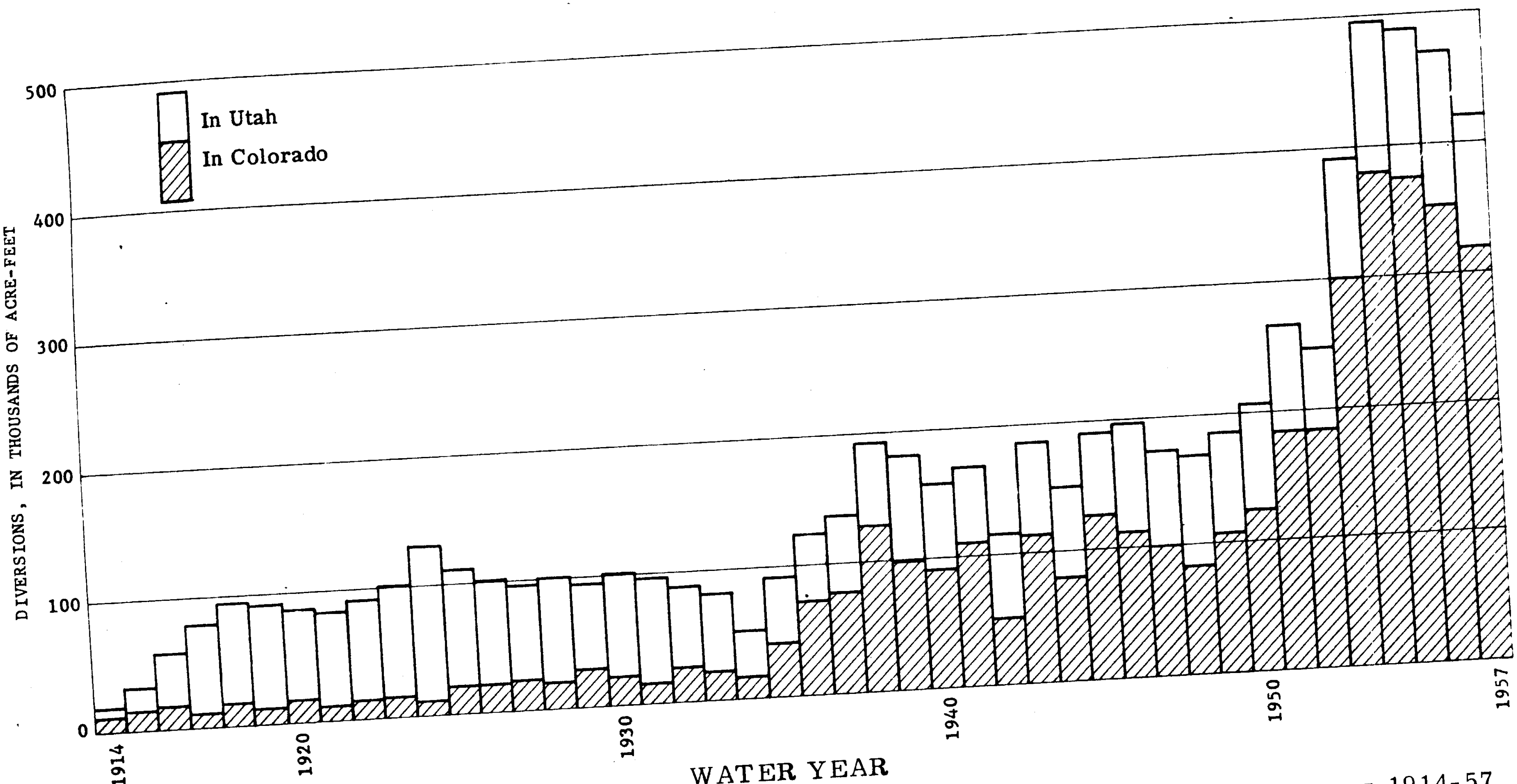


Figure 4. --Transmountain diversions from the Upper Colorado River Basin, water years 1914-57.

WATER SUPPLY CHARACTERISTICS

The flow of water in the streams of the basin varies continually--from day to day, month to month, and year to year. The hydrographs on Figure 5 illustrate daily and monthly variations in discharge at four gaging stations in a common year; Figure 6 illustrates the yearly variations at the same stations for water years 1914-1957.

Most of the basin's water supply comes from the mountains, where precipitation is abundant and occurs largely during the winter in the form of snow. With rising temperatures in the late spring and early summer, the snow melts rapidly so that the streams rise sharply. Then, as the stored snow is exhausted, usually by late July, the perennial streams that flow from the mountains subside to a fairly steady base flow, which generally prevails until the next ensuing snow-melt cycle. During the summer, precipitation in the mountainous areas does not contribute much water to the streams; rather, most of the precipitation during that season is consumed by native vegetation.

In the interior of the basin, extensive areas receive little precipitation and contribute little water to the streams. Thus, on about 77 percent of the basin, the average yearly precipitation is less than 20 inches, and on 42 percent of the basin it is less than 12 inches. Accordingly, many of the tributary streams that drain the interior are intermittent or ephemeral.

If comprehensive records of streamflow had been obtained in the basin before the activities of man began, and since, the man-caused changes in stream regimen could be determined accurately. However, no records were started until after man's use of water in the basin was far advanced. Although the man-caused changes cannot be determined precisely from available data, certain of them can be estimated within reasonable limits of accuracy and can be discriminated from natural environmental effects. Procedures leading to such estimates are outlined next.

First, streamflow in the 44 water years ending September 30, 1957, was taken as the standard for average water supply. During this 44-year period, however, water use and stream developments increased and in certain streams the flow diminished commensurately. Thus, to have a common base for comparing streamflows, it was assumed that the development works existing in 1957 had been in operation throughout the 44-year base period. Then, the streamflow records were adjusted as necessary to suit the assumption. (In its studies, which are summarized in Part II of this report, the Bureau of Reclamation adopts an 18-year standard period, 1941-1958. Also, it adjusts to a "present level" of development in which certain projects are treated as though all their authorized features were complete, whereas some are incomplete. In general, the differences in amounts of standard streamflow as derived by the Bureau of Reclamation and by the Geological Survey are small and are inconsequential for the purposes of this report.)

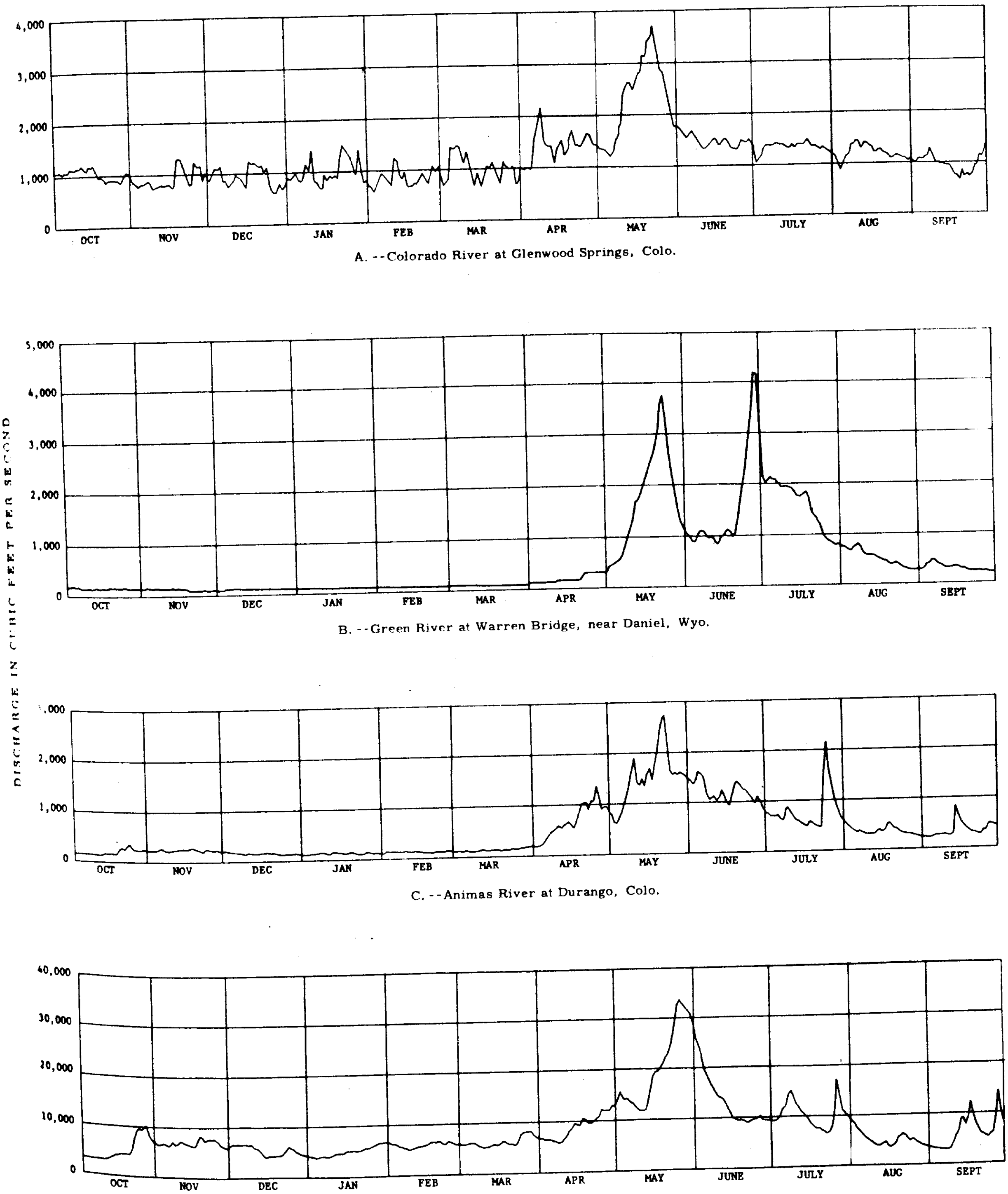


Figure 5. --Seasonal pattern of streamflow for selected streams in the Upper Colorado River Basin, 1954 water year.

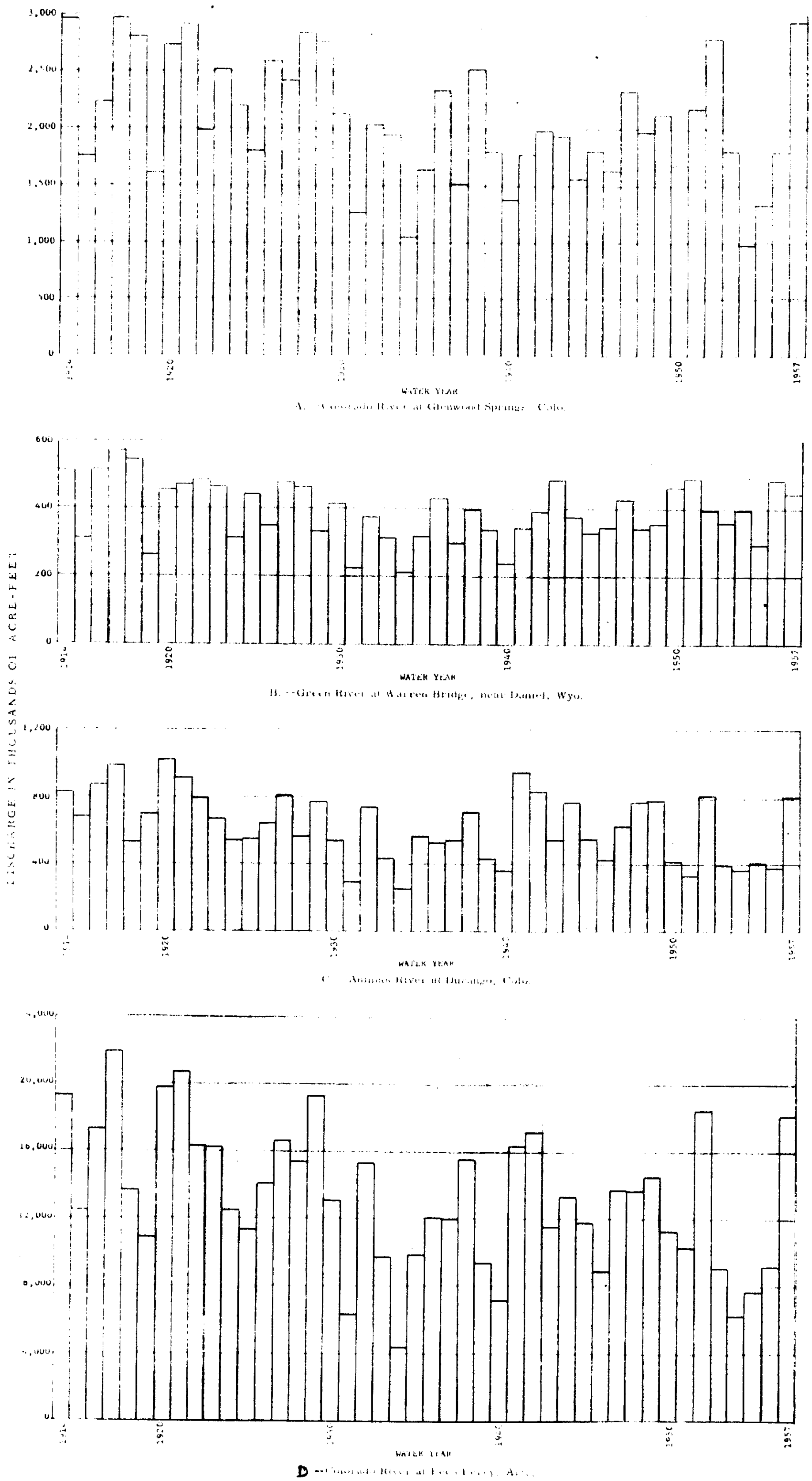


Figure 6.--Variability of yearly discharges of selected streams in the Upper Colorado River Basin.

WATER SUPPLY CHARACTERISTICS

From records so adjusted, flow-duration curves and tables, which show the percentage of time that water discharges of various magnitudes have been equaled or exceeded during the 44-year base period, were developed for many of the streams in the basin. Figure 7 shows such flow-duration curves for four streams. Table 4 arrays the duration characteristics of these same streams, and others, in statistical form. Similar flow-duration curves and tables were developed for many other stream stations in the basin. From these the average (mean) water discharges during the standard period were determined by arithmetic integration of the areas under the several curves.

For many streams in the basin, different shapes and slopes of the flow-duration curves characterize the effects of environmental features on the behavior of the streams. Thus, for streams whose flow is largely meltwater from snow, curves such as those of Figure 7 have a flat slope at the upper, or high-discharge end,and a fairly steep slope in the central part. Further, a densely vegetated drainage area tends to flatten, and a sparsely vegetated area tends to steepen the upper part of the curve. For streams that drain areas underlain by permeable earth materials, the flow-duration curves tend to be relatively horizontal--that is, the flow is relatively uniform. This is because the permeable formations act as ground-water reservoirs which first detain part of the precipitated or snowmelt water and then release that water gradually to maintain streamflow during the dry season. On the other hand, if the drainage basin is underlain by impermeable rocks, the lower part of the curve is steep. So discriminated, numerous short or intermittent streamflow records could be classified according to drainage basin environments and, accordingly, interpretations of water-quality characteristics could be extended with some assurance.

One particular environmental feature is especially informative in extending the interpretation of water-quality characteristics--specifically, the percentage of yearly water discharge that occurs as base flow in the streams. This base, or steady-state flow, is that which is presumed to be chiefly from effluent ground water rather than from immediately antecedent precipitation or snow melt. Its amount is computed from flow-duration data by methods not here detailed.

Among 55 parts of the Upper Basin, large and small, base flow ranges between 9 and 66 percent of average yearly stream discharge. A near-minimum example is Homestake Creek near Redcliff, Colo., 11 percent base flow. The basin of this creek is underlain by Precambrian rocks whose only water-bearing openings are joints and other fractures. For these rocks the rate of water intake, storage capacity, and rate of water release to the stream system are small. The maximum example is that of Gypsum Creek near Gypsum, Colo., 66 percent base flow. The drainage basin of Gypsum Creek is underlain by the Eagle Valley evaporite of Permian age. This formation comprises beds of conglomerate, sandstone,

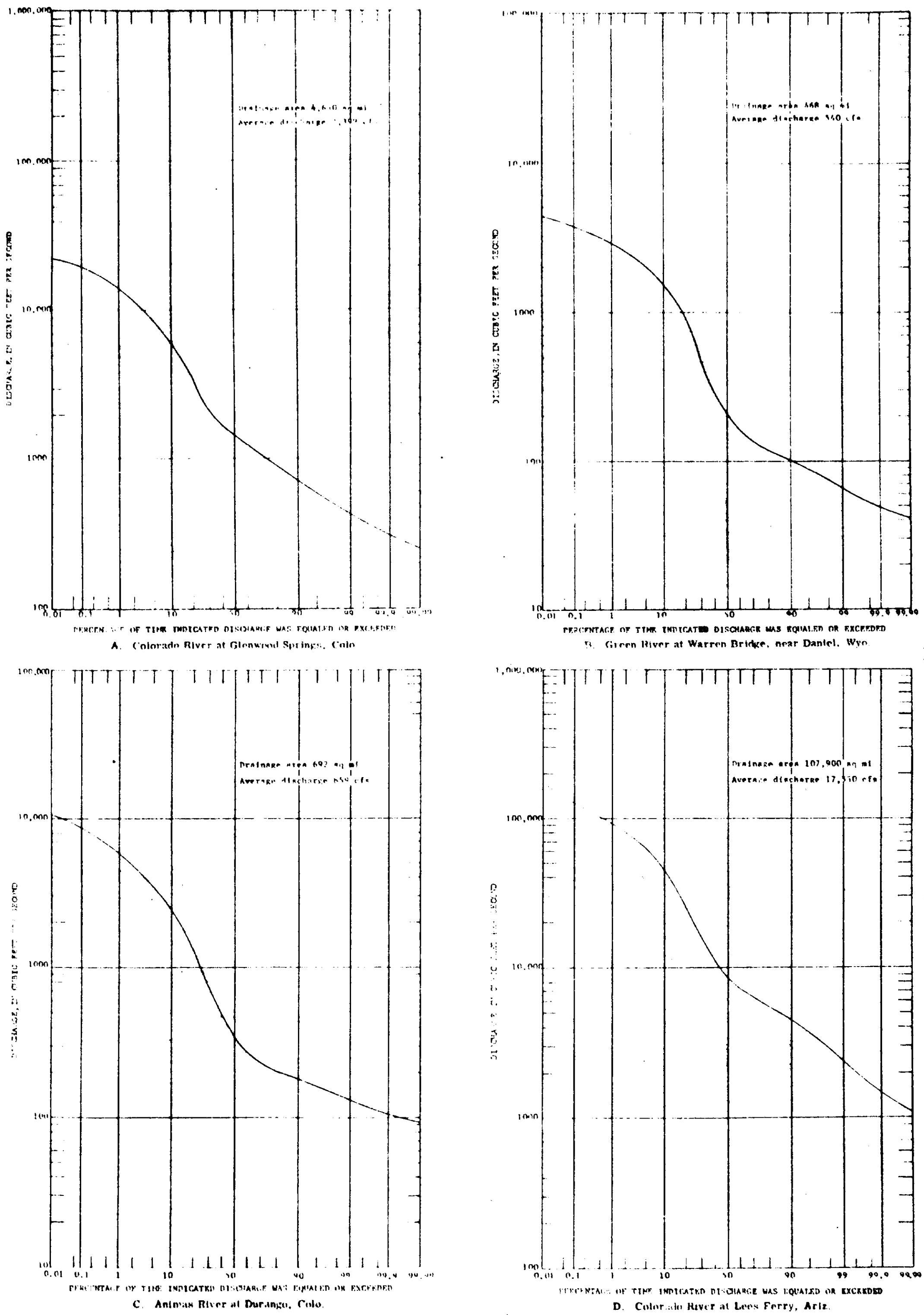


Figure 7. --Flow-duration curves for selected streams in the Upper Colorado River Basin, water years 1914-57 adjusted to 1957 conditions.

Table 4. -*Flow-duration tables for selected gaging stations in the Upper Colorado River Basin, water years 1914-57 adjusted to 1957 conditions*

Station number	Streamflow station	Daily discharge, in cubic feet per second, that was equaled or exceeded for indicated percentage of time																			Mean discharge (cfs)	Mean annual discharge (acre-feet)
		0.01	0.06	0.15	0.6	2.0	4.0	7.0	12	20	30	40	50	60	70	80	90	97	99.4	99.9		
725	Colorado River at Glenwood Springs, Colo.	22,470	20,400	18,760	15,100	11,260	8,960	7,219	5,189	3,220	2,005	1,637	1,417	1,224	1,034	868	695	507	390	308	2,399	1,738,000
955	Colorado River near Cameo, Colo.	35,000	33,500	31,600	26,800	20,500	16,300	12,700	9,100	5,300	3,500	2,670	2,180	1,930	1,730	1,550	1,310	1,040	860	760*	4,138	2,998,000
1050	Plateau Creek near Cameo, Colo.	3,900	3,350	2,980	2,370	1,690	1,250	895	540	225	135	106	90	80	71	60	45	27	19	15	235	170,200
1475	Uncompahgre River at Colona, Colo.	4,080	2,770	2,340	1,830	1,400	1,130	910	675	430	250	154	118	99	88	80	66	47	29	18	278	201,400
1525	Gunnison River near Grand Junction, Colo.	32,000	27,900	25,100	20,000	15,200	12,000	9,400	6,400	3,240	1,790	1,310	1,100	970	860	760	630	390	220	155	2,601	1,884,000
1805	Colorado River near Cisco, Utah	62,270	59,540	55,710	47,950	38,090	30,970	25,250	18,760	11,020	6,060	4,200	3,540	3,180	2,820	2,520	2,160	1,580	975	746	7,639	5,534,000
1885	Green River at Warren Bridge near Daniel, Wyo.	4,400	3,920	3,600	3,100	2,600	2,200	1,820	1,430	960	500	300	210	160	139	119	101	81	61	49	540	391,200
2345	Green River near Greendale, Utah	17,900	17,400	16,700	14,300	11,100	9,150	7,500	5,250	3,490	2,200	1,500	1,150	870	680	540	426	340	296	260	2,271	1,645,000
2395	Yampa River at Steamboat Springs, Colo.	5,800	5,250	4,800	3,990	3,050	2,460	1,960	1,350	615	255	172	140	125	108	92	73	52	29	8.4	472	341,900
2510	Yampa River near Maybell, Colo.	17,300	16,200	14,950	12,500	9,750	8,050	6,600	4,750	2,540	950	550	410	332	280	235	182	108	36	12	1,590	1,152,000
2600	Little Snake River near Lily, Colo.	8,000	7,550	7,000	5,750	4,340	3,460	2,720	1,920	946	350	190	123	87	65	41	11	.1	.0	.0	622	450,600
2795	Duchesne River at Duchesne, Utah	3,830	3,460	3,150	2,520	1,800	1,373	1,025	632	317	234	200	180	166	151	137	113	79	50	30	323	234,000
3070	Green River near Ouray, Utah	63,000	55,500	49,700	39,800	30,200	24,900	20,000	15,400	9,600	5,450	3,750	2,850	2,380	2,060	1,750	1,420	990	580	370	6,223	4,508,000
3150	Green River at Green River, Utah	63,430	56,430	51,450	41,720	32,100	25,850	20,210	14,800	9,267	5,614	3,881	2,966	2,439	2,091	1,793	1,424	1,006	637	462	6,292	4,558,000
3285	San Rafael River near Green River, Utah	4,050	3,150	2,690	2,020	1,370	865	475	242	117	76	64	51	41	32	24	1.4	.0	.0	.0	141	102,100
3565	San Juan River near Blanco, N. Mex.	19,250	16,200	14,200	11,400	8,580	6,950	5,550	4,000	2,450	1,300	760	530	388	302	252	200	130	64	34	1,519	1,100,000
3615	Animas River at Durango, Colo.	10,700	9,180	8,170	6,400	4,750	3,740	2,900	2,090	1,290	730	470	338	272	235	203	180	152	123	106	859	622,300
3795	San Juan River near Bluff, Utah	32,000	27,000	24,000	19,100	14,400	11,400	9,200	6,900	4,400	2,690	1,810	1,240	930	750	610	440	240	76	20	2,800	2,028,000
3800	Colorado River at Lees Ferry, Ariz.	178,200	137,300	122,200	101,500	82,090	69,120	55,060	41,660	25,690	16,120	11,280	8,678	7,428	6,492	5,646	4,584	3,263	2,162	1,493	17,550	12,710,000
3820	Paria River at Lees Ferry, Ariz.	7,500	3,400	1,800	570	190	97	60	38	27	22	18	14	11	6.8	4.9	3.8	2.9	2.3	1.9	31.9	23,110

some limestone, and shale with interbedded and interspersed gypsum; it weathers deeply and is relatively permeable.

Thus, over a considerable part of the mountainous areas of the Upper Colorado River Basin, where precipitation and water yield are most plentiful, effluent ground water also is plentiful. Here, because the streams are deeply incised, the ground-water reservoirs are effluent much of the time. Accordingly, here and elsewhere under such an hydrologic environment, many of the available chemical analyses of ground water can be taken appropriately to reconstruct part of the natural water-quality regimen of the stream. Such is one of the bases from which the magnitude of man-caused changes in the quality regimen will be estimated.

THE WATER BUDGET

Table 5 gives an approximate gross water budget for the Upper Basin. This budget is based on the assumption that no water is lost from the basin by ground water underflow. The yearly volume of precipitation is taken to be 92,739,000 acre-feet, which is equivalent to 15.88 inches average depth of yearly precipitation. The quantity of irrigation consumptive use is that compiled by the Upper Colorado River Basin Compact Commission (1948).1/ All the precipitation supply not accounted for in outflow from the basin, transmountain exports less imports, consumptive use due to the activities of man, and evaporation from water surfaces is considered to be natural evapotranspiration from the land surface and from native vegetation.

Table 5

Disposal of precipitation in the Upper Colorado River Basin

	Acre-feet a year
Outflow at Lees Ferry, Ariz.	12,733,100
Transmountain exports	468,400
Transmountain imports	-2,600
Irrigation consumptive use	1,769,100
Domestic and industrial consumptive use	22,600
Evaporation from water surfaces	575,000
Natural evapotranspiration loss	77,173,400
Total (yearly precipitation)	92,739,000

1/ Upper Colorado River Basin Compact Commission, 1948, Final Report of Engineering Advisory Committee to Upper Colorado River Basin Compact Comm.: Upper Colorado Commission, 1948, 203 p., 18 figs.

CHEMICAL QUALITY OF THE WATER

Dissolved-solids Discharge and Concentration

Discharge of water and of dissolved solids, and weighted-average concentration of dissolved solids at selected stations in the Upper Colorado River Basin are given in Table 6. These data on discharge represent the long-term averages that would have occurred if the water use developments existing in 1957 had been in place and in operation throughout water years 1914-1957. In essence, the data on dissolved-solids concentration represent conditions of 1957, because most of the available chemical analyses are of samples taken late in the 44-year period.

Similar data were developed for many other stations in the basin. The records from which, and the methods by which these averages were derived are given in detail in the voluminous two reports which await publication by the Geological Survey.

Figure 8 pictures the data of Table 6, expressed as percentages of the outflow from the Upper Colorado River Basin--that is, percentages of water and dissolved-solids discharges of the Colorado River combined with those of the Paria River, both at Lees Ferry, Ariz. On this figure, percentages are expressed to the nearest hundredth so that the smaller discharges can be indicated; they are not to be construed to indicate great precision in the quantities. The figure shows that most of the water comes from the mountains and from the high plateaus, but that most of the dissolved solids comes from the lower parts of the basin which receive little precipitation and which yield relatively little water to the streams. The rocks exposed in the mountains are generally much more resistant to the solvent action of water than are the rocks that underlie a large part of the lowlands. The activities of man that modify the dissolved-solids regimen are largely on the lowlands where the more soluble rocks and rock debris occur.

For water years 1914-1957 adjusted to 1957 conditions, the average combined water discharge of the Colorado and Paria Rivers at Lees Ferry, Ariz., is 12,733,100 acre-feet a year; weighted-average concentration is 501 ppm; and average dissolved-solids discharge is 8,676,300 tons a year. These discharges are not uniformly distributed. Thus, among the three major parts of the Upper Basin, the Grand division is least in extent (26,500 square miles or 24 percent of the total area) but yields the greatest discharges of water and of dissolved solids (44 percent and 48 percent, respectively, of those at Lees Ferry). The Green division is greatest in extent (44,700 square miles or 41 percent of the basin); it yields about 37 percent of the water and 33 percent of the dissolved solids. The San Juan division, 38,300 square miles or 35 percent of the upper basin, yields only about 19 percent of the water and a like percentage of the dissolved solids.

Table 6. --Water and dissolved-solids discharge at selected stations in the Upper Colorado River Basin

[Water and dissolved-solids discharge for the water years 1914-57 adjusted to 1957 conditions except as indicated]

Station number	Chemical-quality station	Drainage area (sq mi)	Water discharge: Average (cfs)	Water discharge: Average annual (acre-feet)	Dissolved solids: Weighted-average concentration (ppm)	Dissolved solids: Average discharge (tons per day)	Dissolved solids: Average annual yield per square mile (tons)	Dissolved solids: Average annual discharge (tons)
345	Colorado River at Hot Sulphur Springs, Colo.	782	244	176, 800	76	50	23	18, 260
690	Eagle River at Gypsum, Colo.	844	602	436, 100	303	492	213	179, 700
705C	Colorado River near Glenwood Springs, Colo.	4, 486	2, 399	1, 738, 000	270	1, 750	142	639, 200
850	Roaring Fork at Glenwood Springs, Colo.	1, 460	1, 353	980, 200	225	821	205	299, 900
955	Colorado River near Cameo, Colo.	8, 060	4, 138	2, 998, 000	387	4, 320	196	1,578,000
1050	Plateau Creek near Cameo, Colo.	604	235	170, 200	285	181	109	66, 110
1145	Gunnison River near Gunnison, Colo.	1, 010	753	545, 500	126	256	93	93, 500
1280	Gunnison River below Gunnison Tunnel, Colo.	3, 980	1, 303	944, 000	111	391	36	142, 800
1475	Uncompahgre River at Colona, Colo.	437	278	201, 400	376	282	236	103, 000
1495	Uncompahgre River at Delta, Colo.[a]	1, 110	286	207, 200	1, 550	1, 200	395	438, 300
1525	Gunnison River near Grand Junction, Colo.	8, 020	2, 601	1, 884, 000	592	4, 160	189	1,519,000
1665	Dolores River at Dolores, Colo.	556	492	356, 400	125	166	109	60, 630
1755	San Miguel River at Naturita, Colo.	1, 080	351	254, 300	316	299	101	109, 200
1800	Dolores River near Cisco, Utah	4, 630	940	681, 000	496	1, 260	99	460, 200
1805	Colorado River near Cisco, Utah	24, 100	7, 639	5, 534, 000	547	11, 280	171	4,120,000
1885	Green River at Warren Bridge, near Daniel, Wyo.	468	540	391, 200	151	220	172	80, 360
2010	New Fork River near Boulder, Wyo.	552	401	290, 500	69	75	50	27, 390
2095	Green River near Fontenelle, Wyo.	3, 970	1, 609	1, 166, 000	185	805	74	294, 000
2135	Big Sandy Creek near Farson, Wyo.	320	86. 6	62, 740	47	11	13	4, 020
2160	Big Sandy Creek below Eden, Wyo.	1, 610	48. 8	35, 350	1, 340	176	40	64, 280
2165	Green River at Green River, Wyo.	7, 670	1, 802	1, 305, 000	284	1, 380	66	504, 000
2250	Blacks Fork near Green River, Wyo.[b]	3, 670	345	249, 900	537	500	50	182, 600
2345	Green River near Greendale, Utah	15, 100	2, 271	1, 645, 000	378	2, 320	56	847, 400
2395	Yampa River at Steamboat Springs, Colo.	604	472	341, 900	74	94	57	34, 330
2425	Elk River near Trull, Colo.	415	544	394, 100	44	64	56	23, 380
2510A	Yampa River at bridge on county road, near Maybell, Colo.	3, 590	1, 590	1, 152, 000	140	599	61	218, 800
2570	Little Snake River near Dixon, Wyo.	988	547	396, 300	91	135	50	49, 310
2595C	Little Snake River at Bridge on State Highway 318, near Lily, Colo.	3, 355	622	450, 600	196	330	36	120, 500
2635A	Green River at Jensen, Utah	26, 100	4, 607	3, 338, 000	316	3, 930	55	1,435,000
2795	Duchesne River at Duchesne, Utah	660	323	234, 000	218	190	105	69, 400
2885	Strawberry River at Duchesne, Utah	1, 040	157	113, 700	396	168	59	61, 360
3020	Duchesne River near Randlett, Utah	3, 920	767	555, 700	608	1, 260	117	460, 200
3045	White River near Meeker, Colo.	762	638	462, 200	244	420	201	153, 400
3065	White River near Watson, Utah	4, 020	764	553, 500	439	905	82	330, 600
3070	Green River near Ouray, Utah	35, 500	6, 223	4, 508, 000	392	6, 590	68	2,407,000
3145	Price River at Woodside, Utah	1, 500	116	84, 040	2, 110	662	161	241, 800
3150	Green River at Green River, Utah	40, 600	6, 292	4, 558, 000	427	7, 260	65	2,652,000
3285	San Rafael River near Green River, Utah	1, 690	141	102, 100	1, 370	521	113	190, 300
3300	Fremont River near Bicknell, Utah[c]	776	85. 8	62, 160	302	70	33	25, 570
3335	Dirty Devil River near Hite, Utah[d]	4, 360	102	73, 890	1, 960	541	45	197, 600
3350	Colorado River at Hite, Utah	76, 600	14, 167	10,260, 000	527	20, 170	96	7,367,000
3395	Escalante River at mouth, near Escalante, Utah[e]	2, 010	85. 2	61, 720	300	69	13	25, 200
3425	San Juan River at Pagosa Springs, Colo.	298	403	292, 000	73	79	97	28, 850
3565	San Juan River near Blanco, N. Mex.	3, 560	1, 519	1, 100, 000	125	512	53	187, 000
3615	Animas River at Durango, Colo.	692	859	622, 300	183	425	224	155, 200
3645	Animas River at Farmington, N. Mex.	1, 360	971	703, 500	233	611	164	223, 200
3680	San Juan River at Shiprock, N. Mex.	12, 900	2, 679	1, 941, 000	256	1, 850	52	675, 700
3795	San Juan River near Bluff, Utah	23, 000	2, 800	2, 028, 000	361	2, 730	43	997, 100
3800	Colorado River at Lees Ferry, Ariz.	107, 900	17, 550	12,710, 000	499	23, 660	80	8,642,000
3820	Paria River at Lees Ferry, Ariz.	1, 570	31. 9	23, 110	1, 090	94	22	34, 330

a For 1939-57 water years. b For 1948-57 water years. c For 1938-43, 1947-57 water years. d For 1947-57 water years. e For 1951-55 water years.

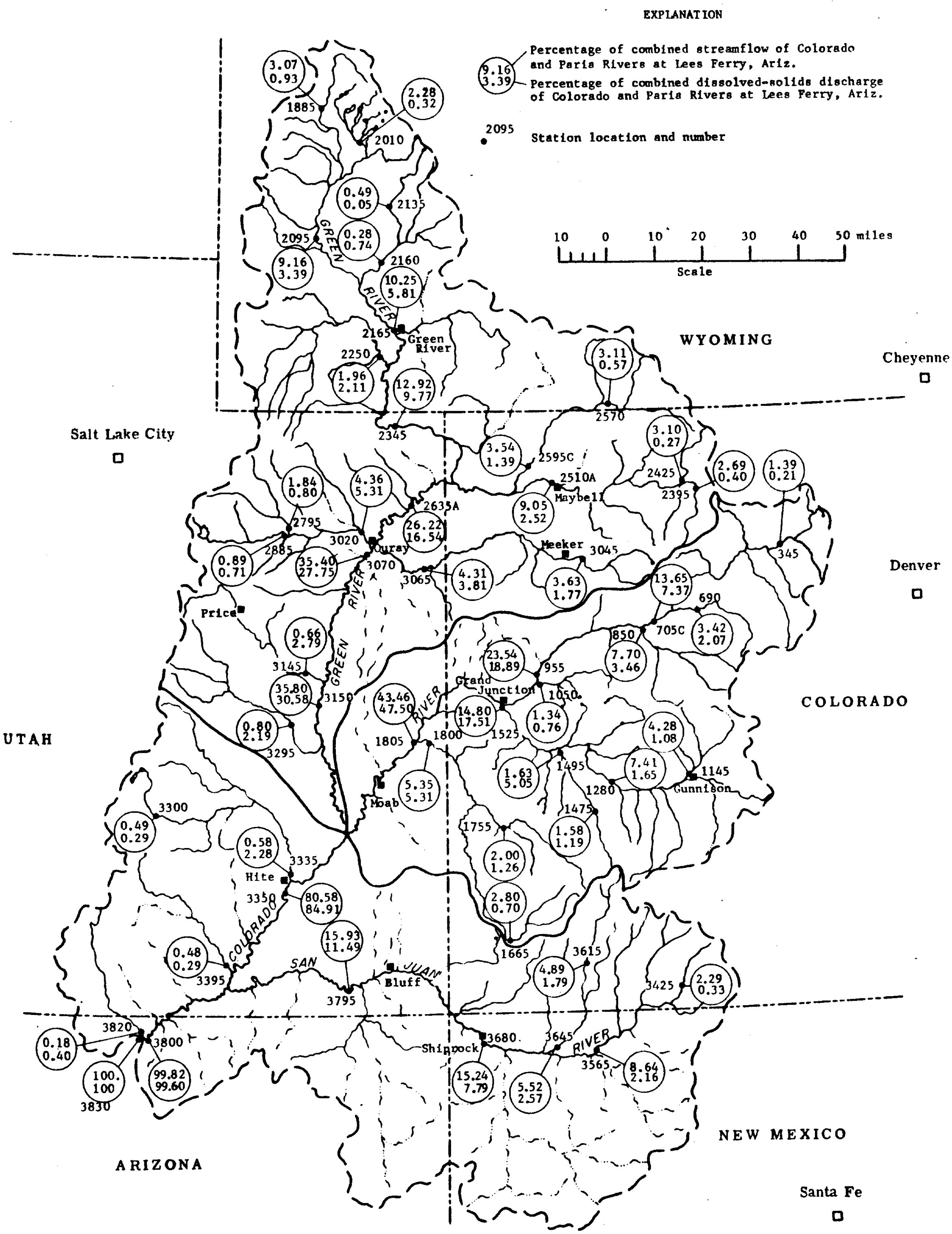


Figure 8.--Approximate dissolved-solids discharge and streamflow in percentage of the combined dissolved-solids discharge and streamflow of the Colorado and Paria Rivers at Lees Ferry, Ariz.

CHEMICAL QUALITY OF THE WATER

Variations in Chemical Quality

In addition to the variations from place to place, just summarized, the chemical quality of water in the streams of the basin changes from day to day and from month to month. The concentration of dissolved solids varies nearly in inverse relation to water discharge, being least during high flows and greatest during low flows. The range in concentration between high and low flows is relatively small in the headwater areas but is large in the downstream reaches of many streams. Figures 9 and 10 show typical relationships.

Variation in relation to streamflow

Figure 11 and Tables 7 to 10 show relationships between chemical composition of water and streamflow at four stations on main streams of the Upper Colorado River Basin. Among the four stations the water may be a calcium-bicarbonate, calcium-sulfate, or sodium-sulfate type according to the stream and to the amount of flow. During high flows, the waters of all the streams commonly are of the calcium-bicarbonate type. At median and low flows, the Colorado River near Cisco, Utah, and the Green River at Green River, Utah, yield a sodium-sulfate water, and the San Juan River near Bluff, Utah, yields a calcium-sodium-sulfate water. The Colorado River at Lees Ferry, Ariz., yields calcium-sulfate water at median flows and sodium-sulfate water at low flows. On the figure and in the four tables, a high flow is of a magnitude equaled or exceeded 10 percent of the time, a median flow is that equaled or exceeded 50 percent of the time, and a low flow is that equaled or exceeded 90 percent of the time.

In the headwater areas of the Upper Basin, the range in dissolved-solids concentration is considerably less than in the same streams at lower altitudes, where commonly the channels are underlain by sedimentary rocks and where the climate is more arid. Thus, Figure 12 shows the relation of chemical composition and dissolved-solids concentration to water discharge at four typical headwater stream stations. These streams are of calcium-bicarbonate water during high flows at all four stations, also during flows of all magnitudes at two of the four. The two discordant streams--the Uncompahgre River at Colona, Colo., and the San Juan River near Blanco, N. Mex.--yield calcium-sulfate water at the low flow. The principal reason for the difference in low-flow composition appears to be the character of soils and rocks that underlie the respective drainage areas.

Variation in relation to geology

Among major environmental factors that determine the chemical quality of the stream waters are the kinds of rocks that underlie the several drainage basins. Thus, the headwaters of the Colorado, Green,

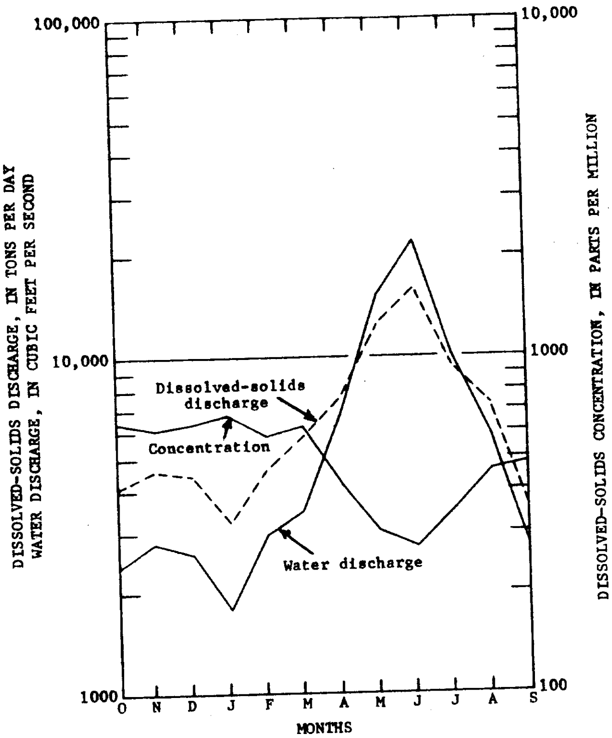


Figure 9.--Dissolved-solids concentration and discharge and water discharge of Green River near Ouray, Utah for the 1951 water year.

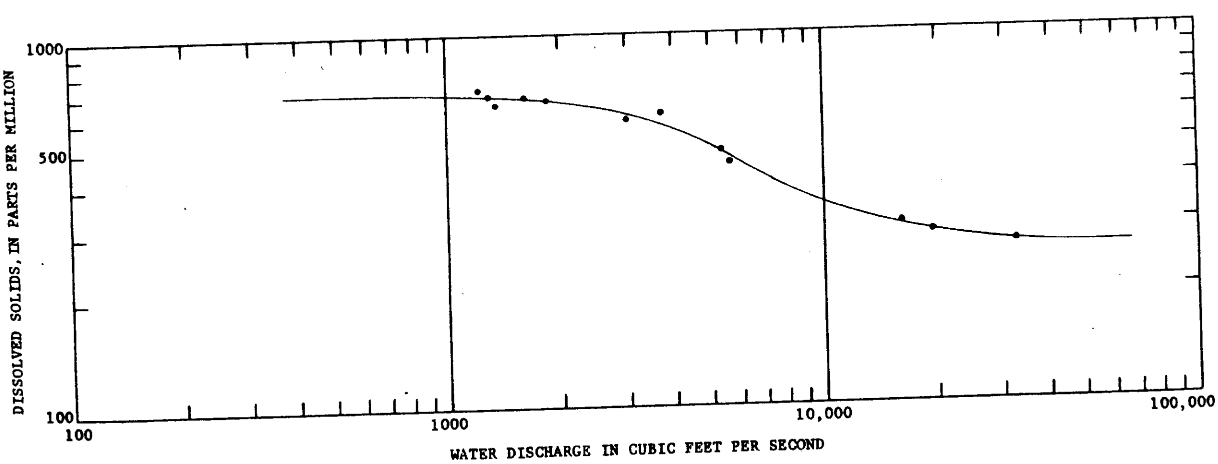


Figure 10.--Relation of concentration of dissolved solids to water discharge, Green River near Ouray, Utah. Plotted points are monthly average discharges and monthly weighted-average concentrations for 1957 water year.

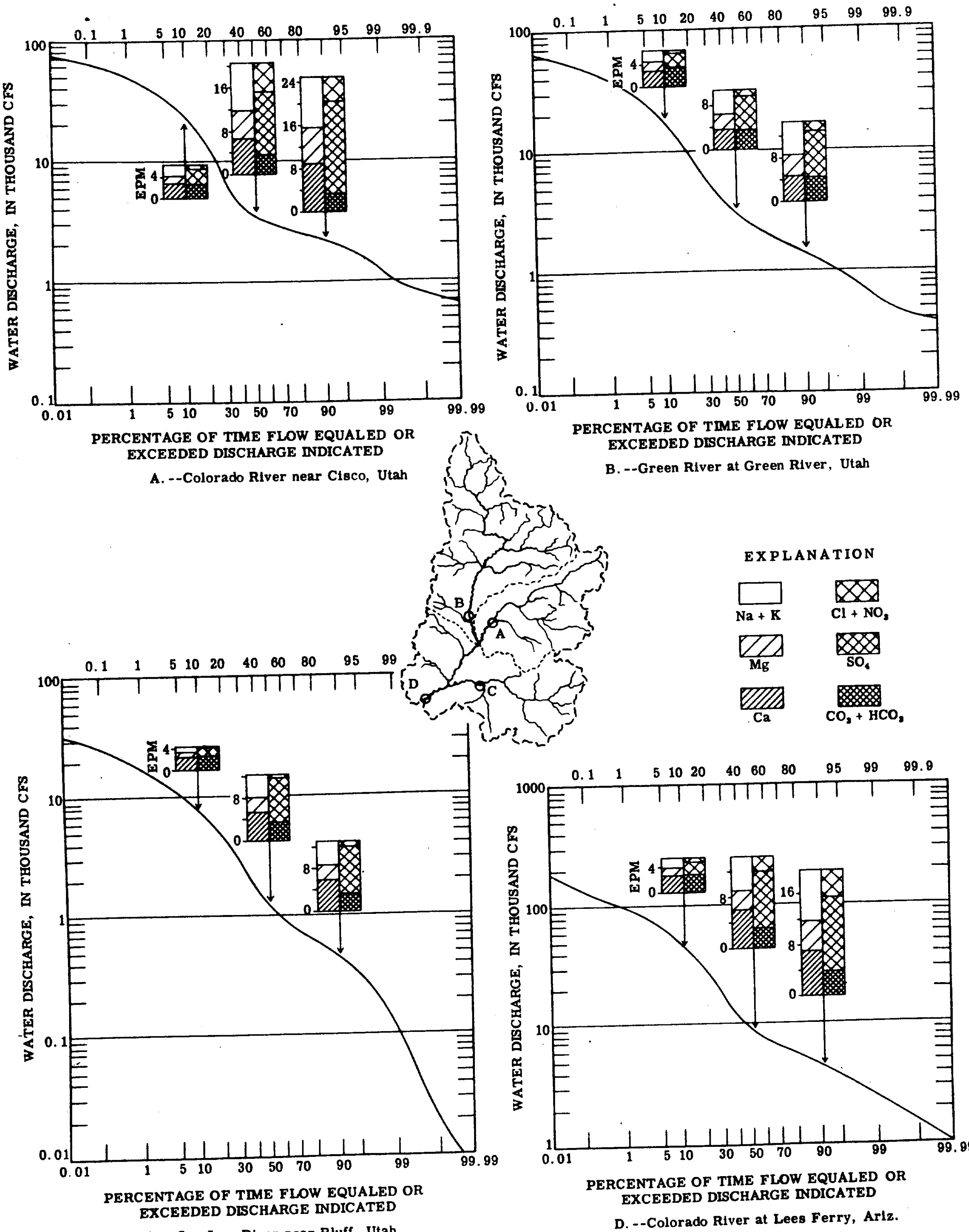


Figure 11.--Relation of the chemical composition and concentration of dissolved solids to water discharge at stations on the three main streams in the Upper Colorado River Basin. The concentration of specific ions, in equivalents per million (epm) is shown for the tenth, fiftieth, and ninetieth centiles of the flow-duration curve for each location. The flow-duration curves are for the water years 1914-57 adjusted to 1957 conditions.

Table 7. -Relation between water discharge and chemical quality of the water of the Colorado River near Cisco, Utah, water years 1914-57 adjusted to 1957 conditions

[Chemical-quality data is in parts per million and equivalents per million (underlined) except as indicated]

	Discharge (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Boron (B)	Dissolved solids (sum): Parts per million	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Percent sodium	Specific conductance (micromhos per cm at 25°C)	Sodium adsorption ratio
	62,270	39 1.95	6.8 .56	13 .57	2.2 .06	120 1.97	53 1.10	2.4 .07	0.04	238	0.32	40,010	126	27	18	378	0.5
	59,540	39 1.95	6.9 .57	14 .61	2.2 .06	121 1.98	55 1.14	2.5 .07	.04	239	.33	38,420	126	27	19	380	.5
	55,710	40 2.00	7.1 .58	15 .65	2.2 .06	122 2.00	57 1.19	2.5 .07	.04	240	.33	36,100	129	29	20	380	.6
	47,950	41 2.05	7.5 .62	16 .70	2.2 .06	125 2.05	63 1.31	2.6 .07	.04	241	.33	31,200	134	31	20	380	.6
	38,090	43 2.15	8.5 .70	18 .78	2.2 .06	128 2.10	73 1.52	3.0 .08	.05	248	.34	25,510	142	36	21	390	.7
	30,970	45 2.25	9.3 .76	22 .96	2.2 .06	134 2.20	85 1.77	3.2 .09	.05	258	.35	21,570	150	40	24	403	.8
	25,250	47 2.35	11 .90	25 1.09	2.3 .06	139 2.28	97 2.02	3.6 .10	.05	273	.37	18,610	162	48	25	435	.9
a	18,760	51 2.54	13 1.07	31 1.35	2.5 .06	146 2.39	121 2.52	4.5 .13	.05	309	.42	15,650	180	61	27	480	1.0
	11,020	60 2.99	17 1.40	47 2.04	2.7 .07	160 2.62	176 3.66	6.6 .19	.06	415	.56	12,350	220	88	31	645	1.4
	6,060	70 3.49	25 2.06	79 3.44	3.6 .09	178 2.92	281 5.84	11 .31	.08	660	.90	10,800	278	132	38	1,010	2.1
	4,200	84 4.19	33 2.71	106 4.61	4.3 .11	194 3.18	389 8.09	15 .42	.09	895	1.22	10,150	345	186	40	1,300	2.5
b	3,540	97 4.84	37 3.04	123 5.35	4.9 .13	202 3.31	460 9.57	17 .48	.10	1,030	1.40	9,840	394	228	40	1,480	2.7
	3,180	102 5.09	40 3.29	138 6.00	5.1 .13	211 3.46	506 10.52	19 .54	.11	1,130	1.54	9,700	419	246	41	1,600	2.9
	2,820	109 5.44	46 3.78	160 6.96	5.6 .14	219 3.59	575 11.96	21 .59	.12	1,240	1.69	9,440	461	282	43	1,740	3.2
	2,520	125 6.24	50 4.11	172 7.48	5.9 .15	230 3.77	650 13.52	24 .68	.14	1,350	1.84	9,190	518	329	42	1,850	3.3
c	2,160	142 7.09	60 4.93	190 8.26	6.7 .17	230 3.77	770 16.02	29 .82	.17	1,470	2.00	8,570	601	412	40	2,000	3.4
	1,580	180 8.98	78 6.41	210 9.14	8.5 .22	230 3.77	975 20.28	35 .99	.22	1,680	2.28	7,170	770	581	37	2,260	3.3
	975	220 10.98	85 6.99	215 9.35	10 .26	230 3.77	1,080 22.46	48 1.35	.27	1,810	2.46	4,760	898	710	34	2,400	3.1
	746	235 11.73	90 7.40	220 9.57	12 .31	230 3.77	1,150 23.92	60 1.69	.28	1,850	2.52	3,730	956	768	33	2,450	3.1
Weighted Average	7,639	66 3.29	21 1.73	62 2.70	3.2 0.08	162 2.66	233 4.85	8.8 0.25	0.07	547	0.74	11,280	251	118	35	806	1.7

Lines a, b, and c indicate the 12, 50, and 90 percentiles of water discharge, respectively.

Table 8. - Relation between water discharge and chemical quality of the water of the Green River at Green River, Utah, water years 1914-57 adjusted to 1957 conditions

	Mean discharge (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Boron (B)	Dissolved solids (residue at 180°C): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25°C)	Sodium adsorption ratio
	63,430	44 2.20	10 .82	19 .83	1.9 .05	160 2.62	52 1.08	8.5 .24	0.07	222	0.30	38,020	151	20	21	345	0.7
	56,430	44 2.20	10 .82	19 .83	1.9 .05	160 2.62	52 1.08	8.6 .24	.07	222	.30	33,820	151	20	21	350	.7
	51,450	44 2.20	10 .82	19 .83	2.0 .05	160 2.62	52 1.08	8.6 .24	.07	222	.30	30,840	151	20	21	350	.7
	41,720	44 2.20	10 .82	20 .87	2.0 .05	160 2.62	54 1.12	8.6 .24	.07	225	.31	25,350	151	20	22	350	7
	32,100	45 2.25	10 .82	21 .91	2.2 .06	160 2.62	59 1.23	8.8 .25	.08	230	.31	19,930	154	22	23	355	.7
	25,850	45 2.25	11 .90	23 1.00	2.3 .06	160 2.62	64 1.33	9.2 .26	.08	240	.33	16,750	158	26	24	375	.8
	20,210	45 2.25	11 .90	25 1.09	2.4 .06	160 2.62	69 1.44	10 .28	.08	270	.37	14,730	158	26	25	410	.9
a	14,800	46 2.30	12 .99	29 1.26	2.6 .07	162 2.66	80 1.66	11 .31	.09	326	.44	13,030	164	32	27	475	1.0
	9,267	50 2.50	14 1.15	37 1.61	2.8 .07	169 2.77	104 2.16	15 .42	.09	430	.58	10,760	182	44	30	615	1.2
	5,614	57 2.84	20 1.64	56 2.44	3.1 .08	193 3.17	153 3.18	23 .65	.10	570	.78	8,640	224	66	35	780	1.6
	3,881	65 3.24	26 2.14	75 3.26	3.4 .09	214 3.51	210 4.37	30 .85	.11	655	.89	6,860	269	94	37	890	2.0
b	2,966	71 3.54	31 2.55	86 3.74	3.6 .09	228 3.74	252 5.24	36 1.02	.11	700	.95	5,610	304	118	38	945	2.1
	2,439	74 3.69	34 2.79	95 4.13	3.8 .10	230 3.77	280 5.82	39 1.10	.11	735	1.00	4,840	324	136	39	1,000	2.3
	2,091	76 3.79	36 2.96	100 4.35	3.9 .10	232 3.80	300 6.24	43 1.21	.12	755	1.03	4,260	338	148	39	1,030	2.4
	1,793	78 3.89	39 3.21	106 4.61	4.0 .10	234 3.84	322 6.70	46 1.30	.12	775	1.05	3,750	355	163	39	1,060	2.4
c	1,424	81 4.04	41 3.37	112 4.87	4.2 .11	236 3.87	345 7.18	50 1.41	.12	800	1.09	3,080	370	177	39	1,100	2.5
	1,006	83 4.14	42 3.45	119 5.18	4.5 .12	238 3.90	360 7.49	54 1.52	.13	820	1.12	2,230	380	184	40	1,130	2.7
	637	85 4.24	43 3.53	122 5.31	5.0 .13	240 3.94	370 7.70	57 1.61	.14	850	1.16	1,460	388	192	40	1,170	2.7
	462	87 4.34	44 3.62	122 5.31	5.4 .14	240 3.94	370 7.70	58 1.64	.14	860	1.17	1,070	398	201	40	1,170	2.7
Weighted Average	6,292	54 2.69	18 1.48	45 1.96	2.8 0.07	181 2.97	130 2.70	19 0.54	0.09	427	0.58	7,260	208	60	32	608	1.4

Lines a, b, and c indicate the 12, 50, and 90 percentiles of water discharge, respectively.

Table 9. - Relation between water discharge and chemical quality of the water of the San Juan River near Bluff, Utah, water years 1914-57 adjusted to 1957 conditions

[Chemical-quality data is in parts per million and equivalents per million (underlined) except as indicated]

	Discharge (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Boron (B)	Dissolved solids (residue at 180°C): Parts per million	Dissolved solids: Tons per acre-foot	Dissolved solids: Tons per day	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos per cm at 25°C)	Sodium adsorption ratio
	32,000	39 1.95	8.4 .69	14 .61	1.9 .05	118 1.94	60 1.25	3.7 .10	0.05	183	0.25	15,810	132	35	18	285	0.5
	27,000	39 1.95	8.6 .71	14 .61	2.0 .05	118 1.94	60 1.25	3.7 .10	.05	190	.26	13,850	133	36	18	295	.5
	24,000	39 1.95	8.6 .71	14 .61	2.0 .05	118 1.94	60 1.25	3.7 .10	.05	194	.26	12,570	133	36	18	305	.5
	19,100	40 2.00	8.9 .73	14 .61	2.1 .05	118 1.94	64 1.33	3.8 .11	.05	203	.28	10,470	136	40	18	315	.5
	14,400	41 2.05	9.2 .76	15 .65	2.2 .06	119 1.95	68 1.41	4.0 .11	.05	217	.30	8,440	140	43	18	340	.5
	11,400	43 2.15	9.4 .77	16 .70	2.4 .06	120 1.97	74 1.54	4.2 .12	.05	230	.31	7,080	146	48	19	355	.6
	9,200	44 2.20	9.8 .81	17 .74	2.5 .06	121 1.98	80 1.66	4.5 .13	.05	243	.33	6,040	150	52	19	375	.6
a	6,900	46 2.30	10 .82	18 .78	2.6 .07	123 2.02	86 1.79	5.2 .15	.05	[illegible]	.36	4,940	156	55	20	410	.6
	4,400	52 2.59	12 .99	22 .96	2.8 .07	130 2.13	112 2.33	6.6 .19	.06	309	.42	3,660	179	72	21	470	.7
	2,690	64 3.19	14 1.15	33 1.44	3.1 .08	145 2.38	157 3.27	9.3 .26	.06	385	.52	2,800	217	98	25	590	1.0
	1,810	76 3.79	17 1.40	48 2.09	3.4 .09	160 2.62	210 4.37	13 .37	.06	500	.68	2,440	260	128	28	750	1.3
b	1,240	91 4.54	23 1.89	70 3.04	3.7 .09	174 2.85	305 6.34	17 .48	.07	660	.90	2,210	322	179	32	950	1.7
	930	105 5.24	29 2.38	85 3.70	3.9 .10	182 2.98	375 7.80	22 .62	.08	780	1.06	1,960	381	232	32	1,100	1.9
	750	113 5.64	33 2.71	94 4.09	4.0 .10	187 3.07	415 8.63	26 .73	.09	845	1.15	1,710	418	264	33	1,170	2.0
	610	117 5.84	36 2.96	102 4.44	4.2 .11	191 3.13	445 9.26	29 .82	.10	900	1.22	1,480	440	284	33	1,250	2.1
c	440	123 6.14	39 3.21	111 4.83	4.5 .12	197 3.23	480 9.98	33 .93	.11	960	1.31	1,140	468	306	34	1,330	2.2
	240	125 6.24	40 3.29	122 5.31	5.1 .13	201 3.30	500 10.40	39 1.10	.12	1,050	1.43	680	476	312	35	1,450	2.4
	76	128 6.39	42 3.45	130 5.66	6.4 .16	201 3.30	540 11.23	46 1.30	.12	1,080	1.47	222	492	327	36	1,480	2.6
	20	130 6.49	43 3.53	135 5.87	8.2 .21	202 3.31	550 11.44	49 1.38	.12	1,100	1.50	59	501	336	36	1,500	2.6
Weighted Average	2,800	58 2.89	14 1.15	31 1.35	2.8 0.07	136 2.23	143 2.97	8.6 0.24	0.06	361	0.49	2,730	202	90	25	539	0.9

Lines a, b, and c indicate the 12, 50, and 90 percentiles of water discharge, respectively.

Table 10.--Relation between water discharge and chemical quality of the water of the Colorado River at Lees Ferry, Ariz., water years 1914-57 adjusted to 1957 conditions

[Chemical-quality data is in parts per million and equivalents per million (underlined) except as indicated]

	Discharge (cfs)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Boron (B)	Dissolved solids (sum): Parts per million	Dissolved solids (sum): Tons per acre-foot	Dissolved solids (sum): Tons per day	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Percent sodium	Specific conductance (micromhos per cm at 25°C)	Sodium adsorption ratio
	178,200	46 2.30	13 1.07	22 .96	3.5 .09	149 2.44	80 1.66	10 .28	0.09	250	0.34	120,300	168	46	22	405	0.7
	137,300	46 2.30	13 1.07	22 .96	3.5 .09	149 2.44	80 1.66	11 .31	.09	253	.34	93,790	168	46	22	410	.7
	123,200	46 2.30	13 1.07	22 .96	3.5 .09	149 2.44	81 1.68	11 .31	.09	256	.35	84,460	171	49	22	415	.7
	101,800	47 2.35	13 1.07	23 1.00	3.5 .09	149 2.44	82 1.71	12 .34	.09	262	.36	71,800	171	49	22	425	.8
	82,090	48 2.40	13 1.07	24 1.04	3.5 .09	150 2.46	83 1.73	13 .37	.09	270	.37	59,840	174	50	23	440	.8
	69,120	49 2.45	13 1.07	26 1.13	3.5 .09	152 2.49	87 1.81	14 .39	.09	280	.38	52,250	176	52	24	460	.9
	55,060	50 2.50	14 1.15	29 1.26	3.5 .09	154 2.53	95 1.98	16 .45	.09	295	.40	43,860	182	56	25	480	.9
a	41,660	53 2.64	15 1.23	35 1.52	3.5 .09	158 2.59	115 2.39	20 .56	.09	322	.44	36,220	194	64	28	520	1.1
	25,690	62 3.09	19 1.56	51 2.22	3.7 .09	170 2.79	160 3.33	31 .87	.09	420	.57	29,130	232	93	32	660	1.5
	16,120	76 3.79	25 2.06	74 3.22	4.0 .10	184 3.02	235 4.89	48 1.35	.11	580	.79	25,240	292	142	35	890	1.9
	11,280	90 4.49	31 2.55	100 4.35	4.8 .12	199 3.26	310 6.45	66 1.86	.14	730	.99	22,230	352	189	38	1,120	2.3
b	8,680	103 5.14	37 3.04	122 5.31	5.3 .14	208 3.41	372 7.74	83 2.34	.16	860	1.17	20,150	409	238	39	1,300	2.6
	7,430	112 5.59	40 3.29	135 5.87	5.8 .15	213 3.49	410 8.53	95 2.68	.18	935	1.27	18,760	444	270	39	1,400	2.8
	6,490	118 5.89	44 3.62	145 6.31	6.2 .16	218 3.58	445 9.26	105 2.96	.19	990	1.35	17,350	476	296	39	1,470	2.9
	5,650	125 6.24	48 3.95	150 6.52	6.6 .17	221 3.62	480 9.98	115 3.24	.20	1,040	1.41	15,870	510	328	39	1,550	2.9
c	4,580	133 6.64	53 4.36	157 6.83	7.2 .18	226 3.71	510 10.61	130 3.67	.21	1,120	1.52	13,850	550	364	38	1,620	2.9
	3,260	142 7.09	60 4.93	165 7.18	7.8 .20	230 3.77	550 11.44	145 4.09	.23	1,170	1.59	10,300	601	412	37	1,700	2.9
	2,160	146 7.29	66 5.43	173 7.53	8.3 .21	230 3.77	590 12.27	151 4.26	.23	1,200	1.63	7,000	636	448	37	1,720	3.0
	1,490	147 7.34	68 5.59	175 7.61	8.6 .22	230 3.77	600 12.48	156 4.40	.23	1,210	1.65	4,870	646	458	37	1,720	3.0
Weighted Average	17,550	70 3.49	23 1.89	62 2.70	4.2 0.11	174 2.85	198 4.12	41 1.16	0.11	499	0.68	23,660	269	126	33	772	1.6

Lines a, b, and c indicate the 12, 50, and 90 percentiles of water discharge, respectively.

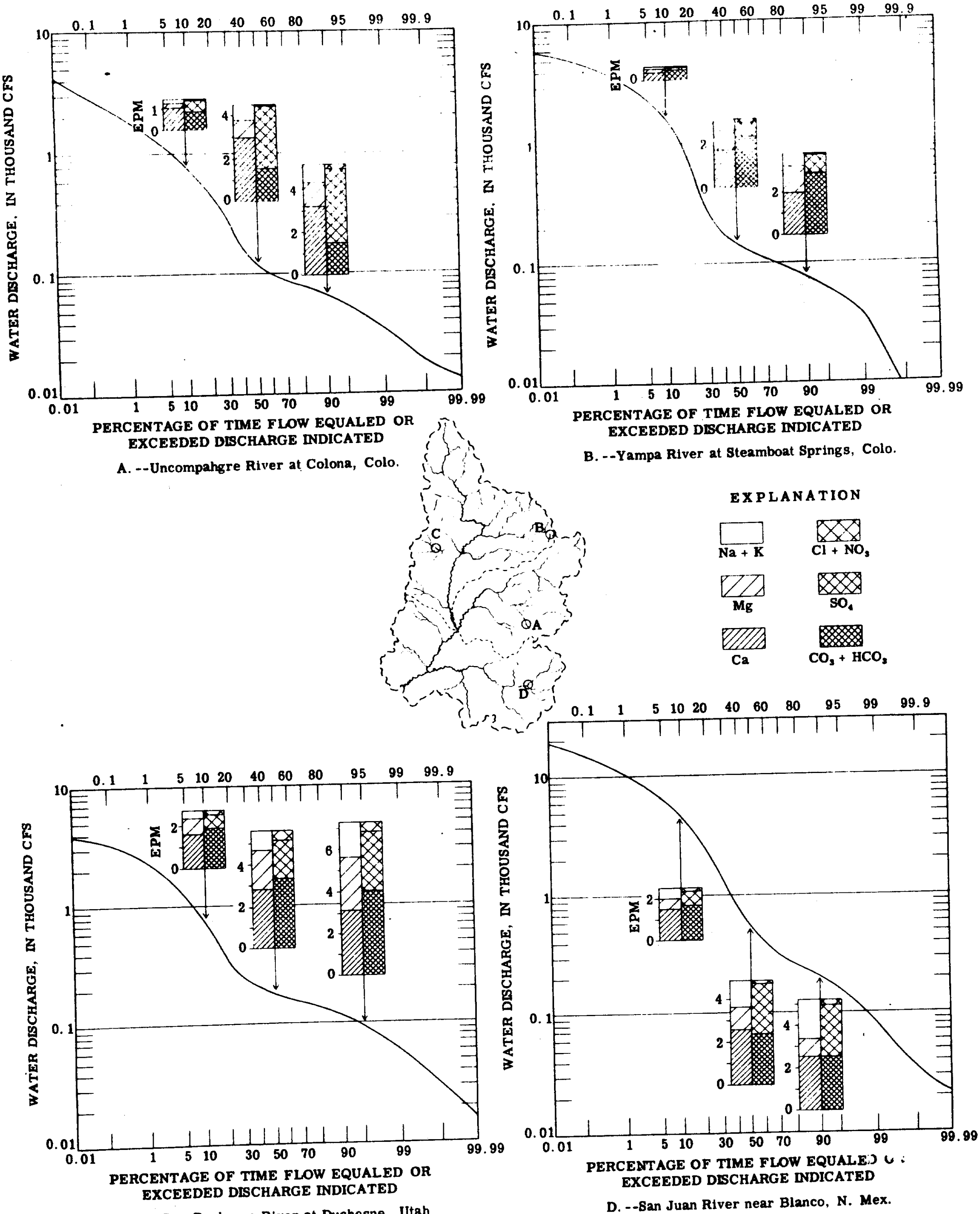


Figure 12.--Relation of the chemical composition and concentration of dissolved solids to water discharge for streams in the headwaters of the Upper Colorado River Basin. The concentration of specific ions, in equivalents per million (epm) is shown for the tenth, fiftieth, and ninetieth centiles of the flow-duration curve for each location. The flow-duration curves are for the water years 1914-57 adjusted to 1957 conditions.

and San Juan Rivers and their principal tributaries are underlain by comparatively insoluble rocks; these are chiefly granite and associated metamorphics, volcanics, and the more indurated sedimentary rocks. The granitic and metamorphic terrains are composed of similar minerals; therefore, the waters of their streams are much alike in chemical composition. In dissolved-solids concentration these are the most dilute waters in the Upper Basin; commonly they contain no more than 20 ppm of dissolved solids. The weighted-average concentration of the streams at any point along the Continental Divide, in the higher parts of the San Juan Mountains, in the Uinta Mountains, and on some of the high plateaus nowhere exceeds 100 ppm and usually does not exceed 50 ppm.

These high-mountain stream waters are a calcium-bicarbonate type at all stages of streamflow, but those with concentrations less than about 30 ppm may contain relatively large proportions of sodium and sulfate. The concentration of silica ranges about from 6 to 15 ppm except in streams that drain areas of volcanic rocks, as the San Juan Mountains and certain of the high mesas. In the streams draining these volcanic terrains, the concentration of silica may exceed 40 ppm and usually is more than 20 ppm.

In contrast to the headwater reaches just described, the middle and lower reaches of the Colorado, Green, and San Juan Rivers and their principal tributaries are underlain chiefly by sedimentary rocks--limestone, sandstone, siltstone, and shale. These rocks contain minerals that are more readily soluble. Thus, in a downstream direction the concentration of dissolved solids in the streams increases progressively, as does the content of magnesium, sodium, sulfate, and chloride.

In general, near the mountains which yield most of the surface water, the weighted-average concentration of the stream waters is less than 100 ppm; in most main streams and their principal tributaries, except in their lower reaches, it is generally no more than about 500 ppm; and only in a few downstream reaches does it exceed 800 ppm. Figure 13 shows the approximate weighted-average concentration of streams at 50 sites in the upper basin for water years 1914-1957 adjusted to 1957 conditions.

Variation in ground waters

Effluent ground water reaches the streams in the Upper Colorado River Basin from reservoirs that are recharged wholly by precipitation, from alluvium that borders certain streams and that is recharged intermittently by these streams, from thermal springs, and from beneath irrigated lands. The chemical quality of such effluent ground water may substantially influence, or even dominate, the chemical quality of the water in the receiving stream; for example, during base-flow periods when the stream is very largely effluent ground water.

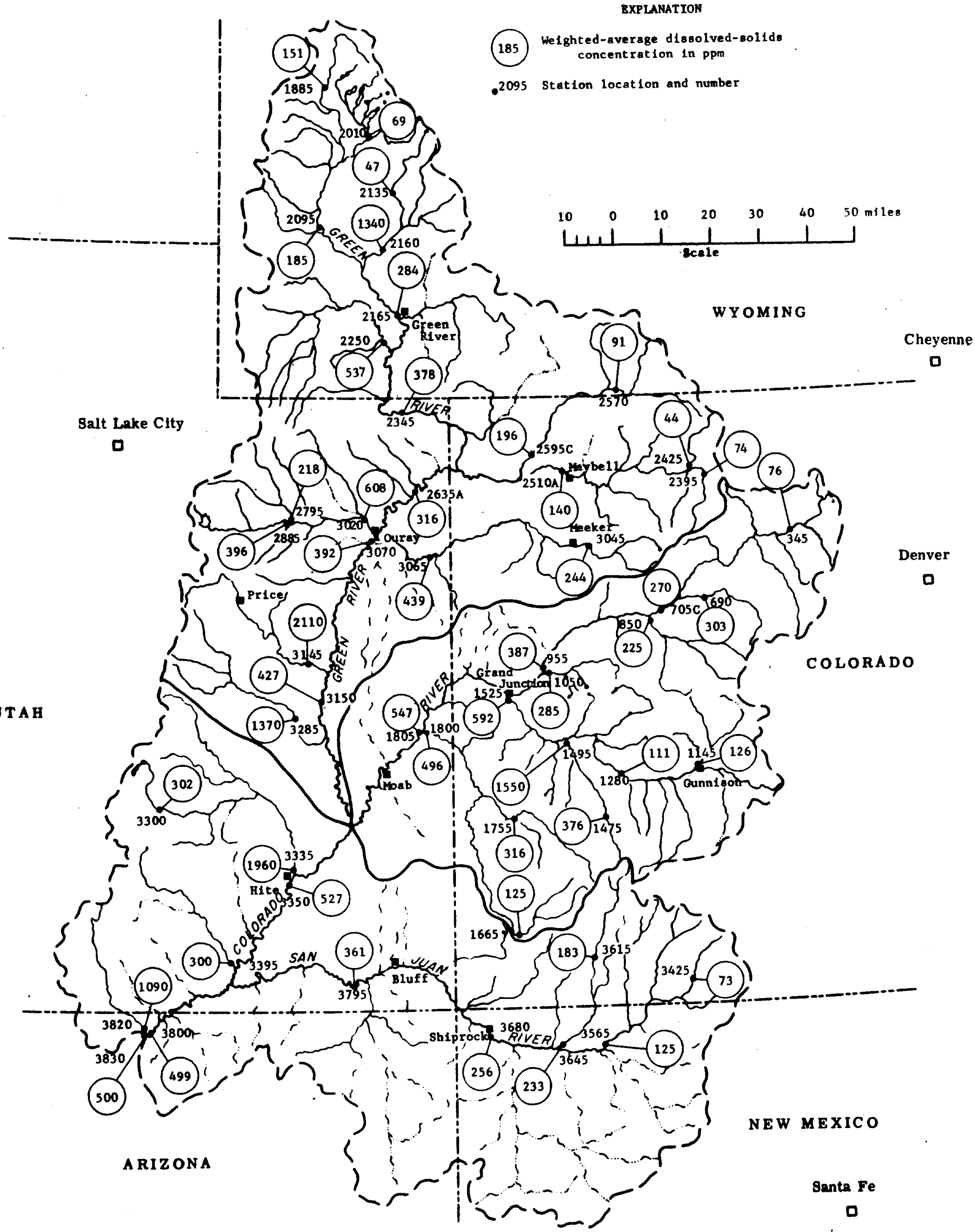


Figure 13.--Weighted-average concentration of dissolved solids at selected sites in the Upper Colorado River Basin, water years 1914-57 adjusted to 1957 conditions.

CHEMICAL QUALITY OF THE WATER

Extensive ground-water reservoirs occur in the mountainous areas where precipitation is abundant. Table 11 gives quantitative estimates of the amount of dissolved solids contributed to certain headwater streams by their base-flow components. These estimates are based on the dissolved-solids concentration of the water in the streams during near-minimum flow. This weighted-average concentration at near-minimum flow almost invariably is substantially greater than at other times.

Commonly, the chemical composition of a stream water is much like that of ground water in the adjacent floodplain alluvium. This is not unexpected because water commonly interchanges between the stream channel and the alluvium, owing either to rise and fall of the stream or to the application of irrigation water on floodplain lands. Generally, the water in the alluvium is the more concentrated, owing both to the concentrating effect of evapotranspiration and to the solution of minerals from the alluvium (Fig. 14).

Locally certain mineral constituents are highly concentrated in water in the alluvium. Thus, in certain arid parts of the upper basin, water in alluvium contains large amounts of calcium, magnesium, sodium, or sulfate; in these same areas, the stream waters may be uncommonly concentrated in chloride, carbonate, and bicarbonate. At a few places, nitrate in the ground water exceeds 45 ppm. Boron in the ground water exceeds 10 ppm along some of the northward-flowing tributaries in the Duchesne River basin; boron is also high in ground water along the lower reaches of Willow Creek near Ouray, Utah.

Numerous thermal springs occur along the streams in the Upper Basin. Most of these flow much less than the streams into which they discharge, so that their net effect on the quality of the stream water is small. From certain springs, however, the effluent is substantial in quantity and highly concentrated, so that the quality of the receiving stream is deteriorated markedly. For example, hot springs along the 17-mile reach of the Colorado River between Eagle River and the Shoshone powerplant contribute about 182,600 tons of dissolved solids to the river each year; of this, about 160,700 tons is sodium chloride. From all known thermal springs in the Upper Colorado River Basin the yearly water and dissolved-solids discharges are about 59,100 acre-feet and 541,600 tons, respectively; these are distributed as follows:

	Water-discharge (acre-feet)	Dissolved-solids discharge (tons)
Grand division	41,000	482,000
Green division	15,900	48,600
San Juan division	2,200	11,000
The Upper Basin	59,100	541,600

Table 11.--Water and dissolved solids contributed by ground water to selected headwater streams in the Upper Colorado River Basin, water years 1914-57 adjusted to 1957 conditions

Station number	Station	Stream water: Acre-feet per year	Stream water: Dissolved solids: Tons per year	Stream water: Dissolved solids: Weighted-average concentration (ppm)	Ground water: Acre-feet per year	Ground water: Dissolved solids: Tons per year	Ground water: Dissolved solids: Weighted-average concentration (ppm)
125	North Inlet at Grand Lake, Colo......	56,800	1,240	16	4,900	120	18
200	Willow Creek near Granby, Colo	50,570	4,380	65	9,200	820	66
695	Gypsum Creek near Gypsum, Colo....	26,950	10,230	279	17,700	9,410	391
1125	East River at Almont, Colo.	243,400	48,580	147	56,400	15,700	206
1155	Tomichi Creek at Sargents, Colo.	131,100	31,410	83	19,000	2,440	94
1855	Green River at Warren Bridge near Daniel, Wyo.....................	391,200	80,360	151	105,800	48,000	187
2260	Henrys Fork near Lonetree, Wyo.....	31,590	2,500	59	7,600	930	90
2665	Ashley Creek near Vernal, Utah......	76,790	5,840	56	23,300	2,600	82
2790	Rock Creek near Mountain Home, Utah	136,900	9,130	49	49,200	4,800	72
3245	Cottonwood Creek near Orangeville, Utah........................	70,200	22,280	233	18,300	7,100	285
3400	San Juan River near Pagosa Springs, Colo.	97,800	10,230	77	15,400	2,090	100
3610	Hermosa Creek near Hermosa, Colo..	106,500	31,780	219	20,400	11,400	411

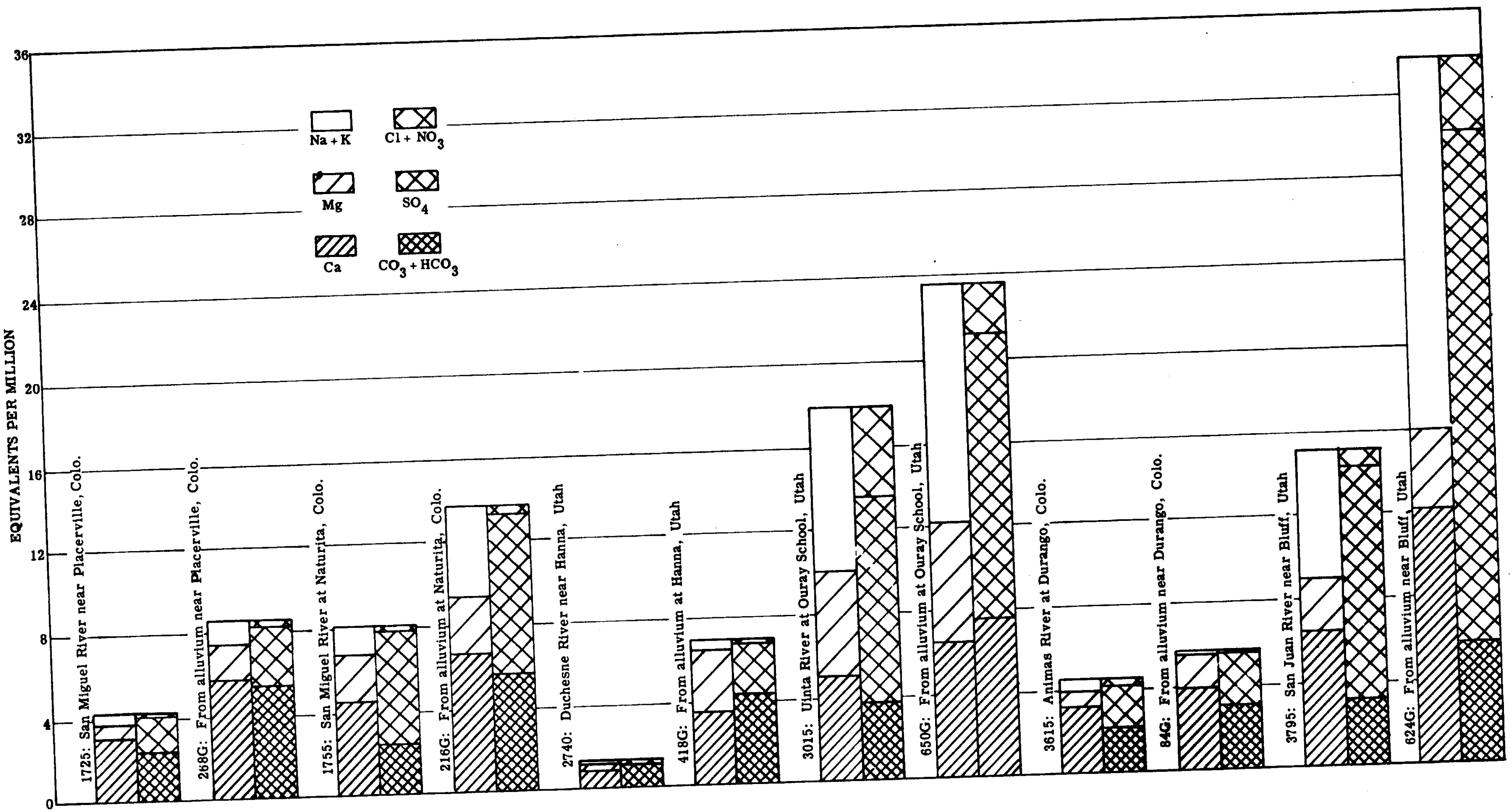


Figure 14. --Analyses of water from selected streams in the Upper Colorado River Basin and from the alluvium nearby.

CHEMICAL QUALITY OF THE WATER

Effects of Man's Activities

Transmountain diversions

As of the 1957 water year, net averages of about 465,800 acre-feet of water and 37,500 tons of dissolved solids were being taken from the Upper Colorado River Basin each year by transmountain diversions. Of these totals, about 353,400 acre-feet and 17,800 tons were from the Colorado River and its tributaries above the Gunnison River, and about 112,200 acre-feet of water and 19,300 tons were from the Green division, mostly from the Strawberry and Duchesne River basins in Utah.

Locally, these transmountain diversions may modify substantially the weighted-average dissolved-solids concentration of the remaining stream waters. For example, it can be computed that the diversions from the Colorado River above Hot Sulphur Springs, Colo., diminish the average yearly water discharge about from 417,300 acre-feet to 176,800 acre-feet, diminish the dissolved-solids discharge about from 34,900 tons to 18,260 tons, and increase the weighted-average concentration about from 61 ppm to 76 ppm, similarly, that the diversion through Strawberry River and Duchesne River tunnels increases the weighted-average concentration of the Duchesne River below the mouth of the Uinta River about from 533 ppm to 608 ppm. However, the net effect of all the transmountain diversions is only moderate at the basin-outflow point at Lee Ferry, Ariz. There, the weighted-average concentration of the Colorado River was about 501 ppm as of 1957. Thus, if there were no transmountain diversions, but if otherwise the stream regimen remained as in 1957, the water and dissolved-solids discharges of the Colorado River at Lee Ferry would be about 13,201,400 acre-feet and 8,713,800 tons, respectively. In other terms, the weighted-average concentration of the river at Lee Ferry would be 485 ppm, or 16 ppm less than with the transmountain diversions and about 3.4 ppm less for each 100,000 acre-feet of water diverted.

Domestic and industrial uses of water

Only part of the water that is withdrawn for domestic and industrial purposes in the Upper Colorado River Basin is consumed; the remainder returns ultimately to the stream system, carrying dissolved solids which were picked up incidentally to the use. The effect is to diminish the amount of water flowing in the streams and to increase the dissolved-solids load and concentration.

For purposes of this report it is estimated, probably somewhat generously, that domestic and industrial uses of water add about 100 tons of dissolved solids to the stream system each year for each 1,000 residents in the basin. Because population is sparse and industrial development is modest, the water-quality effects are relatively small, as is indicated by the table on the following page. (Table 12.)

Table 12
Average yearly increment to dissolved-solids discharge in the Upper Colorado River Basin, owing to domestic and industrial uses of water, as of 1957

Subbasins and divisions	Dissolved solids (tons)
Colorado River basin above the Gunnison River	2,600
Gunnison River basin	3,800
Colorado River basin between the Gunnison and Green Rivers	6,600
Subtotal, Grand division	13,000
Green River basin above the Yampa River	3,400
Yampa River basin	1,400
Green River basin below the Yampa River, to and including the White River basin	2,500
Green River basin below the White River	2,700
Subtotal, Green division	10,000
San Juan River basin	10,000
Colorado River basin below the Green and San Juan Rivers and above Lee Ferry, Ariz.	600
Subtotal, San Juan division	10,600
Total, Upper Colorado River Basin	33,600

If there were no domestic and industrial uses of water, but if otherwise the stream regimen remained as in 1957, the weighted-average concentration of the Colorado River at Lee Ferry would be 498 ppm. In other words, domestic and industrial uses increase the dissolved-solids concentration at the basin outlet, Lee Ferry, by about 3 ppm only.

Irrigation

Likewise, part of the water diverted for irrigation never returns to the stream system, but is used consumptively by evaporation from the surfaces of canals, ponded areas, and wetted land, also through transpiration by the crop plants. Of the water involved in the evapotranspiration process, only a minute part of the dissolved solids is taken into plant tissue; essentially all the dissolved solids are rejected by the plant and remain in the soil or in the soil solution. The dissolved solids so rejected cannot be allowed to accumulate in the root zone but must be flushed away; otherwise, salinity of the soil ultimately will increase sufficiently that productivity of the land will diminish.

To maintain a favorable salt balance in irrigation, sufficient water is applied to the land to flush beyond the root zone the dissolved solids that were contained in the water consumed. Thus, part of the applied water percolates downward through the soil and subsoil to the water table. This water not only flushes the root zone but also leaches soluble minerals, if present, from the soils and rocks as it moves to and through the ground-water reservoir on its route back to the stream system. Another part of the applied water may move over the land surface and there pick up additional solubles.

Irrigated lands in the upper basin are on the flood plains of the streams, on terraces, and on bench lands. Surface runoff from the irrigated lands, and effluent ground water from beneath those lands usually return to the stream from which the irrigation supply is diverted. Because the return waters, surface and ground, usually are enriched in dissolved solids as has been explained, dissolved-solids concentration and load of the streams increase below the irrigated areas.

In certain headwater areas, such as the Fraser River and New Fork River basins, the soils and rocks that underlie the irrigated lands are relatively insoluble. Accordingly, the streams pick up relatively little dissolved solids as they traverse these areas. However, most of the large irrigated tracts in the basin are on the arid and semiarid lowlands, where the soils and underlying rocks commonly contain soluble minerals in relative abundance. Here, therefore, relatively large amounts of dissolved solids may be added to the streams by irrigation. These additions constitute the principal man-caused changes in the water-quality regimen of the Upper Colorado River Basin.

There are in the Upper Colorado River Basin 21 valley or lowland areas in which the overriding use of water is for irrigation, and for which available data suffice to compute, approximately, the man-caused increments of dissolved solids in the stream waters, as of 1957. Deductions having been made for the partial increments due to municipal and industrial uses of water and, in two areas of the Green division, to certain oil-field waters that mingle with stream waters, the residual man-caused increment presumably is that due to irrigation. Table 13 assembles the results.

The values of irrigation-caused yields of dissolved solids in Table 13 range between 0.1 ton and 5.6 tons per irrigated acre, yearly. Their weighted mean is 2.4 tons per acre. In this connection, it is noteworthy that a large yield per unit of area requires not only a substantial quantity of available soluble material--in the rocks, their weathering products, and the soils--but also sufficient percolating and flowing water to dissolve that material and transport it to a stream. Conversely, that a small dissolved-solids yield per unit of area may imply any one of three environmental conditions: (1) little soluble material exists or ever existed in the soil and rocks of the area of concern; (2) precipitation and runoff are so large and so widely

Table 13.—Approximate average yield of dissolved solids due to irrigation in selected areas of the Upper Colorado River Basin, as of 1957

Area	Underlying formation	Average annual precipitation (inches)	Irrigated acreage	Dissolved-solids yield* (tons per acre per year)
Grand division				
Fraser River basin, Colo.	Precambrian rocks and North Park formation.	16-25	10,200	0.1
Colorado River basin below Granby and Willow Creek Reservoirs and above Hot Sulphur Springs, Colo., exclusive of Fraser River basin.	Alluvium derived from Precambrian rocks, Tertiary volcanics, and Middle Park formation.	14-16	5,500	1.0
Troublesome Creek basin, Colo.	North Park formation.	12-16	8,000	.5
Roaring Fork basin, Colo.	Permian rocks, Mancos shale, and Mesaverde formation.	18-25	31,400	3.0
Gunnison River basin below Gunnison tunnel and Uncompahgre River Valley below Colona, Colo.	Mostly Dakota formation and Mancos shale of Cretaceous age.	8-16	194,800	5.0
Colorado River basin below Plateau Creek and Gunnison River and above Dolores River (Grand Valley).	Mancos shale.	8-10	78,700	5.6
San Miguel River basin between Placerville and Naturita, Colo.	Dakota and Morrison formations.	12-16	15,000	2.8
Green division				
New Fork River basin above Boulder Creek, Wyo.	Alluvium of glacial origin.	12-16	29,000	.5
Fontenelle Creek basin, Wyo.	Mostly Wasatch and Green River formations of Tertiary age.	10-16	4,000	1.3
Big Sandy Creek basin, Wyo.	Shallow alluvium underlain by Bridger formation.	8-10	13,000	5.0
Black Fork basin above Muddy Creek, Wyo.	River alluvium underlain by Green River and Bridger formation.	8-10	60,500	.9
Hams Fork above Frontier, Wyo.	River alluvium underlain by Wasatch formation.	12-16	4,000	.3
Yampa River basin between Morrison Creek and Steamboat Springs, Colo.	Alluvium of glacial origin.	25-30	12,000	.2
Elk River basin, Colo.	Mancos shale.	20-30	8,000	.4
Little Snake River basin above Dixon, Colo.	River alluvium underlain by Fort Union, Lance, and Bridger formations and Mancos shale.	16-30	4,000	1.2
Ashley Creek basin, Utah	Alluvium underlain by Mancos shale.	8-12	23,800	2.1
Duchesne River basin above Duchesne, Utah.	Uinta formation.	9-14	6,500	3.3
White River basin between Buford and Meeker, Colo.	Permian rocks and Mancos shale.	19-28	11,000	4.8
San Fafael basin, Utah	Shales of Cretaceous age.	8-10	36,000	3.2
San Juan division				
La Plata River basin in Colorado	Alluvium underlain by Mesaverde formation.	12-20	16,500	.5
La Plata River basin in New Mexico	Mesaverde formation and Tertiary rocks.	8-12	9,500	1.4

*Of necessity, the indicated yields of irrigation-caused dissolved solids have been derived in part from short or fragmentary records. As implied on page 13 this paucity of available records precludes conclusive determinations; however, the approximate values here listed are judged to be credible as interim indicators of the general order of magnitude of such yields.

Records adequate to measure dissolved-solids yields now are being taken at several locations in the basin; hopefully, these will yield definitive results after some years.

dispersed that all the soil and rocks long since have been leached thoroughly to a substantial depth below the land surface, even though solubles may be plentiful at greater depth; or (3) precipitation is so very small that, even though solubles may be plentiful, the streams reach and can leach only a minor part of the nominal drainage area. All three of these environments exist in the Upper Colorado River Basin. It is implicit in this situation that, to characterize any particular area, yields of water and of dissolved solids must be considered jointly.

The 21 selected areas of Table 13 cover somewhat less than half the irrigated land in the basin of the Colorado River above Lee Ferry. For areas not covered, the man-caused increment of dissolved solids in the streams has been estimated according to the values in Table 13 and according to similarities among soils and underlying rocks, climatic environments, and chemical analyses of stream waters. Among these bases of similarity, the major rock classes are especially useful as an index to the relative quantities of soluble salts contained by overlying soils.

Table 14 summarizes the average yearly discharge of dissolved solids from all the Upper Colorado River Basin as of 1957, and indicates both that which probably is from natural sources (total 5,196,000 tons per year) and that which probably is man-caused (total 3,480,300 tons per year). Nearly all this man-caused total, excluding only about one percent, is presumptively an effect of irrigation.

From preceding Table 14, the average yearly water and dissolved-solids discharges from the Upper Colorado River Basin for the water years 1914-1957, adjusted to 1957 conditions, are about 12,733,100 acre-feet and 8,676,300 tons, respectively. If there had been no activities of man in the upper basin, exclusive of transmountain diversions, the long-term weighted-average concentration of dissolved solids of the Colorado River at Lee Ferry, Ariz., would be about 263 ppm. The indicated increase in dissolved-solids concentration of 238 ppm (501 ppm minus 263 ppm) caused by domestic, industrial, and agricultural uses of water is equivalent to 13.3 ppm for each 100,000 acre-feet of water consumed. This increase in concentration is about four times that caused by the diversion of an equivalent amount of water from the basin.

Table 14. --Average yearly dissolved-solids discharge in the Upper Colorado River Basin, as of 1957

Subbasins and divisions	Drainage area (sq mi)	Water discharge (acre-feet)	Acres irrigated	Dissolved-solids discharge: Total (tons)	Probable from natural sources: Tons	Probable from natural sources: Tons per sq mi	Probable from activities of man: Tons	Probable from activities of man: Tons per acre irrigated
Colorado River basin above the Gunnison River basin	8,670	3,168,200	192,500	1,644,100	1,242,100	143	402,000	2.1
Gunnison River basin	8,020	1,884,000	269,400	1,519,000	542,000	68	977,000	3.6
Colorado River basin between the Gunnison and Green Rivers	9,810	a 481,800	121,300	1,041,500	469,900	48	571,600	4.7
Total for Grand division	26,500	a 5,534,000	583,200	4,204,600	2,254,000	85	1,950,600	3.4
Green River basin above the Yampa River	17,000	b 1,645,000	258,400	967,100	646,600	38	320,500	1.2
Yampa River basin	8,000	c 1,602,600	73,700	405,800	343,400	43	62,400	0.8
Green River basin between the Yampa and White Rivers, including the White River basin	10,800	d 1,260,400	198,000	1,034,100	471,800	44	562,300	2.3
Green River basin below the White River	8,900	e 152,100	60,000	521,100	288,400	32	232,700	3.9
Total for Green division	44,700	f 4,660,100	590,100	2,928,100	1,750,200	39	1,177,900	2.0
San Juan River basin	24,900	g 2,028,000	206,400	h 1,073,000	h 784,900	32	288,100	1.4
Colorado River basin below the Green and San Juan Rivers and above Lee Ferry, Ariz.	13,400	i 511,000	33,300	470,600	406,900	30	j 63,700	1.9
Total for San Juan division	38,300	2,539,000	239,700	1,543,600	1,191,800	31	351,800	1.5
Total for Upper Colorado River Basin	109,500	12,733,100	1,413,000	8,676,300	5,196,000	47	3,480,300	2.5

a Does not include runoff from 2,400 square miles between the Colorado River near Cisco, Utah, gaging station and the Green River.
b Does not include runoff from 1,900 sq mi in the subbasin between the Green River near Greendale gaging station and the Yampa River.
c Does not include runoff from 800 sq mi in the subbasin between the Yampa River near Maybell, Colo., and Little Snake River near Lily, Colo., gaging station and the Green River.
d Includes runoff from the two areas described in footnotes b and c.
e Does not include runoff from 2,400 sq mi between the Green River at Green River, Utah, and San Rafael River near Green River, Utah, gaging stations and the Colorado River.
f Includes runoff from the two areas described in footnotes b and c but not that described in e.
g From San Juan River basin above gaging station near Bluff, Utah.
h Includes 17,000 tons of dissolved solids imported from the Dolores River.
i Includes contribution from San Juan River basin below the gaging station near Bluff, Utah and from the areas described in footnotes a and e.
j Includes 700 tons of dissolved solids imported in the Tropic and East Fork Canal.

PART II

PROJECTION OF

WATER QUALITY EFFECTS

BUREAU OF RECLAMATION

QUALITY OF WATER
UPPER COLORADO RIVER BASIN
PROGRESS REPORT

PART II

PROJECTION OF WATER QUALITY EFFECTS

SUMMARY

Part II of this report sets forth the quality of water of the Colorado River under three different conditions. The first is the existing or historic situation at fifteen quality of water stations for the 1941-1958 period.

The second is the present modified condition at the same stations. This condition assumes that new developments during the 1941-1958 period were in operation for the full 18-year period.

The third is an estimate of the quality of water situation after the presently authorized developments are placed in operation. The quality for the third condition has been estimated in four different increments.

The results of the studies show that under historic conditions the average concentration of the Colorado River at Lees Ferry for the 18-year period would be 0.72 of a ton per acre-foot, or 529 parts per million. Under present modified conditions with the recently constructed projects in operation, including transmountain diversions, the average concentration becomes 0.75 ton per acre-foot, or 551 parts per million.

Under the third condition with the authorized projects in operation, the average concentration increases to 0.84 ton per acre-foot, or 617 parts per million. This is assuming that equilibrium (salt balance) conditions prevail for irrigated lands in the Upper Colorado River Basin. A salt balance is in effect when the same amount of dissolved solids applied to the land by irrigation water is carried off the land by return flows. If it is assumed that 2 tons of dissolved solids are picked up from each acre of irrigated land, the concentration would increase to 0.87 ton per acre-foot, or 639 parts per million.

The derived concentrations are not deemed to be excessive, nor will they hamper present uses of the water downstream from Lees Ferry.

INTRODUCTION

Comprehensive plans have been developed by the Department of the Interior looking forward to the complete utilization of the water resources of the Colorado River Basin. Many of these plans have now been authorized and are being translated into completed projects under rapidly moving construction programs. Among the great milestones of this development in the past decade was the authorization of the Colorado River Storage project and participating projects in April 1956 which provided for the regulation of the streams in the Upper Colorado River Basin and the means to utilize the water throughout the upper basin for irrigation and other beneficial purposes.

With the accelerated development and attendant increased uses of water came the need to study and report on other phases of the water resources picture. Among these problems was the determination of the chemical quality of the basin's waters at many points within the stream system and the need to estimate what effect increased developments would have upon the chemical quality of the water throughout the basin. The Congress recognized this need in the authorizing legislation for the Colorado River Storage project and participating projects.

This report is the first in this prospective series. It is considered as an interim report indicating mainly progress to date and a discussion of the scope of the report series. It will be limited to a discussion of chemical quality and to the presentation of total dissolved solids load data at various points in the Colorado River system for historical and present modified conditions and a discussion of the anticipated effects on the quality of water brought about by authorized Federal projects and other developments. These anticipated effects will be reported in increments in order of their authorization or likelihood of construction. The first increment will include the storage units of the Colorado River Storage project; the second, authorized participating projects of the Colorado River Storage project together with other miscellaneous developments; the third, the San Juan-Chama project and Navajo Indian Irrigation project; and the fourth, the Fryingpan-Arkansas project.

Fifteen streamflow and quality of water stations were selected to be studied and reported upon. These stations comprise a broad geographical network which represents the quality of water conditions at key points throughout the basin on the main stream and principal tributaries. Flow and quality of water data and analyses were generally available at each of these stations or could be developed by adequate correlations for a chosen 18-year period of study from 1941-58, inclusive. Also, most of the planning reports for the various units of the Colorado River Storage project and participating projects are now available to furnish needed data on water uses and anticipated depletions for the selected period of study up to the year 1958.

INTRODUCTION

Additional daily and seasonal quality of water sampling stations have been installed and others may be needed to supplement the basic network to provide adequate data to detect changes brought about by installation and operation of the many projects authorized or contemplated in the basin. Corollary studies are now in progress to interpret the available data. Many more detailed studies should also be carried on to adequately portray the existing conditions and potential changes in the quality of water in the Colorado River Basin.

DESCRIPTION OF THE COLORADO RIVER SYSTEM

The Colorado River rises high on the western slopes of the Continental Divide in Colorado and then flows 1,400 miles southwest before finally emptying into the Gulf of California in Mexico. It is the second longest river in the continental United States and drains a total of 242,000 square miles of the United States. Portions of the States of Wyoming, Utah, Colorado, New Mexico, Arizona, Nevada, and California are included in its vast drainage network. The principal tributary drainages in the Upper Colorado River Basin are the Gunnison, Dolores, Green, and San Juan Rivers, which all join the Colorado River in western Colorado and southeastern Utah. Lower Basin tributaries of importance include the Little Colorado, Virgin, Bill Williams, and Gila Rivers (Figure 1).

The upper or northern portion of the Colorado River Basin in Wyoming and Colorado is a mountainous plateau 5,000 to 8,000 feet in elevation marked by broad, rolling valleys, deep canyons, and intersecting mountain ranges. Hundreds of peaks in these mountain chains rise to more than 13,000 feet above sea level and many exceed 14,000 feet elevation. Mountain lakes exist in considerable numbers. The southern portion of the basin is studded with rugged mountain peaks interspersed with broad, level, alluvial valleys and rolling plateaus. The main stream and tributaries in Colorado generally flow in deep mountain canyons. The Green River, primary tributary of the Colorado River, flows in similar canyons in Wyoming, Colorado, and Utah after rising in the Wind River Mountains. The San Juan River, a large tributary, emerges from the mountains of southwestern Colorado, flows through northwestern New Mexico, and then traverses the deep canyons of the San Juan in Utah before joining the Colorado River in Glen Canyon. The Glen Canyon section of the main stream and tributaries thereto is buried in deep canyons almost the whole of the way.

Immediately below the Glen Canyon, the Colorado River plunges into the incomparable Grand Canyon in northern Arizona and then is stilled by Lake Mead behind Hoover Dam. Below Hoover Dam the area is characterized by broad valleys bordered by mesas. The great delta area of the Colorado River is then traversed before it flows into the Gulf of California in Mexico. The Gila River, the principal tributary in the far south section of the basin, rises in the mountainous region of southwestern New Mexico and drains most of southern Arizona.

Rocks of all ages from those of the Archean Age (the oldest known geological period) to the recent alluvial deposits, including igneous, sedimentary, and metamorphic types, are found in the Colorado River Basin. The high Rocky Mountains which dominate the topography of the upper regions are composed of granites, schists, gneisses, lava, and sharply folded sedimentary rocks. Many periods of deposition and erosion have played a part in the present structure of these mountains. Ancient seas have settled in the basin countless times depositing beds of limestone, sandstone, and shale.

In contrast to the folded rocks of the mountains which fringe the basin, the plateau country of southwestern Wyoming, eastern Utah, and northern Arizona is composed principally of horizontal strata of sedimentary rocks. Slow but constant elevation of the land area has allowed the Colorado River and its tributaries to cut narrow, deep canyons into the flat-topped mesas. The type of erosion reaches its culmination in the Grand Canyon where the Colorado River has cut through all of the sedimentary rocks down to the oldest Archean granites.

The southern part of the basin is characterized by broad, flat valleys separated by low ranges. These valleys are filled by large accumulations of alluvial deposits.

Silt removed by constant erosion of the upper areas was deposited and now forms the great delta of the Colorado River in Arizona, California, and Mexico.

Agreement by the several States to the Colorado River Compact of 1922 and subsequent authorizing legislation signalled large-scale development in the lower basin. Completion of Hoover Dam in 1935 provided the necessary control of the river, and downstream developments proceeded rapidly. Major structures downstream from Hoover Dam now include Davis Dam (Lake Mohave), Parker Dam (Havasu Lake), Headgate Rock Dam, Palo Verde Diversion Dam, Imperial Dam and Desilting Works, All-American Canal, and Laguna Dam.

In contrast to the rapid development in the lower basin, construction of projects in the Upper Colorado River Basin has proceeded at a moderate pace. In the first half of the 20th Century, the Uncompahgre project and Grand Valley project, two sizeable projects in Colorado, were begun by private interests and completed under the Reclamation Act. Other Reclamation and private construction accounted for several completed projects within the basin and some transmountain diversions on both the eastern and western boundaries. The Colorado-Big Thompson project, built in the period 1938-59, is one of the large projects which diverts water from the basin to the eastern slopes of the Rocky Mountains.

The agreement by the States of Arizona, Colorado, New Mexico, Utah, and Wyoming to the Upper Colorado River Basin Compact on October 11, 1948, cleared the way for comprehensive development in the upper basin.

DESCRIPTION OF THE COLORADO RIVER SYSTEM

Extensive investigations were launched by the Department of the Interior, which resulted in authorization of the Colorado River Storage project and participating projects in 1956. Construction is now well advanced on the Glen Canyon, Navajo, Flaming Gorge, and Curecanti storage units and several of the participating projects (Figure 1). Additional recent authorizations include the San Juan-Chama project, Colorado-New Mexico; the Navajo Indian Irrigation project, New Mexico, and the Fryingpan-Arkansas project, Colorado.

SOURCES OF BASIC DATA

The years 1941-58 were selected as a base period for this study to project water-quality effects to be expected from additional developments that involve storage and use of river waters above Lee Ferry. Quality of water and flow records were generally available for eleven stations in the Upper Colorado River Basin or it was practicable to develop corollary studies to fill in missing periods of records. Measurements were also available for the Grand Canyon and below Hoover Dam stations for the full period with lesser periods for two other downstream stations on the main Colorado River. Thus, the stations and records shown on Figures 1 and 2 represent a wide range of locations on the main stem of the Colorado River and principal tributaries.

Figure 2 also shows a summary of the actual and derived records during the period of study. For this report extensions were not made for two of the records in the Lower Colorado River Basin. However, subsequent reports will include extension of these records.

Basic records of water flow and quality were obtained by the Geological Survey data-gathering program using standard methods and procedures. The Bureau of Reclamation has provided financial and field service assistance to enable collection of records at a number of key stations. Some records in the Lower Colorado River Basin were obtained from the California Department of Water Resources.

A brief resume of the source and method of derivation for each of the records shown on Figure 2 and in Tables 1 to 15, inclusive, follows:

Stations with complete records by measurement

Flow and quality measurement are available for nearly all of the 1941-58 period for the Green River at Green River, Utah (Table 4); for the Colorado River near Cameo, Colo. (Table 6); Gunnison River near Grand Junction, Colo. (Table 7); Colorado River near Cisco, Utah (Table 8); San Juan River near Bluff, Utah (Table 10); Colorado River near Grand Canyon, Arizona (Table 12); and Colorado River below Hoover Dam, Arizona-Nevada (Table 13). Minor extensions only were needed to fill in short periods of record for a few of these stations.

Green River at Greendale, Utah, and Ouray, Utah

Flow measurements are available for the Green River near Greendale (Table 1), but chemical quality of water measurements are available only for the years 1957 and 1958. Flow measurements at Ouray, Utah (Table 3), are available for the 1948-58 period, but quality records are limited to the years 1951, 1952, 1957, and 1958. Extensive correlations were employed with other available records on the Green River system to develop the estimates shown herein for both streamflow and data on dissolved solids.

SOURCES OF BASIC DATA

Duchesne River near Randlett, Utah

Flow records have been obtained continuously since 1943 and quality data are available for 1951, 1957, and 1958 (Table 2). Detailed correlations were employed to estimate the data for the missing periods using data from other stations in the Duchesne River system.

San Juan River near Archuleta, New Mexico

Flow and quality load data presented are a combination of measurements obtained at Archuleta and at Blanco, New Mexico, with some adjustments and correlations for the period 1945-58 (Table 9). Correlations and summations were employed to estimate the data shown for 1941-45.

San Rafael River near Green River, Utah

Correlations were used to estimate flow at this gage from 1941 to 1945 after which measurements of flow were taken (Table 5). Quality sampling was begun in 1946 and is complete for the remainder of the study period except for 1950. Extensions of available data provided satisfactory estimates of the quality load for the missing years.

Colorado River at Lees Ferry, Arizona

This station has complete flow records available for the study period but lacks quality of water measurements for 1941, 1942, 1946, and 1947 (Table 11). Estimates of the load data for these years were supplied by extensive multiple correlations using data from the gages on the Colorado River near Cisco, Utah, and near Grand Canyon, Arizona; the Green River at Green River, Utah; and the San Juan River near Bluff, Utah; as well as the Lees Ferry record.

Colorado River at Parker Dam and at Imperial Dam, Arizona-California

These stations both have full periods of records for water flow but only intermittent data is available for quality of water loads (Tables 14 and 15). Studies have not been made as yet to fill in the missing periods of load data.

HISTORIC AND PRESENT MODIFIED WATER QUALITY CONDITION

Historic Condition

The historic water quality situation at the fifteen key stations for the 18-year period of record has been tabulated in Tables 1 to 15, inclusive. Where historic records were not available, the missing data have been filled in by correlation methods on all but the Parker and Imperial stations. The methods of correlating the data were discussed previously.

The range in average concentration for the study period varies from 0.21 ton total dissolved solids per acre-foot at the Archuleta station on the San Juan River (Table 9) to 2.2 tons per acre-foot on the San Rafael River (Table 5) with the average at Lees Ferry (Table 11) amounting to 0.72 ton per acre-foot. In addition to the fluctuation in average values there is a wide fluctuation in monthly values at each of the stations.

The high flows generally accompany the low concentrations and the low flows have characteristically higher concentrations throughout the period. The month of lowest total dissolved solids concentration at Lees Ferry is June 1942 with 0.29 and the highest is October 1953 with 1.77 tons per acre-foot (Table 11). The concentration range is as high as 5 tons at the Randlett station in September 1956 (Table 2) and 6 tons during several of the low runoff months at the San Rafael station. The minimum concentrations at the San Rafael station are high also making the water questionable for domestic, industrial, or agricultural purposes. The high mineral concentration at Randlett and San Rafael stations results primarily from watershed drainages that pass through and over barren soils derived largely from shale and sandstone.

The tables also show that the low flows of the Gunnison River near Grand Junction (Table 7) and the Colorado River near Cisco (Table 8) frequently carry sufficient dissolved solids to make the water of questionable chemical quality or at times unsatisfactory for domestic and industrial purposes.

By comparing the flow and quality data of the Colorado River near Grand Canyon above Lake Mead (Table 12), and the Colorado River below Hoover Dam (Table 13), the value of storage is apparent. The dissolved solids listed vary over a wide range for the station above Lake Mead compared to results below the reservoir where they are fairly uniform throughout the year (Figure 3). This uniformity is essentially carried on downstream to the Parker and Imperial Dams, except that comparison is limited by the shorter period of record at those two stations.

This historic record will serve as a basis for evaluating future changes in quality as each development comes into operation and it will serve as a basis for estimating changes that may be brought about by proposed new developments.

To facilitate these studies, all monthly flow and quality data in the tabulations have been rounded to the nearest 1,000 acre-feet of flow and the nearest 1,000 tons of dissolved solids. This rounding presents problems in computing concentrations in drainage areas where the flows often go near or below 1,000 acre-feet and the loads below 1,000 tons. For example, in the San Rafael and Duchesne drainages some of the late summer flows are below 1,000 acre-feet per month so the values of the table may be either low or high depending on the rounding.

In addition to the table of total dissolved solids for the 15 key stations included in this report, an extensive tabulation of supporting data has been prepared for six different ions found in the water of the basin. This tabulation was prepared on a monthly basis by use of an electronic data computer and shows the amounts of calcium, magnesium, sodium, bicarbonate, sulphate, and chloride. Each table also includes mean discharges in cubic feet per second and acre-feet, total cations, total anions, and total dissolved solids in tons. The data have been prepared for each of the regularly sampled stations in the Upper Colorado River Basin so that data are available at several stations in addition to the 15 key stations. A sample sheet of these computations for a 2-year period for the Green River at Green River, Utah, is shown as Table 16.

A critical look at the summary of historical concentrations in tons per acre-foot in Tables 1 to 15, inclusive, indicates that no significant increase in concentration has taken place during the 18-year period. There have been some inbasin developments plus sizeable new transmountain diversions during the period, but no particular trend in concentration has been established. For the Colorado River near Grand Canyon the flows were nearly the same in 1941 and 1957 but the 1941 concentration was 0.77 ton per acre-foot and for 1957 it was 0.70. A 1944 flow of 13,330,000 acre-feet has a concentration of 0.75, and a 1958 flow of 13,461,000 acre-feet has a concentration of 0.76. Similar flows during 1946 and 1956 have concentrations of 0.96 and 0.82, respectively.

For the Colorado River below Hoover Dam station the 1941 through 1948 concentrations are all higher than 1958. At Lees Ferry the 1941-1945 weighted average is 0.67 ton per acre-foot, 1946-1950 is 0.71, 1951-1955 is 0.79 and for the 1956-1958 period the weighted average is 0.70. Also at Lees Ferry 1941, 1952, and 1957 with similar flows have concentrations of 0.70, 0.64, and 0.67, respectively. The year 1958 with a flow of 13,141,000 acre-feet has a concentration of 0.71, and 1944 with a flow of 13,019,000 acre-feet has a concentration of 0.66 ton per acre-foot.

WATER QUALITY CONDITION

Present Modified Condition

During the 18-year period of development covered by this quality of water study, a number of new projects were completed resulting in additional depletions to the Colorado River system. Some of the projects that were in full operation by 1958 include the Colorado-Big Thompson and Duchesne Tunnel of Provo River project, both transmountain diversions, along with a number of other small inbasin developments. In order to evaluate the effect of these projects through the study period, it was necessary to calculate the present modified flow. The present modified flow is the flow expected at any point with all upstream existing projects, and those projects authorized prior to the Colorado River Storage project in operation. It was estimated at various sites by assuming a recurrence of past water supply conditions and by deducting from historical flows for each year the depletions that would have resulted from the operation of all upstream projects constructed or authorized since that year. The largest project completed during the period was the Colorado-Big Thompson project.

After the present modified flows were computed, the quality data were added to give the expected quality data for the study period. The effect on quality of the transmountain diversions in Colorado was computed by using a concentration based on the weighted average of all diversions as contained in the draft of the Geological Survey basic data report. This concentration was 0.06 ton of total dissolved solids per acre-foot of water transported out of the basin. The concentration applied to Duchesne Tunnel transmountain diversions was 0.03 ton per acre-foot based on quality of water data available from several locations in that vicinity.

The change in quality resulting from the inbasin developments was computed on the basis of an assumed pickup of 2.0 tons of total dissolved solids per acre of irrigated land and a depletion of 1.5 acre-feet of water per irrigated acre. Refinements to these assumptions will be introduced in subsequent reports when more complete data become available.

As indicated by the three right-hand columns of data for each year in Tables 1 to 15, inclusive, the flow is generally smaller and the concentration is generally greater under present modified conditions than under historic conditions. For those drainages where no known development had taken place during the 18-year period the flow and quality data were considered to be the same under historic and present modified conditions.

In developing the anticipated effect of the storage units and the participating projects, the present modified flow and quality data were used as a base.

WATER QUALITY CONDITION

Present modified data for the Grand Canyon, below Hoover Dam, Parker Dam, and Imperial Dam stations have not been computed; however, the corrections would be somewhat similar to those applied at Lees Ferry. In subsequent reports the calculations will be extended to downstream stations.

DETERMINATION OF EFFECTS OF IRRIGATION DEVELOPMENT

Determination of the effects of irrigation development on the overall chemical quality of water in the Colorado River Basin presents difficult problems. Sufficient quality of water and flow records are not extant that will adequately define conditions within the basin that existed prior to irrigation developments. Such records as are available are very meager and were taken at widely scattered locations and time intervals. Adequate sampling is now being accomplished at several locations in the basin.

The same is largely true on particular areas that have been brought under irrigation in the past 60 years. Records that are needed to conclusively show the effects of individual irrigation projects on the waters of tributary streams over a long period of time do not exist. In late years a larger network of either daily or seasonal sampling stations has been established that is slowly providing data on surface inflow-outflow relationships on certain irrigated areas in the basin under the present state of development, and in some areas data are being gathered on areas that are largely in the virgin state as far as effects of irrigation are concerned.

A number of preliminary studies have been made with available data in an attempt to determine or estimate the probable effects of irrigation developments in tributary areas. One study has been completed that gives valuable data on the contribution of total dissolved solids from a virgin area or one that has not been affected by irrigation. These studies will be described briefly and the general results applied to the remainder of this quality of water study to estimate the overall effects of irrigation development.

The Green River Basin upstream from Green River, Wyoming, but below Fontenelle, Wyoming, and below certain tributaries, is a large area now essentially in a virgin state as far as irrigation use of water is concerned. Quality of water and flow records are available for the years 1955-60, inclusive, that measure the total volume of water and load of dissolved solids that move in and out of this study area. The outflow is measured at the Green River near Green River, Wyoming, gage while the inflow to the area is gaged at Green River near Fontenelle, Wyoming; Fontenelle Creek near Fontenelle, Wyoming; and Big Sandy Creek below Eden, Wyoming. Minor adjustments were made for industrial diversions. This study area includes 1,516 square miles or 970,000 acres. Measured pickup of dissolved solids for the study area shows an average of 117,000 tons annually for the 6-year period or a rate of 0.12 ton per acre. This same area will eventually include all of the 43,420 acres of irrigated land included in the Seedskadee project now under construction. Continued measurements in the forthcoming years until the Seedskadee project area is developed will provide data to strengthen derivation of an annual rate of natural pickup. After irrigation has begun, collection of data will measure the effect of new irrigated acreages and thus provide excellent comparison with the rate of pickup now existing in the virgin condition.

A number of additional stream gages were installed, and periodic quality of water sampling was begun in 1955 in the Big Sandy Creek drainage basin. The stated purpose of this testing was to determine the quantity and chemical quality of the water flowing into and out of a study area containing the irrigated lands of the Eden project and to determine the amounts of pickup of dissolved solids that would accrue naturally and those amounts which could be assigned directly to the effects of irrigation. The term "pickup of dissolved solids from irrigated lands" as used in this report applies to dissolved solids picked up in addition to salt balance conditions. Under salt balance conditions the same amount of dissolved solids carried to the land by irrigation water is assumed to be carried off the land by irrigation return flows. The study area contains 320,000 acres with 3.5 percent or 11,100 acres being irrigated. This program of measurement and sampling has continued until the present time. Preliminary results of this study showed that an average of about 46,700 tons of dissolved solids were picked up annually. If a natural pickup rate of 0.12 ton per acre, as obtained from the adjacent Green River area described above, was applied to the total 320,000 acres, the amount assigned to natural pickup would be 38,400 tons. This would leave 8,300 tons to be picked up as additional contribution from the 11,100 acres of irrigated land or a rate of 0.75 ton per acre annually.

The Lyman area in southwestern Wyoming has also been studied recently for the purpose of estimating the total dissolved load pickup caused by irrigation. The gross study area between the inflow and outflow gages consists of 368,000 acres with 50,000 acres of irrigated land all located in the Blacks Fork drainage of the Green River Basin. Irrigation water supplies have all been obtained by direct diversion of the tributary streams as no storage has been utilized. The area was developed between 1890 and 1920, so most of the land has been irrigated for at least 40 years and some of it for 70 years.

Records and estimates compiled for this area indicate that for an average year (1953) about 94,000 tons of dissolved material is picked up in the study area. A high flow year (1952) shows a 151,000-ton pickup, and a minimum flow year (1954), a 48,500-ton pickup. If the entire amount of pickup were assigned to irrigation in an average year, a rate of 1.9 tons per irrigated acre would result. However, other studies show this rate should be on the order of 1.0 ton per irrigated acre. If the aforementioned natural pickup rate of 0.12 ton per acre for nonirrigated lands derived from the Green River area were applied to the gross 368,000-acre study area, a natural pickup of slightly over 44,000 tons could be expected. Reduction of the 94,000 tons gross pickup in an average year by this amount would leave 50,000 tons as pickup from the 50,000 irrigated acres, or 1.0 ton per acre. Another comparison is illustrated by Figure 4 which shows the inflow-outflow relationship of water and total dissolved solids.

Total dissolved solids outflow load is sensitive to the total amount of applied water including precipitation. The curve indicates a difference in inflow-outflow tonnage of 40,000 tons when the outflow is zero. Subtracting this figure from the 94,000 tons for an average year leaves a 54,000 tonnage or a rate of 1.1 tons assigned as pickup from each irrigated acre. It appears from the results of these evaluations that by having arrived at rates of 1.0 ton and 1.1 tons pickup per irrigated acre by two different procedures, that pickup of dissolved material as the result of irrigation in the Lyman area should be about 1.0 ton per acre per year. Additional sampling stations have been installed to provide data for continuing studies.

Preliminary results of a study of the Vernal, Utah, area in the eastern end of the Uinta Basin shows that the gross average annual pickup of total dissolved solids amounts to 1.6 tons per acre of irrigated land if all of the pickup in the study area is assigned to the irrigated lands. Irrigated lands comprise about 26,000 acres or 28 percent of the 93,000-acre study area. This area was placed in production before 1900. Data are not now available in the immediate area to indicate a rate of pickup that could be expected from natural sources. However, a considerable reduction in the rate of pickup would ensue if a proper proportion of the total pickup were assigned to the nonirrigated area. Collection of quality of water and flow records is continuing to ascertain the portions of the total pickup of dissolved solids that should be ascribed to irrigation and that due to natural pickup from the study area.

The Florida River area, which encompasses the Florida participating project of the Colorado River Storage project in southwestern Colorado, has been sampled and measured for a few years to define the inflow-outflow relationship on water quality. The 14,000 acres of presently irrigated lands is 5.7 percent of the 246,600 acres in the study area. Irrigation has been practiced for about 50 years in this area. Preliminary results show a pickup of 1 ton of dissolved material per acre annually if the gross pickup is assigned to the irrigated lands. If a logical division were made between natural pickup and that caused by irrigated lands, preliminary estimates indicate that the rate of pickup per irrigated acre should be in the order of 0.3 ton annually.

DETERMINATION OF EFFECTS OF IRRIGATION DEVELOPMENT

Based upon the data now available from the above described studies, it appears that pickup of dissolved material from irrigated land will probably not exceed 1.0 ton per acre annually. However, it was decided to apply a range of values from zero to 2.0 tons per acre pickup in subsequent analyses in this report to estimate the effects on water quality at selected key stations under various increments of development. A zero pickup rate for irrigated land will be used for the first analysis, and a 2.0-ton per acre pickup from irrigated lands for a second analysis. More refined estimates on the effects of irrigation development will be presented in future reports as additional data and analyses become available from continuing studies or from new studies.

ANTICIPATED EFFECTS OF ADDITIONAL DEVELOPMENTS INVOLVING THE STORAGE AND USE OF COLORADO RIVER WATER

In order to estimate the probable effect of authorized or contemplated developments on the quality of the water at various points in the Colorado River, these developments have been separated into four different increments. The increments are: (1) Storage units of the Colorado River Storage project, (2) Participating projects of the Colorado River Storage project and other miscellaneous developments, (3) San Juan-Chama project and Navajo Indian Irrigation project, and (4) Fryingpan-Arkansas project. A summary of anticipated depletions caused by these developments is shown in Table 17.

The first increment or the effect of storage was computed by imposing the storage regulation and reservoir losses on the present modified conditions at applicable locations as given in Table 18. The second increment was then added to the effect of the storage units and the new flows, loads, and concentrations were computed at the key stations. The effects from the remaining two increments were then added only to the records of appropriate stations in the Colorado and San Juan River Basins as these developments do not alter conditions in the Green River Basin. The final figures listed show the cumulative effects of the four increments.

Following is a discussion of each increment including a brief description of the physical conditions for each development authorized or contemplated for authorization within each increment and the anticipated effect of each increment on the quality of water at appropriate key stations.

Description of Projects

Increment No. 1
Storage units of the Colorado River Storage project

Glen Canyon Unit.

The Glen Canyon Dam is located on the Colorado River in Arizona 4 miles south of the Utah-Arizona boundary and 15 miles upstream from Lees Ferry. The bulk of the reservoir lies in Utah. At a normal water surface elevation of 3,700 feet m.s.l., Lake Powell would extend 186 river miles up the Colorado River and 71 miles up from the mouth of the San Juan River. River mile 71 on the San Juan River is 133 river miles from Glen Canyon Dam. This 28,040,000-acre-foot reservoir will regulate the flow of the river for compact delivery purpose and for power generation and thus permit exchanges for upstream consumptive use of the water. Annual reservoir losses are computed at 556,000 acre-feet per year. The storage of inflowing sediment was a major consideration in selection of the size of this reservoir.

Flaming Gorge Unit

This storage unit is located on the Green River in northeastern Utah and southwestern Wyoming. With a storage capacity of 3,789,000 acre-feet, the flow of the Green River will be largely regulated and the releases for power will be fairly uniform. Annual reservoir losses amount to 56,000 acre-feet. Without the benefit of actual operating conditions it is assumed that the concentration of dissolved solids in the released water will be uniform.

Navajo Unit

The Navajo Dam is located on the San Juan River in northwestern New Mexico. Total storage capacity of the reservoir is 1,709,000 acre-feet with reservoir losses estimated at 36,000 acre-feet annually. Since no power is to be produced, the effect on quality of water will be slightly different based on a different pattern of reservoir releases until the Navajo Indian Irrigation project is constructed.

Curecanti Unit

The storage dams for this unit--Blue Mesa and Morrow Point--are located in west-central Colorado. The total storage capacity of 940,000 acre-feet for Blue Mesa and 117,000 acre-feet for Morrow Point will largely regulate the flows of the Gunnison River, resulting in relatively uniform flow and concentration of dissolved solids below the Curecanti unit. Reservoir losses are estimated at 15,000 acre-feet.

Increment No. 2
Participating projects and other miscellaneous projects

Seedskadee Project

It has been assumed for this report that the Seedskadee project in Wyoming would develop 43,420 acres of new land along the Green River and that the depletion would be 128,000 acre-feet annually including 13,000 acre-feet of evaporation from Fontenelle Reservoir and 20,000 from the wildlife refuge. Later on an additional 15,000 acres will be irrigated after a determination has been made of the effect that the mining of trona will have on land subsidence and irrigation development. The total depletion would be increased to 140,000 acre-feet when the full acreage is developed.

Lyman Project

This project in southwestern Wyoming will furnish a supplemental water supply to lands now inadequately irrigated and no new acreage is being developed. In the 1950 Lyman project report it was estimated that no new depletions would result from project development and therefore none have been included in this Quality of Water study. A Lyman project report now in preparation will more accurately define the estimated new depletions, if any, from this project.

Central Utah Project

Bonneville Unit.-- The Bonneville unit consists primarily of a transmountain diversion from the Colorado River Basin to the Bonneville Basin in central Utah. The annual depletion during the study period would be 167,000 acre-feet. About 46,000 acres of new land would be irrigated, and the total depletion would include 58,000 acre-feet for municipal and industrial water uses in the Bonneville Basin. Some additional storage regulation would be provided in the Colorado River Basin to furnish water to lands not now having an adequate irrigation supply.

Vernal Unit.--The Vernal unit diverts water from the Ashley Creek drainage to furnish a supplemental supply to 14,700 acres of partially irrigated land and 1,600 acre-feet of supplemental water for municipal use near Vernal, Utah. The new consumptive use of water by the Vernal unit amounts to 12,000 acre-feet annually.

Upalco and Jensen Units.--The Upalco and Jensen Units of the Central Utah project will both be developments within the Uinta Basin and will provide supplemental water for lands presently irrigated. Investigations are incomplete, but present indications are that there will be no new lands developed and no new depletions. This report has been prepared on that basis.

Emery County Project

The Emery County project is located in east-central Utah. It will furnish a supplemental irrigation water supply to 18,000 acres and a full supply to 770 acres of new land with a new depletion of 17,000 acre-feet. This project depletes the flow of the San Rafael River, a tributary of the Green River.

Smith Fork Project

This project provides a supplemental supply of water for 8,056 acres and a full supply to 1,420 acres of new land in west-central Colorado. It will deplete the flow of the Colorado River by 6,000 acre-feet.

Hammond Project

This project will provide a water supply for 3,900 acres of land in northwestern New Mexico. This will be a direct diversion from the San Juan River, depleting the flow by 9,000 acre-feet annually.

Florida Project

The Florida project is located in southwestern Colorado and will provide a full supply of water for the irrigation of 5,730 acres of new land and a supplemental supply for 13,700 acres. The flow of the San Juan River will be depleted by 14,000 acre-feet as a result of this project.

ANTICIPATED EFFECTS OF ADDITIONAL DEVELOPMENTS

Collbran Project

This project is located on Plateau Creek, a tributary of the Colorado River in western Colorado. It will provide supplemental water to 19,750 acres and a full supply to 2,460 acres of new land. The new consumptive use will be 7,000 acre-feet.

Private Industrial Developments

A number of private industrial developments either under construction or contemplated will result in annual stream depletions, mostly by evaporation, in the Upper Colorado River Basin.

A potash development near Moab, Utah, now in the final construction stages, will consumptively use 8,000 acre-feet of water annually.

Industrial developments in southwestern Wyoming, including the Utah Power & Light Company's steamplant at Kemmerer, will evaporate 17,000 acre-feet each year.

In northwestern New Mexico a large steamplant being developed by Utah Construction Company will evaporate 39,000 acre-feet annually.

Denver, Colorado Springs, and Englewood Diversions

The so-called "Blue River Settlement" authorizes the diversion of an average of 191,000 acre-feet of water per year from the Blue River in the headwaters of the Colorado River to the cities of Denver and Colorado Springs and from the Fraser basin to the city of Englewood on the eastern slope. These diversions would vary from a low of 47,000 acre-feet (1954) to a high of 288,000 acre-feet (1947).

Increment No. 3
San Juan-Chama project and Navajo Indian Irrigation project

San Juan-Chama Project

This project will divert an average of 104,000 acre-feet annually from the headwaters of the San Juan River across the Continental Divide to the Rio Grande Basin. The effect on the Colorado River will be a 104,000-acre-foot decrease in the average flow and a decrease in the dissolved solids load by the amount transported out of the basin.

Navajo Indian Irrigation Project

This project contemplates the diversion of 508,000 acre-feet from Navajo Reservoir to 110,000 acres of Indian-owned lands south of the San Juan River in New Mexico. With certain miscellaneous areas in the San Juan River Basin included, the estimated depletion would be 259,000 acre-feet annually during the 18-year study period. The 508,000-acre-foot diversion would affect the Archuleta and other downstream stations. Return flows from the irrigated lands would also be reflected at the Bluff and downstream gages along with any change in concentration or total dissolved solids load.

ANTICIPATED EFFECTS OF ADDITIONAL DEVELOPMENTS

Increment No. 4
Fryingpan-Arkansas project

This transmountain diversion project will transfer water from the headwaters of the Colorado to the Arkansas River. The average annual depletion during the 1941-1958 period would be 68,000 acre-feet includint 1,000 acre-feet of evaporation from the Ruedi Reservoir on the west slope. The physical effect of this diversion would be a decrease in flow and dissolved solids load at Cameo and other downstream stations.

Anticipated Effects of Developments

Increment No. 1
Storage units of the Colorado River Storage project

One of the principal effects of storage is the mixing of varying qualities of water from different drainages and of different seasons. The higher concentrated flows of the fall and winter months are sweetened by the better quality spring runoffs from snowmelt, and the runoffs from the more potent drainages are mixed with the better flows of other drainages. Summer torrential flows, regardless of quality, are also well mixed in a storage reservoir. Analyses of water released from Lake Mead show a variation in concentration generally less than 0.13 ton per acre-foot dissolved solids during a single year (Figure 3). The variation is very small in contrast to variations shown by analyses of the inflowing water which commonly are greater than 1.20 tons per acre-foot in a single year (Tables 12 and 13).

Another effect of reservoir storage is the precipitation of dissolved solids from solution in the reservoir basin. This effect has been studied in detail at Elephant Butte Reservoir and at Lake Mead. At Lake Mead the substantial quantities of dissolved solids that precipitate from solution are offset by the solution of soluble materials from gypsum and saline beds within the reservoir basin. The concentrations in the outflowing water were expected to be much greater than the analyses show, considering the large quantities of gypsum along the lake bottom and shores.

The only gypsum beds noted in Lake Powell Reservoir basin are in the narrow Cataract Canyon area, and these are expected to be covered by the initial deposits of sediment. Therefore, the condition resulting in solution of soluble reservoir bed material described at Lake Mead is not expected to be repeated at Lake Powell except for a brief period during initial filling. There are no known gypsum deposits in the Flaming Gorge, Navajo, or Curecanti unit reservoirs.

The actual phenomenon of precipitation within a reservoir is not entirely understood, although it is apparent that the less soluble salts have a tendency to precipitate and the more soluble salts go into or remain in solution. There may also be some tendency for the dissolved solids to be deposited with the sediment.

The study at Elephant Butte Reservoir concluded that one-eighth of the total quantity of dissolved solids entering the reservoir is precipitated from solution within the reservoir basin. Studies will be conducted in the Colorado River Storage project reservoirs after filling has started by making use of the data from the network of quality of water stations to determine precipitation and solution of salts.

Another effect of reservoir storage on water quality results from reservoir losses. In this case a large loss of water is not offset by a loss of dissolved solids, so the result is a higher concentration of dissolved solids in the reservoir.

The overall effect of the many factors accompanying reservoir storage is a stabilization of water quality. The following is quoted from C. S. Howard in the Lake Mead studies:

"Although there has been an increase in dissolved solids through the evaporation and solution processes, there has also been a stabilization of the chemical quality during the period of storage, which has been of considerable value to the users of water below Hoover Dam. As a result of the stabilization, a lower tonnage of soluble salts has been delivered to the irrigated lands below Hoover Dam than would have been delivered if there had been no storage. This is because the concentration of soluble salts in the unregulated river water as indicated by the Grand Canyon records is higher than the concentration in the released water during the periods when most of the water is taken from the river for irrigation."1/

The anticipated effect of storage in the units of the Colorado River Storage project, aside from the effects of irrigation and transmountain diversions, is expected to be further stabilization of water quality entering and leaving Lake Mead.

The condition of near-uniform quality water being released from Lake Mead as indicated by Figure 3 justifies the assumption that similar results can be expected from the reservoirs now under construction. The operation studies have been conducted on this basis by averaging the present modified concentrations and applying that average to reservoir releases to obtain total dissolved solids in tons (Table 18).

1/ Geological Survey Professional Paper 295, "Comprehensive Survey of Sedimentation in Lake Mead, 1948-49," p. 124.

ANTICIPATED EFFECTS OF ADDITIONAL DEVELOPMENTS

Effect of Flaming Gorge Reservoir Operation

Operation of the Flaming Gorge Reservoir is expected to deplete 56,000 acre-feet annually from the stream system. The concentration of total dissolved solids increases from 0.52 to 0.54 ton per acre-foot at the Green River near Greendale station as a result of this depletion, and there would be no change in the total dissolved load unless solids were precipitated in the reservoir. It can be seen from the historic and present modified data that water quality of the Green River is generally good throughout its length and the operation of Flaming Gorge Reservoir is expected to further stabilize the quality at the downstream stations including Lees Ferry. Table 18 shows that the Flaming Gorge effect at the Ouray station is an increased concentration of 0.01 ton per acre-foot and that no change takes place at the Green River, Utah, station, because of the large gain in flow between the Greendale and Green River stations.

Effect of Navajo Reservoir Operation

The Navajo Reservoir operation study for this portion of the report assumed no diversions to the Navajo Indian Irrigation project. The effects on quality result from reservoir losses and reservoir regulation.

With reservoir losses averaging 36,000 acre-feet per year, the concentration increases from 0.21 to 0.22 ton per acre-foot over present modified conditions at the Archuleta gage. At the Bluff gage the concentration is 0.56 ton per acre-foot under present modified conditions and would increase to 0.58 ton with Navajo Reservoir in operation.

Effect of Curecanti Unit Operation

The 18-year quality of water operation study of the Curecanti unit reservoirs shows an average depletion of 15,000 acre-feet per year. There would be a change in the total dissolved solids from 0.83 to 0.84 ton per acre-foot at the Gunnison River near Grand Junction station.

The more uniform flows resulting from Curecanti Reservoir operation will tend to dilute the concentrated low flows of the Gunnison River in the late summer months and thus will improve the quality at both the Gunnison and the Colorado River near Cisco stations in the months of low runoff.

Effect of Lake Powell Operation

The overall effects of the upstream developments on water quality are all channeled through Lake Powell to emerge as a single effect from Glen Canyon Dam. Operation studies indicate annual reservoir losses at Lake Powell of 556,000 acre-feet and nearly uniform annual releases of water. As mentioned earlier in the report, this large reservoir, with holdover storage and mixing effects, will allow release of fairly uniform quality of water.

The Lake Powell reservoir losses alone will increase the concentration from 0.75 to 0.79 ton per acre-foot. However, it is estimated that at least 5 percent of the incoming dissolved solids will be precipitated in the reservoir basin, which would lower the concentration to 0.75 ton per acre-foot. It is expected that some precipitation of dissolved material will occur in all of the upstream reservoirs, Flaming Gorge, Navajo, Morrow Point, and Blue Mesa, and that there will be more than 5 percent retained in Lake Powell under actual operating conditions. For the purposes of this study it has been estimated that there would be no losses from solution in the upstream reservoirs and only 5 percent at Lake Powell. This estimate is on the conservative side and can be adjusted when actual quality of water operating data become available. It has been estimated that there would be no pickup in the reservoir basins since there are no known soluble deposits in the upstream storage reservoirs and the gypsum beds near the head of Lake Powell will be covered by sediment deposits early in the reservoir operation.

The anticipated effect of all the storage reservoirs at the Lees Ferry station will be to increase the concentration from 0.75 to 0.80 as a result of reservoir losses only. With an estimated 5 percent of the incoming solids retained in Lake Powell, the average concentration would be reduced to 0.76. The stabilizing effect on quality attributed to operation of Lake Powell will be further enhanced by the upstream storage units.

Increment No. 2
Participating projects and other miscellaneous projects

The projects to be included in this category, the amount of new irrigated land in each project, and the average annual depletions are listed in Table 17.

The effect of the irrigation projects has been studied under two separate conditions--one assuming zero pickup of dissolved solids from the irrigated lands and the second assuming 2 tons of pickup per acre of new irrigated land. This range of values for estimated pickup of dissolved solids was determined from studies of the individual areas mentioned previously in this report. The effect under these two conditions has been combined with the effect of the transmountain diversions and the inbasin depletions.

At the Cameo gage on the Colorado River the effect of the Denver, Colorado Springs, and Englewood diversions and the Silt project, assuming zero pickup of dissolved solids, is an average increase in concentration from 0.57 to 0.61 ton of dissolved solids per acre-foot. If a pickup of 2 tons per acre is assumed for the Silt project, the concentration does not increase above 0.61 ton per acre-foot. The average flow is reduced by 197,000 acre-feet a year during the 18-year period.

The effect of the Paonia and Smith Fork projects at the Gunnison station with the Curecanti unit in operation is an increase in concentration from 0.84 to 0.85 ton per acre-foot. This condition prevails assuming either zero pickup or 2 tons of pickup per acre because only 3,650 acres of new land are developed by the two projects and any pickup from this small area is not significant.

The effect of the Seedskadee project combined with the evaporation from various industrial developments including the Utah Power & Light Company steamplant at Kemmerer, Wyoming, and with Flaming Gorge unit in operation, is an increase from 0.54 to 0.59 ton per acre-foot at the Greendale station if there is zero pickup from the Seedskadee irrigated land. If the pickup is assumed to be 2 tons per acre, the concentration becomes 0.65 ton per acre-foot.

At the San Juan River near Bluff gage, the Hammond and Florida projects together with the proposed Utah Construction Company steamplant will deplete the flow by 62,000 acre-feet annually. This will increase the concentration from 0.58 to 0.60 if there is zero pickup from the irrigated land and will increase the concentration to 0.61 ton per acre-foot if the pickup is 2 tons per acre with Navajo Reservoir in operation.

Since no new acreage is being developed at the Vernal unit, the effect on quality results from storage regulation and a new depletion of 12,000 acre-feet per year. The results of the operation study show no discernible change in average quality at the Ouray station.

The Emery County project will develop only 770 new acres of land and the new depletion will amount to 17,000 acre-feet. The storage regulation provided by Joes Valley Reservoir may improve the quality of water on a monthly basis below the Emery County project by eliminating the heavy applications of water in the early spring and providing more flow for the late summer months. The change in average concentration at the San Rafael station as indicated by an operation study would be an increase from 2.2 to 2.6 tons per acre-foot with zero pickup. Because of the small amount of new acreage developed, no significant increase in concentration would result from 2 tons pickup per acre.

The potash development now under construction on the Colorado River below Moab will result in a depletion of 8,000 acre-feet per year. The only gage affected by this development is the Lees Ferry gage, and, since the depletion is so small compared with the flow at Lees Ferry, the change in concentration is not discernible.

ANTICIPATED EFFECTS OF ADDITIONAL DEVELOPMENTS

The estimated effect of all the above developments at Glen Canyon Dam with the storage units in operation will be a reduction in average flow of 631,000 acre-feet, an increase in concentration of from 0.76 to 0.80 ton per acre-foot, and a decrease in load of 803,000 tons a year with zero pickup from the irrigated land. If the pickup from new irrigated land is 2 tons per acre, the concentration will be increased to 0.81 and the load decreased by 681,000 tons annually.

The decrease in dissolved solids load at Lees Ferry results from several factors. In using operation studies for power purposes, it was assumed that 8,840,000 acre-feet would be impounded in the reservoirs, and consequently the dissolved solids are impounded with the water. The assumed precipitation of 5 percent of the dissolved material in Lake Powell accounts for part of the decrease in tonnage and the transmountain diversions account for the remainder of the decrease. At this point in the study the increased tonnage resulting from new irrigation amounts to only 122,000 tons annually, with a pickup of 2 tons per acre, leaving the net decreases mentioned above.

The estimated effects of the above developments at the applicable key stations have been tabulated in Table 18.

Increment No. 3
San Juan-Chama project and Navajo Indian Irrigation project

The incremental effect of these two projects has been computed by using a concentration of 0.16 ton per acre-foot for the San Juan-Chama transmountain diversion and by assuming the same conditions for the Navajo Indian Irrigation project as used for the participating projects. The first condition assumes that no dissolved material would be picked up from the irrigated land and that any change in quality would result from the depletion of 259,000 acre-feet annually. The second condition is based on an estimated pickup of 2 tons per acre from 110,000 acres of irrigated land plus the effect of the depletion.

The effect of the San Juan-Chama project 104,000-acre-foot transmountain diversion and the Navajo Indian Irrigation project 508,000-acre-foot diversion from Navajo Reservoir has been computed for the Archuleta station. The total effect of both projects, including the return flow from the Navajo Indian Irrigation project, is shown in Table 18 for the Bluff station.

The decrease in flow at Archuleta from these two projects is 612,000 acre-feet, and the decrease in dissolved solids is 129,000 tons each year. The concentration of dissolved solids in the water diverted by the San Juan-Chama project is less than the normal concentration at the Archuleta station, so this results in a 0.02-ton increase in concentration at Archuleta after the diversion and with Navajo Reservoir in operation.

ANTICIPATED EFFECTS OF ADDITIONAL DEVELOPMENTS

At the Bluff station with zero pickup from the Navajo Indian Irrigation project, the concentration increases from 0.60 to 0.74 ton per acre-foot; and with 2 tons of pickup, the concentration goes from 0.61 to 0.92 ton per acre-foot. These increases assume operation of the Navajo Reservoir, Florida and Hammond projects, and the Utah Construction Company development.

At Lees Ferry, if only the depletions are considered with zero pickup from irrigated land, the concentration will increase from 0.80 to 0.83 ton per acre-foot; and if a 2-ton pickup per irrigated acre is assumed, the concentration goes from 0.81 to 0.86 ton per acre-foot.

Increment No. 4
Fryingpan-Arkansas project

The incremental effect of adding the Fryingpan-Arkansas project was computed for the Cameo, Cisco, and Lees Ferry stations. The decrease in flow averages 68,000 acre-feet, and the decrease in dissolved solids averages 4,000 tons per year. The concentration of dissolved solids in the diverted water was estimated to be 0.06 and is based on available quality data from the diversion area.

The depletion would cause an increase in concentration of 0.02 ton per acre-foot at the Cameo gage and 0.01 at the Lees Ferry station.

Summary of the four increments at Lees Ferry

Reservoir losses from the four storage units will average 663,000 acre-feet per year. Depletions from all other projects authorized or contemplated for authorization, including the proposed industrial developments, will average 1,062,000 acre-feet for a total depletion of 1,725,000 acre-feet annually. This depletion will result in an increase in concentration at Lees Ferry from 0.75 to 0.84 if no additional dissolved solids are picked up from the irrigated land. The combination of 1.7 million-acre-foot depletion and the pickup of 2 tons of dissolved solids for each acre of new irrigated land increases the concentration to 0.87 ton per acre-foot, for a 16.0-percent increase in average concentration.

The increase in concentration resulting from Lake Mead operation for the same 1941-58 period is an average of 14.8 percent between the Grand Canyon and below Hoover stations.

The combined operation study shows a net decrease in total dissolved solids at Lees Ferry. This results from the previously described increase in reservoir content of 8,840,000 acre-feet in all of the storage reservoirs and from the assumption that 5 percent of the dissolved solids entering Lake Powell are precipitated in the reservoir basin. The magnitude of the decrease in dissolved solids for each increment is shown in Table 18.

DISCUSSION OF ESTIMATED PROJECTIONS

It must be realized that the estimates presented in this report are preliminary and are based upon presently available data. As previously pointed out, comparisons between the waters now available in the stream system and those existing before the advent of man-made developments are practically impossible due to the almost complete absence of records on water quality prior to substantial developments in the basin. In addition, the effects of present and future authorizations necessarily had to be estimated on the basis of data and methods that are not fully substantiated. Much more data must be gathered and research completed to understand the complex relationships that govern the movement and change in water quality as the waters of the basin drain from the mountains, are diverted, applied to the land, stored, controlled, and mixed in numerous reservoirs. Maintenance of an adequate network of stream measuring and quality of water sampling stations in the years ahead will provide the most reliable data to detect and interpret changes in water quality brought about by authorized developments on the stream system.

Use of water for irrigation represents the greatest depletions in the basin so it has been assumed by some that the practice of irrigation has and will materially affect the overall quality of water situation. However, this has not been proved in other large drainage basins where some quality of water records existed prior to development of large acreages of irrigated lands. On the Missouri River, quality of water records are available for the period October 1906 to October 1907 for the station at Florence (near Omaha), Nebraska. These records indicate that the total dissolved solids averaged 454 ppm at that time. Between 1907 and 1950 about 700,000 acres were developed for irrigation in the basin but data for the period 1951-1955 at Nebraska City (near Omaha), Nebraska, show that the total dissolved solids averaged 427 ppm. It would be erroneous to infer that irrigation has improved the quality because irrigation actually has the effect of concentrating soluble salts. The important point is that in a large river basin such as the Missouri or the Colorado River basin, the natural accretions of total dissolved solids to the overall total far outweigh the influences of irrigation. Further evidence that irrigation in itself has only slight effects on total water quality is found in various areas of the upper Colorado River basin. At Hot Sulphur Springs the Colorado River drains an area of 782 square miles and contains an irrigated area of 15,700 acres. Here the total dissolved solids varied from 59 to 109 ppm during the period 1948-1955. At Gypsum, Colorado, the total dissolved solids of the Eagle River water have fluctuated from 278 to 479 ppm in the same period even though the drainage area and irrigated areas are nearly identical in size to those at Hot Sulphur Springs. These data indicate that the type of geologic material or other factors have a greater influence on the presence of dissolved solids than has irrigation.

DISCUSSION OF ESTIMATED PROJECTIONS

Preliminary results of other studies of areas in the basin indicate that natural accretions to the streams amount to large amounts of total dissolved solids. Results measured in the general area of the authorized Seedskadee project in southwestern Wyoming show 117,000 tons of total dissolved solids natural pickup in a stretch of the Green River above Green River, Wyoming, and below Fontenelle, Wyoming, or at the rate of 0.12 ton per acre. This study area is largely in a virgin condition as far as irrigation is concerned. Although such a rate of 0.12 ton total dissolved material appears to be relatively small, the effect on total tonnages is large because of the tremendous areas involved compared to the irrigated acreage. Other areas illustrate this overriding influence of the total areas compared to the irrigated areas. As examples, the irrigated area above the Cisco station on the Colorado amounts to 3.7 percent of the drainage area; above the Green River, Utah, station about 2.1 percent of the area is irrigated; and on the San Juan River above Bluff about 1.3 percent of the area is irrigated. Since irrigation acreages are so limited, it appears entirely possible that the major proportion of the total dissolved solids load at the more important measuring points in the basin was present in the stream and has been little affected by the advent of irrigation.

Patterns and total amounts of water flow also exert a great influence on the total dissolved material carried by a stream at a particular measuring point. Historical measurements at Lees Ferry for the period of study (1941-58) show an annual variation in total dissolved material moving past the gaging station of 6,385,000 tons in 1954 to 12,603,000 in 1957 with an average for the period of 8,820,000 tons (Table 11). This station is rated as excellent by the Geological Survey, it having an accuracy in water volume within 5 percent. Variations in the sampling and analyses to determine the total dissolved loads could also be assumed to amount to about 5 percent. Thus combining the two errors the annual loads may range from 90 to 110 percent of those reported.

The net increase in the tonnage of dissolved solids developed from all projects in this study under the assumed high condition of 2 tons pickup per acre of irrigated land is 274,000 tons per year without the storage units in operation (342,000 tons added by the inbasin projects and 68,000 tons leaving the basin via transmountain diversions results in a net of 274,000 tons). This is well within 5 percent of the total load measured in 1954, the lowest year of the study period, and it is only 3.1 percent of the average of 8,820,000 tons. In this study the decrease in flow resulting from upstream consumptive uses has a greater effect on concentration than the increased load from irrigation projects under the assumed high pickup condition.

Figure 5 illustrates the variation in flow, total loads, and concentrations for the Lees Ferry station in the various years of the study period.

DISCUSSION OF ESTIMATED PROJECTIONS

The results presented in this report based on data presently available show that, after depletions are consummated by all authorized projects mentioned in this report in the Upper Colorado River Basin, the remaining water leaving the upper basin will not be significantly affected and the quality of the remaining waters will not hamper present uses.

Measurements to determine the quality of water actually present in the streams should continue for many years. Additional stations should be established as the need for more detailed measurements is shown by continuing study of this problem.

Table I
Colorado River Basin
Flow and Quality of Water Data
Green River near Greendale, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	27	0.93	25	27	0.93	25
	Feb.	25	1.16	29	25	1.16	29
	March	72	.94	68	72	.94	68
	April	131	.56	74	131	.56	74
	May	276	.58	160	274	.59	161
	June	441	.40	175	438	.40	177
1941	July	171	.55	94	169	.57	96
	Aug.	110	.73	80	110	.75	82
	Sept.	67	.78	52	67	.81	54
	Oct.	94	.97	91	95	.97	92
	Nov.	71	.93	66	72	.93	67
	Dec.	36	1.19	43	36	1.22	44
	Total	1,521	.63	957	1,516	0.64	969
	Jan.	30	1.00	30	30	1.00	30
	Feb.	31	1.00	31	31	1.00	31
	March	69	1.07	74	69	1.07	74
	April	261	.65	170	261	.65	170
	May	235	.76	180	234	.77	181
	June	434	.44	193	431	.45	195
1942	July	239	.40	97	236	.42	99
	Aug.	73	.57	42	71	.62	44
	Sept.	40	.72	29	39	.79	31
	Oct.	36	1.00	36	37	1.00	37
	Nov.	35	1.17	41	36	1.17	42
	Dec.	34	1.06	36	35	1.06	37
	Total	1,517	.63	959	1,510	.64	971
	Jan.	33	1.09	36	33	1.09	36
	Feb.	37	.97	36	37	.97	36
	March	96	.74	71	96	.74	71
	April	262	.48	125	262	.48	125
	May	338	.38	130	337	.39	131
	June	552	.33	182	549	.34	184
1943	July	393	.29	115	390	.30	117
	Aug.	163	.47	76	161	.48	78
	Sept.	64	.56	36	63	.60	38
	Oct.	60	.72	43	61	.72	44
	Nov.	54	.83	45	55	.84	46
	Dec.	37	.89	33	38	.89	34
	Total	2,089	.44	928	2.082	.45	940
	Jan.	30	.93	28	30	.93	28
	Feb.	32	1.00	32	32	1.00	32
	March	48	1.48	71	48	1.48	71
	April	345	.55	190	345	.55	190
	May	245	.58	142	243	.59	143
	June	469	.37	174	466	.38	176
1944	July	278	.39	109	275	.40	111
	Aug.	76	.49	37	74	.53	39
	Sept.	36	.61	22	35	.68	24
	Oct.	47	.83	39	48	.83	40
	Nov.	39	.92	36	40	.92	37
	Dec.	27	.85	23	28	.86	24
	Total	1,672	.54	903	1,664	.55	915
	Jan.	29	.97	28	29	.97	28
	Feb.	34	.94	32	34	.94	32
	March	65	.88	57	65	.88	57
	April	113	.70	79	113	.70	79
	May	176	.60	105	174	.61	106
	June	310	.46	144	307	.48	146
1945	July	325	.37	120	322	.38	122
	Aug.	174	.47	82	172	.49	84
	Sept.	103	.43	44	102	.45	46
	Oct.	74	.74	55	75	.75	56
	Nov.	52	.88	46	53	.89	47
	Dec.	42	.81	34	43	.81	35
	Total	1,497	.55	826	1,489	.56	838
	Jan.	39	.90	35	39	.90	35
	Feb.	33	.85	28	33	.85	28
	March	88	.67	59	88	.67	59
	April	237	.48	115	237	.48	115
	May	298	.44	130	295	.44	131
1946	June	354	.37	133	349	.39	135
	July	162	.40	64	158	.42	66
	Aug.	81	.57	46	78	.62	48
	Sept.	62	.60	37	62	.63	39
	Oct.	68	.76	52	70	.76	53
	Nov.	63	.82	52	64	.83	53
	Dec.	62	.77	48	63	.78	49
	Total	1,547	.52	799	1,536	53	811
	Jan.	32	0.81	26	32	0.81	26
	Feb.	37	.89	33	37	.89	33
	March	195	.62	120	195	.62	120
	April	136	.62	84	136	.61	84
	May	521	.40	210	516	.41	211
	June	628	.36	225	620	.37	227
1947	July	372	.35	131	365	.36	133
	Aug.	218	.45	99	214	.47	101
	Sept.	91	.53	48	91	.55	50
	Oct.	90	.70	63	93	.69	64
	Nov.	71	.77	55	73	.77	56
	Dec.	56	.87	49	58	.86	50
	Total	2,447	.47	1,143	2,430	.48	1,155
	Jan.	47	.91	43	47	.91	43
	Feb.	40	.88	35	40	.88	35
	March	102	.79	81	102	.79	81
	April	157	.70	110	157	.70	110
	May	336	.38	126	335	.38	127
	June	454	.36	162	453	.36	164
1948	July	126	.50	63	125	.52	65
	Aug.	59	.56	33	58	.60	35
	Sept.	33	.76	25	33	.82	27
	Oct.	39	.77	30	40	.77	31
	Nov.	34	.85	29	34	.88	30
	Dec.	31	1.00	31	31	1.03	32
	Total	1,458	.53	768	1,455	.54	780
	Jan.	31	.90	28	31	.90	28
	Feb.	29	.93	27	29	.93	27
	March	73	.89	65	73	.89	65
	April	152	.69	105	152	.69	105
	May	310	.53	165	302	.55	166
	June	493	.47	230	478	.49	232
1949	July	205	.52	106	194	.56	108
	Aug.	72	.61	44	69	.67	46
	Sept.	42	.74	31	41	.80	33
	Oct.	70	.93	65	75	.88	66
	Nov.	66	.97	64	70	.93	65
	Dec.	40	.97	39	43	.93	40
	Total	1,583	.61	969	1,557	.63	981
	Jan.	36	1.19	43	36	1.19	43
	Feb.	45	.95	43	45	.95	43
	March	150	.61	92	150	.61	92
	April	323	.46	150	323	.46	150
	May	416	.46	190	405	.47	191
	June	741	.37	275	723	.38	277
1950	July	458	.34	154	441	.35	156
	Aug.	153	.51	78	146	.55	80
	Sept.	86	.62	53	85	.65	55
	Oct.	76	.72	55	83	.67	56
	Nov.	80	.75	60	85	.72	61
	Dec.	61	.84	51	65	.80	52
	Total	2,625	.47	1,244	2,587	.49	1,256
	Jan.	45	.80	36	45	.80	36
	Feb.	61	.82	50	61	.82	50
	March	93	.78	73	93	.78	73
	April	212	.47	100	212	.47	100
	May	395	.45	177	389	.46	178
	June	626	.36	225	617	.37	227
1951	July	366	.36	132	359	.37	134
	Aug.	228	.44	101	224	.46	103
	Sept.	98	.56	55	98	.58	57
	Oct.	99	.71	70	102	.70	71
	Nov.	57	.91	52	60	.88	53
	Dec.	54	.87	47	56	.86	48
	Total	2,334	.48	1,118	2,316	.49	1,130
	Jan.	49	.82	40	49	.82	40
	Feb.	52	.81	42	52	.81	42
	March	63	.75	47	63	.75	47
	April	318	.62	198	318	.62	198
	May	600	.39	235	598	.39	236
	June	554	.36	201	550	.37	203
1952	July	205	.56	114	201	.58	116
	Aug.	121	.60	72	119	.62	74
	Sept.	67	.67	45	67	.70	47
	Oct.	49	.86	42	50	.86	43
	Nov.	37	1.11	41	38	1.10	42
	Dec.	34	1.18	40	35	1.17	41
	Total	2,149	.52	1,117	2,140	.53	1,129

Table I

Colorado River Basin

Flow and Quality of Water Data

Green River near Greendale, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	48	0.81	39	48	0.81	39
	Feb.	48	.85	41	48	.85	41
	March	73	.86	63	73	.86	63
	April	96	.76	73	96	.76	73
	May	110	.64	70	106	.67	71
	June	452	.39	175	445	.40	177
1953	July	198	.39	77	192	.41	79
	Aug.	105	.54	57	102	.58	59
	Sept.	43	.63	27	43	.67	29
	Oct.	35	.89	31	37	.86	32
	Nov.	42	.98	41	44	.95	42
	Dec.	32	.97	31	34	.94	32
	Total	1,282	.57	725	1,268	.58	737
	Jan.	28	1.11	31	28	1.11	31
	Feb.	39	.87	34	39	.87	34
	March	62	.81	50	62	.81	50
	April	101	.65	66	101	.65	66
	May	302	.31	94	296	.32	95
	June	223	.36	81	212	.39	83
1954	July	265	.28	73	256	.29	75
	Aug.	81	.43	35	77	.48	37
	Sept.	45	.69	31	44	.75	33
	Oct.	42	.95	40	46	.89	41
	Nov.	41	.85	35	44	.82	36
	Dec.	20	1.05	21	22	1.00	22
	Total	1,249	.47	591	1,227	.49	603
	Jan.	24	.75	18	24	.75	18
	Feb.	24	.71	17	24	.71	17
	March	44	1.11	49	44	1.11	49
	April	106	.64	68	106	.64	68
	May	168	.52	88	163	.55	89
	June	288	.33	95	275	.35	96
1955	July	130	.38	49	124	.41	51
	Aug.	80	.52	42	77	.57	44
	Sept.	38	.58	22	37	.62	23
	Oct.	38	.68	26	41	.66	27
	Nov.	36	.75	27	39	.72	28
	Dec.	45	.82	37	47	.81	38
	Total	1,021	.53	538	1,001	.55	548
	Jan.	50	0.86	43	50	0.86	43
	Feb.	38	.76	29	38	.76	29
	March	150	.47	70	150	.47	70
	April	203	.43	87	203	.43	87
	May	368	.39	144	351	.41	145
	June	615	.29	178	583	.31	180
1956	July	207	.33	69	200	.35	71
	Aug.	104	.42	44	100	.46	46
	Sept.	48	.44	21	47	.47	22
	Oct.	46	.74	34	53	.66	35
	Nov.	39	.82	32	45	.73	33
	Dec.	26	.88	23	31	.77	24
	Total	1,894	.41	774	1,851	.42	785
	Jan.	28	.68	19	28	.68	19
	Feb.	43	.79	34	43	.79	34
	March	66	.98	65	66	.98	65
	April	86	.67	58	86	.67	58
	May	275	.44	120	272	.44	120
	June	685	.37	251	679	.37	252
1957	July	433	.36	155	427	.37	156
	Aug.	142	.57	81	139	.59	82
	Sept.	82	.58	48	82	.60	49
	Oct.	77	.69	53	79	.68	54
	Nov.	57	1.00	57	59	.98	58
	Dec.	46	.91	42	47	.91	43
	Total	2,020	.49	983	2,007	.49	990
	Jan.	43	.77	33	43	.77	33
	Feb.	55	.80	44	55	.80	44
	March	66	.71	47	66	.71	47
	April	134	.67	90	134	.67	90
	May	387	.39	151	386	.39	151
	June	338	.38	127	336	.38	128
1958	July	88	.50	44	86	.52	45
	Aug.	57	.56	32	56	.59	33
	Sept.	39	.69	27	39	.72	28
	Oct.	36	.72	26	37	.70	26
	Nov.	34	.70	24	35	.68	24
	Dec.	38	.84	32	38	.84	32
	Total	1,315	.51	677	1,311	.52	681

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	1,521	0.63	957	1,516	0.64	969
1942	1,517	.63	959	1,510	.64	971
1943	2,089	.44	928	2,082	.45	940
1944	1,672	.54	903	1,664	.55	915
1945	1,497	.55	826	1,489	.56	838
1946	1,547	.52	799	1,536	.53	811
1947	2,447	.47	1,143	2,430	.48	1,155
1948	1,458	.53	768	1,455	.54	780
1949	1,583	.61	969	1,552	.63	981
1950	2,625	.47	1,244	2,587	.49	1,256
1951	2,334	.48	1,118	2,316	.49	1,130
1952	2,149	.52	1,117	2,140	.53	1,129
1953	1,282	.57	725	1,268	.58	737
	1,249	.47	591	1,227	.49	603
	1,021	.53	538	1,001	.55	548
1956	1,894	.41	774	1,851	.42	785
1957	2,020	.49	983	2,007	.49	990
1958	1,315	.51	677	1,311	.52	681
Total	31,220		16,019	30,947		16,219
Average	1,734	.51	890	1,719	.52	901

Table 2

Colorado River Basin

Flow and Quality of Water Data

Duchesne River near Randlett, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	25	1.12	28	25	1.12	28
	Feb.	24	1.29	31	24	1.29	31
	March	21	1.71	36	21	1.71	36
	April	20	1.50	30	17	1.76	30
	May	155	1.35	210	139	1.51	210
	June	232	1.16	270	214	1.26	269
1941	July	35	1.11	39	30	1.30	39
	Aug.	18	1.50	27	16	1.69	27
	Sept.	15	1.60	24	13	1.85	24
	Oct.	54	.93	50	53	.94	50
	Nov.	51	.90	46	50	.92	46
	Dec.	44	1.04	46	44	1.04	46
	Total	694	1.21	837	646	1.30	836
	Jan.	40	.90	36	40	.90	36
	Feb.	39	1.00	39	39	1.00	39
	March	39	1.23	48	39	1.23	48
	April	50	.90	45	48	.94	45
	May	83	.72	60	71	.85	60
	June	171	.15	25	158	.15	24
1942	July	23	1.43	33	19	1.74	33
	Aug.	8	2.12	17	7	2.42	17
	Sept.	5	2.40	12	4	3.00	12
	Oct.	18	1.50	27	17	1.59	27
	Nov.	22	1.41	31	21	1.48	31
	Dec.	28	1.28	36	28	1.28	36
	Total	526	.78	409	491	.83	408
	Jan.	26	1.12	29	26	1.12	29
	Feb.	29	1.17	34	29	1.17	34
	March	29	1.51	44	29	1.52	44
	April	43	1.00	43	40	1.07	43
	May	100	.64	64	85	.75	64
	June	103	.62	64	86	.73	63
1943	July	28	1.21	34	23	1.48	34
	Aug.	23	1.39	32	21	1.52	32
	Sept.	8	2.00	16	6	2.67	16
	Oct.	22	1.40	31	21	1.48	31
	Nov.	24	1.29	31	23	1.35	31
	Dec.	25	1.28	32	25	1.28	32
	Total	460	.99	454	414	1.09	453
	Jan.	23	1.08	25	23	1.09	25
	Feb.	26	1.31	34	26	1.31	34
	March	43	1.20	52	43	1.21	52
	April	48	.94	45	45	1.00	45
	May	128	.57	73	113	.65	73
	June	255	.37	94	237	.39	93
[illegible]	July	82	.72	59	77	.77	59
	Aug.	8	2.00	16	6	2.67	16
	Sept.	7	2.14	15	5	3.00	15
	Oct.	24	1.37	33	23	1.43	33
	Nov.	26	1.30	34	25	1.36	34
	Dec.	28	1.32	37	28	1.32	37
	Total	698	.74	517	651	.79	516
	Jan.	30	1.00	30	30	1.00	30
	Feb.	27	1.18	32	27	1.18	32
	March	32	1.40	45	32	1.41	45
	April	24	1.29	31	22	1.41	31
	May	59	.86	51	46	1.11	51
	June	91	.67	61	77	.78	60
[illegible]	July	30	1.23	37	26	1.42	37
	Aug.	31	1.19	37	29	1.27	37
	Sept.	12	1.75	21	11	1.91	21
	Oct.	21	1.38	29	20	1.45	29
	Nov.	26	1.27	33	25	1.32	33
	Dec.	24	1.37	33	24	1.37	33
	Total	407	1.08	440	359	1.19	439
	Jan.	23	1.13	26	23	1.13	26
	Feb.	21	1.38	29	21	1.38	29
	March	29	1.41	41	29	1.41	41
	April	40	1.00	40	38	1.05	40
	May	70	.78	55	57	.96	55
	June	47	.95	45	31	1.42	44
[illegible]	July	5	2.60	13	3	4.33	13
	Aug.	6	2.33	14	5	2.80	14
	Sept.	4	2.75	11	3	3.67	11
	Oct.	17	1.53	26	16	1.62	26
	Nov.	32	1.22	39	31	1.26	39
	Dec.	30	1.20	36	30	1.20	36
	Total	324	1.16	375	287	1.30	374
	Jan.	26	1.07	28	26	1.08	28
	Feb.	36	1.08	39	36	1.08	39
	March	36	1.27	46	36	1.28	46
	April	23	1.30	30	20	1.50	30
	May	143	.53	76	127	.60	76
	June	158	.49	78	140	.55	77
1947	July	33	1.18	39	28	1.39	39
	Aug.	25	1.28	32	23	1.39	32
	Sept.	12	1.75	21	10	2.10	21
	Oct.	17	1.65	28	16	1.75	28
	Nov.	29	1.21	35	28	1.25	35
	Dec.	31	1.19	37	31	1.19	37
	Total	569	.86	489	521	.94	488
	Jan.	29	1.00	29	29	1.00	29
	Feb.	26	1.31	34	26	1.31	34
	March	40	1.20	48	40	1.20	48
	April	31	1.23	38	29	1.31	38
	May	70	.79	55	59	.93	55
	June	51	.92	47	37	1.24	46
1948	July	3	3.00	9	2	4.50	9
	Aug.	2	3.50	7	2	3.50	7
	Sept.	1	3.00	3	0	0	0
	Oct.	5	2.40	12	4	3.00	12
	Nov.	14	1.71	24	13	1.85	24
	Dec.	26	1.27	33	26	1.27	33
	Total	298	1.14	339	267	1.25	335
	Jan.	24	1.08	26	24	1.08	26
	Feb.	23	1.30	30	23	1.30	30
	March	44	1.20	53	44	1.20	53
	April	46	.98	45	43	1.05	45
	May	127	.56	71	111	.64	71
	June	230	.39	90	212	.42	89
1949	July	50	.94	47	44	1.07	47
	Aug.	7	2.14	15	5	3.00	15
	Sept.	8	2.13	17	6	2.83	17
	Oct.	25	1.28	32	24	1.33	32
	Nov.	29	1.21	35	28	1.25	35
	Dec.	28	1.29	36	28	1.29	36
	Total	641	.78	497	592	.84	496
	Jan.	31	1.00	31	31	1.00	31
	Feb.	26	1.23	32	26	1.23	32
	March	40	1.30	52	40	1.30	52
	April	44	1.00	44	40	1.10	44
	May	97	.67	65	79	.81	64
	June	193	.43	83	173	.47	82
1950	July	45	1.00	45	40	1.12	45
	Aug.	9	2.00	18	7	2.57	18
	Sept.	13	1.77	23	11	2.09	23
	Oct.	16	1.56	25	14	1.78	25
	Nov.	27	1.26	34	25	1.36	34
	Dec.	33	1.36	45	33	1.36	45
	Total	574	.87	497	519	.95	495
	Jan.	26	1.00	26	26	1.00	26
	Feb.	26	1.31	34	26	1.31	34
	March	23	1.56	36	23	1.56	36
	April	14	1.71	24	10	2.40	24
	May	79	.75	59	62	.94	58
	June	124	.73	91	105	.86	90
1951	July	31	1.29	40	26	1.54	40
	Aug.	26	1.46	38	24	1.58	38
	Sept.	10	1.90	19	9	2.11	19
	Oct.	25	1.28	32	24	1.33	32
	Nov.	32	1.22	39	31	1.26	39
	Dec.	32	1.22	39	32	1.22	39
	Total	448	1.06	477	398	1.19	475
	Jan.	28	1.07	30	28	1.07	30
	Feb.	26	1.31	34	26	1.31	34
	March	31	1.42	44	31	1.42	44
	April	111	.60	67	1.06	.63	67
	May	304	.34	103	281	.36	102
	June	302	.33	100	276	.36	99
1952	July	70	.79	55	63	.87	55
	Aug.	49	.94	46	45	1.02	46
	Sept.	30	1.20	36	28	1.28	36
	Oct.	21	1.38	29	19	1.53	29
	Nov.	26	1.31	34	24	1.42	34
	Dec.	37	1.11	41	37	1.11	41
	Total	1035	.60	619	964	.64	617

Table 2
Colorado River Basin
Flow and Quality of Water Data
Duchesne River near Randlett, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	39	0.90	35	39	0.95	35
	Feb.	33	1.12	37	33	1.12	37
	March	34	1.41	48	34	1.41	48
	April	13	1.77	23	8	3.00	23
	May	15	1.60	24	5	4.80	24
	June	107	.60	64	94	.67	63
	July	13	1.77	23	9	2.56	23
	Aug.	12	1.75	21	11	1.91	21
	Sept.	5	2.20	11	4	2.75	11
	Oct.	9	2.00	18	8	2.25	18
	Nov.	20	1.40	28	19	1.47	28
	Dec.	26	1.31	34	26	1.31	34
	Total	326	1.12	366	290	1.26	365
1954	Jan.	27	1.11	30	Same as historical		
	Feb.	25	1.28	32			
	March	20	1.80	36			
	April	13	1.77	23			
	May	36	1.11	40			
	June	5	2.40	12			
	July	2	3.00	6			
	Aug.	1	4.00	4			
	Sept.	6	2.33	14			
	Oct.	17	1.59	27			
	Nov.	18	1.50	27			
	Dec.	18	1.50	27			
	Total	188	1.48	278			
1955	Jan.	25	1.08	27			
	Feb.	21	1.43	30			
	March	34	1.38	47			
	April	22	1.41	31			
	May	45	1.00	45			
	June	34	1.09	37			
	July	2	3.00	6			
	Aug.	8	2.50	17			
	Sept.	4	2.50	10			
	Oct.	6	2.33	14			
	Nov.	15	1.60	24			
	Dec.	29	1.21	35			
	Total	245	1.32	323			
1956	Jan.	27	1.00	27	Same as historical		
	Feb.	23	1.35	31			
	March	25	1.60	40			
	April	17	1.59	27			
	May	74	.76	56			
	June	90	.68	61			
	July	4	2.75	11			
	Aug.	2	4.00	8			
	Sept.	1	5.00	5			
	Oct.	4	2.25	9			
	Nov.	17	1.59	27			
	Dec.	19	1.21	23			
	Total	303	1.07	325			
1957	Jan.	21	1.05	22			
	Feb.	20	1.05	21			
	March	22	1.54	34			
	April	12	1.83	22			
	May	39	1.23	48			
	June	184	.41	76			
	July	35	.91	32			
	Aug.	18	1.61	29			
	Sept.	15	1.47	22			
	Oct.	19	1.74	33			
	Nov.	41	1.41	58			
	Dec.	30	1.07	32			
	Total	456	.94	429			
1958	Jan.	29	.83	24			
	Feb.	31	1.00	31			
	March	35	1.37	48			
	April	29	1.07	31			
	May	141	.46	65			
	June	103	.42	43			
	July	4	2.50	10			
	Aug.	1	4.00	4			
	Sept.	3	2.33	7			
	Oct.	5	2.60	13			
	Nov.	14	1.93	27			
	Dec.	21	1.24	26			
	Total	416	.79	329			

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	694	1.21	837	646	1.30	836
1942	526	.78	409	491	.83	408
1943	460	.99	454	414	1.09	453
1944	698	.74	517	651	.79	516
1945	407	1.08	440	369	1.19	439
1946	324	1.16	375	287	1.30	374
1947	569	.86	489	521	.94	488
1948	298	1.14	339	267	1.25	335
1949	641	.78	497	592	.84	496
1950	574	.87	497	519	.95	495
1951	448	1.06	477	398	1.19	475
1952	1,035	.60	619	964	.64	617
1953	326	1.12	366	290	1.26	365
1954	188	1.48	278	188	1.48	278
1955	245	1.32	323	245	1.32	323
1956	303	1.07	325	303	1.07	325
1957	456	.94	429	456	.94	429
1958	416	.79	329	416	.79	329
Total	8,608		8,000	8,017		7,981
Average	478	.93	444	445	1.00	443

Table 3

Colorado River Basin

Flow and Quality of Water Data

Green River near Ouray, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	93	0.95	88	93	0.95	88
	Feb.	111	.97	108	111	.97	108
	March	202	.90	182	202	.90	182
	April	316	.64	202	313	.65	202
	May	1,200	.47	560	1,179	.48	562
	June	1,140	.45	510	1,116	.46	513
	July	333	.58	195	323	.62	199
	Aug.	245	.98	240	240	1.02	244
	Sept.	158	.95	150	156	.99	154
	Oct.	284	.93	265	285	.94	267
	Nov.	214	.85	182	215	.85	184
	Dec.	151	.92	139	152	.93	141
	Total	4,447	.63	2,821	4,385	.65	2,844
1942	Jan.	110	.88	97	110	.88	97
	Feb.	113	.91	103	113	.91	103
	March	247	.91	225	247	.91	225
	April	840	.58	483	838	.58	483
	May	1,030	.47	485	1,015	.48	487
	June	1,250	.34	420	1,232	.34	422
	July	395	.51	200	385	.53	204
	Aug.	138	.74	102	133	.80	106
	Sept.	82	.96	79	78	1.05	82
	Oct.	108	.99	107	109	1.00	109
	Nov.	113	1.09	123	114	1.10	125
	Dec.	109	1.10	120	111	1.10	122
	Total	4,535	.56	2,544	4,485	.57	2,565
1943	Jan.	98	1.09	107	98	1.09	107
	Feb.	119	.91	108	119	.91	108
	March	227	.81	183	227	.81	183
	April	573	.51	290	570	.51	290
	May	820	.34	275	802	.34	276
	June	1,090	.36	392	1,068	.37	394
	July	591	.38	223	581	.39	227
	Aug.	278	.76	210	272	.78	213
	Sept.	109	.84	92	105	.90	95
	Oct.	115	.96	111	116	.97	113
	Nov.	132	1.00	132	133	1.01	134
	Dec.	105	1.04	109	107	1.04	111
	Total	4,257	.52	2,232	4,198	.54	2,251
1944	Jan.	79	1.05	83	79	1.05	83
	Feb.	101	1.03	104	101	1.03	104
	March	210	1.08	226	210	1.08	226
	April	535	.68	365	532	.69	365
	May	970	.39	380	951	.40	382
	June	1,390	.28	395	1,367	.29	397
	July	572	.39	222	561	.40	226
	Aug.	128	.63	80	122	.69	84
	Sept.	68	.78	53	63	.89	56
	Oct.	107	.95	102	108	.96	104
	Nov.	110	1.02	112	111	1.03	114
	Dec.	87	1.07	93	89	1.07	95
	Total	4,357	.51	2,215	4,294	.52	2,236
1945	Jan.	103	.95	98	103	.95	98
	Feb.	116	.95	110	116	.95	110
	March	171	.94	160	171	.94	160
	April	289	.74	215	287	.75	215
	May	952	.37	354	935	.38	355
	June	1,050	.34	360	1,031	.35	362
	July	675	.37	248	666	.38	252
	Aug.	320	.67	213	314	.69	216
	Sept.	159	.64	102	156	.67	105
	Oct.	150	.85	128	151	.86	130
	Nov.	139	.91	126	140	.91	128
	Dec.	108	.97	105	110	.97	107
	Total	4,232	.52	2,219	4,180	.53	2,238
1946	Jan.	112	.91	102	112	.91	102
	Feb.	110	.83	91	110	.83	91
	March	222	.83	185	222	.83	185
	April	535	.53	286	533	.54	286
	May	760	.38	292	742	.40	294
	June	772	.33	255	751	.34	257
	July	252	.44	110	241	.47	114
	Aug.	143	.74	106	137	.80	110
	Sept.	101	.82	83	99	.87	86
	Oct.	147	.83	122	149	.83	124
	Nov.	160	.90	144	161	.91	146
	Dec.	148	.85	126	150	.85	128
	Total	3,462	.55	1,902	3,407	.56	1,923
1947	Jan.	94	0.89	84	94	0.89	84
	Feb.	138	.79	109	138	.79	109
	March	403	.69	279	403	.69	279
	April	425	.54	228	422	.54	228
	May	1,439	.36	512	1,416	.36	513
	June	1,351	.36	480	1,323	.36	482
	July	644	.38	248	630	.40	252
	Aug.	336	.61	205	328	.63	208
	Sept.	159	.71	113	156	.74	116
	Oct.	171	.82	140	174	.82	142
	Nov.	163	.86	140	165	.86	142
	Dec.	151	.91	137	154	.90	139
	Total	5,474	.49	2,675	5,403	.50	2,694
1948	Jan.	130	.91	118	130	.91	118
	Feb.	139	.76	106	139	.76	106
	March	277	.83	230	277	.83	230
	April	544	.62	335	542	.62	335
	May	1,089	.34	370	1,075	.35	371
	June	939	.32	300	925	.33	302
	July	242	.53	128	238	.55	131
	Aug.	123	.65	80	120	.69	83
	Sept.	66	.79	52	64	.86	55
	Oct.	90	.84	76	91	.86	78
	Nov.	96	.94	90	96	.96	92
	Dec.	93	1.04	97	93	1.05	98
	Total	3,828	.52	1,982	3,790	.53	1,999
1949	Jan.	97	.89	86	97	.89	86
	Feb.	104	.82	85	104	.82	85
	March	263	.78	205	263	.78	205
	April	490	.59	287	487	.59	287
	May	1,229	.38	470	1,204	.39	471
	June	1,548	.37	580	1,514	.38	581
	July	558	.48	270	541	.50	273
	Aug.	153	.70	108	148	.75	111
	Sept.	104	.77	80	101	.81	82
	Oct.	193	.85	165	197	.84	166
	Nov.	175	.89	155	178	.88	156
	Dec.	114	1.04	118	117	1.02	119
	Total	5,028	.52	2,609	4,951	.53	2,622
1950	Jan.	125	1.00	125	125	1.00	125
	Feb.	135	.85	115	135	.85	115
	March	321	.78	250	321	.78	250
	April	649	.50	325	645	.50	325
	May	1,069	.45	480	1,039	.45	480
	June	1,597	.33	520	1,558	.34	522
	July	711	.43	308	688	.45	311
	Aug.	226	.62	140	217	.66	143
	Sept.	145	.79	114	142	.82	117
	Oct.	144	.87	126	149	.85	127
	Nov.	165	.83	137	168	.82	138
	Dec.	159	.86	137	163	.85	138
	Total	5,446	.51	2,777	5,350	.52	2,791
1951	Jan.	108	.91	98	108	.91	98
	Feb.	164	.79	130	164	.79	130
	March	214	.79	170	214	.79	170
	April	394	.57	225	390	.58	225
	May	938	.41	385	914	.42	385
	June	1,299	.37	481	1,270	.38	483
	July	616	.40	250	603	.42	253
	Aug.	358	.61	220	352	.63	223
	Sept.	160	.65	104	159	.67	107
	Oct.	207	.82	170	209	.82	171
	Nov.	158	.87	137	160	.86	138
	Dec.	131	.92	120	133	.91	121
	Total	4,747	.52	2,490	4,676	.54	2,504
1952	Jan.	125	.90	112	125	.90	112
	Feb.	132	.86	114	132	.86	114
	March	151	.85	129	151	.85	129
	April	959	.68	652	954	.68	652
	May	1,888	.42	793	1,862	.43	793
	June	1,738	.34	590	1,707	.35	592
	July	477	.57	270	465	.59	273
	Aug.	294	.70	206	288	.73	209
	Sept.	166	.80	133	164	.83	136
	Oct.	117	.98	115	116	1.00	116
	Nov.	115	1.04	120	114	1.06	121
	Dec.	120	1.08	130	121	1.08	131
	Total	6,282	.54	3,364	6,199	.54	3,378

Table 3

Colorado River Basin

Flow and Quality of Water Data

Green River near Ouray, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	139	0.86	120	139	0.86	120
	Feb.	137	.88	120	137	.88	120
	March	215	.86	185	215	.86	185
	April	234	.79	185	231	.80	185
	May	501	.45	225	485	.47	226
	June	1,185	.33	390	1,164	.34	391
	July	354	.42	150	344	.44	153
	Aug.	200	.68	137	196	.71	140
	Sept.	83	.78	65	82	.82	67
	Oct.	82	.95	78	83	.95	79
	Nov.	118	.97	115	119	.98	116
	Dec.	105	1.00	105	107	.99	106
	Total	3,353	.56	1,875	3,302	.57	1,888
1954	Jan.	105	.95	100	105	.95	100
	Feb.	139	.86	120	139	.86	120
	March	172	.84	145	172	.84	145
	April	291	.60	175	291	.60	175
	May	693	.32	220	687	.32	221
	June	373	.39	145	361	.41	147
	July	348	.37	130	339	.39	133
	Aug.	122	.49	60	118	.53	63
	Sept.	117	.77	90	116	.79	92
	Oct.	127	.94	120	131	.92	121
	Nov.	116	.90	105	119	.89	106
	Dec.	76	1.12	85	78	1.10	86
	Total	2,679	.56	1,495	2.656	.57	1,509
1955	Jan.	78	.90	70	78	.90	70
	Feb.	83	.84	70	83	.84	70
	March	203	.91	185	203	.91	185
	April	319	.64	205	319	.64	205
	May	707	.34	240	701	.34	241
	June	676	.32	215	663	.33	216
	July	214	.40	85	208	.42	88
	Aug.	151	.73	110	148	.76	113
	Sept.	68	.81	55	66	.85	56
	Oct.	75	.89	67	70	.97	68
	Nov.	84	.96	81	87	.94	82
	Dec.	126	.87	110	128	.87	111
	Total	2,784	.54	1,493	2,754	.55	1,505
1956	Jan.	140	0.86	120	140	0.86	120
	Feb.	93	.97	90	93	.97	90
	March	330	.67	220	330	.67	220
	April	489	.45	220	489	.45	220
	May	1,040	.31	325	1,023	.32	326
	June	1,180	.30	355	1,147	.31	357
	July	288	.42	120	281	.44	123
	Aug.	166	.60	100	162	.64	103
	Sept.	70	.61	43	69	.64	44
	Oct.	75	.80	60	82	.74	61
	Nov.	96	.92	88	102	.87	89
	Dec.	80	.95	76	85	.90	77
	Total	4,047	.45	1,817	4,003	.46	1,830
1957	Jan.	83	.88	73	83	.88	73
	Feb.	102	.90	92	102	.90	92
	March	230	.83	191	230	.83	191
	April	317	.66	209	317	.66	209
	May	987	.42	414	983	.42	414
	June	1,915	.31	590	1,909	.31	591
	July	1,185	.30	360	1,179	.31	362
	Aug.	345	.61	210	342	.62	212
	Sept.	179	.70	125	178	.71	126
	Oct.	181	.79	143	183	.79	144
	Nov.	206	.83	171	208	.83	172
	Dec.	140	.84	118	141	1.01	142
	Total	5,870	.46	2,696	5,855	.47	2,728
1958	Jan.	122	.79	96	122	.79	96
	Feb.	178	.73	130	178	.73	130
	March	246	.79	194	246	.79	194
	April	422	.58	245	422	.58	245
	May	1,357	.33	450	1,355	.33	450
	June	1,115	.28	312	1,113	.28	313
	July	189	.53	100	187	.55	102
	Aug.	99	.65	64	98	.67	66
	Sept.	83	.82	68	82	.84	69
	Oct.	85	.84	71	86	.83	71
	Nov.	99	.91	90	100	.90	90
	Dec.	110	.87	96	110	.87	96
	Total	4,105	.47	1,016	4,099	.47	1,922

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	4,447	0.63	2,821	4,385	0.65	2,844
1942	4,535	.56	2,544	4,485	.57	2,565
1943	4,257	.52	2,232	4,198	.54	2,251
1944	4,357	.51	2,215	4,294	.52	2,236
1945	4,232	.52	2,219	4,180	.53	2,238
1946	3,462	.55	1,902	3,407	.56	1,923
1947	5,474	.49	2,675	5,403	.50	2,694
1948	3,828	.52	1,982	3,790	.53	1,999
1949	5,028	.52	2,609	4,951	.53	2,622
1950	5,446	.51	2,777	5,350	.52	2,791
1951	4,747	.52	2,490	4,676	.54	2,504
1952	6,282	.54	3,364	6,199	.54	3,378
1953	3,353	.56	1,875	3,302	.57	1,888
1954	2,679	.56	1,495	2,656	.57	1,509
1955	2,784	.54	1,493	2,754	.55	1,505
1956	4,047	.45	1,817	4,003	.46	1,830
1957	5,870	.46	2,696	5,855	.47	2,728
1958	4,105	.47	1,916	4,099	.47	1,922
Total	78,933		41,122	77,987		41,427
Average	4,385	.52	2,285	4,333	.53	2,302

Table 4

Colorado River Basin

Flow and Quality of Water Data

Green River at Green River, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	100	1.01	101	102	1.01	103
	Feb.	126	1.06	134	127	1.06	135
	March	216	1.01	218	216	1.01	218
	April	314	.75	235	311	.76	235
	May	1,172	.53	621	1,140	.55	625
	June	1,146	.49	562	1,112	.51	569
1941	July	359	.63	226	339	.70	236
	Aug.	267	1.09	292	254	1.19	303
	Sept.	182	1.01	184	176	1.10	194
	Oct.	318	1.00	318	324	1.00	325
	Nov.	240	.90	216	245	.90	221
	Dec.	168	.98	165	171	.99	169
	Total	4,608	.71	3,272	4,517	.74	3,333
	Jan.	112	1.04	117	113	1.04	118
	Feb.	122	.98	120	123	.98	121
	March	264	.94	248	264	.94	248
	April	858	.65	557	856	.65	557
	May	980	.57	558	955	.59	562
	June	1,271	.39	495	1,243	.40	501
1942	July	414	.57	236	396	.62	246
	Aug.	152	.85	129	141	.99	139
	Sept.	91	1.10	100	84	1.29	108
	Oct.	118	1.20	142	123	1.20	148
	Nov.	124	1.18	146	128	1.18	151
	Dec.	116	1.22	141	120	1.21	145
	Total	4,622	.65	2,989	4,546	.67	3,044
	Jan.	112	1.13	127	113	1.13	128
	Feb.	130	1.02	132	131	1.02	133
	March	236	.91	215	236	.91	215
	April	569	.57	325	566	.57	325
	May	763	.39	298	738	.41	300
	June	1,074	.40	430	1,044	.42	435
1943	July	612	.43	263	595	.46	271
	Aug.	300	.83	249	289	.89	257
	Sept.	116	.98	114	110	1.10	121
	Oct.	124	1.10	136	128	1.10	141
	Nov.	146	1.04	152	149	1.05	156
	Dec.	112	1.11	124	116	1.10	128
	Total	4,294	.60	2,565	4,215	.62	2,610
	Jan.	80	1.20	96	82	1.20	98
	Feb.	111	1.06	118	112	1.01	119
	March	252	1.07	270	252	1.08	270
	April	529	.81	428	526	.81	428
	May	924	.48	444	894	.50	448
	June	1,391	.30	417	1,358	.31	423
1944	July	591	.44	260	570	.47	270
	Aug.	143	.73	104	129	.89	115
	Sept.	73	.96	70	64	1.23	79
	Oct.	115	1.13	130	121	1.13	137
	Nov.	119	1.14	136	124	1.14	141
	Dec.	88	1.23	108	92	1.22	112
	Total	4,416	.58	2,561	4,324	.61	2,540
	Jan.	109	1.04	113	110	1.04	114
	Feb.	128	.99	127	129	.99	128
	March	185	1.03	191	185	1.03	191
	April	291	.84	244	289	.85	244
	May	909	.44	400	884	.45	402
	June	1,016	.39	396	989	.41	401
1945	July	701	.41	287	685	.43	296
	Aug.	335	.74	248	324	.79	256
	Sept.	163	.77	125	157	.84	132
	Oct.	161	.99	159	165	1.00	165
	Nov.	149	.99	148	153	.99	152
	Dec.	113	1.06	120	117	1.06	124
	Total	4,260	.60	2,558	4,187	.62	2,505
	Jan.	123	.95	117	124	.95	118
	Feb.	117	.91	106	118	.91	107
	March	236	.90	212	236	.90	212
	April	528	.60	317	526	.60	317
	May	775	.41	318	750	.43	321
	June	746	.36	269	716	.38	275
1946	July	264	.47	124	245	.54	133
	Aug.	152	.84	128	141	.97	137
	Sept.	105	.91	96	100	1.04	104
	Oct.	149	1.00	149	154	1.01	155
	Nov.	170	.98	167	174	.98	171
	Dec.	154	.94	145	158	.94	149
	Total	3,519	.61	2,148	3,442	.64	2,199

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	92	1.07	98	93	1.06	99
	Feb.	151	.86	130	152	.86	131
	March	411	.79	325	411	.79	325
	April	422	.59	249	419	.59	249
	May	1,400	.38	532	1,370	.39	534
	June	1,348	.39	526	1,313	.40	531
1947	July	656	.40	262	635	.43	270
	Aug.	365	.71	259	352	.76	267
	Sept.	166	.77	128	161	.84	135
	Oct.	181	.91	165	187	.91	170
	Nov.	179	.91	163	183	.91	167
	Dec.	152	1.01	154	157	1.01	158
	Total	5,523	.54	2,991	5,433	.56	3,036
	Jan.	141	.94	132	142	.94	133
	Feb.	137	.91	124	138	.90	124
	March	313	.86	270	313	.86	270
	April	558	.69	385	556	.69	385
	May	1,061	.39	414	1,043	.40	416
	June	952	.34	324	933	.35	328
1948	July	268	.54	145	260	.58	151
	Aug.	137	.81	111	130	.90	117
	Sept.	69	.81	56	65	.95	62
	Oct.	92	1.02	94	95	1.03	98
	Nov.	104	1.05	109	105	1.08	113
	Dec.	97	1.10	107	98	1.11	109
	Total	3,929	.58	2,271	3,876	.59	2,306
	Jan.	100	1.01	101	100	1.01	101
	Feb.	110	.92	101	110	.92	101
	March	276	.92	254	276	.92	254
	April	474	.69	327	471	.69	327
	May	1,221	.43	525	1,193	.44	526
	June	1,547	.42	650	1,510	.43	652
1949	July	592	.57	338	572	.60	343
	Aug.	172	.77	132	166	.83	137
	Sept.	112	.89	100	108	.96	104
	Oct.	207	.98	203	212	.97	205
	Nov.	190	.90	171	194	.89	173
	Dec.	128	1.07	137	132	1.05	139
	Total	5,129	.59	3,039	5,044	.61	3,062
	Jan.	141	1.01	142	142	1.01	143
	Feb.	147	1.01	148	147	1.01	148
	March	356	.90	321	356	.90	321
	April	620	.64	397	616	.64	397
	May	1,026	.53	544	993	.55	545
	June	1,567	.35	548	1,525	.36	552
1950	July	734	.49	360	707	.52	365
	Aug.	246	.63	155	234	.68	160
	Sept.	149	.89	133	144	.96	138
	Oct.	153	.96	147	160	.94	150
	Nov.	166	.99	164	170	.98	166
	Dec.	171	.96	164	176	.94	166
	Total	5,476	.59	3,223	5,370	.61	3,251
	Jan.	113	1.13	128	114	1.13	129
	Feb.	167	.92	154	167	.92	154
	March	205	.93	190	205	.93	190
	April	372	.70	260	368	.71	260
	May	882	.45	397	855	.47	398
	June	1,309	.40	524	1,277	.41	528
1951	July	627	.43	270	610	.45	275
	Aug.	379	.69	261	370	.72	266
	Sept.	178	.79	140	175	.83	145
	Oct.	211	.99	210	215	.99	213
	Nov.	164	1.05	172	167	1.04	174
	Dec.	132	1.07	142	135	1.07	144
	Total	4,739	.60	2,848	4,658	.62	2,876
	Jan.	134	1.01	136	134	1.02	136
	Feb.	140	.96	135	140	.96	135
	March	160	1.05	168	160	1.05	168
	April	988	.88	869	983	.88	869
	May	2,087	.48	1,002	2,058	.49	1,002
	June	1,809	.36	651	1,775	.37	654
1952	July	514	.60	309	499	.63	314
	Aug.	315	.89	280	308	.93	285
	Sept.	184	.96	177	181	1.01	182
	Oct.	129	1.09	140	129	1.10	142
	Nov.	122	1.24	151	122	1.25	153
	Dec.	129	1.20	155	131	1.20	157
	Total	6,711	.62	4,173	6,620	.63	4,197

Table 4

Colorado River Basin
Flow and Quality of Water Data

Green River at Green River, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	140	1.05	147	140	1.05	147
	Feb.	141	1.04	147	141	1.04	147
	March	217	1.00	217	217	1.00	217
	April	221	.93	212	216	.97	212
	May	454	.55	250	435	.56	251
	June	1,167	.37	432	1,143	.38	434
	July	376	.48	181	363	.51	186
	Aug.	212	.84	178	207	.88	183
	Sept.	87	.99	86	85	.95	90
	Oct.	86	1.20	104	88	1.20	106
	Nov.	125	1.15	144	127	1.15	146
	Dec.	107	1.18	126	110	1.16	128
	Total	3,333	.67	2,224	3,274	.69	2,247
1954	Jan.	107	1.09	117	107	1.09	117
	Feb.	138	1.03	142	138	1.03	142
	March	169	1.03	174	169	1.03	174
	April	270	.75	202	270	.75	202
	May	640	.38	243	631	.39	244
	June	376	.45	169	361	.48	172
	July	346	.46	159	334	.49	164
	Aug.	120	.65	78	115	.72	83
	Sept.	134	1.02	137	132	1.07	141
	Oct.	139	1.14	159	144	1.12	161
	Nov.	120	1.06	127	124	1.04	129
	Dec.	80	1.25	100	83	1.23	102
	Total	2,639	.68	1,807	2,608	.70	1,831
1955	Jan.	80	1.06	85	80	1.06	85
	Feb.	86	.92	79	86	.92	79
	March	237	.92	218	237	.92	218
	April	311	.77	239	311	.77	239
	May	677	.39	264	669	.40	265
	June	654	.36	236	639	.37	238
	July	223	.46	102	215	.49	106
	Aug.	161	.83	134	157	.88	138
	Sept.	71	.92	66	69	.99	68
	Oct.	77	1.08	83	81	1.05	85
	Nov.	86	1.13	97	90	1.10	99
	Dec.	127	1.02	130	129	1.02	131
	Total	2,790	.62	1,733	2,763	.63	1,751
1956	Jan.	155	0.91	141	155	0.91	141
	Feb.	100	1.05	105	100	1.05	105
	March	314	.81	255	314	.81	255
	April	460	.53	244	460	.53	244
	May	995	.35	348	978	.36	349
	June	1,207	.32	386	1,173	.33	388
	July	294	.49	144	286	.52	148
	Aug.	169	.67	113	166	.70	117
	Sept.	72	.72	52	71	.75	53
	Oct.	77	.94	73	84	.88	74
	Nov.	99	1.02	101	105	.97	102
	Dec.	79	1.05	83	84	1.00	84
	Total	4,021	.51	2,045	3,976	.52	2,060
1957	Jan.	83	.95	79	84	.95	80
	Feb.	100	.94	94	100	.94	94
	March	237	.89	210	237	.89	210
	April	290	.73	212	290	.73	212
	May	913	.48	438	906	.48	439
	June	1,871	.34	636	1,862	.34	639
	July	1,164	.27	396	1,154	.35	400
	Aug.	386	.79	305	380	.81	309
	Sept.	202	.76	153	199	.78	156
	Oct.	185	.94	174	189	.94	177
	Nov.	228	.96	219	231	.96	221
	Dec.	149	.97	144	151	.97	146
	Total	5,808	.53	3,060	5,783	.53	3,083
1958	Jan.	128	.93	119	128	.93	119
	Feb.	183	.86	158	183	.96	158
	March	246	.92	227	246	.92	227
	April	432	.71	307	432	.71	307
	May	1,311	.41	537	1,306	.41	537
	June	1,174	.35	411	1,169	.35	413
	July	224	.62	139	220	.55	143
	Aug.	110	.82	91	107	.94	95
	Sept.	96	1.07	103	95	1.12	106
	Oct.	91	1.01	92	93	1.00	93
	Nov.	102	1.10	113	104	1.10	114
	Dec.	114	1.09	124	115	1.09	125
	Total	4,211	.57	2,421	4,198	.58	2,437

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	4,608	0.71	3,272	4,517	0.74	3,333
1942	4,622	.65	2,989	4,546	.67	3,044
1943	4,294	.60	2,565	4,215	.62	2,610
1944	4,416	.58	2,581	4,324	.61	2,640
1945	4,260	.60	2,558	4,187	.62	2,605
1946	3,519	.61	2,148	3,442	.64	2,199
1947	5,523	.54	2,991	5,433	.56	3,036
1948	3,929	.58	2,271	3,878	.59	2,306
1949	5,129	.59	3,039	5,044	.61	3,062
1950	5,476	.59	3,223	5,370	.61	3,251
1951	4,739	.60	2,848	4,658	.62	2,876
1952	6,711	.62	4,173	6,620	.63	4,197
1953	3,333	.67	2,224	3,274	.69	2,247
1954	2,639	.68	1,807	2,608	.70	1,831
1955	2,790	.62	1,733	2,763	.63	1,751
1956	4,021	.51	2,045	3,976	.52	2,060
1957	5,808	.53	3,060	5,783	.53	3,083
1958	4,211	.57	2,421	4,198	.58	2,437
Total	80,028		47,948	78,836		48,568
Average	4,446	.60	2,664	4,380	.62	2,698

Table 5
Colorado River Basin
Flow and Quality of Water Data
San Rafael River near Green River, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	2	4.0	8	Same as Historical		
	Feb.	2	4.0	8			
	March	6	3.5	21			
	April	1	4.0	4			
	May	50	1.2	62			
	June	49	1.2	59			
	July	7	2.9	20			
	Aug.	6	3.3	20			
	Sept.	2	4.5	9			
	Oct.	5	4.0	20			
	Nov.	5	4.2	21			
	Dec.	4	4.0	16			
	Total	139	1.9	268			
1942	Jan.	6	2.8	17			
	Feb.	5	3.6	18			
	March	6	3.7	22			
	April	14	2.8	39			
	May	34	1.4	49			
	June	51	1.2	61			
	July	6	3.0	18			
	Aug.	6	3.2	19			
	Sept.	1	5.0	5			
	Oct.	2	5.0	10			
	Nov.	3	4.7	14			
	Dec.	3	4.7	14			
	Total	137	2.1	286			
1943	Jan.	4	3.0	12			
	Feb.	5	3.4	17			
	March	6	3.8	23			
	April	15	2.9	44			
	May	13	2.1	27			
	June	14	2.0	28			
	July	2	3.5	7			
	Aug.	6	3.2	19			
	Sept.	1	5.0	5			
	Oct.	2	5.0	10			
	Nov.	2	5.0	10			
	Dec.	3	3.7	11			
	Total	73	2.9	213			
1944	Jan.	2	3.5	7			
	Feb.	3	3.0	9			
	March	6	3.5	21			
	April	1	5.0	5			
	May	40	1.3	53			
	June	72	1.1	78			
	July	9	2.9	26			
	Aug.	7	3.1	22			
	Sept.	1	5.0	5			
	Oct.	2	5.0	10			
	Nov.	3	4.7	14			
	Dec.	3	4.3	13			
	Total	149	1.8	263			
1945	Jan.	3	3.3	10			
	Feb.	3	4.0	12			
	March	6	3.5	21			
	April	1	6.0	6			
	May	22	1.6	35			
	June	27	1.5	41			
	July	6	3.2	19			
	Aug.	7	3.4	24			
	Sept.	2	4.0	8			
	Oct.	3	5.0	15			
	Nov.	3	4.7	14			
	Dec.	2	4.5	9			
	Total	85	2.5	214			
1946	Jan.	2	4.0	8			
	Feb.	4	3.3	13			
	March	6	3.7	22			
	April	11	3.2	35			
	May	20	1.8	36			
	June	8	2.4	19			
	July	1	4.0	4			
	Aug.	7	5.4	38			
	Sept.	0	0	0			
	Oct.	2	5.0	10			
	Nov.	5	3.8	19			
	Dec.	3	4.3	13			
	Total	69	3.2	218			

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1947	Jan.	2	4.5	9	Same as Historical		
	Feb.	5	3.0	15			
	March	4	3.8	15			
	April	3	4.3	13			
	May	33	1.4	46			
	June	26	1.8	47			
	July	5	3.6	18			
	Aug.	20	3.4	68			
	Sept.	3	5.0	15			
	Oct.	2	6.0	12			
	Nov.	4	3.8	15			
	Dec.	4	3.5	14			
	Total	111	2.6	287			
1948	Jan.	3	3.7	11			
	Feb.	6	3.0	18			
	March	7	3.6	25			
	April	4	3.5	14			
	May	16	1.4	23			
	June	13	2.2	29			
	July	2	4.0	8			
	Aug.	6	2.2	13			
	Sept.	0	0	0			
	Oct.	1	5.0	5			
	Nov.	2	5.0	10			
	Dec.	2	4.5	9			
	Total	62	2.7	165			
1949	Jan.	2	4.0	8			
	Feb.	2	4.0	8			
	March	9	3.3	30			
	April	10	2.2	22			
	May	30	1.3	38			
	June	52	1.2	64			
	July	14	2.7	38			
	Aug.	5	3.0	15			
	Sept.	3	4.7	14			
	Oct.	3	4.7	14			
	Nov.	3	4.7	14			
	Dec.	2	4.5	9			
	Total	135	2.0	274			
1950	Jan.	2	4.5	9			
	Feb.	6	3.3	20			
	March	5	4.0	20			
	April	3	4.7	14			
	May	9	2.2	20			
	June	11	2.2	24			
	July	9	2.9	26			
	Aug.	1	3.0	3			
	Sept.	1	5.0	5			
	Oct.	1	6.0	6			
	Nov.	2	5.5	11			
	Dec.	3	4.3	13			
	Total	53	3.2	171			
1951	Jan.	2	5.0	10			
	Feb.	3	3.7	11			
	March	2	5.0	10			
	April	1	6.0	6			
	May	15	1.9	29			
	June	23	1.7	40			
	July	3	3.7	11			
	Aug.	12	2.2	27			
	Sept.	1	5.0	5			
	Oct.	6	4.0	24			
	Nov.	4	4.5	18			
	Dec.	3	5.0	15			
	Total	75	2.8	207			
1952	Jan.	3	3.7	11			
	Feb.	5	3.6	18			
	March	14	3.1	44			
	April	24	2.4	58			
	May	93	.8	78			
	June	128	.9	114			
	July	19	1.9	36			
	Aug.	12	3.3	40			
	Sept.	5	3.8	19			
	Oct.	3	4.7	14			
	Nov.	4	4.5	18			
	Dec.	4	4.0	16			
	Total	314	1.5	467			

Table 5
Colorado River Basin
Flow and Quality of Water Data
San Rafael River near Green River, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	6	2.8	17	Same as Historical		
	Feb.	7	3.1	22			
	March	6	3.2	19			
	April	3	4.3	13			
	May	2	5.5	11			
	June	31	1.3	47			
	July	5	3.8	19			
	Aug.	9	3.7	33			
	Sept.	1	5.0	5			
	Oct.	4	4.3	17			
	Nov.	4	4.5	18			
	Dec.	3	4.8	14			
	Total	81	2.9	235			
1954	Jan.	3	4.0	12			
	Feb.	5	3.8	19			
	March	4	3.8	15			
	April	3	4.3	13			
	May	6	2.9	23			
	June	1	5.0	5			
	July	1	5.0	5			
	Aug.	1	3.0	3			
	Sept.	4	4.0	16			
	Oct.	2	4.0	8			
	Nov.	2	4.5	9			
	Dec.	2	4.5	9			
	Total	36	3.8	137			
1955	Jan.	2	4.0	8			
	Feb.	2	3.5	7			
	March	6	3.5	21			
	April	3	3.7	11			
	May	4	3.0	12			
	June	6	2.8	17			
	July	0	0	0			
	Aug.	3	3.7	11			
	Sept.	0	0	0			
	Oct.	0	0	0			
	Nov.	1	5.0	5			
	Dec.	2	4.5	9			
	Total	29	3.5	101			

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1956	Jan.	3	3.7	11	Same as Historical		
	Feb.	3	3.3	10			
	March	3	3.3	10			
	April	1	5.0	5			
	May	11	1.6	18			
	June	8	2.0	16			
	July	1	4.0	4			
	Aug.	1	3.0	3			
	Sept.	0	0	0			
	Oct.	0	0	0			
	Nov.	1	5.0	5			
	Dec.	1	5.0	5			
	Total	33	2.6	87			
1957	Jan.	2	3.0	6			
	Feb.	4	3.0	12			
	March	2	5.0	10			
	April	1	5.0	5			
	May	9	3.1	28			
	June	94	.8	79			
	July	24	1.5	37			
	Aug.	13	2.8	36			
	Sept.	4	3.5	14			
	Oct.	10	3.3	33			
	Nov.	21	2.5	53			
	Dec.	5	3.4	17			
	Total	189	1.7	331			
1958	Jan.	5	2.6	13			
	Feb.	8	2.8	22			
	March	6	3.3	20			
	April	13	1.6	21			
	May	66	.9	60			
	June	57	.8	47			
	July	2	4.0	8			
	Aug.	4	4.5	18			
	Sept.	4	4.3	17			
	Oct.	1	5.0	5			
	Nov.	2	4.0	8			
	Dec.	4	3.3	13			
	Total	172	1.5	252			

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	139	1.9	268	Same	as	Historical
1942	137	2.1	286			
1943	73	2.9	213			
1944	149	1.8	263			
1945	85	2.5	214			
1946	69	3.2	218			
1947	111	2.6	287			
1948	62	2.7	165			
1949	135	2.0	274			
1950	53	3.2	171			
1951	75	2.8	207			
1952	314	1.5	467			
1953	81	2.9	235			
1954	36	3.8	137			
1955	29	3.5	101			
1956	33	2.6	87			
1957	189	1.7	331			
1958	172	1.5	252			
Total	1,942		4,176			
Average	108	2.2	232			

Table 6

Colorado River Basin

Flow and Quality of Water Data

Colorado River near Cameo, Colorado

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	65	1.23	80	51	1.55	79
	Feb.	67	1.15	77	53	1.43	76
	March	82	1.11	91	64	1.41	90
	April	133	.83	111	119	.92	110
	May	940	.34	322	909	.35	320
	June	803	.28	225	710	.31	220
	July	315	.47	148	247	.59	145
	Aug.	144	.91	131	108	1.19	129
	Sept.	122	.97	118	104	1.12	117
	Oct.	166	.88	146	152	.95	145
	Nov.	124	.96	119	110	1.07	118
	Dec.	104	1.11	115	90	1.27	114
	Total	3,073	.55	1,683	2,717	.61	1,663
1942	Jan.	90	1.24	112	72	1.54	111
	Feb.	86	1.19	102	68	1.48	101
	March	103	1.13	116	80	1.43	115
	April	334	.62	207	316	.65	206
	May	757	.41	311	707	.44	309
	June	1,215	.24	292	1,096	.26	286
	July	407	.44	179	321	.54	175
	Aug.	139	.85	118	94	1.23	116
	Sept.	86	1.15	99	63	1.55	98
	Oct.	94	1.18	111	76	1.44	110
	Nov.	94	1.24	117	76	1.52	116
	Dec.	84	1.26	106	66	1.59	105
	Total	3,489	.54	1,870	3,035	.61	1,848
1943	Jan.	77	1.30	100	63	1.57	99
	Feb.	74	1.26	93	60	1.53	92
	March	89	1.22	109	72	1.50	108
	April	237	.56	133	223	.59	132
	May	509	.32	163	471	.34	161
	June	931	.23	214	839	.25	209
	July	387	.39	151	321	.46	148
	Aug.	192	.73	140	157	.88	138
	Sept.	117	.89	104	100	1.03	103
	Oct.	111	1.00	111	97	1.13	110
	Nov.	115	.90	103	101	1.01	102
	Dec.	107	.93	100	93	1.06	99
	Total	2,946	.52	1,521	2,597	.58	1,501
1944	Jan.	74	1.24	92	61	1.49	91
	Feb.	76	1.11	84	63	1.32	83
	March	81	1.11	90	65	1.37	89
	April	118	.85	100	105	.94	99
	May	564	.36	203	531	.38	201
	June	890	.24	214	809	.26	210
	July	378	.38	143	319	.44	140
	Aug.	123	.80	98	92	1.04	96
	Sept.	78	1.09	85	62	1.35	84
	Oct.	99	1.05	104	86	1.19	103
	Nov.	100	1.01	101	87	1.14	100
	Dec.	99	1.02	101	86	1.16	100
	Total	2,680	.53	1,415	2,366	.59	1,396
1945	Jan.	78	1.15	90	64	1.39	89
	Feb.	72	1.18	85	58	1.45	84
	March	95	.99	94	78	1.19	93
	April	115	.90	104	101	1.02	103
	May	601	.36	216	564	.38	214
	June	795	.27	215	705	.30	211
	July	499	.33	165	434	.37	162
	Aug.	287	.52	149	252	.58	147
	Sept.	118	.83	98	101	.96	97
	Oct.	126	.79	100	112	.88	99
	Nov.	125	.81	101	111	.90	100
	Dec.	117	.89	104	103	1.00	103
	Total	3,028	.50	1,521	2,683	.56	1,502
1946	Jan.	109	.90	98	98	.99	97
	Feb.	91	.97	88	80	1.09	87
	March	99	.94	93	85	1.08	92
	April	285	.45	128	274	.46	127
	May	449	.32	144	419	.34	142
	June	683	.28	193	619	.30	189
	July	267	.51	136	215	.62	133
	Aug.	126	.85	107	99	1.07	106
	Sept.	92	1.01	93	79	1.16	92
	Oct.	122	.89	109	111	.97	108
	Nov.	104	.92	96	93	1.02	95
	Dec.	121	.82	99	110	.89	98
	Total	2,554	.54	1,364	2,282	.60	1,366
1947	Jan.	82	1.04	85	63	1.33	84
	Feb.	82	.99	81	63	1.27	80
	March	107	.96	103	83	1.22	102
	April	178	.63	112	159	.70	111
	May	809	.28	227	756	.30	224
	June	1,027	.25	257	901	.28	251
	July	733	.27	198	641	.30	193
	Aug.	240	.58	139	192	.71	137
	Sept.	143	.78	111	119	.92	110
	Oct.	153	.80	122	134	.83	111
	Nov.	135	.77	104	116	.89	103
	Dec.	118	.86	102	99	1.02	101
	Total	3,807	.43	1,641	3,326	.48	1,607
1948	Jan.	116	.84	97	102	.94	96
	Feb.	111	.81	90	97	.92	89
	March	115	.90	104	97	1.06	103
	April	252	.59	149	238	.62	148
	May	920	.30	276	881	.31	274
	June	844	.26	219	752	.28	214
	July	312	.47	146	244	.59	143
	Aug.	161	.77	124	126	.97	122
	Sept.	88	1.03	91	70	1.28	90
	Oct.	109	1.02	111	95	1.16	110
	Nov.	107	.96	103	93	1.10	102
	Dec.	90	1.04	94	76	1.22	93
	Total	3,225	.50	1,604	2,871	.55	1,584
1949	Jan.	99	.96	95	82	1.15	94
	Feb.	84	.92	77	67	1.13	76
	March	98	.98	96	77	1.23	95
	April	201	.65	131	184	.71	130
	May	572	.36	206	525	.39	204
	June	1,080	.26	281	969	.28	275
	July	594	.34	202	513	.39	198
	Aug.	184	.69	127	141	.89	125
	Sept.	122	.93	113	101	1.11	112
	Oct.	125	.98	123	108	1.13	122
	Nov.	108	1.01	109	91	1.19	108
	Dec.	101	1.05	106	84	1.25	105
	Total	3,368	.49	1,666	2,942	.56	1,644
1950	Jan.	91	1.04	95	87	1.09	95
	Feb.	88	.95	84	84	1.00	84
	March	118	.87	103	113	.91	103
	April	212	.59	125	208	.60	125
	May	418	.40	167	406	.41	166
	June	787	.27	212	759	.28	211
	July	273	.54	147	252	.58	146
	Aug.	124	.87	108	113	.95	107
	Sept.	111	.97	108	106	1.02	108
	Oct.	97	1.19	115	93	1.23	115
	Nov.	98	1.14	112	94	1.19	112
	Dec.	98	1.07	105	94	1.11	105
	Total	2,515	.59	1,481	2,409	.61	1,477
1951	Jan.	96	1.01	97	91	1.06	97
	Feb.	88	.95	84	83	1.01	84
	March	99	1.01	100	92	1.08	100
	April	151	.70	106	146	.73	106
	May	536	.34	182	521	.35	181
	June	857	.27	232	820	.28	230
	July	471	.36	170	444	.38	169
	Aug.	207	.68	141	193	.72	140
	Sept.	111	.90	100	104	.96	100
	Oct.	120	.92	110	115	.96	110
	Nov.	104	.97	101	99	1.02	101
	Dec.	106	.96	102	101	1.01	102
	Total	2,946	.52	1,525	2,809	.54	1,520
1952	Jan.	96	1.01	97	87	1.11	97
	Feb.	84	1.06	89	75	1.19	89
	March	113	.99	112	102	1.09	111
	April	313	.60	188	304	.62	188
	May	978	.36	352	954	.37	351
	June	1,320	.26	343	1,263	.27	340
	July	449	.44	197	409	.48	195
	Aug.	276	.70	193	255	.75	192
	Sept.	171	.78	133	160	.82	132
	Oct.	123	.97	119	114	1.04	119
	Nov.	112	1.04	117	103	1.14	117
	Dec.	99	1.12	111	90	1.23	111
	Total	4,134	.50	2,051	3,916	.52	2,042

Table 6

Colorado River Basin

Flow and Quality of Water Data

Colorado River near Cameo, Colorado

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	99	1.03	102	95	1.07	102
	Feb.	80	1.06	85	76	1.12	85
	March	102	.96	98	97	1.01	98
	April	136	.78	106	132	.80	106
	May	346	.44	152	336	.45	151
	June	866	.27	239	862	.28	238
	July	294	.52	154	277	.55	153
	Aug.	194	.72	140	185	.76	140
	Sept.	101	.99	100	96	1.04	100
	Oct.	101	1.06	107	98	1.09	107
	Nov.	99	1.13	112	96	1.16	112
	Dec.	92	1.17	108	89	1.21	108
	Total	2,530	.59	1,503	2,439	.62	1,500
1954	Jan.	95	1.00	95	93	1.02	95
	Feb.	81	1.05	85	79	1.07	85
	March	94	1.01	95	92	1.03	95
	April	136	.78	106	134	.79	106
	May	296	.48	142	292	.49	142
	June	204	.60	123	195	.63	123
	July	146	.81	118	140	.84	118
	Aug.	105	.97	102	101	1.01	102
	Sept.	103	1.07	110	101	1.09	110
	Oct.	125	.97	121	123	.98	121
	Nov.	98	1.07	105	96	1.09	105
	Dec.	82	1.23	101	80	1.26	101
	Total	1,565	.83	1,303	1,526	.85	1,303
1955	Jan.	74	1.23	91	72	1.26	91
	Feb.	67	1.25	84	65	1.29	84
	March	86	1.13	97	84	1.15	97
	April	142	.77	110	140	.78	110
	May	384	.42	161	378	.42	161
	June	448	.37	166	435	.38	165
	July	214	.61	130	204	.63	129
	Aug.	157	.87	137	152	.90	137
	Sept.	100	.94	94	98	.96	94
	Oct.	91	1.02	93	89	1.04	93
	Nov.	94	1.06	100	92	1.08	100
	Dec.	89	1.07	95	87	1.09	95
	Total	1,946	.70	1,358	1,896	.72	1,356
1956	Jan.	81	1.07	87	79	1.10	87
	Feb.	75	1.11	83	73	1.14	83
	March	104	.98	102	102	1.00	102
	April	184	.66	122	182	.67	122
	May	685	.34	233	679	.34	233
	June	637	.31	197	624	.31	196
	July	173	.70	121	164	.74	121
	Aug.	115	.95	109	110	.99	109
	Sept.	88	.90	79	86	.92	79
	Oct.	93	.95	88	91	.97	88
	Nov.	84	1.07	90	82	1.10	90
	Dec.	73	1.21	88	71	1.24	88
	Total	2,392	.59	1,399	2,343	.60	1,398
1957	Jan.	80	1.10	88	78	1.13	88
	Feb.	77	1.10	85	75	1.13	85
	March	83	1.16	96	81	1.18	96
	April	151	.83	125	149	.84	125
	May	591	.47	278	587	.47	278
	June	1,415	.27	382	1,406	.27	382
	July	1,072	.27	289	1,065	.27	289
	Aug.	338	.50	169	334	.50	169
	Sept.	157	.78	123	155	.79	123
	Oct.	136	.89	121	134	.90	121
	Nov.	123	.91	112	121	.92	112
	Dec.	102	.96	98	100	.98	98
	Total	4,325	.45	1,966	4,285	.46	1,966
1958	Jan.	92	.93	86	91	.94	86
	Feb.	95	.93	88	94	.94	88
	March	123	.89	110	121	.91	110
	April	172	.76	130	171	.76	130
	May	847	.31	263	844	.31	263
	June	808	.27	218	800	.27	218
	July	193	.67	129	187	.69	129
	Aug.	109	.97	106	106	1.00	106
	Sept.	103	1.03	106	101	1.05	106
	Oct.	100	1.09	109	99	1.10	109
	Nov.	94	1.09	102	93	1.09	102
	Dec.	86	1.12	96	85	1.13	96
	Total	2,822	.55	1,543	2,792	.55	1,543

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	3,073	0.55	1,683	2,717	0.61	1,663
1942	3,489	.54	1,870	3,035	.61	1,848
1943	2,946	.52	1,521	2,597	.58	1,501
1944	2,680	.53	1,415	2,366	.59	1,396
1945	3,028	.50	1,521	2,683	.56	1,502
1946	2,554	.54	1,384	2,282	.60	1,366
1947	3,807	.43	1,641	3,326	.48	1,607
1948	3,225	.50	1,604	2,871	.55	1,584
1949	3,368	.49	1,666	2,942	.56	1,644
1950	2,515	.59	1,481	2,409	.61	1,477
1951	2,946	.52	1,525	2,809	.54	1,520
1952	4,134	.50	2,051	3,916	.52	2,042
1953	2,530	.59	1,503	2,439	.62	1,500
1954	1,565	.83	1,303	1,526	.85	1,303
1955	1,946	.70	1,358	1,896	.72	1,356
1956	2,392	.59	1,399	2,343	.60	1,398
1957	4,325	.45	1,966	4,285	.46	1,966
1958	2,822	.55	1,543	2,792	.55	1,543
Total	53,345		28,434	49,234		28,226
Average	2,964	.53	1,580	2,735	.57	1,568

Table 7
Colorado River Basin
Flow and Quality of Water Data
Gunnison River near Grand Junction, Colorado

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	51	1.90	97	52	1.88	98
	Feb.	50	1.82	93	51	1.84	94
	March	63	1.67	105	65	1.63	106
	April	123	1.00	123	125	1.00	125
	May	871	.40	349	865	.41	353
	June	563	.46	259	554	.47	263
	July	192	.94	180	183	1.01	184
	Aug.	95	1.41	134	88	1.56	138
	Sept.	81	2.11	171	76	2.28	174
	Oct.	198	1.35	267	201	1.34	270
	Nov.	121	1.33	161	123	1.32	163
	Dec.	84	1.58	133	86	1.55	134
	Total	2,492	.83	2,072	2,469	.85	2,102
1942	Jan.	71	1.59	113	72	1.58	114
	Feb.	62	1.66	103	63	1.65	104
	March	76	1.64	125	77	1.64	126
	April	546	.52	284	548	.52	286
	May	759	.47	357	754	.48	360
	June	688	.38	261	681	.39	265
	July	167	.93	156	159	1.00	159
	Aug.	68	2.18	148	62	2.44	151
	Sept.	56	2.36	132	52	2.60	135
	Oct.	57	2.58	147	60	2.48	149
	Nov.	65	1.92	125	67	1.89	127
	Dec.	58	1.83	106	59	1.81	107
	Total	2,673	.77	2,057	2,654	.78	2,083
1943	Jan.	57	1.72	98	58	1.71	99
	Feb.	48	1.60	77	49	1.59	78
	March	56	1.55	87	57	1.54	88
	April	280	.44	123	282	.44	124
	May	389	.48	187	385	.49	190
	June	397	.46	183	390	.48	186
	July	113	1.08	122	106	1.18	125
	Aug.	154	1.43	220	150	1.49	223
	Sept.	87	1.59	138	83	1.69	140
	Oct.	69	1.84	127	71	1.82	129
	Nov.	75	1.59	119	77	1.56	120
	Dec.	61	1.57	96	62	1.56	97
	Total	1,786	.88	1,577	1,770	.90	1,599
1944	Jan.	51	1.65	84	52	1.63	85
	Feb.	48	1.44	69	49	1.43	70
	March	53	1.42	75	54	1.41	76
	April	102	.97	99	104	.97	101
	May	758	.32	242	753	.32	245
	June	694	.33	229	687	.34	233
	July	230	.69	159	222	.73	162
	Aug.	51	1.94	99	45	2.27	102
	Sept.	45	2.44	110	41	2.76	113
	Oct.	58	2.31	134	61	2.23	136
	Nov.	71	1.86	132	73	1.84	134
	Dec.	64	1.73	111	65	1.72	112
	Total	2,225	.69	1,543	2,206	.71	1,569
1945	Jan.	55	1.58	87	56	1.57	88
	Feb.	47	1.62	76	48	1.60	77
	March	52	1.48	77	53	1.47	78
	April	91	1.00	91	93	.99	92
	May	628	.35	220	624	.36	223
	June	407	.46	187	400	.48	190
	July	164	.85	139	157	.90	142
	Aug.	122	1.22	149	118	1.29	152
	Sept.	46	2.39	110	42	2.67	112
	Oct.	76	2.00	152	78	1.97	154
	Nov.	73	1.63	119	75	1.60	120
	Dec.	58	1.59	92	59	1.58	93
	Total	1,819	.82	1,499	1,803	.84	1,521
1946	Jan.	58	1.55	90	59	1.54	91
	Feb.	48	1.44	69	49	1.43	70
	March	58	1.28	74	59	1.27	75
	April	182	.59	108	184	.59	109
	May	228	.59	135	223	.62	138
	June	321	.52	167	315	.54	170
	July	64	1.62	104	57	1.88	107
	Aug.	56	2.16	121	51	2.43	124
	Sept.	54	2.31	125	50	2.54	127
	Oct.	69	2.06	140	71	2.00	142
	Nov.	67	1.70	114	69	1.67	115
	Dec.	56	1.55	87	57	1.54	88
	Total	1,261	1.06	1,334	1,244	1.09	1,356
1947	Jan.	45	1.67	75	46	1.65	76
	Feb.	47	1.49	70	48	1.48	71
	March	55	1.27	70	56	1.27	71
	April	96	.82	79	97	.82	80
	May	455	.39	177	451	.40	179
	June	502	.46	231	496	.47	234
	July	242	.64	155	236	.67	158
	Aug.	120	1.50	180	116	1.57	182
	Sept.	95	1.63	155	92	1.71	157
	Oct.	114	1.60	183	116	1.59	185
	Nov.	96	1.35	130	97	1.35	131
	Dec.	70	1.41	99	71	1.41	100
	Total	1,937	.83	1,604	1,922	.85	1,624
1948	Jan.	58	1.38	80	59	1.37	81
	Feb.	65	1.43	93	66	1.42	94
	March	76	1.38	105	77	1.38	106
	April	324	.51	165	325	.51	166
	May	835	.30	251	831	.30	253
	June	546	.40	218	541	.41	220
	July	141	.92	129	135	.97	131
	Aug.	71	1.84	131	67	1.98	133
	Sept.	49	2.25	110	47	2.38	112
	Oct.	57	2.09	119	59	2.05	121
	Nov.	70	1.84	129	71	1.83	130
	Dec.	70	1.64	115	71	1.63	116
	Total	2,362	.70	1,645	2,349	.71	1,663
1949	Jan.	51	1.49	76	51	1.49	76
	Feb.	52	1.48	77	52	1.48	77
	March	69	1.42	98	70	1.41	99
	April	235	.57	134	236	.57	135
	May	481	.38	183	479	.38	184
	June	651	.42	273	648	.42	274
	July	265	.65	172	261	0.66	173
	Aug.	65	1.80	117	63	1.87	118
	Sept.	53	2.15	114	52	2.21	115
	Oct.	70	2.09	146	71	2.07	147
	Nov.	74	1.58	117	75	1.57	118
	Dec.	54	1.74	94	55	1.73	95
	Total	2,120	.76	1,601	2,113	.76	1,611
1950	Jan.	54	1.57	85	54	1.57	85
	Feb.	57	2.00	112	57	1.96	112
	March	60	1.33	80	61	1.33	81
	April	219	.50	110	220	.50	111
	May	309	.45	139	307	.46	140
	June	319	.50	160	316	.51	162
	July	88	1.43	126	84	1.52	128
	Aug.	37	2.16	80	34	2.38	81
	Sept.	46	2.61	120	44	2.75	121
	Oct.	37	2.65	98	38	2.61	99
	Nov.	49	2.12	104	50	2.10	105
	Dec.	60	1.73	104	61	1.72	105
	Total	1,335	.99	1,318	1,326	1.00	1,330
1951	Jan.	47	1.64	77	47	1.64	77
	Feb.	46	1.59	73	46	1.59	73
	March	55	1.27	70	55	1.29	71
	April	62	.97	60	63	.97	61
	May	265	.51	135	263	.52	136
	June	323	.52	168	320	.53	169
	July	93	1.06	99	90	1.11	100
	Aug.	53	1.72	91	50	1.84	92
	Sept.	37	2.30	85	36	2.39	86
	Oct.	49	2.41	118	50	2.38	119
	Nov.	60	1.88	113	61	1.87	114
	Dec.	46	1.65	76	47	1.64	77
	Total	1,136	1.03	1,165	1,128	1.04	1,175
1952	Jan.	53	1.53	81	53	1.53	81
	Feb.	48	1.48	71	48	1.48	71
	March	53	1.41	75	54	1.39	75
	April	342	.46	157	343	.46	158
	May	818	.33	270	816	.33	271
	June	759	.35	266	756	.35	267
	July	201	.79	158	198	.80	159
	Aug.	121	1.54	187	119	1.58	188
	Sept.	76	1.86	141	76	1.87	142
	Oct.	67	1.90	127	68	1.88	126
	Nov.	64	2.00	128	65	1.98	129
	Dec.	72	1.68	121	72	1.68	121
	Total	2,674	.67	1,782	2,668	.67	1,790

Table 7

Colorado River Basin

Flow and Quality of Water Data

Gunnison River near Grand Junction, Colorado

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	65	1.51	98	65	1.51	98
	Feb.	50	1.48	74	50	1.48	74
	March	61	1.26	77	62	1.26	78
	April	86	1.01	87	87	1.01	88
	May	230	.57	131	228	.58	132
	June	437	.43	188	434	.44	189
	July	86	1.13	97	82	1.20	98
	Aug.	67	1.75	117	65	1.82	118
	Sept.	46	2.28	105	45	2.36	106
	Oct.	58	2.40	139	59	2.37	140
	Nov.	74	1.78	132	75	1.77	133
	Dec.	52	1.83	95	53	1.81	96
	Total	1,312	1.02	1,340	1,305	1.03	1,350
1954	Jan.	49	1.75	84	49	1.75	84
	Feb.	45	1.58	71	45	1.58	71
	March	45	1.49	67	46	1.48	68
	April	70	.84	59	71	.85	60
	May	110	.85	93	108	.87	94
	June	39	1.92	75	36	2.11	76
	July	40	2.10	84	36	2.36	85
	Aug.	31	2.64	82	29	2.86	83
	Sept.	52	2.50	130	51	2.57	131
	Oct.	64	1.94	124	65	1.92	125
	Nov.	51	1.92	98	52	1.90	99
	Dec.	49	1.90	93	50	1.88	94
	Total	645	1.64	1,060	638	1.68	1,070
1955	Jan.	46	1.70	78	46	1.70	78
	Feb.	40	1.67	67	40	1.67	67
	March	59	1.47	87	59	1.47	87
	April	108	.74	80	108	.74	80
	May	262	.52	136	261	.52	137
	June	219	.63	138	217	.64	139
	July	46	1.74	80	44	1.84	81
	Aug.	52	1.86	97	51	1.92	98
	Sept.	35	2.48	87	34	2.59	88
	Oct.	38	2.47	94	39	2.44	95
	Nov.	54	2.08	112	55	2.04	112
	Dec.	57	1.65	94	57	1.65	94
	Total	1,016	1.13	1,150	1,011	1.14	1,156
1956	Jan.	50	1.64	82	50	1.64	82
	Feb.	44	1.59	70	44	1.59	70
	March	56	1.30	73	56	1.30	73
	April	142	.60	85	142	.60	85
	May	324	.45	146	324	.45	146
	June	262	.53	139	262	.53	140
	July	37	1.92	71	36	2.00	72
	Aug.	29	2.07	60	29	2.07	60
	Sept.	20	3.15	63	20	3.15	63
	Oct.	34	2.94	100	34	2.94	100
	Nov.	55	1.95	107	55	1.95	107
	Dec.	47	1.87	88	47	1.87	88
	Total	1,100	.99	1,084	1,099	.99	1,086
1957	Jan.	52	1.73	90	52	1.73	90
	Feb.	55	1.69	93	55	1.69	93
	March	56	1.36	76	57	1.35	77
	April	135	.67	91	136	.68	92
	May	554	.44	244	552	.44	245
	June	1,168	.32	374	1,165	.32	375
	July	719	.39	281	715	.39	282
	Aug.	224	.83	186	222	.84	187
	Sept.	108	1.47	159	107	1.50	160
	Oct.	106	1.92	204	107	1.92	205
	Nov.	111	1.33	148	112	1.33	149
	Dec.	92	1.26	116	93	1.26	117
	Total	3,380	.61	2,062	3,373	.61	2,072
1958	Jan.	65	1.40	91	65	1.40	91
	Feb.	70	1.50	105	70	1.50	105
	March	82	1.24	102	82	1.24	102
	April	254	.57	145	254	.57	145
	May	873	.32	279	872	.32	280
	June	570	.42	239	569	.42	240
	July	65	1.52	99	63	1.59	100
	Aug.	43	1.74	75	42	1.81	76
	Sept.	51	2.31	118	51	2.33	119
	Oct.	52	2.42	126	53	2.40	127
	Nov.	71	1.82	129	71	1.82	129
	Dec.	65	1.60	104	65	1.60	104
	Total	2,261	.71	1,612	2,257	.72	1,618

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	2,492	0.83	2,072	2,469	0.85	2,102
1942	2,673	.77	2,057	2,654	.78	2,083
1943	1,786	.88	1,577	1,770	.90	1,599
1944	2,225	.69	1,543	2,206	.71	1,569
1945	1,819	.82	1,499	1,803	.84	1,521
1946	1,261	1.06	1,334	1,244	1.09	1,356
1947	1,937	.83	1,604	1,922	.85	1,624
1948	2,362	.70	1,645	2,349	.71	1,663
1949	2,120	.76	1,601	2,113	.76	1,611
1950	1,335	.99	1,318	1,326	1.00	1,330
1951	1,136	1.03	1,165	1,128	1.04	1,175
1952	2,674	.67	1,782	2,668	.67	1,790
1953	1,312	1.02	1,340	1,305	1.03	1,350
1954	645	1.64	1,060	638	1.68	1,070
1955	1,016	1.13	1,150	1,011	1.14	1,156
1956	1,100	.99	1,084	1,099	.99	1,086
1957	3,380	.61	2,062	3,373	.61	2,072
1958	2,261	.71	1,612	2,257	.72	1,618
Total	33,534		27,505	33,335		27,775
Average	1,863	.82	1,528	1,852	.83	1,543

Table 8
Colorado River Basin
Flow and Quality of Water Data
Colorado River near Cisco, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	139	1.86	259	126	2.05	259
	Feb.	153	1.78	272	140	1.94	272
	March	206	1.64	337	190	1.77	337
	April	445	1.00	445	433	1.03	446
	May	2,355	.42	989	2,286	.44	995
	June	1,582	.46	728	1,449	.51	740
	July	579	.73	423	485	.91	443
	Aug.	251	1.67	419	193	2.27	438
	Sept.	237	1.81	430	206	2.15	443
	Oct.	579	1.10	637	578	1.12	647
	Nov.	311	1.18	367	309	1.22	376
	Dec.	229	1.51	346	226	1.57	354
	Total	7,066	.80	5,652	6,621	.87	5,750
1942	Jan.	161	1.67	302	164	1.84	302
	Feb.	166	1.73	288	149	1.93	288
	March	228	1.52	347	206	1.68	347
	April	1,344	.61	820	1,328	.62	821
	May	1,809	.45	814	1,730	.47	819
	June	1,961	.37	725	1,806	.41	735
	July	579	.78	451	470	.99	467
	Aug.	185	1.84	340	121	2.94	356
	Sept.	134	2.46	329	100	3.42	342
	Oct.	162	2.33	378	157	2.46	386
	Nov.	186	1.99	370	179	2.11	378
	Dec.	164	1.96	322	156	2.11	329
	Total	7,099	.77	5,486	6,566	.85	5,570
1943	Jan.	153	1.90	291	140	2.08	291
	Feb.	146	1.85	270	133	2.03	270
	March	174	1.77	308	158	1.95	308
	April	709	.64	454	697	.65	454
	May	996	.46	458	935	.49	462
	June	1,365	.38	518	1,244	.42	525
	July	502	.78	392	417	.97	405
	Aug.	368	1.26	463	319	1.49	476
	Sept.	212	1.85	392	185	2.17	401
	Oct.	184	1.84	339	180	1.92	346
	Nov.	215	1.47	317	210	1.54	323
	Dec.	190	1.56	296	184	1.64	301
	Total	5,214	.86	4,498	4,802	.95	4,562
1944	Jan.	140	1.77	248	128	1.94	248
	Feb.	152	1.56	237	140	1.69	237
	March	166	1.51	251	151	1.66	251
	April	304	1.09	331	293	1.13	332
	May	1,764	.41	732	1,722	.43	737
	June	1,843	.35	645	1,726	.38	657
	July	677	.61	413	595	.72	430
	Aug.	149	1.62	241	199	1.29	257
	Sept.	99	2.54	252	72	3.68	265
	Oct.	159	2.18	347	159	2.23	355
	Nov.	196	1.78	348	194	1.83	356
	Dec.	171	1.70	291	168	1.77	298
	Total	5,840	.74	4,336	5,547	.80	4,423
1945	Jan.	149	1.73	258	136	1.90	258
	Feb.	151	1.74	263	138	1.90	263
	March	178	1.56	277	162	1.71	277
	April	329	.88	289	317	.91	289
	May	1,495	.36	538	1,435	.38	542
	June	1,311	.37	485	1,192	.41	493
	July	676	.67	453	592	.79	466
	Aug.	446	1.01	451	397	1.17	464
	Sept.	146	1.85	270	119	2.34	279
	Oct.	217	1.75	380	213	1.82	387
	Nov.	224	1.41	316	219	1.47	322
	Dec.	183	1.26	230	177	1.33	235
	Total	5,505	.76	4,210	5,097	.84	4,275
1946	Jan.	174	1.37	239	164	1.46	239
	Feb.	155	1.27	197	145	1.36	197
	March	191	1.24	236	178	1.32	236
	April	525	.61	320	516	.62	320
	May	726	.49	356	672	.54	360
	June	1,027	.42	432	928	.47	441
	July	309	.98	303	237	1.33	316
	Aug.	196	1.66	325	154	2.20	339
	Sept.	135	2.10	283	112	2.61	292
	Oct.	206	1.85	382	205	1.89	389
	Nov.	206	1.56	322	205	1.60	328
	Dec.	208	1.37	285	205	1.42	291
	Total	4,058	.91	3,680	3,721	1.01	3,748

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1947	Jan.	145	1.58	229	127	1.80	229
	Feb.	151	1.44	217	133	1.63	217
	March	189	1.39	263	166	1.58	263
	April	316	.85	268	298	.90	268
	May	1,423	.40	569	1,349	.42	571
	June	1,594	.39	621	1,441	.44	627
	July	985	.47	463	876	.54	473
	Aug.	369	1.21	447	307	1.49	458
	Sept.	259	1.44	373	227	1.68	382
	Oct.	328	1.47	483	318	1.54	489
	Nov.	277	1.24	343	266	1.31	348
	Dec.	223	1.40	312	211	1.50	317
	Total	6,259	.73	4,588	5,719	.81	4,642
1948	Jan.	191	1.34	257	178	1.44	257
	Feb.	210	1.33	280	197	1.42	280
	March	245	1.36	333	228	1.46	333
	April	830	.64	531	817	.65	531
	May	1,959	.36	705	1,906	.37	707
	June	1,499	.39	585	1,390	.42	587
	July	446	.86	384	365	1.07	390
	Aug.	225	1.52	342	180	1.94	349
	Sept.	121	1.88	228	98	2.38	233
	Oct.	175	1.96	344	167	2.08	348
	Nov.	204	1.67	341	195	1.76	344
	Dec.	186	1.66	308	177	1.76	311
	Total	6,291	.74	4,638	5,898	.79	4,670
1949	Jan.	188	1.54	289	171	1.68	288
	Feb.	187	1.35	253	170	1.48	252
	March	243	1.40	340	223	1.52	340
	April	615	.67	412	599	.69	412
	May	1,289	.41	529	1,233	.43	529
	June	1,910	.37	707	1,788	.39	706
	July	908	.55	499	819	.61	501
	Aug.	224	1.58	354	175	2.04	356
	Sept.	156	2.08	328	134	2.47	331
	Oct.	225	1.83	411	212	1.95	413
	Nov.	210	1.71	359	197	1.83	361
	Dec.	180	1.66	299	165	1.82	301
	Total	6,337	.75	4,780	5,886	.81	4,792
1950	Jan.	199	1.52	302	195	1.55	302
	Feb.	201	1.44	289	197	1.47	289
	March	209	1.31	274	205	1.34	275
	April	541	.61	330	538	.61	331
	May	764	.51	389	742	.52	390
	June	1,113	.42	467	1,072	.44	472
	July	347	1.03	357	317	1.15	364
	Aug.	109	2.02	220	91	2.47	225
	Sept.	138	2.12	292	128	2.32	297
	Oct.	125	2.35	294	125	2.38	298
	Nov.	161	1.96	316	161	1.99	320
	Dec.	167	1.75	293	167	1.77	296
	Total	4,074	.94	3,823	3,938	.98	3,859
1951	Jan.	153	1.69	258	148	1.74	258
	Feb.	151	1.51	228	146	1.56	228
	March	161	1.46	236	154	1.54	237
	April	173	1.21	209	169	1.24	210
	May	758	.54	409	733	.56	410
	June	1,173	.43	505	1,123	.45	508
	July	530	.68	360	494	.74	366
	Aug.	238	1.47	350	216	1.65	356
	Sept.	131	2.06	270	120	2.29	275
	Oct.	169	1.99	336	169	2.01	340
	Nov.	178	1.74	310	177	1.77	314
	Dec.	172	1.67	287	171	1.70	291
	Total	3,987	.94	3,758	3,820	.99	3,793
1952	Jan.	191	1.59	303	182	1.66	303
	Feb.	156	1.65	257	147	1.75	257
	March	194	1.48	287	184	1.55	286
	April	969	.53	514	961	.52	515
	May	2,152	.35	753	2,119	.36	754
	June	2,314	.33	764	2,245	.34	766
	July	641	.72	462	593	.79	467
	Aug.	358	1.18	422	331	1.29	427
	Sept.	213	1.58	337	200	1.70	341
	Oct.	166	1.92	318	161	1.99	321
	Nov.	177	1.89	334	172	1.96	337
	Dec.	188	1.66	313	181	1.74	315
	Total	7,719	.66	5,064	7,476	.68	5,089

Table 8
Colorado River Basin
Flow and Quality of Water Data
Colorado River near Cisco, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	185	1.65	306	181	1.69	306
	Feb.	142	1.63	232	138	1.68	232
	March	187	1.52	284	183	1.56	285
	April	250	1.00	250	247	1.02	251
	May	606	.60	364	588	.62	365
	June	1,399	.41	574	1,365	.42	577
	July	353	.95	335	328	1.03	339
	Aug.	256	1.23	315	242	1.32	320
	Sept.	128	2.22	284	120	2.40	288
	Oct.	177	1.89	334	178	1.89	337
	Nov.	207	1.77	366	207	1.78	369
	Dec.	171	1.75	299	171	1.76	301
	Total	4,061	.97	3,943	3,948	1.01	3,970
1954	Jan.	177	1.76	312	175	1.78	312
	Feb.	143	1.65	236	141	1.67	236
	March	161	1.46	236	160	1.48	237
	April	221	.98	217	220	.99	218
	May	436	.74	323	423	.77	325
	June	217	1.17	254	197	1.31	258
	July	150	1.69	253	136	1.90	259
	Aug.	98	2.30	225	89	2.58	230
	Sept.	171	2.09	358	167	2.17	362
	Oct.	215	1.59	342	217	1.59	345
	Nov.	164	1.70	278	165	1.70	281
	Dec.	140	1.90	266	141	1.91	269
	Total	2,293	1.44	3,300	2,231	1.49	3,332
1955	Jan.	134	1.84	247	132	1.87	247
	Feb.	121	1.78	215	119	1.81	215
	March	198	1.33	263	196	1.34	263
	April	321	.82	263	319	.82	263
	May	752	.50	376	741	.51	378
	June	689	.55	379	669	.57	381
	July	214	1.21	259	199	1.32	262
	Aug.	185	1.66	307	177	1.76	311
	Sept.	108	2.16	233	103	2.29	236
	Oct.	119	2.19	261	120	2.19	263
	Nov.	169	1.89	319	170	1.88	320
	Dec.	176	1.70	299	175	1.71	300
	Total	3,186	1.07	3,421	3,120	1.10	3,439
1956	Jan.	155	1.69	262	153	1.71	262
	Feb.	141	1.70	239	139	1.72	239
	March	187	1.50	281	185	1.52	281
	April	356	.72	256	354	.72	256
	May	1,005	.45	452	998	.45	452
	June	924	.44	406	910	.45	407
	July	172	1.47	253	161	1.58	255
	Aug.	119	1.97	234	113	2.08	235
	Sept.	81	2.38	193	79	2.45	194
	Oct.	121	2.22	269	120	2.24	269
	Nov.	165	1.87	308	163	1.89	308
	Dec.	142	1.94	275	140	1.96	275
	Total	3,568	.96	3,428	3,515	.98	3,433
1957	Jan.	164	1.80	296	162	1.83	296
	Feb.	168	1.55	260	166	1.57	260
	March	167	1.56	260	166	1.57	261
	April	398	.86	342	397	.86	343
	May	1,375	.44	605	1,361	.45	607
	June	2,859	.29	829	2,837	.29	834
	July	1,952	.37	722	1,936	.38	729
	Aug.	661	.83	549	650	.85	555
	Sept.	314	1.21	380	309	1.24	385
	Oct.	292	1.78	520	295	1.77	523
	Nov.	300	1.44	431	302	1.44	434
	Dec.	239	1.71	408	241	1.70	411
	Total	8,889	.63	5,602	8,822	.64	5,638
1958	Jan.	200	1.52	304	199	1.53	304
	Feb.	225	1.34	302	224	1.35	302
	March	254	1.29	328	252	1.30	328
	April	756	.50	380	755	.50	380
	May	2,032	.34	684	2,022	.34	686
	June	1,560	.40	624	1,545	.41	628
	July	234	1.22	285	222	1.31	290
	Aug.	109	2.17	236	102	2.35	240
	Sept.	153	2.14	328	150	2.21	331
	Oct.	155	2.04	317	157	2.04	320
	Nov.	190	1.66	315	191	1.66	317
	Dec.	176	1.63	287	177	1.63	288
	Total	6,044	.73	4,390	5,996	.74	4,414

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	7,066	0.80	5,652	6,621	0.87	5,750
1942	7,099	.77	5,486	6,566	.85	5,570
1943	5,214	.86	4,498	4,802	.95	4,562
1944	5,840	.74	4,336	5,547	.80	4,423
1945	5,505	.76	4,210	5,097	.84	4,275
1946	4,058	.91	3,680	3,721	1.01	3,748
1947	6,259	.73	4,588	5,719	.81	4,642
1948	6,291	.74	4,638	5,898	.79	4,670
1949	6,337	.75	4,780	5,886	.81	4,792
1950	4,074	.94	3,823	3,938	.98	3,859
1951	3,987	.94	3,758	3,820	.99	3,793
1952	7,719	.66	5,064	7,476	.68	5,089
1953	4,061	.97	3,943	3,948	1.01	3,970
1954	2,293	1.44	3,300	2,231	1.49	3,332
1955	3,186	1.07	3,421	3,120	1.10	3,439
1956	3,568	.96	3,428	3,515	.98	3,433
1957	8,889	.63	5,602	8,822	.64	5,638
1958	6,044	.73	4,390	5,996	.74	4,414
Total	97,490		78,597	92,723		79,399
Average	5,416	.80	4,367	5,151	.86	4,411

Table 9
Colorado River Basin
Flow and Quality of Water Data
San Juan River near Archuleta, New Mexico

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	22	0.41	9	Same as historical		
	Feb.	46	.35	16			
	March	98	.38	37			
	April	251	.21	53			
	May	709	.16	110			
	June	560	.12	68			
	July	324	.14	46			
	Aug.	84	.19	16			
	Sept.	68	.24	16			
	Oct.	273	.12	33			
	Nov.	87	.17	15			
	Dec.	52	.21	11			
	Total	2,574	.17	430			
1942	Jan.	45	.33	15			
	Feb.	48	.25	12			
	March	54	.42	23			
	April	383	.21	82			
	May	320	.15	48			
	June	310	.12	38			
	July	76	.18	14			
	Aug.	41	.22	9			
	Sept.	28	.25	7			
	Oct.	23	.26	6			
	Nov.	22	.27	6			
	Dec.	16	.38	6			
	Total	1,366	.19	266			
1943	Jan.	16	.44	7			
	Feb.	26	.35	9			
	March	55	.38	21			
	April	198	.19	37			
	May	184	.16	30			
	June	134	.15	20			
	July	51	.24	12			
	Aug.	48	.21	10			
	Sept.	28	.25	7			
	Oct.	35	.20	7			
	Nov.	24	.29	7			
	Dec.	19	.32	6			
	Total	818	.21	173			
1944	Jan.	16	.38	6			
	Feb.	19	.32	6			
	March	34	.47	16			
	April	131	.21	27			
	May	371	.16	61			
	June	382	.13	49			
	July	134	.16	22			
	Aug.	45	.20	9			
	Sept.	43	.23	10			
	Oct.	41	.22	9			
	Nov.	21	.29	6			
	Dec.	14	.43	6			
	Total	1,251	.18	227			
1945	Jan.	14	.43	6			
	Feb.	22	.45	10			
	March	35	.49	17			
	April	143	.20	28			
	May	278	.16	44			
	June	209	.13	28			
	July	68	.21	14			
	Aug.	40	.22	9			
	Sept.	21	.24	5			
	Oct.	30	.37	11			
	Nov.	19	.37	7			
	Dec.	12	.46	6			
	Total	891	.21	185			
1946	Jan.	14	.43	6			
	Feb.	17	.47	8			
	March	22	.50	11			
	April	66	.23	15			
	May	73	.18	13			
	June	87	.18	16			
	July	27	.33	9			
	Aug.	40	.35	14			
	Sept.	29	.31	9			
	Oct.	36	.31	11			
	Nov.	26	.35	9			
	Dec.	19	.32	6			
	Total	456	.28	127			
1947	Jan.	15	0.40	6	Same as historical		
	Feb.	24	.38	9			
	March	32	.34	11			
	April	50	.24	12			
	May	186	.17	32			
	June	140	.13	18			
	July	43	.28	12			
	Aug.	73	.30	22			
	Sept.	56	.23	13			
	Oct.	77	.21	16			
	Nov.	37	.22	8			
	Dec.	27	.26	7			
	Total	760	.22	166			
1948	Jan.	27	.26	7			
	Feb.	39	.33	13			
	March	43	.35	15			
	April	246	.20	49			
	May	306	.14	43			
	June	338	.12	40			
	July	79	.16	13			
	Aug.	49	.24	12			
	Sept.	22	.32	7			
	Oct.	23	.35	8			
	Nov.	18	.39	7			
	Dec.	13	.46	6			
	Total	1,203	.18	220			
1949	Jan.	16	.44	7			
	Feb.	25	.36	9			
	March	73	.37	27			
	April	228	.24	55			
	May	318	.15	48			
	June	406	.13	53			
	July	199	.15	30			
	Aug.	57	.24	14			
	Sept.	33	.27	9			
	Oct.	30	.30	9			
	Nov.	21	.38	8			
	Dec.	14	.50	7			
	Total	1,420	.19	276			
1950	Jan.	16	.37	6			
	Feb.	29	.41	12			
	March	31	.42	13			
	April	116	.19	22			
	May	126	.15	19			
	June	112	.16	18			
	July	44	.27	12			
	Aug.	20	.35	7			
	Sept.	24	.38	9			
	Oct.	20	.35	7			
	Nov.	14	.50	7			
	Dec.	12	.50	6			
	Total	564	.24	138			
1951	Jan.	10	.50	5			
	Feb.	11	.45	5			
	March	20	.45	9			
	April	35	.29	10			
	May	117	.18	21			
	June	94	.17	16			
	July	21	.38	8			
	Aug.	33	.36	12			
	Sept.	22	.36	8			
	Oct.	17	.47	8			
	Nov.	15	.47	7			
	Dec.	18	.44	8			
	Total	413	.28	117			
1952	Jan.	19	.53	10			
	Feb.	19	.53	10			
	March	47	.49	23			
	April	326	.26	85			
	May	396	.16	63			
	June	454	.13	59			
	July	136	.18	24			
	Aug.	66	.26	17			
	Sept.	33	.27	9			
	Oct.	22	.32	7			
	Nov.	16	.44	7			
	Dec.	18	.39	7			
	Total	1,552	.21	321			

Table 9
Colorado River Basin
Flow and Quality of Water Data
San Juan River near Archuleta, New Mexico

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	18	0.39	7	Same as historical		
	Feb.	18	.39	7			
	March	37	.41	15			
	April	75	.24	18			
	May	117	.19	22			
	June	148	.15	22			
	July	41	.32	13			
	Aug.	33	.33	11			
	Sept.	16	.44	7			
	Oct.	23	.43	10			
	Nov.	23	.43	10			
	Dec.	14	.50	7			
	Total	563	.26	149			
1954	Jan.	11	.45	5			
	Feb.	21	.48	10			
	March	28	.46	13			
	April	90	.21	19			
	May	143	.18	26			
	June	67	.19	13			
	July	37	.41	15			
	Aug.	45	.29	13			
	Sept.	30	.43	13			
	Oct.	42	.24	10			
	Nov.	18	.39	7			
	Dec.	13	.46	6			
	Total	545	.28	150			
1955	Jan.	12	.42	5			
	Feb.	13	.31	4			
	March	27	.37	10			
	April	45	.24	11			
	May	132	.18	24			
	June	119	.16	19			
	July	42	.29	12			
	Aug.	67	.28	19			
	Sept.	28	.29	8			
	Oct.	20	.30	6			
	Nov.	17	.35	6			
	Dec.	15	.40	6			
	Total	537	.24	130			

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1956	Jan.	16	0.38	6	Same as historical		
	Feb.	15	.40	6			
	March	48	.33	16			
	April	79	.20	16			
	May	174	.14	24			
	June	117	.15	18			
	July	25	.32	8			
	Aug.	23	.35	8			
	Sept.	11	.36	4			
	Oct.	12	.42	5			
	Nov.	11	.45	5			
	Dec.	9	.44	4			
	Total	540	.22	120			
1957	Jan.	13	.46	6			
	Feb.	30	.47	14			
	March	46	.43	20			
	April	120	.28	34			
	May	222	.19	42			
	June	480	.13	62			
	July	326	.16	52			
	Aug.	164	.22	36			
	Sept.	67	.19	13			
	Oct.	67	.30	20			
	Nov.	68	.26	18			
	Dec.	44	.30	13			
	Total	1,647	.20	330			
1958	Jan.	22	.36	8			
	Feb.	51	.43	22			
	March	77	.42	32			
	April	279	.30	84			
	May	460	.17	78			
	June	270	.13	35			
	July	42	.26	11			
	Aug.	35	.31	11			
	Sept.	40	.30	12			
	Oct.	25	.36	9			
	Nov.	17	.41	7			
	Dec.	14	.43	6			
	Total	1,332	.24	315			

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	2,574	0.17	430	Same	as	Historical
1942	1,366	.19	266			
1943	818	.21	173			
1944	1,251	.18	227			
1945	891	.21	185			
1946	456	.28	127			
1947	760	.22	166			
1948	1,203	.18	220			
1949	1,420	.19	276			
1950	564	.24	138			
1951	413	.28	117			
1952	1,552	.21	321			
1953	563	.26	149			
1954	545	.28	150			
1955	537	.24	130			
1956	540	.22	120			
1957	1,647	.20	330			
1958	1,332	.24	315			
Total	18,432		3,840			
Average	1,024	0.21	213			

Table 10
Colorado River Basin
Flow and Quality of Water Data
San Juan River near Bluff, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	78	1.01	79	Same as historical		
	Feb.	127	.98	124			
	March	211	.78	165			
	April	392	.62	243			
	May	1,323	.50	662			
	June	915	.30	275			
1941	July	526	.30	158			
	Aug.	174	.70	122			
	Sept.	202	.87	176			
	Oct.	655	.64	419			
	Nov.	191	.61	117			
	Dec.	104	.81	84			
	Total	4,898	.54	2,624			
	Jan.	81	.93	75			
	Feb.	68	.93	63			
	March	126	.95	120			
	April	602	.51	307			
	May	479	.38	182			
	June	533	.26	139			
1942	July	150	.48	72			
	Aug.	51	.82	42			
	Sept.	38	1.00	38			
	Oct.	37	1.22	45			
	Nov.	39	1.23	48			
	Dec.	43	1.26	54			
	Total	2,247	.53	1,185			
	Jan.	43	1.26	54			
	Feb.	49	1.18	58			
	March	95	1.09	104			
	April	293	.47	138			
	May	332	.39	129			
	June	254	.38	96			
1943	July	106	.57	60			
	Aug.	91	1.01	92			
	Sept.	62	.90	56			
	Oct.	58	1.00	58			
	Nov.	59	.97	57			
	Dec.	51	1.12	57			
	Total	1,493	.64	959			
	Jan.	37	1.16	43			
	Feb.	49	1.14	56			
	March	76	1.06	81			
	April	204	.62	126			
	May	640	.36	230			
	June	705	.25	176			
1944	July	283	.35	99			
	Aug.	61	.85	52			
	Sept.	66	.92	61			
	Oct.	75	.91	68			
	Nov.	52	1.12	58			
	Dec.	43	1.19	51			
	Total	2,291	.48	1,101			
	Jan.	41	1.22	50			
	Feb.	63	1.13	71			
	March	72	1.03	74			
	April	196	.61	120			
	May	456	.35	160			
	June	377	.29	109			
1945	July	128	.50	64			
	Aug.	96	1.13	108			
	Sept.	22	1.18	26			
	Oct.	62	1.10	68			
	Nov.	46	1.04	48			
	Dec.	30	1.27	38			
	Total	1,589	.59	936			
	Jan.	37	1.14	42			
	Feb.	36	1.19	43			
	March	47	1.04	49			
	April	95	.66	63			
	May	125	.49	61			
1946	June	204	.40	82			
	July	63	.86	54			
	Aug.	75	1.12	84			
	Sept.	44	.93	41			
	Oct.	55	.98	54			
	Nov.	60	1.02	61			
	Dec.	46	1.02	47			
	Total	887	.77	681			
	Jan.	31	1.13	35	Same as historical		
	Feb.	45	1.07	48			
	March	51	.90	46			
	April	68	.63	43			
	May	329	.38	125			
	June	276	.30	83			
1947	July	110	.41	45			
	Aug.	294	1.01	296			
	Sept.	124	.73	91			
	Oct.	207	.78	163			
	Nov.	77	.73	56			
	Dec.	65	.86	56			
	Total	1,677	.65	1,087			
	Jan.	52	.83	43			
	Feb.	79	.84	66			
	March	90	.83	75			
	April	358	.37	133			
	May	519	.27	140			
	June	603	.28	169			
1948	July	147	.41	60			
	Aug.	86	.78	67			
	Sept.	36	1.11	40			
	Oct.	75	1.05	79			
	Nov.	55	1.07	59			
	Dec.	41	1.12	46			
	Total	2,141	.46	977			
	Jan.	63	1.11	70			
	Feb.	74	.99	73			
	March	152	.81	123			
	April	338	.45	152			
	May	503	.31	156			
	June	748	.31	232			
	July	342	.33	113			
1949	Aug.	90	.66	59			
	Sept.	42	1.05	44			
	Oct.	56	1.00	56			
	Nov.	45	1.07	48			
	Dec.	34	1.26	43			
	Total	2,487	.47	1,169			
	Jan.	41	1.12	46			
	Feb.	49	1.08	53			
	March	56	.93	52			
	April	136	.46	62			
	May	169	.40	68			
	June	191	.38	73			
1950	July	68	.72	49			
	Aug.	15	1.13	17			
	Sept.	42	1.14	48			
	Oct.	30	1.07	32			
	Nov.	25	1.44	36			
	Dec.	32	1.34	43			
	Total	854	.68	579			
	Jan.	30	1.30	39			
	Feb.	29	1.41	41			
	March	34	1.15	39			
	April	34	.85	29			
	May	142	.51	72			
	June	188	.36	68			
1951	July	30	.80	24			
	Aug.	49	1.06	52			
	Sept.	45	1.07	48			
	Oct.	35	1.23	43			
	Nov.	39	1.10	43			
	Dec.	36	1.28	46			
	Total	691	.79	544			
	Jan.	88	1.16	102			
	Feb.	40	1.20	48			
	March	87	1.03	90			
	April	453	.42	190			
	May	618	.30	185			
	June	769	.24	185			
1952	July	238	.42	100			
	Aug.	83	.69	57			
	Sept.	56	.93	52			
	Oct.	38	1.05	40			
	Nov.	41	1.29	53			
	Dec.	43	1.26	54			
	Total	2,554	.45	1,156			

Table 10
Colorado River Basin
Flow and Quality of Water Data
San Juan River near Bluff, Utah

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	42	1.24	52	Same as historical		
	Feb.	36	1.17	42			
	March	56	1.02	57			
	April	107	.64	68			
	May	156	.44	69			
	June	267	.27	72			
	July	77	.84	65			
	Aug.	71	1.15	82			
	Sept.	12	1.50	18			
	Oct.	54	1.28	69			
	Nov.	55	1.13	62			
	Dec.	35	1.31	46			
	Total	968	.73	702			
1954	Jan.	32	1.34	43			
	Feb.	36	1.17	42			
	March	48	1.02	49			
	April	113	.53	60			
	May	218	.39	85			
	June	120	.48	58			
	July	120	1.03	123			
	Aug.	66	.86	57			
	Sept.	89	1.19	106			
	Oct.	95	.75	71			
	Nov.	39	1.05	41			
	Dec.	35	1.26	44			
	Total	1,011	.77	779			
1955	Jan.	31	1.26	39			
	Feb.	34	1.12	38			
	March	63	1.00	63			
	April	62	.74	46			
	May	186	.38	71			
	June	208	.32	67			
	July	65	.88	57			
	Aug.	143	1.07	153			
	Sept.	28	.82	23			
	Oct.	25	1.00	25			
	Nov.	31	1.26	39			
	Dec.	35	1.34	47			
	Total	911	.73	668			
1956	Jan.	41	1.22	50	Same as historical		
	Feb.	34	1.29	44			
	March	75	.83	62			
	April	107	.50	54			
	May	241	.35	84			
	June	203	.31	63			
	July	31	1.10	34			
	Aug.	36	1.33	48			
	Sept.	4	1.50	6			
	Oct.	13	1.54	20			
	Nov.	30	1.23	37			
	Dec.	25	1.40	35			
	Total	840	.64	537			
1957	Jan.	38	1.26	48			
	Feb.	64	1.05	67			
	March	71	.97	69			
	April	171	.55	94			
	May	327	.48	157			
	June	786	.28	220			
	July	566	.38	215			
	Aug.	364	.63	229			
	Sept.	142	.68	97			
	Oct.	150	.86	129			
	Nov.	141	.72	102			
	Dec.	88	.81	71			
	Total	2,908	.51	1,498			
1958	Jan.	53	1.02	54			
	Feb.	119	.92	109			
	March	159	.87	139			
	April	413	.48	198			
	May	742	.26	193			
	June	507	.25	126			
	July	74	.65	48			
	Aug.	42	1.02	43			
	Sept.	61	.95	58			
	Oct.	47	1.04	49			
	Nov.	43	1.23	53			
	Dec.	36	1.28	46			
	Total	2,296	.49	1,116			

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	4,898	0.54	2,624	Same as Historical		
1942	2,247	.53	1,185			
1943	1,493	.64	959			
1944	2,291	.48	1,101			
1945	1,589	.59	936			
1946	887	.77	681			
1947	1,677	.65	1,087			
1948	2,141	.46	977			
1949	2,487	.47	1,169			
1950	854	.68	579			
1951	691	.79	544			
1952	2,554	.45	1,156			
1953	968	.73	702			
1954	1,011	.77	779			
1955	911	.73	668			
1956	840	.64	537			
1957	2,908	.51	1,498			
1958	2,296	.49	1,116			
Total	32,743		18,298			
Average	1,819	0.56	1,017			

Table 11

Colorado River Basin

Flow and Quality of Water Data

Colorado River at Lees Ferry, Arizona

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	Jan.	348	1.36	474	337	1.41	476
	Feb.	423	1.29	546	411	1.33	547
	March	668	1.12	749	652	1.15	749
	April	1,091	.79	862	1,076	.80	863
	May	4,974	.45	2,239	4,873	.46	2,249
	June	4,004	.38	1,522	3,837	.40	1,541
	July	1,666	.51	850	1,552	.57	880
	Aug.	798	1.16	925	727	1.31	955
	Sept.	608	1.35	821	571	1.48	844
	Oct.	1,797	1.09	1,959	1,802	1.10	1,976
	Nov.	903	.94	849	906	.95	863
	Dec.	576	1.19	685	576	1.21	697
	Total	17,856	.70	12,481	17,320	.73	12,640
1942	Jan.	407	1.34	545	391	1.40	546
	Feb.	396	1.28	507	380	1.34	508
	March	630	1.16	731	608	1.20	731
	April	2,844	.55	1,564	2,826	.55	1,565
	May	3,209	.46	1,476	3,105	.48	1,485
	June	4,202	.29	1,219	4,019	.31	1,235
	July	1,317	.57	751	1,190	.65	777
	Aug.	454	1.08	490	379	1.36	516
	Sept.	275	1.59	438	234	1.96	459
	Oct.	334	1.58	528	334	1.62	542
	Nov.	368	1.58	582	365	1.63	595
	Dec.	357	1.54	550	353	1.59	561
	Total	14,793	.63	9,381	14,184	.67	9,520
1943	Jan.	330	1.50	494	318	1.56	495
	Feb.	332	1.41	469	320	1.47	470
	March	516	1.19	614	500	1.23	614
	April	1,450	.67	971	1,435	.68	971
	May	2,158	.43	928	2,072	.45	934
	June	2,729	.40	1,092	2,578	.43	1,104
	July	1,429	.47	672	1,327	.52	693
	Aug.	793	1.09	864	733	1.21	885
	Sept.	448	1.15	514	415	1.28	530
	Oct.	378	1.60	604	378	1.63	616
	Nov.	456	1.35	616	454	1.38	626
	Dec.	395	1.36	537	393	1.39	546
	Total	11,414	.73	8,375	10,923	.78	8,484
1944	Jan.	278	1.50	418	268	1.57	420
	Feb.	344	1.32	454	333	1.37	455
	March	509	1.31	668	494	1.35	668
	April	1,027	.89	914	1,013	.90	915
	May	3,251	.47	1,528	3,159	.49	1,537
	June	4,136	.32	1,323	3,986	.34	1,341
	July	1,782	.45	802	1,679	.49	829
	Aug.	417	1.07	446	353	1.34	473
	Sept.	229	1.50	343	193	1.89	365
	Oct.	342	1.66	567	348	1.67	582
	Nov.	384	1.51	579	387	1.53	592
	Dec.	320	1.51	483	321	1.54	494
	Total	13,019	.66	8,525	12,534	.69	8,671
1945	Jan.	325	1.48	481	313	1.54	482
	Feb.	351	1.39	489	339	1.44	490
	March	437	1.28	559	421	1.33	559
	April	755	.99	748	741	1.01	748
	May	2,805	.44	1,234	2,720	.46	1,240
	June	2,761	.37	1,021	2,615	.39	1,034
	July	1,668	.47	784	1,568	.51	806
	Aug.	1,011	.89	900	951	.97	921
	Sept.	370	1.28	474	337	1.45	490
	Oct.	505	1.51	763	505	1.54	776
	Nov.	443	1.34	594	442	1.37	604
	Dec.	337	1.35	454	335	1.38	463
	Total	11,768	.72	8,501	11,287	.76	8,613
1946	Jan.	366	1.28	468	357	1.31	469
	Feb.	319	1.24	396	310	1.28	397
	March	496	1.15	570	483	1.18	570
	April	1,013	.83	841	1,002	.84	841
	May	1,732	.47	814	1,653	.50	821
	June	1,993	.43	857	1,864	.47	872
	July	730	.73	533	639	.87	555
	Aug.	478	1.28	612	425	1.49	635
	Sept.	310	1.62	502	282	1.84	519
	Oct.	403	1.50	604	407	1.51	617
	Nov.	466	1.30	607	469	1.31	617
	Dec.	445	1.22	542	446	1.24	552
	Total	8,751	.84	7,346	8,337	.89	7,465
1947	Jan.	277	1.40	388	260	1.50	389
	Feb.	357	1.29	462	340	1.36	463
	March	654	1.09	713	631	1.13	713
	April	780	.78	608	759	.80	608
	May	3,121	.39	1,217	3,017	.40	1,221
	June	3,275	.40	1,310	3,087	.43	1,321
	July	1,926	.43	828	1,796	.47	846
	Aug.	1,203	.98	1,179	1,128	1.06	1,198
	Sept.	584	1.13	660	547	1.23	676
	Oct.	818	1.17	956	814	1.19	969
	Nov.	585	1.07	626	578	1.10	635
	Dec.	466	1.21	564	459	1.25	573
	Total	14,046	.68	9,513	13,416	.72	9,612
1948	Jan.	406	1.18	479	394	1.22	480
	Feb.	458	1.14	522	446	1.17	522
	March	645	1.14	735	628	1.17	735
	April	1,703	.64	1,090	1,688	.65	1,090
	May	3,507	.38	1,333	3,436	.39	1,337
	June	3,339	.34	1,135	3,211	.35	1,141
	July	980	.65	637	891	.73	649
	Aug.	531	1.23	653	479	1.39	666
	Sept.	230	1.40	322	203	1.64	333
	Oct.	331	1.65	545	326	1.70	553
	Nov.	408	1.46	595	400	1.50	602
	Dec.	347	1.40	485	339	1.44	490
	Total	12,885	.66	8,531	12,441	.69	8,598
1949	Jan.	337	1.39	469	320	1.46	468
	Feb.	361	1.25	451	344	1.31	450
	March	706	1.18	834	686	1.21	834
	April	1,307	.78	1,020	1,288	.79	1,020
	May	3,098	.43	1,332	3,014	.44	1,333
	June	4,419	.41	1,812	4,260	.42	1,813
	July	2,137	.52	1,111	2,028	.55	1,118
	Aug.	576	1.00	576	521	1.12	585
	Sept.	313	1.51	473	285	1.68	480
	Oct.	509	1.48	753	501	1.51	757
	Nov.	473	1.31	619	464	1.34	623
	Dec.	368	1.37	504	357	1.42	508
	Total	14,604	.68	9,954	14,068	.71	9,989
1950	Jan.	350	1.41	493	347	1.42	494
	Feb.	398	1.23	490	394	1.24	490
	March	650	1.11	721	646	1.12	722
	April	1,217	.74	900	1,210	.74	901
	May	1,971	.49	966	1,916	.51	968
	June	2,979	.37	1,102	2,896	.38	1,111
	July	1,377	.67	923	1,320	.71	935
	Aug.	422	1.02	430	392	1.12	440
	Sept.	330	1.47	485	315	1.57	495
	Oct.	342	1.47	502	349	1.46	509
	Nov.	350	1.55	542	354	1.55	548
	Dec.	415	1.31	544	420	1.31	549
	Total	10,801	.75	8,098	10,559	.77	8,162
1951	Jan.	315	1.43	451	311	1.45	452
	Feb.	361	1.25	451	356	1.27	451
	March	417	1.19	497	410	1.21	498
	April	531	1.00	531	523	1.02	532
	May	1,645	.57	938	1,593	.59	940
	June	2,886	.41	1,184	2,804	.42	1,191
	July	1,357	.48	651	1,304	.51	662
	Aug.	787	1.11	874	756	1.17	885
	Sept.	411	1.32	542	397	1.39	552
	Oct.	412	1.47	606	416	1.47	613
	Nov.	445	1.41	628	447	1.42	634
	Dec.	333	1.44	480	335	1.45	486
	Total	9,900	.79	7,833	9,652	.82	7,896
1952	Jan.	476	1.23	586	467	1.25	586
	Feb.	379	1.26	478	370	1.29	478
	March	440	1.31	576	430	1.34	575
	April	2,267	.74	1,677	2,254	.74	1,678
	May	5,081	.41	2,083	5,019	.41	2,084
	June	5,192	.36	1,869	5,089	.37	1,874
	July	1,573	.55	865	1,510	.58	875
	Aug.	821	1.06	870	787	1.12	880
	Sept.	542	1.31	710	526	1.37	719
	Oct.	369	1.43	527	364	1.46	532
	Nov.	386	1.55	599	381	1.58	604
	Dec.	378	1.47	556	373	1.50	560
	Total	17,904	.64	11,396	17,570	.65	11,445

Table 11
Colorado River Basin
Flow and Quality of Water Data
Colorado River at Lees Ferry, Arizona

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	394	1.36	536	390	1.37	536
	Feb.	365	1.30	475	361	1.31	475
	March	458	1.22	558	454	1.23	559
	April	529	1.07	566	523	1.08	567
	May	1,047	.69	723	1,010	.72	725
	June	2,992	.38	1,137	2,934	.39	1,142
1953	July	950	.64	608	912	.68	617
	Aug.	661	1.19	787	642	1.24	797
	Sept.	258	1.59	410	248	1.68	418
	Oct.	321	1.77	568	324	1.77	573
	Nov.	414	1.50	621	416	1.50	626
	Dec.	341	1.46	498	344	1.46	502
	Total	8,730	.86	7,487	8,558	.88	7,537
	Jan.	318	1.46	465	316	1.47	465
	Feb.	342	1.30	444	340	1.30	444
	March	393	1.24	487	392	1.24	488
	April	546	1.00	546	545	1.00	547
	May	1,277	.56	715	1,255	.57	718
	June	792	.63	499	757	.67	506
1954	July	647	.87	563	621	.92	574
	Aug.	321	1.19	382	307	1.28	392
	Sept.	389	1.66	645	383	1.70	653
	Oct.	512	1.43	733	519	1.42	738
	Nov.	349	1.39	485	354	1.38	490
	Dec.	278	1.51	421	282	1.51	426
	Total	6,164	1.04	6,385	6,071	1.06	6,441
	Jan.	244	1.58	386	242	1.59	386
	Feb.	243	1.39	338	241	1.40	338
	March	580	1.29	748	578	1.29	748
	April	617	1.05	649	615	1.05	649
	May	1,570	.56	879	1,551	.57	882
	June	1,586	.49	777	1,551	.50	781
1955	July	571	.70	399	548	.74	406
	Aug.	510	1.40	713	498	1.45	721
	Sept.	230	1.60	368	223	1.67	373
	Oct.	214	1.70	363	219	1.67	367
	Nov.	275	1.67	458	280	1.65	461
	Dec.	326	1.44	470	327	1.44	472
	Total	6,966	.94	6,548	6,873	.96	6,584
	Jan.	373	1.28	477	371	1.28	477
	Feb.	280	1.39	390	278	1.40	390
	March	511	1.16	592	509	1.16	592
	April	898	.75	673	896	.75	673
	May	2,190	.48	1,051	2,166	.48	1,052
	June	2,594	.39	1,012	2,546	.40	1,015
1956	July	557	.75	418	538	.79	424
	Aug.	356	1.33	473	347	1.38	478
	Sept.	166	1.48	246	163	1.52	248
	Oct.	187	1.74	325	193	1.69	326
	Nov.	300	1.58	474	304	1.56	475
	Dec.	247	1.55	383	250	1.54	384
	Total	8,659	.75	6,514	8,561	.76	6,534
	Jan.	284	1.46	415	283	1.47	416
	Feb.	323	1.34	433	321	1.35	433
	March	499	1.23	613	498	1.23	614
	April	828	.90	745	827	.90	746
	May	2,569	.56	1,439	2,548	.57	1,442
	June	5,645	.39	2,201	5,614	.39	2,209
1957	July	4,015	.43	1,727	3,989	.44	1,738
	Aug.	1,604	.78	1,251	1,587	.79	1,261
	Sept.	822	1.03	847	814	1.05	855
	Oct.	748	1.48	1,107	755	1.47	1,113
	Nov.	848	1.39	1,179	853	1.39	1,184
	Dec.	517	1.25	646	521	1.25	651
	Total	18,702	.67	12,603	18,610	.68	12,662
	Jan.	397	1.27	504	396	1.27	504
	Feb.	536	1.18	632	535	1.18	632
	March	696	1.10	766	694	1.10	766
	April	1,574	.64	1,007	1.573	.64	1,007
	May	3,992	.46	1,836	3,977	.46	1,838
	June	3,678	.40	1,471	3,658	.40	1,477
1958	July	628	.74	465	612	.77	474
	Aug.	286	1.43	409	276	1.51	417
	Sept.	320	1.69	540	316	1.73	546
	Oct.	311	1.62	505	315	1.62	509
	Nov.	357	1.65	589	360	1.64	592
	Dec.	366	1.52	556	368	1.52	558
	Total	13,141	.71	9,280	13,080	.71	9,320

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	17,856	0.70	12,481	17,320	0.73	12,640
1942	14,793	.63	9,381	14,184	.67	9,520
1943	11,414	.73	8,375	10,923	.78	8,484
1944	13,019	.66	8,525	12,534	.69	8,671
1945	11,768	.72	8,501	11,287	.76	8,613
1946	8,751	.84	7,346	8,337	.89	7,465
1947	14,046	.68	9,513	13,416	.72	9,612
1948	12,885	.66	8,531	12,441	.69	8,598
1949	14,604	.68	9,954	14,068	.71	9,989
1950	10,801	.75	8,098	10,559	.77	8,162
1951	9,900	.79	7,833	9,652	.82	7,896
1952	17,904	.64	11,396	17,570	.65	11,445
1953	8,730	.86	7,487	8,558	.88	7,537
1954	6,164	1.04	6,385	6,071	1.06	6,441
1955	6,966	.94	6,548	6,873	.96	6,584
1956	8,659	.75	6,514	8,561	.76	6,534
1957	18,702	.67	12,603	18,610	.68	12,662
1958	13,141	.71	9,280	13,080	.71	9,320
Total	220,103		158,751	214,044		160,173
Average	12,228	0.72	8,820	11,891	0.75	8,899

Table 12
Colorado River Basin
Flow and Quality of Water Data
Colorado River near Grand Canyon, Arizona

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	434	1.42	616			
	Feb.	515	1.31	675			
	March	838	1.17	980			
	April	1,209	.87	1,052			
	May	4,976	.50	2,488			
	June	4,100	.45	1,845			
- 1941	July	1,753	.55	964			
	Aug.	861	1.29	1,111			
	Sept.	659	1.43	942			
	Oct.	1,904	1.14	2,171			
	Nov.	953	.98	934			
	Dec.	594	1.22	725			
	Total	18,796	0.77	14,503			
	Jan.	430	1.40	602			
	Feb.	435	1.33	579			
	March	653	1.25	816			
	April	2,763	.60	1,658			
	May	3,163	.49	1,550			
	June	4,241	.32	1,357			
- 1942	July	1,345	.59	794			
	Aug.	486	1.15	559			
	Sept.	294	1.67	491			
	Oct.	356	1.67	575			
	Nov.	386	1.67	645			
	Dec.	373	1/1.50	560			
	Total	14,925	.68	10,206			
	Jan.	347	1/1.49	517			
	Feb.	351	1/1.48	519			
	March	580	1/1.26	731			
	April	1,417	1/ .83	1,176			
	May	2,161	1/ .57	1,232			
	June	2,676	1/ .49	1,311			
- 1943	July	1,459	1/ .60	875			
	Aug.	834	1/1.17	976			
	Sept.	494	1/1.40	692			
	Oct.	408	1.69	690			
	Nov.	477	1.47	701			
	Dec.	420	1.46	613			
	Total	11,624	.86	10,033			
	Jan.	298	1.61	480			
	Feb.	363	1.23	446			
	March	551	1.41	777			
	April	1,099	.95	1,044			
	May	3,206	.55	1,763			
	June	4,144	.41	1,699			
- 1944	July	1,854	.52	964			
	Aug.	456	1.14	520			
	Sept.	251	1.61	404			
	Oct.	362	1.78	644			
	Nov.	401	1.64	658			
	Dec.	345	1.59	549			
	Total	13,330	.75	9,948			
	Jan.	356	1.55	552			
	Feb.	381	1.48	564			
	March	472	1.41	666			
	April	804	1.01	812			
	May	2,803	.52	1,458			
	June	2,754	.48	1,322			
- 1945	July	1,732	.56	970			
	Aug.	1,071	1.05	1,125			
	Sept.	394	1.38	544			
	Oct.	524	1.63	854			
	Nov.	465	1.51	702			
	Dec.	359	1.47	528			
	Total	12,115	.83	10,097			
	Jan.	384	1.41	541			
	Feb.	333	1.38	460			
	March	514	1.29	663			
	April	1,016	.94	955			
	May	1,775	.53	941			
	June	1,995	.54	1,077			
- 1946	July	784	.82	643			
	Aug.	567	1.50	850			
	Sept.	372	1.71	636			
	Oct.	419	1.62	679			
	Nov.	492	1.39	684			
	Dec.	468	1.31	613			
	Total	9,119	.96	8,742			

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	303	1.50	455			
	Feb.	371	1.38	512			
	March	653	1.18	771			
	April	785	.92	722			
	May	3,088	.48	1,482			
	June	3,233	.48	1,552			
- 1947	July	1,953	.50	976			
	Aug.	1,329	1.17	1,555			
	Sept.	640	1.26	806			
	Oct.	894	1.28	1,144			
	Nov.	608	1.14	693			
	Dec.	490	1.28	627			
	Total	14,347	.79	11,295			
	Jan.	427	1.27	542			
	Feb.	458	1.28	586			
	March	669	1.25	836			
	April	1,732	.74	1,282			
	May	3,392	.45	1,526			
	June	3,358	.40	1,343			
- 1948	July	1,009	.73	737			
	Aug.	587	1.33	781			
	Sept.	242	1.65	399			
	Oct.	336	1.82	612			
	Nov.	434	1.61	699			
	Dec.	365	1.25	456			
	Total	13,009	.75	9,799			
	Jan.	363	1.51	548			
	Feb.	374	1.36	509			
	March	796	1.20	955			
	April	1,337	.92	1,230			
	May	2,959	.48	1,420			
	June	4,303	.48	2,065			
- 1949	July	2,128	.58	1,234			
	Aug.	632	1.12	708			
	Sept.	340	1.65	561			
	Oct.	521	1.58	823			
	Nov.	488	1.36	664			
	Dec.	381	1.41	537			
	Total	14,622	.77	11,254			
	Jan.	358	1.56	558			
	Feb.	414	1.35	559			
	March	670	1.21	811			
	April	1,192	.88	1,049			
	May	1,941	.59	1,145			
	June	2,925	.47	1,375			
- 1950	July	1,401	.76	1,065			
	Aug.	444	1.13	502			
	Sept.	343	1.56	535			
	Oct.	359	1.67	600			
	Nov.	355	1.75	621			
	Dec.	434	1.48	642			
	Total	10,836	.87	9,462			
	Jan.	326	1.59	518			
	Feb.	366	1.45	531			
	March	429	1.35	579			
	April	535	1.17	626			
	May	1,552	.67	1,040			
	June	2,800	.49	1,372			
- 1951	July	1,397	.57	796			
	Aug.	833	1.18	983			
	Sept.	452	1.46	660			
	Oct.	425	1.67	710			
	Nov.	466	1.61	750			
	Dec.	353	1.61	568			
	Total	9,934	.92	9,133			
	Jan.	593	1.28	759			
	Feb.	396	1.42	562			
	March	435	1.46	635			
	April	2,209	.84	1,855			
	May	5,062	.52	2,632			
	June	5,203	.46	2,393			
- 1952	July	1,590	.65	1,033			
	Aug.	833	1.18	983			
	Sept.	596	1.43	852			
	Oct.	393	1.52	597			
	Nov.	396	1.64	649			
	Dec.	400	1.58	632			
	Total	18,106	.75	13,582			

Table 12

Colorado River Basin

Flow and Quality of Water Data

Colorado River near Grand Canyon, Arizona

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	408	1.46	596			
	Feb.	378	1.42	537			
	March	478	1.35	645			
	April	533	1.21	645			
	May	989	.87	860			
	June	2,932	.47	1,378			
	July	980	.76	745			
	Aug.	703	1.30	914			
	Sept.	290	1.73	502			
	Oct.	325	1.88	611			
	Nov.	428	1.63	698			
	Dec.	360	1.56	562			
	Total	8,804	.99	8,693			
1954	Jan.	333	1.58	526			
	Feb.	353	1.40	494			
	March	424	1.34	568			
	April	566	1.11	628			
	May	1,211	.68	823			
	June	798	.68	543			
	July	669	.95	636			
	Aug.	349	1.32	461			
	Sept.	415	1.67	693			
	Oct.	526	1.52	800			
	Nov.	360	1.47	529			
	Dec.	296	1.60	474			
	Total	6,300	1.14	7,175			
1955	Jan.	261	1.70	444			
	Feb.	269	1.50	404			
	March	586	1.35	791			
	April	621	1.15	714			
	May	1,515	.59	894			
	June	1,596	.55	878			
	July	618	.77	476			
	Aug.	668	1.39	929			
	Sept.	265	1.63	432			
	Oct.	236	1.84	434			
	Nov.	298	1/1.88	560			
	Dec.	354	1/1.52	538			
	Total	7,287	1.03	7,494			
1956	Jan.	398	1/1.42	565			
	Feb.	310	1.30	403			
	March	511	1.21	618			
	April	878	.82	720			
	May	2,125	.49	1,041			
	June	2,584	.45	1,163			
	July	598	.82	490			
	Aug.	383	1.31	502			
	Sept.	185	1.58	292			
	Oct.	202	1.86	376			
	Nov.	325	1.69	549			
	Dec.	274	1.66	455			
	Total	8,773	.82	7,174			
1957	Jan.	343	1.45	497			
	Feb.	370	1.37	507			
	March	541	1.26	682			
	April	812	.93	755			
	May	2,501	.57	1,426			
	June	5,541	.40	2,216			
	July	4,033	.40	1,613			
	Aug.	1,672	.88	1,471			
	Sept.	884	1.13	999			
	Oct.	784	1.46	1,144			
	Nov.	892	1.42	1,266			
	Dec.	537	1.28	687			
	Total	18,910	.70	13,263			
1958	Jan.	415	1.31	544			
	Feb.	536	1.24	665			
	March	749	1.13	846			
	April	1,580	.83	1,311			
	May	3,900	.45	1,755			
	June	3,763	.41	1,542			
	July	683	.91	622			
	Aug.	337	1/1.60	539			
	Sept.	379	1/1.54	584			
	Oct.	346	1/1.76	609			
	Nov.	385	1/1.65	635			
	Dec.	388	1/1.47	570			
	Total	13,461	.76	10,222			

1/ Correlated.

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	18,796	0.77	14,503			
1942	14,925	.68	10,206			
1943	11,624	.86	10,033			
1944	13,330	.75	9,948			
1945	12,115	.83	10,097			
1946	9,119	.96	8,742			
1947	14,347	.79	11,295			
1948	13,009	.75	9,799			
1949	14,622	.77	11,254			
1950	10,836	.87	9,462			
1951	9,934	.92	9,133			
1952	18,106	.75	13,582			
1953	8,804	.99	8,693			
1954	6,300	1.14	7,175			
1955	7,287	1.03	7,494			
1956	8,773	.82	7,174			
1957	18,910	.70	13,263			
1958	13,461	.76	10,222			
Total	224,298		182,075			
Average	12,461	0.81	10,115			

Table 13

Colorado River Basin

Flow and Quality of Water Data

Colorado River below Hoover Dam, Arizona-Nevada

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	589	1.08	636			
	Feb.	500	1.11	555			
	March	552	1.10	607			
	April	518	1.08	560			
	May	1,435	1.08	1,550			
	June	1,810	1.07	1,935			
-1941	July	951	1.06	1,007			
	Aug.	1,429	.97	1,386			
	Sept.	1,576	.94	1,481			
	Oct.	1,641	.95	1,559			
	Nov.	1,817	.90	1,636			
	Dec.	2,071	.85	1,760			
	Total	14,889	.99	14,672			
	Jan.	2,011	.87	1,749			
	Feb.	1,550	.89	1,380			
	March	1,425	.93	1,325			
	April	1,301	.95	1,235			
	May	1,343	.94	1,263			
	June	1,561	.93	1,451			
-1942	July	1,285	.91	1,169			
	Aug.	846	.92	778			
	Sept.	1,025	.91	933			
	Oct.	1,163	.94	1,093			
	Nov.	1,095	.93	1,018			
	Dec.	1,157	.94	1,089			
	Total	15,762	.92	14,481			
	Jan.	1,109	1.00	1,109			
	Feb.	823	.99	816			
	March	971	1.00	971			
	April	915	1.00	915			
	May	1,029	1.00	1,029			
	June	1,040	1.01	1,050			
-1943	July	1,109	.99	1,098			
	Aug.	1,042	.99	1,032			
	Sept.	1,042	.97	1,010			
	Oct.	1,179	.90	1,061			
	Nov.	1,179	.86	1,014			
	Dec.	1,277	.86	1,098			
	Total	12,715	.96	12,203			
	Jan.	1,303	.88	1,147			
	Feb.	1,269	.97	1,231			
	March	1,307	.96	1,254			
	April	1,170	.97	1,135			
	May	1,216	.98	1,192			
	June	1,097	.95	1,042			
-1944	July	1,111	.93	1,033			
	Aug.	1,211	.92	1,113			
	Sept.	1,132	.89	1,007			
	Oct.	1,226	1/.94	1,152			
	Nov.	1,186	1/.99	1,174			
	Dec.	1,199	.94	1,127			
	Total	14,427	.94	13,607			
	Jan.	1,239	.93	1,152			
	Feb.	1,100	1/.96	1,056			
	March	1,250	2/.96	1,200			
	April	1,042	1/.95	990			
	May	1,068	1/.90	961			
	June	1,014	2/.91	923			
-1945	July	861	.92	792			
	Aug.	885	1/.93	823			
	Sept.	869	1/.90	782			
	Oct.	1,080	1/.88	950			
	Nov.	1,042	1/.90	938			
	Dec.	1,062	1/.89	945			
	Total	12,512	.92	11,512			
	Jan.	1,116	.87	971			
	Feb.	1,047	1/.95	994			
	March	1,004	.88	884			
	April	892	.89	794			
	May	903	1/.96	867			
	June	817	1/.92	752			
-1946	July	838	.90	754			
	Aug.	751	1/.91	683			
	Sept.	759	2/.91	691			
	Oct.	857	1/.92	788			
	Nov.	762	2/.91	693			
	Dec.	859	1/.90	773			
	Total	10,605	91	9,644			
	Jan.	984	0.90	886			
	Feb.	886	.91	806			
	March	956	.92	879			
	April	859	1/.99	850			
	May	951	1/1.03	979			
	June	919	1/.95	873			
-1947	July	925	.96	888			
	Aug.	865	1/.92	796			
	Sept.	843	2/.92	776			
	Oct.	828	1/.92	762			
	Nov.	880	2/.92	810			
	Dec.	1,063	1/.92	978			
	Total	10,959	.94	10,283			
	Jan.	1,169	2/.93	1,087			
	Feb.	1,138	1/.93	1,058			
	March	1,150	1/.93	1,070			
	April	1,202	1/.97	1,166			
	May	1,142	1/.93	1,062			
	June	1,076	1/.88	947			
-1948	July	1,156	1/.86	994			
	Aug.	968	2/.86	833			
	Sept.	981	1/.85	834			
	Oct.	917	1/.80	734			
	Nov.	1,028	.88	905			
	Dec.	1,124	1/.91	1,023			
	Total	13,051	.90	11,713			
	Jan.	1,212	.83	1,006			
	Feb.	1,214	1/.84	1,020			
	March	1,291	1/.85	1,097			
	April	1,178	1/.86	1,013			
	May	1,026	1/.83	852			
	June	986	.87	858			
-1949	July	1,020	.84	857			
	Aug.	1,062	.80	850			
	Sept.	1,141	.78	890			
	Oct.	1,176	.75	882			
	Nov.	1,022	1/.83	848			
	Dec.	1,238	.87	1,077			
	Total	13,566	.83	11,250			
	Jan.	1,277	.83	1,060			
	Feb.	1,132	.81	917			
	March	1,246	.85	1,059			
	April	1,089	.85	926			
	May	1,120	1/.84	941			
	June	960	1/.83	797			
-1950	July	982	.79	776			
	Aug.	872	1/.82	715			
	Sept.	824	1/.79	651			
	Oct.	848	.89	755			
	Nov.	815	.88	717			
	Dec.	851	.86	732			
	Total	12,016	.84	10,046			
	Jan.	928	.87	807			
	Feb.	756	.87	658			
	March	860	.91	783			
	April	796	.93	740			
	May	898	.92	826			
	June	691	.91	629			
-1951	July	783	.92	720			
	Aug.	.907	.93	844			
	Sept.	848	.92	780			
	Oct.	756	.93	703			
	Nov.	818	.93	761			
	Dec.	829	.91	754			
	Total	9,870	.91	9,005			
	Jan.	1,070	.90	963			
	Feb.	1,212	.93	1,127			
	March	1,371	.94	1,289			
	April	1,385	.94	1,302			
	May	1,532	.94	1,440			
	June	1,432	.91	1,303			
-1952	July	1,304	.83	1,082			
	Aug.	1,307	.79	1,033			
	Sept.	1,359	.73	992			
	Oct.	1,291	.69	891			
	Nov.	1,215	.66	802			
	Dec.	1,338	.88	1,177			
	Total	15,816	.85	13,401			

Table 13

Colorado River Basin

Flow and Quality of Water Data

Colorado River below Hoover Dam, Arizona-Nevada

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1953	Jan.	1,227	0.93	1,141			
	Feb.	1,043	.91	949			
	March	1,046	.93	973			
	April	971	.94	913			
	May	998	.91	908			
	June	819	.89	729			
	July	897	.87	780			
	Aug.	968	.87	842			
	Sept.	968	.86	832			
	Oct.	802	.86	690			
	Nov.	749	.86	644			
	Dec.	814	.85	692			
	Total	11,302	.89	10,093			
1954	Jan.	836	.88	736			
	Feb.	721	.94	678			
	March	911	.95	865			
	April	975	.94	916			
	May	1,101	.93	1,024			
	June	929	.94	873			
	July	1,027	.94	965			
	Aug.	888	.97	861			
	Sept.	933	.97	905			
	Oct.	776	.94	729			
	Nov.	676	.95	642			
	Dec.	741	.97	719			
	Total	10,514	.94	9,913			
1955	Jan.	725	.99	718			
	Feb.	705	1.04	733			
	March	906	1.08	978			
	April	882	1.11	979			
	May	928	1.12	1,039			
	June	680	1.12	762			
	July	847	1.11	940			
	Aug.	789	1.12	884			
	Sept.	622	1.11	690			
	Oct.	526	1.12	589			
	Nov.	487	1.12	545			
	Dec.	492	1.09	536			
	Total	8,589	1.09	9,393			
1956	Jan.	583	1.09	635			
	Feb.	499	1.10	549			
	March	769	1.12	861			
	April	840	1.14	958			
	May	748	1.15	860			
	June	784	1.17	917			
	July	782	1.19	931			
	Aug.	696	1.17	814			
	Sept.	610	1.15	702			
	Oct.	490	1.16	568			
	Nov.	554	1.12	620			
	Dec.	457	1.10	503			
	Total	7,812	1.14	8,918			
1957	Jan.	534	1.07	571			
	Feb.	470	1.08	508			
	March	739	1.11	820			
	April	890	1.09	970			
	May	769	1.07	823			
	June	828	1.06	878			
	July	786	1.05	825			
	Aug.	786	1.03	810			
	Sept.	785	1.02	801			
	Oct.	697	1.02	711			
	Nov.	958	.99	948			
	Dec.	1,081	.94	1,016			
	Total	9,323	1.04	9,681			
1958	Jan.	1,245	.90	1,120			
	Feb.	846	.94	795			
	March	1,435	.90	1,292			
	April	1,473	.88	1,296			
	May	1,115	.84	937			
	June	819	.85	696			
	July	894	.85	760			
	Aug.	911	.83	756			
	Sept.	792	.83	657			
	Oct.	728	.82	597			
	Nov.	746	.82	612			
	Dec.	873	.83	725			
	Total	11,877	.86	10,243			

1/ Estimated from data taken near intake towers of Lake Mead.
2/ Average of adjacent values

Annual Summary

Year	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
1941	14,889	.99	14,672			
1942	15,762	.92	14,481			
1943	12,715	.96	12,203			
1944	14,427	.94	13,607			
1945	12,512	.92	11,512			
1946	10,605	.91	9,644			
1947	10,959	.94	10,283			
1948	13,051	.90	11,713			
1949	13,566	.83	11,250			
1950	12,016	.84	10,046			
1951	9,870	.91	9,005			
1952	15,816	.85	13,401			
1953	11,302	.89	10,093			
1954	10,514	.94	9,913			
1955	8,589	1.09	9,393			
1956	7,812	1.14	8,918			
1957	9,323	1.04	9,681			
1958	11,877	.86	10,243			
Total	215,605		200,058			
Average	11,978	.93	11,114			

Table 14

Colorado River Basin

Flow and Quality of Water Data

Colorado River at Parker Dam, Arizona-California

Units - 1000

Year	Month	Historical Flow (A.F.)	Historical Concentration (T./A.F.)	Historical T.D.S. (Tons)	Present Modified Flow (A.F.)	Present Modified Concentration (T./A.F.)	Present Modified T.D.S. (Tons)
	Jan.	550					
	Feb.	501					
	March	730					
	April	765	0.96	734			
	May	675	.98	662			
	June	862	.97	836			
-1951	July	945	.94	888			
	Aug.	944	.94	887			
	Sept.	723	.93	672			
	Oct.	709					
	Nov.	560	1.00	560			
	Dec.	707	1.09	771			
	Total	8,671					
	Jan.	1,104	1.06	1,170			
	Feb.	1,134	.92	1,043			
	March	1,424	.79	1,125			
	April	1,300	.93	1,209			
	May	1,443	.93	1,342			
	June	1,419	.95	1,348			
-1952	July	1,263	.86	1,086			
	Aug.	1,296	.79	1,024			
	Sept.	1,321	.88	1,162			
	Oct.	1,234	.76	938			
	Nov.	1,172	.90	1,055			
	Dec.	1,303	.82	1,068			
	Total	15,413	.88	13,570			
	Jan.	1,198					
	Feb.	1,020					
	March	947					
	April	808					
	May	953	.96	915			
	June	956					
-1953	July	1,093					
	Aug.	1,056					
	Sept.	823	.86	708			
	Oct.	634					
	Nov.	527					
	Dec.	634					
	Total	10,649					
	Jan.	797					
	Feb.	661					
	March	782					
	April	864					
	May	1,015	.93	944			
	June	883					
-1954	July	1,000					
	Aug.	982					
	Sept.	754	.91	686			
	Oct.	636					
	Nov.	638					
	Dec.	659					
	Total	9,671					
	Jan.	734					
	Feb.	598					
	March	732					
	April	758					
	May	792	1.09	863			
	June	866					
-1955	July	963					
	Aug.	849					
	Sept.	694					
	Oct.	499	1.11	554			
	Nov.	369					
	Dec.	286					
	Total	8,140					
	Jan.	317					
	Feb.	366					
	March	628					
	April	684					
	May	671	1.15	772			
	June	787					
-1956	July	865					
	Aug.	823					
	Sept.	634					
	Oct.	486	1.20	583			
	Nov.	321					
	Dec.	288					
	Total	6,870					
	Jan.	243					
	Feb.	349					
	March	589					
	April	732					
	May	645	1.15	742			
	June	783					
-1957	July	891					
	Aug.	817					
	Sept.	661	1.11	734			
	Oct.	503					
	Nov.	781					
	Dec.	1,005					
	Total	7,999					
	Jan.	1,285					
	Feb.	565					
	March	1,345					
	April	1,333	.88	1,173			
	May	1,013	.94	952			
	June	854	.86	734			
-1958	July	930					
	Aug.	967					
	Sept.	714	.82	585			
	Oct.	610					
	Nov.	623	.86	536			
	Dec.	753					
	Total	10,892					
	Jan.						
	Feb.						
	March						
	April						
	May						
	June						
-	July						
	Aug.						
	Sept.						
	Oct.						
	Nov.						
	Dec.						
	Total						

Table 15

Colorado River Basin

Flow and Quality of Water Data

Colorado River at Imperial Dam, Arizona-California

Units - 1000

Year	Month	Historical			Present Modified		
		Flow (A.F.)	Concentration (T./A.F.)	T.D.S. (Tons)	Flow (A.F.)	Concentration (T./A.F.)	T.D.S. (Tons)
	Jan.	558					
	Feb.	498					
	March	635					
	April	744	1.13	841			
	May	606	1.13	685			
	June	702	1.03	723			
- 1951	July	820	.98	804			
	Aug.	853	.99	844			
	Sept.	697	.98	683			
	Oct.	682	1.03	702			
	Nov.	559	1.12	626			
	Dec.	698	1.13	789			
	Total	8,052					
	Jan.	1,058	1.11	1,174			
	Feb.	1,107	1.00	1,107			
	March	1,424	.92	1,310			
	April	1,279	.96	1,228			
	May	1,345	.97	1,305			
	June	1,309	.96	1,257			
- 1952	July	1,182	.93	1,099			
	Aug.	1,178	.91	1,072			
	Sept.	1,219	.89	1,085			
	Oct.	1,240	.83	1,029			
	Nov.	1,176	.87	1,023			
	Dec.	1,298	.83	1,077			
	Total	14,820	.93	13,766			
	Jan.						
	Feb.						
	March						
	April						
	May						
	June						
-	July						
	Aug.						
	Sept.						
	Oct.						
	Nov.						
	Dec.						
	Total						

Table 16

(Units: 1000 except cfs) Dissolved Constituent Loads of Green River at Green River, Utah

	Mean discharge (cfs)	Mean discharge (a.f.)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Total Ca + Mg + Na	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total HCO_3 + SO_4 + Cl	Dissolved solids (tons)
			Ionic loads in equivalents per million times flow in acre-feet								
Oct.	1898	117	436	364	574	1374	413	780	191	1384	116
Nov.	2275	135	533	435	619	1586	514	879	195	1588	133
Dec.	1265	78	357	288	403	1047	342	572	136	1051	86
Year 1933											
Jan.	1455	89	374	272	362	1009	365	508	136	1009	82
Feb.	1678	93	367	276	390	1032	363	529	144	1036	85
Mar.	3095	190	711	594	910	2215	638	1298	274	2210	187
Apr.	4505	268	922	684	1037	2643	874	1477	311	2662	223
May	10770	662	1682	1033	1384	4099	1974	1748	358	4079	331
June	23030	1370	2672	1124	1137	4933	3015	1480	329	4824	397
July	5426	334	930	494	727	2152	857	1068	217	2142	180
Aug.	1752	108	365	256	403	1024	346	562	130	1039	87
Sept.	1345	80	315	231	376	921	264	546	124	934	78
Total		3524	9662	6049	8322	24034	9964	11447	2545	23957	1985
Oct.	1232	76	271	230	373	874	247	496	130	873	73
Nov.	1486	88	343	305	470	1118	333	630	157	1121	94
Dec.	1392	86	371	317	472	1160	354	657	152	1163	98
Year 1934											
Jan.	1625	100	428	370	535	1332	417	739	172	1328	111
Feb.	2149	119	470	393	597	1459	449	825	189	1462	123
Mar.	2155	133	482	403	640	1525	472	871	205	1548	130
Apr.	2927	174	494	343	545	1382	505	704	197	1406	117
May	4632	285	555	282	459	1295	629	510	160	1299	108
June	2128	127	272	156	237	664	309	274	82	665	54
July	645	40	114	85	148	347	131	168	46	345	29
Aug.	712	44	144	108	227	478	162	246	74	482	40
Sept.	603	36	139	94	175	408	124	220	67	410	34
Total		1306	4083	3085	4876	12045	4132	6339	1631	12103	1010

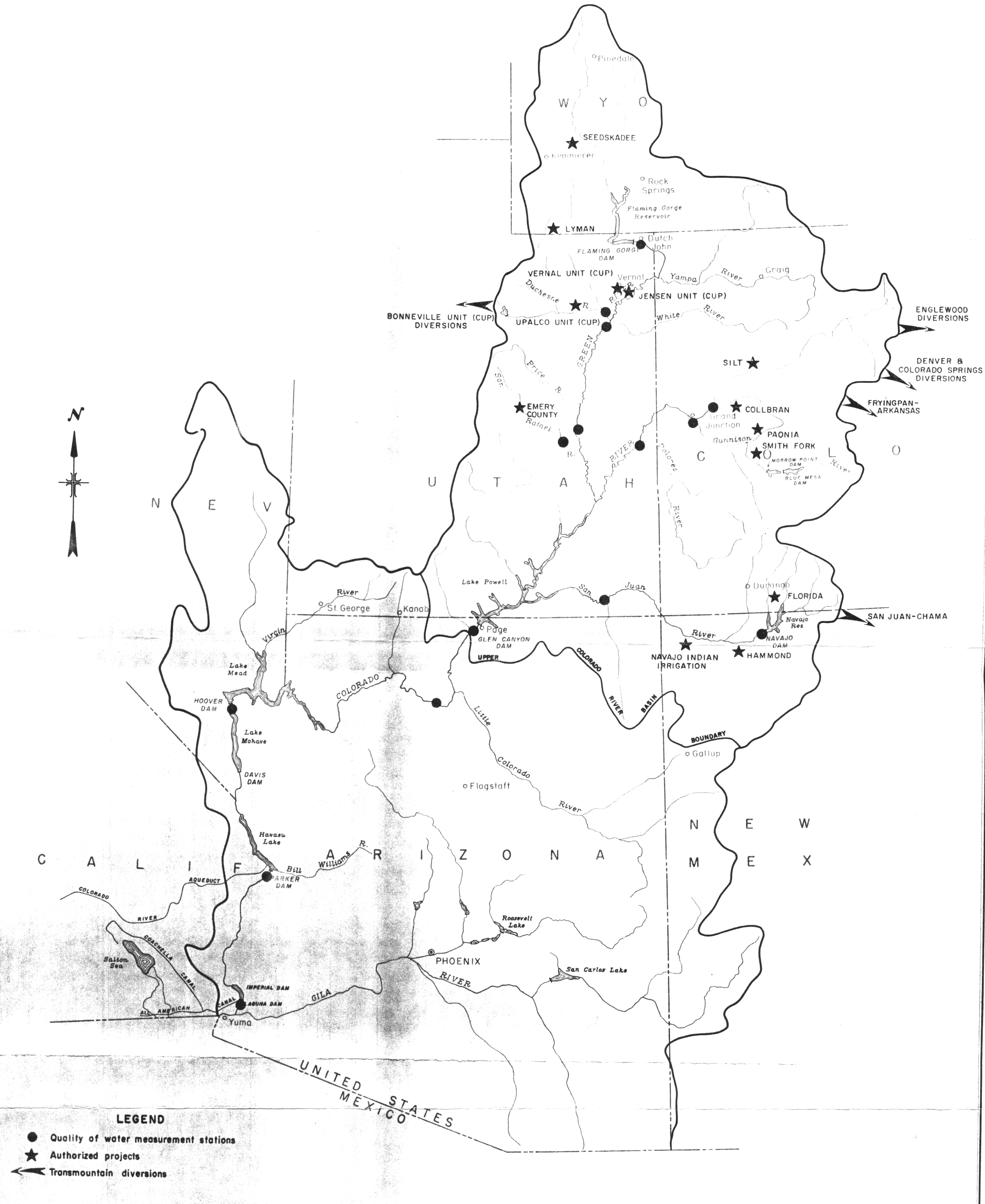
Table 17
PROJECTS DEPLETING COLORADO RIVER WATER

Increment No. 1
Storage Units of the Colorado River Storage Project

Storage unit	Depletions (Reservoir losses--ac.ft.)
Glen Canyon	556,000
Flaming Gorge	56,000
Navajo	36,000
Curecanti	15,000
Subtotal	663,000

Project and state	Depletions (Acre-feet)	New irrig. land (Acres)
Increment No. 2 — Participating projects and other miscellaneous projects		
Lyman, Wyoming	0	0
Silt, Colorado	6,000	2,120
Paonia, Colorado	10,000	2,230
Emery County, Utah	17,000	770
Florida, Colorado	14,000	5,730
Hammond, New Mexico	9,000	3,000
Seedskadee, Wyoming	128,000	43,420
Smith Fork, Colorado	6,000	1,420
Central Utah, Utah		
Bonneville Unit	167,000	1/
Jensen Unit	0	0
Upalco	0	0
Vernal Unit	12,000	0
Denver, Colo. Springs, and Englewood diversions, Colorado	191,000	1/
Collbran, Colorado	7,000	2,460
Potash Development, Utah	8,000	--
Utah Construction Co., New Mexico	39,000	--
Utah Power & Light Co., Wyoming	17,000	--
Subtotal	631,000	61,150
Increment No. 3 — San Juan-Chama and Navajo Indian Irrigation Projects		
San Juan-Chama, Colorado-New Mexico	104,000	1/
Navajo Indian Irrigation, New Mexico	2/259,000	110,000
Subtotal	363,000	110,000
Increment No. 4 — Fryingpan-Arkansas Project		
Fryingpan-Arkansas, Colorado	68,000	1/
Subtotal	68,000	
Total (all developments)	1,725,000	171,150

1/ Transmountain Diversion.
2/ Also includes uses by miscellaneous areas in San Juan River Basin.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLORADO RIVER BASIN

QUALITY OF WATER MAP

25 0 25 50 75 100 125 150

SCALE OF MILES

65-400-70

JULY 17, 1962
REVISED SEPT. 1962

FIGURE 1

Table 18

Summary of anticipated effects of additional developments on quality of water at eleven stations

Units--1,000 except concentrations

Present modified condition, and Effects of storage unit operations - Increment No. 1

Station (1)	Present modified condition: Flow (AF) (2)	Concentration (T/AF) (3)	T.D.S. (T) (4)	Increment No. 1 project	Flow adjustment (AF) (5)	Flow (AF) (6)	Concentration (T/AF) (7)	T.D.S. adjustment (T) (8)	T.D.S. (T) (9)
Green River near Greendale, Utah	1,719	0.52	901	Flaming Gorge Unit	-57	1,662	0.54	-3	898
Duchesne River near Randlett, Utah	445	1.00	443						
Green River near Ouray, Utah	4,333	0.53	2,302	Flaming Gorge Unit	-57	4,276	0.54	-3	2,299
Green River at Green River, Utah	4,380	0.62	2,698	Flaming Gorge Unit	-57	4,323	0.62	-3	2,695
San Rafael River near Green River, Utah	108	2.20	232						
Colorado River near Cameo, Colorado	2,735	0.57	1,567						
Gunnison River near Grand Junction, Colorado	1,852	0.83	1,543	Curecanti Unit	-24	1,828	0.84	-8	1,535
Colorado River near Cisco, Utah	5,151	0.86	4,411	Curecanti Unit	-24	5,127	0.86	-8	4,403
San Juan River near Archuleta, New Mexico	1,024	0.21	213	Navajo Unit	-51	973	0.22	1	214
San Juan River near Bluff, Utah	1,819	0.56	1,016	Navajo Unit	-51	1,768	0.58	1	1,017
Colorado River at Lees Ferry, Arizona	11,891	0.75	8,899	Total - Increment No. 1	-1,154	10,737	0.76	-756	8,143

Effects of developments - Increment No. 2

Station (1)	Project	Zero pickup: Flow adjustment (AF) (10)	Flow (AF) (11)	Concentration (T/AF) (12)	T.D.S. adjustment (T) (13)	T.D.S. (T) (14)	T.D.S. pickup at 2T/A: T.D.S. adjustment (T) (15)	Concentration (T/AF) (16)	T.D.S. (T) (17)
Green River near Greendale, Utah	Seedskadee and Utah Power and Light Company	-145	1,517	0.59	0	898	87	0.65	985
Duchesne River near Randlett, Utah	Central Utah - Bonneville Unit	-167	278	1.49	-28	415			
Green River near Ouray, Utah	Seedskadee, Vernal Unit, Bonneville Unit, and Utah Power & Light Company	-324	3,952	0.58	-28	2,271	87	0.60	2,358
Green River at Green River, Utah	Seedskadee, Vernal Unit, Bonneville Unit, and Utah Power & Light Company	-324	3,999	0.67	-28	2,667	87	0.69	2,754
San Rafael River near Green River, Utah	Emery County Project	-17	91	2.60	0	232	2	2.60	234
Colorado River near Cameo, Colorado	Denver, Englewood, and Colorado Springs Diversions and Silt Project	-197	2,538	0.61	-19	1,548	4	0.61	1,552
Gunnison River near Grand Junction, Colorado	Paonia and Smith Fork Projects	-16	1,812	0.85	0	1,535	7	0.85	1,542
Colorado River near Cisco, Utah	Denver, Englewood, and Colorado Springs Diversions; Silt, Paonia, Collbran, and Smith Fork Projects	-220	4,907	0.89	-19	4,384	16	0.90	4,400
San Juan River near Archuleta, New Mexico									
San Juan River near Bluff, Utah	Hammond, Florida, and Utah Construction Company	-62	1,706	0.60	0	1,017	17	0.61	1,034
Colorado River at Lees Ferry, Arizona	Total - Increment No. 2	-631	10,106	0.80	-47	8,096	122	0.81	8,218

Effects of developments - Increment No. 3

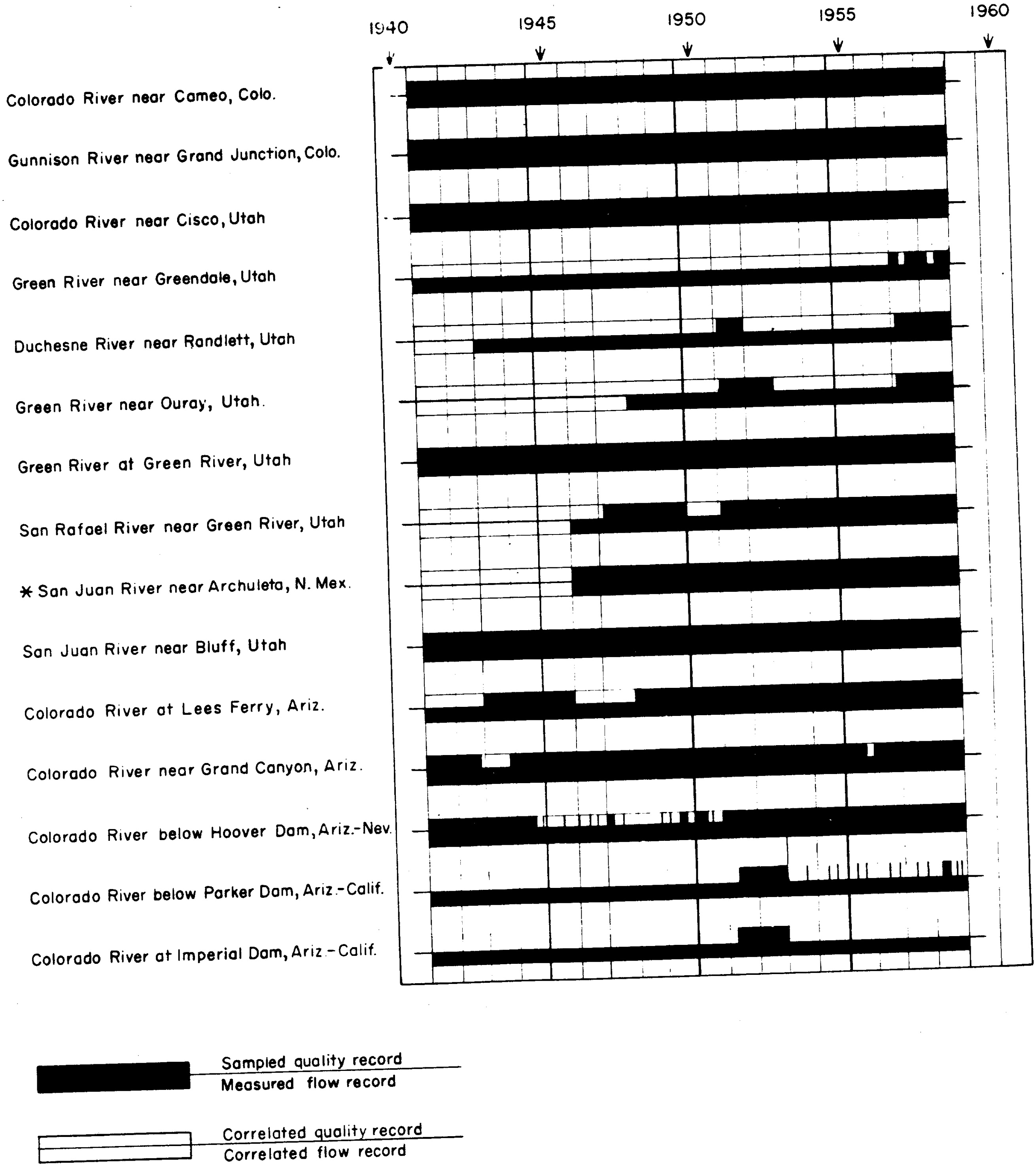
Station (1)	Project	Zero pickup: Flow adjustment (AF) (18)	Flow (AF) (19)	Concentration (T/AF) (20)	T.D.S. adjustment (T) (21)	T.D.S. (T) (22)	T.D.S. pickup at 2T/A: T.D.S. adjustment (T) (23)	Concentration (T/AF) (24)	T.D.S. (T) (25)
San Juan River near Archuleta, New Mexico	San Juan-Chama and Navajo Indian Irrigation Projects	-612	361	0.24	-129	85			
San Juan River near Bluff, Utah	San Juan-Chama and Navajo Indian Irrigation Projects	-363	1,343	0.74	-17	1,000	220	0.92	1,237
Colorado River at Lees Ferry, Arizona	Total - Increment No. 3	-363	9,743	0.83	-17	8,079	220	0.86	8,421

Effects of developments - Increment No. 4

Station (1)	Project	Zero pickup: Flow adjustment (AF) (26)	Flow (AF) (27)	Concentration (T/AF) (28)	T.D.S. adjustment (T) (29)	T.D.S. (T) (30)	T.D.S. pickup at 2T/A: T.D.S. adjustment (T) (31)	Concentration (T/AF) (32)	T.D.S. (T) (33)
Colorado River near Cameo, Colorado	Fryingpan-Arkansas Project	-68	2,470	0.63	-4	1,544	0	0.63	1,548
Colorado River near Cisco, Utah	Fryingpan-Arkansas Project	-68	4,839	0.91	-4	4,380	0	0.91	4,396
Colorado River at Lees Ferry, Arizona	Total - Increment No. 4	-68	9,675	0.84	-4	8,075	0	0.87	8,417

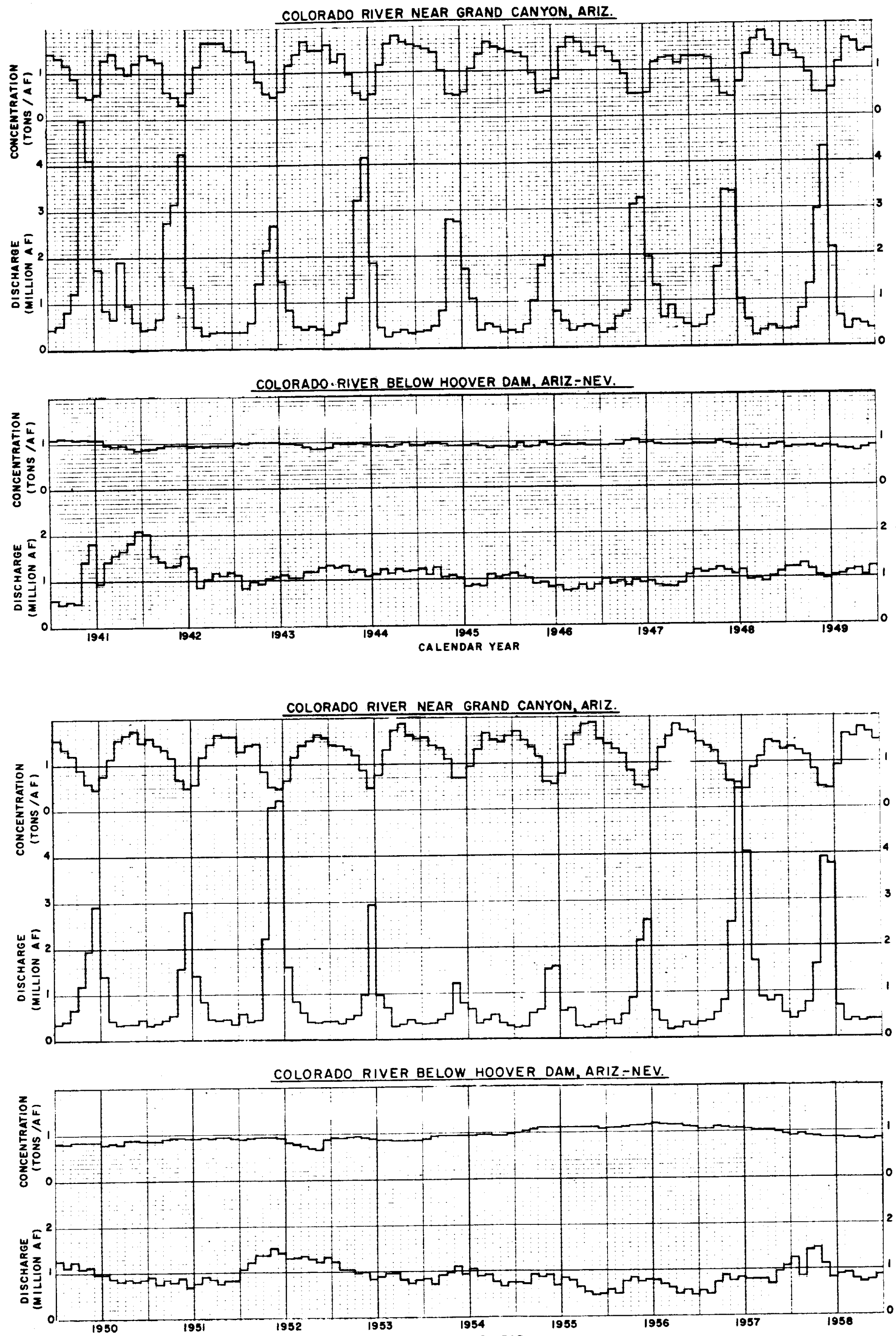
Note.--Flow adjustment in column 5 includes the net effect of water impoundment in the reservoirs as well as reservoir losses.

Colorado River Basin
Flow and Quality of Water Records
1941–58



* October 1945 to November 1954, adjusted quality and flow record for station near Blanco.

FIGURE 2



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

QUALITY OF WATER STUDY

COMPARISON OF QUALITY OF WATER
ABOVE AND BELOW LAKE MEAD

594 - 400 - 36
AUGUST 3, 1962

FIGURE 3

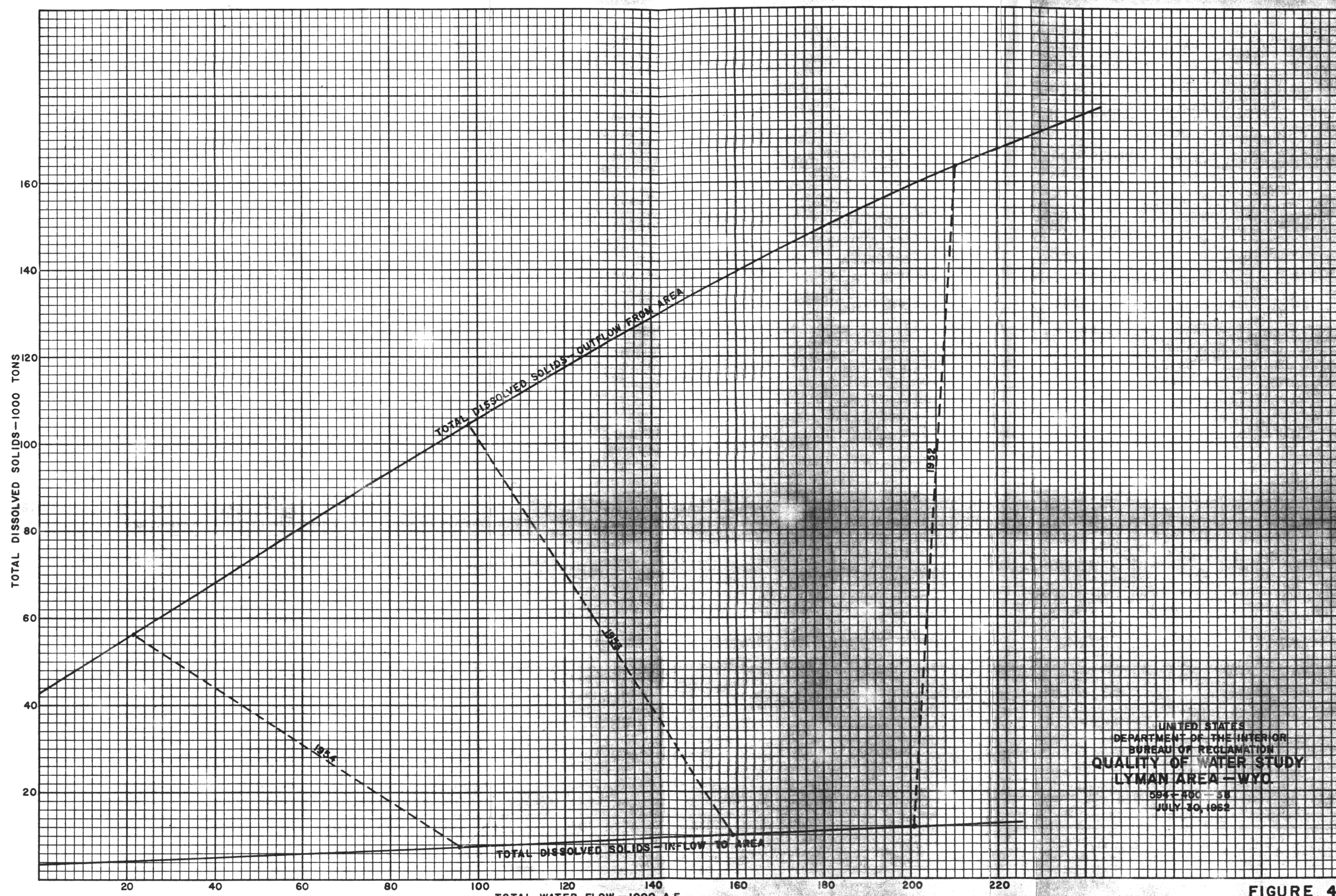
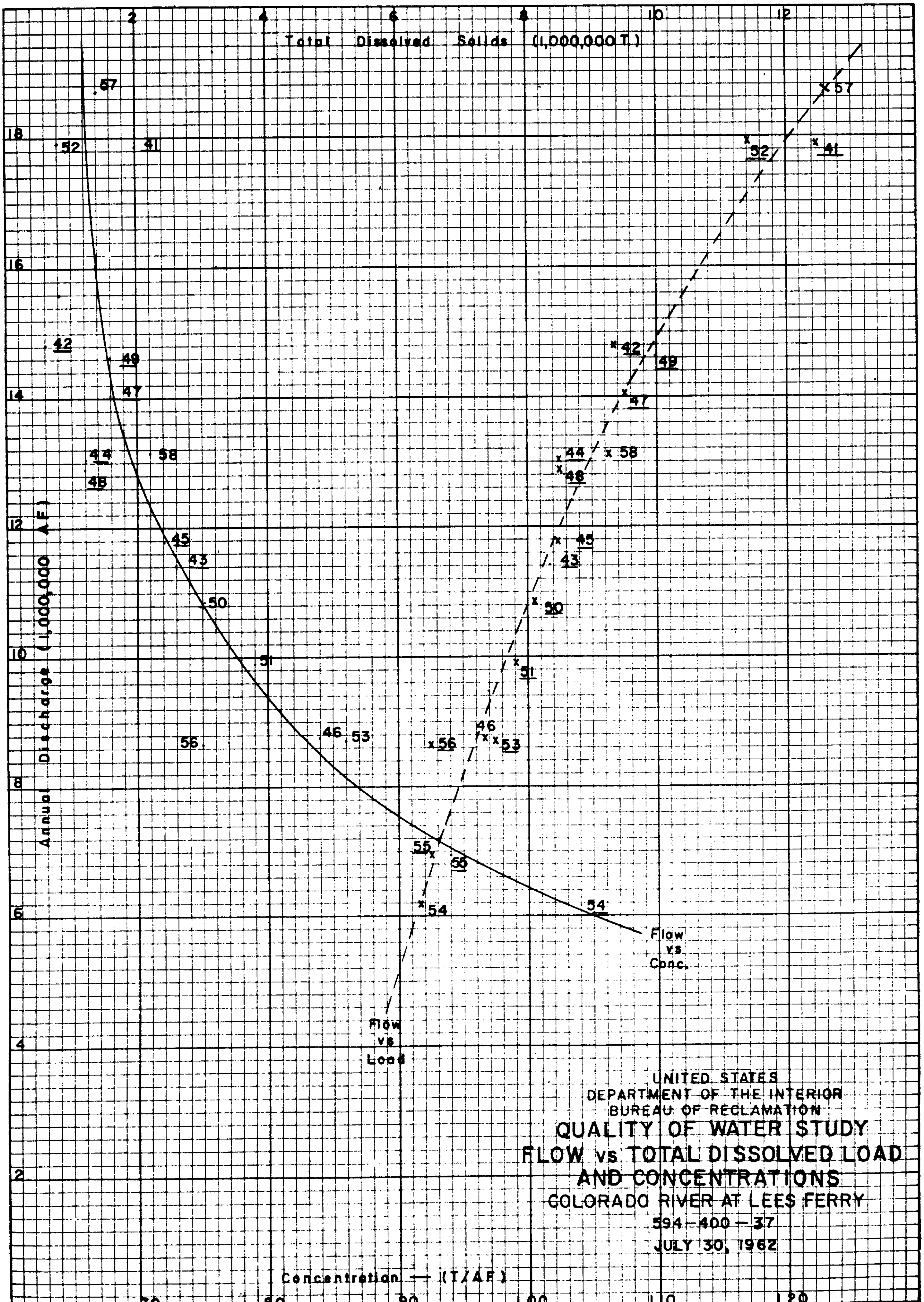

TOTAL DISSOLVED SOLIDS—1000 TONS
TOTAL WATER FLOW—1000 A.F.
TOTAL DISSOLVED SOLIDS—OUTFLOW FROM AREA
TOTAL DISSOLVED SOLIDS—INFLOW TO AREA
1954
1953
1952
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
QUALITY OF WATER STUDY
LYMAN AREA—WYO.
594-400-38
JULY 30, 1952

FIGURE 4



Total Dissolved Solids (1,000,000 T)
Annual Discharge (1,000,000 AF)
Concentration — (T/AF)
Flow vs Conc.
Flow vs Load
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
QUALITY OF WATER STUDY
FLOW vs TOTAL DISSOLVED LOAD
AND CONCENTRATIONS
COLORADO RIVER AT LEES FERRY
594-400-37
JULY 30, 1962

FIGURE 5