Surface-Water Hydrology of California Coastal Basins Between San Francisco Bay and Eel River

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1851

Prepared in cooperation with the California Department of Water Resources

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By S. E. RANTZ *and* T. H. THOMPSON

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1967

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog-card No. GS 67-264

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

CONTENTS

ILLUSTRATIONS

TABLES

SURFACE-WATER HYDROLOGY OF CALIFORNIA COASTAL BASINS BETWEEN SAN FRANCISCO BAY AND EEL RIVER

By S. E. Rantz and T. H. Thompson

ABSTRACT

This report presents an analysis of the surface-water hydrology of the coastal basins of California that lie between the north shore of San Francisco Bay and the south boundary of the Eel River basin. Its purpose is to provide hydrologic information in convenient form for use in project planning by the California Department of Water Resources and other water agencies operating in the State.

The report area, comprising about 5,000 square miles, lies wholly within the northern California Coast Ranges (physiographic section). Most of the streams are small and drain watersheds of less than 100 square miles. A notable exception, however, is the Russian River, which has a drainage area of almost 1,500 square miles.

Precipitation is distinctly seasonal, and very little occurs from June through September. About 80 percent of the total precipitation falls during the 5 months November through March. Mean annual precipitation increases from south to north and is strongly influenced by the altitude, shape, and steepness of mountain slopes. Mean annual precipitation ranges from a low 20 inches in the Napa Valley to a high of 110 inches on the mountain divide of the Mattole River basin. Snow has an insignificant influence on the hydrology of the region.

Average annual natural runoff from the region is about 5.5 million acre-feet, which is equivalent to about 21 inches from the entire region. Runoff, however, has an areal distribution similar to that of precipitation and ranges from about 5 inches in the south to about 85 inches in the north. About 80 percent of the runoff occurs during the 4 rainy months December through March. The rains of November, falling on rather dry ground, generally contribute little runoff. Flow in the summer and early fall is poorly sustained, and many of the smaller streams go dry. This seasonal distribution of runoff reflects not only the seasonal distribution of precipitation but also the influence exerted by the geologic characteristics of the California Coast Ranges. The low permeability of the soil and surficial rock and the limited capacity for subsurface storage impede infiltration, and as a result there is little lag between rainfall and runoff.

Study of the runoff regimen indicates that, for any stream, there is a close relationship between the flow-duration curve and the frequency curves for low flows of various durations. Both are influenced by basin characteristics, and the relationship is maintained by the regional consistency of the seasonal pattern of precipitation. The recurrence intervals of low flows sustained for periods ranging from 1 day to 274 days may be derived from the flow-duration curve with considerable confidence. The characteristics of the flow-duration curve were found to be roughly related to mean discharge.

Seven major floods have occurred in the region in the past 25 years. In many of the coastal basins south of the Russian River, six of the seven floods were of nearly equal magnitude. In the Russian River basin the flood of December 1964 was generally the maximum of these events, but in the coastal basins north and west of the Russian River the flood of December 1955 generally produced the greatest peak discharges. A flood-frequency study of the region indicates that the magnitude of floods of any given frequency can be related to size of drainage area and to mean annual basinwide precipitation. This precipitation is an excellent index of the relative magnitude of storms of any given frequency because the bulk of the precipitation occurs during several general storms each year, and the same number of general storms occur at all stations in any given year.

The magnitude and frequency of high flows, for durations ranging from 1 day to 274 days, were analyzed by a method that closely paralleled that used in the flood-frequency study. Average discharges for each selected duration and frequency were correlated with drainage area and mean annual basinwide precipitation. Results were highly satisfactory because all correlations had coefficients of multiple correlation that were equal to or greater than 0.99.

INTRODUCTION

PURPOSE AND SCOPE

This report on the surface-water hydrology of coastal basins in northern California has been prepared to provide hydrologic data for use in project planning by the California Department of Water Research and by other water agencies operating in the State. The broad objective of this project planning is the full conservation, control, and utilization of the water resources of California to meet future water needs.

The region studied has an area of 5,000 square miles and comprises the coastal drainage basins that lie between the north shore of San Francisco Bay and the south boundary of the Eel River basin. (See fig. 1.) The average annual runoff from the area is about 5.5 million acre-feet; the estimated ultimate water requirement of the area (California Water Resources Board, 1955) is 1.4 million acre-feet annually. Although runoff within the area varies greatly from basin to basin, the large total volume is indicative of a more-than-adequate water supply for the region. The bulk of the runoff, however, occurs in the winter, when the need for water is least. Consequently, there is a need for storage facilities to overcome the difference in time between periods of abundant supply and heavy demand for water, to provide flood control, and to enhance fishlife and the recreation potential of the region. A prerequisite, however, to the planning for full development of the water resources of the region is a detailed inventory of the water supply, covering the distribution of runoff with respect to both area

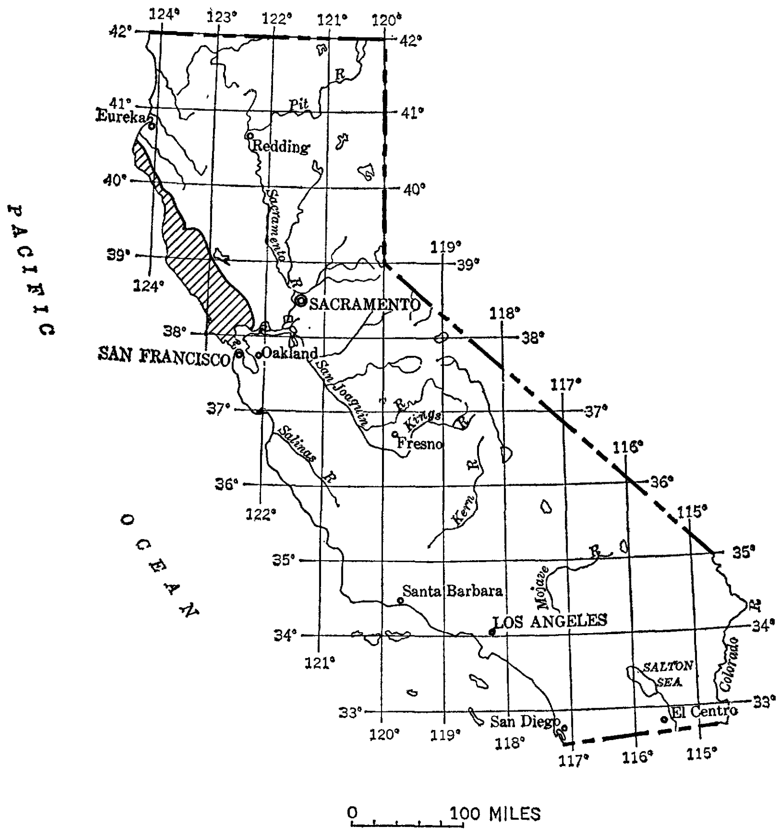

FIGURE 1.—Location of report area (shaded).

and time. This report is directed toward filling the need for that inventory. The great mass of surface-water data compiled by the U.S. Geological Survey has been analyzed. These data have been published in the water-supply paper series titled "Surface-Water Supply of the United States, Part 11, Pacific Slope Basins in California," and, since 1961, in an annual report series titled "Surface Water Records of California." The results of the study are reported in this paper.

A 33-year base period, 1931–63, has been used in this report for studying the hydrologic budget (mean annual precipitation, runoff, and water loss) of watersheds upstream from key gaging stations. Three factors influenced the selection of this base period: (1) No stations on natural streams in the region have records for more than 33 years; (2) rainfall records suggest that the average annual runoff for the period 1931–63 closely approximates the long-term mean annual runoff; (3) this 33-year base period includes years of extreme drought and severe flooding. (Unless otherwise specified, year is used in this report, to refer to the water year, a 12-month period ending September 30. The water year is commonly used in water-supply studies and is designated by the calendar date of the last 9 months of the period; for example, the period October 1, 1951, to September 30, 1952, is designated the 1952 water year.)

The regimen of the various streams is discussed in the report and is analyzed in studies of flow duration, flood frequency, and frequency and duration of sustained high and low flows. For all these aspects of the hydrology of the study area, except flood frequency, the latest data used were those for the 1963 water year. However, before this report was completed the disastrous floods of December 1964 occurred, and the time base of the flood-frequency analysis was extended to include this major event.

Few stream-gaging stations were operated during all years of the base periods used in this report, and it was necessary, therefore, to resort to correlation techniques to produce synthetic streamflow figures to fill existing gaps in the records. Greater refinement in these correlative estimates of flow would have been possible if this study had been postponed for several years to permit the collection of additional data. The pressing need of the planning agencies, however, for information of the type presented in this report permitted no delay.

OTHER INVESTIGATIONS

Shortly before this study was completed, a report on the water resources and future water requirements of north coastal California was published by the California Department of Water Resources (1965). That report discusses not only most of the present report area but also many of the coastal basins to the north that were treated in an earlier U.S. Geological Survey report (Rantz, 1964). The scope of the State report is much broader than that of the Geological Survey reports, and although there is some duplication in the reports of the two agencies, they in general complement each other. The Geological Survey reports stress frequency studies and regional relationships that deal with the regimen of streamflow. These relationships enable the runoff characteristics of ungaged streams in the area to be deduced. The State report is more strongly project-oriented, to meet the immediate needs of the Department of Water Resources.

The ground-water resources of the report area have been studied in recent years, and the results of the investigations have been published in three U.S. Geological Survey water-supply papers (Cardwell, 1958, 1965; Kunkel and Upson, 1960). A summary of ground-water conditions is given in the report of the California Department of Water Resources (1965).

The quality of water in the region has also been investigated. Information concerning surface-water quality is published by the U.S. Geological Survey in its water-supply paper series titled "Quality of Surface Waters of the United States, Parts 9–14." The California Department of Water Resources publishes information relating to the quality of both surface and ground water in its annual Bulletin 65 series titled "Quality of Surface Waters in California," and Bulletin 66 series titled "Quality of Ground Waters in California." There is no duplication of quality-of-water data in the Geological Survey and State reports.

ACKNOWLEDGMENTS

This study was made under the terms of a cooperative agreement between the U.S. Geological Survey and the California Department of Water Resources. The report was prepared by the Geological Survey under the supervision of Walter Hofmann, district chief of the Water Resources Division.

Acknowledgment is made of the assistance given by the California Department of Water Resources, Sacramento, Calif., in furnishing information on consumptive use of water in the region. Runoff data for the ungaged Lagunitas Creek basin in Marin County were obtained through the courtesy of the Marin Municipal Water District.

DESCRIPTION OF REGION

Most streams in the report area are small and drain watersheds of less than 100 square miles. A notable exception, however, is the Russian River, which has a drainage area of almost 1,500 square miles. This drainage basin and other comparatively large basins in the region are delineated on plate 1. The region is mountainous except for about 550-square miles of relatively flat area, 45 percent of which lies in the Russian River basin and the remainder in the lower part of the basins tributary to San Francisco Bay. (The term "relatively flat," as used here, refers to a land slope of less than 200 ft to the mile.) The principal watershed divides range generally from 2,000 to 3,000 feet in altitude, but there are a few isolated peaks that exceed 4,000 feet. The mountainous areas are well covered with timber, and lumbering is the principal industry.

GEOLOGY AND PHYSIOGRAPHY

The study area lies wholly within the northern California Coast Ranges physiographic section (Fenneman, 1931). The rocks of the

258-151—67——2

northern California Coast Ranges consist chiefly of an inadequately mapped and poorly understood assemblage containing mostly sandstone and shale, with minor altered basalt and chert, which together compose the Franciscan Formation of Jurassic and Cretaceous age (Bailey and others, 1964). The rocks are locally intruded by sill-like masses of ultramafic rock that is now largely altered to serpentine. Volcanic rocks, ranging in age from Pliocene to Recent and in composition from basalt to rhyolite, overlie the Franciscan rocks in the mountains between Clear Lake and the San Pablo embayment of San Francisco Bay. The Franciscan rocks and, to a much lesser degree, the younger volcanic rocks, are folded and faulted so that their erosion has yielded a northwest-trending series of ridges and valleys. Some of the valleys are broad and flat because they contain thick deposits of gravels derived from the erosion of the surrounding mountains; others are narrow because they are still being actively eroded and contain almost no gravel. Because many of the valleys follow zones of brecciated rock along major faults, hummocky topography and landslides are prominent features of the landscape.

The major drainage of the area is provided by the Russian River, whose valley trends eastward from Jenner, on the coast, through the coastal mountains to Healdsburg, where it bifurcates into a long northwest-trending branch and a short southeast-trending branch. South of Healdsburg, parallel ranges separate the longitudinal valleys of the Napa River, Sonoma Creek, and Petaluma River; the Petaluma River valley is the southern extension of the Russian River valley. Extending northwest of Healdsburg and forming a narrow belt between the Russian River and the coast, is the Mendocino Plateau. It is a submaturely dissected upland rising from about 1,600 feet on the west to 2,100 feet on the east (Fenneman, 1931). The Mendocino Plateau is drained westward by the Gualala, Navarro, and Mattole Rivers, and other shorter transverse streams; but in a part near the coast, the South Fork Gualala River and a reach of the Garcia River have longitudinal trends where they flow in the rift valley of the San Andreas fault. North of the 39th parallel the ranges form a broad mountainous belt with only scattered alluvial-filled valleys.

CLIMATE

Climatologists and geographers have classified the climate of the study area as Mediterranean because of its mild wet winters and cool dry summers. Along the coast the climate is marked by moderate and equable temperatures, heavy and recurrent fogs, and prevailing west to northwest winds. Inland, temperatures have a wider range and winds are generally moderate. Temperatures are influenced largely by altitude and by local topography. Precipitation is likewise orographically influenced and decreases generally from north to south. Precipitation is distinctly seasonal, and very little occurs from June through September. The seasonal distribution of precipitation is largely controlled by the anticyclonic cell that is normally present off the California coast, particularly in summer. The frequent winter precipitation generally occurs when this anticyclone either is absent or is far south of its usual summer position. Snow occurs in moderate amounts at altitudes above 2,000 feet but rarely remains on the ground for long periods of time, and it has little or no influence on the regimen of runoff.

DESCRIPTION OF THE INDIVIDUAL BASINS

NAPA RIVER BASIN

The Napa River heads on the south flank of Mount Saint Helena, flows southeastward for about 40 miles, and empties into San Pablo Bay. Its principal tributaries are Conn, Dry, Milliken, and Redwood Creeks, all of which enter the river in a 10-mile reach upstream from the city of Napa. The central alluvial plain of Napa Valley is about 30 miles long and ranges in width from less than 1 mile at the north end to nearly 4 miles just north of Napa. The basin is not gaged downstream from Napa because the city is at the head of tide and because there is little accretion to the flow of the river downstream from the city. This study of the hydrology of the Napa River basin is therefore confined to the drainage area of 230 square miles upstream from Napa.

The principal use of water in the basin is for municipal and domestic purposes and for the irrigation of about 2,500 acres of agricultural land in Napa Valley. The principal towns in the valley are Napa, St. Helena, and Calistoga. Prior to 1945 almost all water was obtained from wells. The only surface-water supply of note was Milliken Creek, on which, in 1924, the city of Napa constructed a reservoir having a capacity of 2,000 acre-feet. The supply, however, failed to keep pace with expanding demands, and in 1945 the city built Conn Dam on Conn Creek. The impounding reservoir, Lake Hennessey, which has a capacity of 31,000 acre-feet, became the chief element in the water supply for the city of Napa. In subesequent years the municipal systems of the towns from St. Helena south and many ranches made connections to the pipeline from Lake Hennessey. The only other major surface-water reservoir in the basin is on Rector Creek, a tributary of Conn Creek. Rector Creek is the source of supply for Yountville Veterans Home and Napa State Hospital.

All streams tributary to the Napa River go dry in summer. Napa River is a perennial stream at the St. Helena gaging station but is usually dry at the Napa gaging station for one or more months during the summer. This loss in streamflow between the two gaging stations is attributed to pumping for irrigation both from the stream and from the ground-water reservoir.

SONOMA CREEK BASIN

Sonoma Creek heads on the west side of the Mayacmas Mountains, flows southeastward for about 28 miles, and empties into San Pablo Bay. The gaging station farthest downstream in the basin is at Boyes Hot Springs, 1.5 miles north of the city of Sonoma; only the 62-square-mile drainage area upstream from this gage is considered in this study. The alluvial plain in this basin extends north from Boyes Hot Springs for about 4 miles and is about 1 mile wide. The only tributary stream of appreciable size is Calabazas Creek, which enters Sonoma Creek at Glen Ellen.

The principal use of water in the basin is for municipal and domestic purposes and for the irrigation of about 500 acres of agricultural land. Almost all water is obtained from wells, but in 1963 importation of supplemental water from the Russian River began. At present (1964) the area served with Russian River water is small, but it is expected to increase rapidly.

PETALUMA RIVER BASIN

The Petaluma River has its source about 1 mile south of Cotati, on the south side of the low divide (altitude of less than 500 ft) that separates Petaluma River drainage from Russian River drainage. The river flows southeastward for about 23 miles and empties into San Pablo Bay. The single gaging station in the basin is 1 mile upstream from Petaluma, the only urban center in the basin. This report is concerned only with the 31-square-mile drainage area upstream from the gage. The alluvial plain in this basin comprises about 20 square miles and has a maximum width of about 3½ miles at the gaging station. The tributary streams are small; Lichau Creek is the largest one upstream from Petaluma.

The principal use of water in the basin is for domestic and municipal purposes and for the irrigation of about 200 acres of agricultural land. Water is obtained from wells and small streams diversions. Since 1962 the city of Petaluma has imported more than half its water supply from the Russian River.

MARIN COUNTY BASINS

The principal streams in Marin County are Novato, Corte Madera, Lagunitas, and Walker Creeks.

Novato Creek flows eastward in a valley adjacent to Petaluma Valley and empties into San Pablo Bay. The only gaging station in the basin is on Novato Creek 1 mile west of Novato, the single urban center in the basin. This report deals with the 17.5-square-mile drainage area upstream from the gage. The only significant use of water in this basin is related to the operation of Stafford Lake, a 4,500-acre-foot reservoir on Novato Creek upstream from the gage. Since early 1952, when the reservoir was completed, water has been diverted from Stafford Lake for municipal use in Novato. Since 1961, part of the water needs of the town have been met by importation of water from the Russian River.

Corte Madera Creek flows southeastward through a highly urbanized valley in southeastern Marin County and empties into San Francisco Bay. The principal water use in the basin is for domestic and municipal purposes. The single gaging station in the basin is 4 miles from the mouth of the creek and gages the runoff from a drainage area of 18 square miles; flow is partly regulated by Phoenix Lake, a reservoir whose capacity is 612 acre-feet.

Lagunitas Creek heads on the north slope of Mount Tamalpais at an altitude of about 2,300 feet, flows northwestward along the base of Bolinas Ridge, and empties into Tomales Bay. The stream has a steep gradient in its upper reaches—it falls 1,500 feet in 1½ miles. It is joined by its principal tributary, Nicasio Creek, about 4 miles from its mouth; another large tributary, Olema Creek, joins Lagunitas Creek about 1 mile from its mouth. The total drainage area of the Lagunitas Creek basin is about 80 square miles. The streams in the basin are highly regulated by four reservoirs—Lagunitas Lake, Bon Tempe Lake, Alpine Lake, and Kent Lake—on Lagunitas Creek, and Nicasio Reservoir on Nicasio Creek. Nicasio Reservoir was completed in 1961. The five reservoirs are operated for municipal and domestic supply by the Marin Municipal Water District, and they have a combined capacity of 52,500 acre-feet. The only streamflow records obtained in the basin by the U.S. Geological Survey were from a gage on Nicasio Creek at the site of the present reservoir. This station was operated during the period 1954–60.

Walker Creek heads on the west slope of the divide that separates its drainage from that of Novato Creek. Walker Creek flows northwestward for 16 miles through rough mountainous terrain and then westward for 7 miles through gently rolling country; it empties into Tomales Bay. The principal tributaries are Chileno Creek and Arroyo Sausal. The basin is sparsely populated, and there is little irrigation. The principal economic activity is dairying in the Chileno Creek subbasin. The only streams in the basin that have been gaged are Arroyo Sausal and Walker Creek above the mouth of Chileno Creek.

RUSSIAN RIVER BASIN

The Russian River drains an area of 1,485 square miles that is approximately 100 miles long and from 12 to 32 miles wide. From its source, about 16 miles north of Ukiah, the river flows southward for 90 miles through Redwood, Ukiah, Hopland, and Alexander Valleys, and through the northwestern part of the Santa Rosa Plains. The river then turns abruptly westward at Mirabel Park and flows for 22 miles through a canyon in the mountains before entering the Pacific Ocean at Jenner. The several alluvial valleys through which the river flows are separated by mountain gorges. Altitudes in the basin range from 4,480 feet to sea level. The principal tributaries of the Russian River are East Fork, Sulphur Creek, Maacama Creek, Dry Creek, and Mark West Creek. The principal tributary of Mark West Creek is Laguna de Santa Rosa, which drains a large flat marshy area and enters Mark West Creek about 5 miles upstream from its mouth. The flow in the lower reaches of Mark West Creek reverses during periods of medium and high stage on the Russian River. At those times Russian River water enters Mark West Creek, flows into Laguna de Santa Rosa, and spreads over the surrounding lowlands. These lowlands, when inundated, act as a natural detention basin and thereby reduce peak discharges on the lower reaches of the Russian River.

The principal use of water in the basin is for the irrigation of about 36,000 acres of agricultural land; it is also used for municipal, domestic, and industrial purposes, notably in the communities of Ukiah, Cloverdale, Healdsburg, Santa Rosa, and Sebastopol. Evapotranspiration from the irrigated areas accounts for most of the water actually consumed.

Several major water developments have been made in the Russian River basin. The Pacific Gas and Electric Co. annually diverts about 150,000 acre-feet of Eel River water into the East Fork Russian River through its Potter Valley diversion tunnel and powerplant northeast of Ukiah. This diversion, which began in 1908, is now regulated by storage in Lake Mendocino, a flood-control and water-conservation reservoir that was built in 1959 on the East Fork Russian River near its mouth. Lake Mendocino has a capacity of 122,500 acre-feet. Its releases maintain runoff on the main stem of the Russian River during the dry season to satisfy irrigation and water-supply requirements downstream. This is done by maintaining a minimum flow of 125 cfs (cubic feet per second) at the Geological Survey gage near Guerneville, 74 miles downstream from the mouth of the East Fork.

At a site on the Russian River just upstream from the mouth of Mark West Creek (3 miles upstream from the Guerneville gage), the Sonoma County Flood Control and Water Conservation District diverts water for municipal use in the cities of Santa Rosa and Forestville within the Russian River basin and for other towns outside the basin. This diversion, which began in 1959, increased from 6,600 acre-feet in 1959 to 12,000 acre-feet in 1964. Water for this diversion is pumped from a gallery 60 feet beneath the streambed.

Some water is also diverted from Copeland Creek 9 miles south of Santa Rosa. This water is exported outside the Russian River basin to Petaluma in amounts of less than 100 acre-feet annually.

To meet the increasing water needs in the basin, construction has been authorized for a flood-control and water-conservation reservoir on Dry Creek near the Geyserville gaging station. The authorized capacity of the reservoir is 277,000 acre-feet. This volume of storage would provide an increase of about 90,000 acre-feet in the annual water supply available to the lower basin for municipal use and for such industrial uses as processing lumber, agricultural, and dairy products.

SMALL BASINS IN SONOMA, MENDOCINO, AND HUMBOLDT COUNTIES

Many small coastal streams north and west of the Russian River basin drain the Mendocino Plateau. The principal ones are the Gualala, Navarro, Noyo, and Mattole Rivers. Virtually the entire area is mountainous; the principal ridges range in altitude from 2,000 feet in the south to 3,000 feet in the north. The mountainous parts are well covered with timber, and lumbering is the principal industry. Some crops are raised in the small valleys, but dairying and sheep raising are of greater commercial importance. Of the 2,100 square miles in the area, only about 500 acres is irrigated, and most of this acreage is near Boonville, in the Navarro River basin. Commercial fishing is centered in the vicinity of Fort Bragg. This city, which had a population of 4,430 in 1960, is the largest in this part of the report area. Utilization of the available water resources is almost negligible in this sparsely populated area.

PRECIPITATION

Precipitation in the report area is distinctly seasonal—about 80 percent of the total occurs during the 5 months November through March. The distribution of annual precipitation is shown in table 1, which gives mean monthly precipitation, in percentage of the total, at four representative stations in the region. The bulk of the precipitation occurs during moderately intense general storms of several days duration. Hourly precipitation in excess of 1 inch is uncommon.

Snow falls in moderate amounts at altitudes above 2,000 feet, but it seldom remains on the ground for more than a few days.

Mean annual precipitation generally increases from south to north and is strongly influenced by the altitude, shape, and steepness of mountain slopes. The isohyetal map on plate 1 presents a generalized picture of the areal distribution of mean annual precipitation during the 33-year period 1931–63. The wide range in mean annual precipitation is striking; precipitation decreases from 110 inches in the north to 20 inches in the south. Plate 1 also shows the location of the 43 U.S. Weather Bureau precipitation stations whose records were used in the construction of the isohyetal map; precipitation stations outside the region, whose records were used, are not shown. Table 2 lists mean annual precipitation at each of the 43 stations for the base period 1931–63. (Correlation procedures have been used, where necessary, to adjust station records to the base period.)

Annual precipitation varies greatly from year to year at any particular station. For example, at Fort Bragg the mean annual rainfall for the period 1931–63 was 37.9 inches, but during that period annual precipitation ranged from 19.8 inches in 1931 to 60.3 inches in 1941. Time trends in precipitation are illustrated by graph *A* of figure 2 which shows accumulated departures of annual precipitation from the 68-year mean at Fort Bragg during the period 1896–1963. The progression shown is typical of that for the entire report area. In a graph of this type, the plotted position for any particular year has little significance, and only the slope of the curve is important. A downward slope indicates less than average precipitation; an upward slope indicates that precipitation exceeded the mean. The graph shows that northern California underwent a prolonged wet period from 1900 to 1916, followed by a dry period from 1917 to 1937. The 26 years since 1937 have been predominantly wet. The driest single year in the 68 years of record was 1924, when the annual precipitation totaled 16.6 inches; 1931 was the second driest year. The wettest single year of record was 1941. During the base period (1931–63), chosen for use in this report, the mean annual precipitation at Fort Bragg differed by only 0.7 percent from the mean for the entire 68 years of record at that station.

Mean annual basinwide precipitation has been estimated from the isohyetal map on plate 1 for the larger watersheds in the area and for those watersheds having a potential for development. The watersheds considered are upstream from the stream-gaging stations listed in table 3; these stations can be located on plate 1 by their identifying numbers. Estimates of basinwide precipitation obtained from the existing network of precipitation stations are not precise because of the

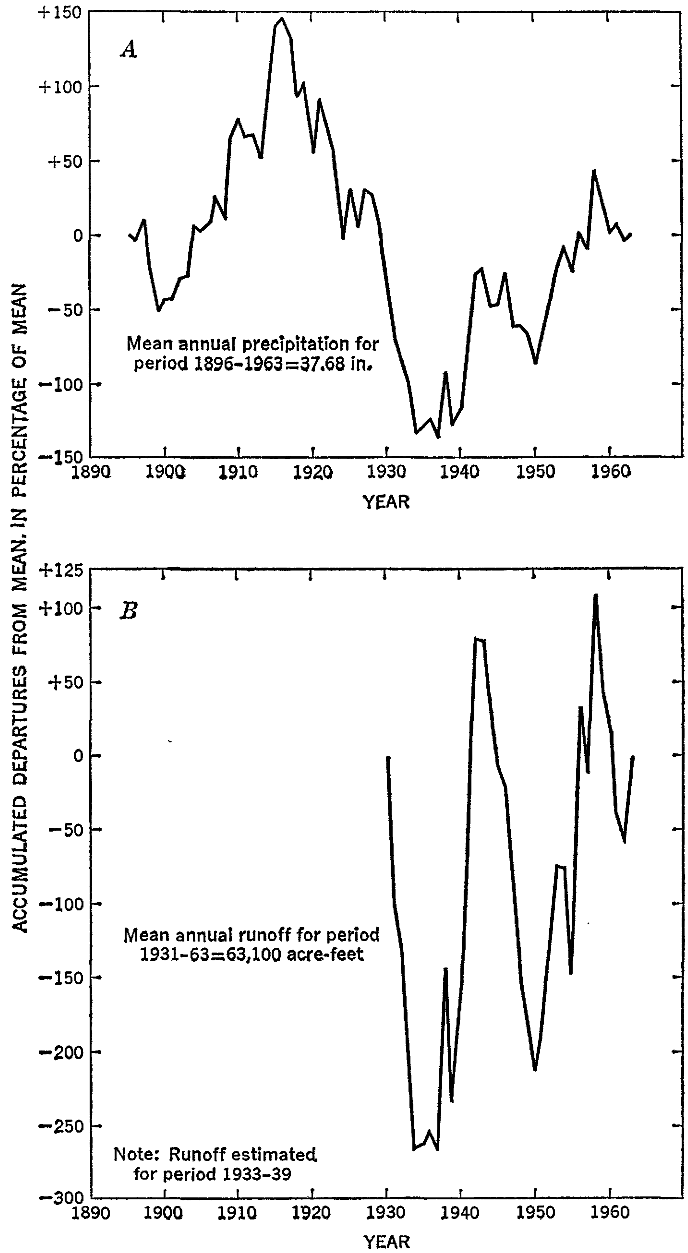

FIGURE 2.—Trends in precipitation and runoff. *A*, Accumulated annual departures from mean annual precipitation at Fort Bragg. *B*, Accumulated annual departures from mean annual runoff of Napa River near St. Helena.

mountainous nature of the terrain. The estimates are useful, nevertheless, as indexes of precipitation. The basinwide averages are given in table 3.

RUNOFF

MEAN ANNUAL VOLUME

Mean annual runoff in the report area is directly related to mean annual precipitation and is influenced principally by (a) latitude, (b) distance from the ocean, (c) altitude and steepness of the mountain slopes, and (d) exposure and orientation of the mountain slopes. Thus, mean annual runoff tends to increase from south to north. The Mattole River basin, in the north end of the report area, has an average annual runoff of 67.7 inches, or the largest annual volume of runoff per square mile of any of the basins studied.

Runoff trends during the period 1931–63 are illustrated by graph (*B*) of figure 2, which shows accumulated departures of annual runoff from the 33-year annual mean for Napa River near St. Helena. This 33-year period is the longest practicable for studying long-term runoff trends for the area (p. 3). The trends depicted are similar to those shown by the precipitation graph (*A*) for Fort Bragg. The driest single year of record was 1931, when runoff was generally about 15 percent of the 33-year mean. The driest 5-year period of record was 1931–35, when runoff was about 50 percent of the long-term mean. The wettest year of record was 1956, when runoff was more than twice the 33-year mean.

Plate 1 shows the location of the 63 stream-gaging stations in the area for which runoff data have been compiled. The stations are numbered in downstream order using the permanent numbering system adopted by the U.S. Geological Survey in 1958. The stations identified by a symbol as being partial-record stations, are sites where discharge measurements of either low flow or both low flow and peak discharge, were systematically made. Stations where only one annual measurement of minimum or maximum discharge was made are not shown. Table 4 lists the 63 gaging stations, with their drainage areas and identifying numbers (pl. 1), and also presents a bar chart showing the period of record at each station.

Table 3 lists estimated mean annual natural runoff from basins upstream from key stream-gaging stations for the period of 1931–63. The runoff figures have been adjusted, where necessary, for the effect of manmade changes in stream regimen. For example, the construction of a reservoir upstream from a gaging station distorts the record of runoff because of evaporation losses and the varying volumes of stored water. Diversion of either surface or ground water for irrigation, domestic, or industrial use likewise affects the runoff record. Where the diverted water is used upstream from the gaging station, the figure for natural runoff in table 3 includes only that part of the diverted water that is lost through evapotranspiration; the remainder is assumed to return eventually to the stream or effluent ground-water body. Table 3 lists average annual consumptive use of applied water in areas upstream from the key gaging stations. Because consumptive use has increased through the years, the average annual consumptive use is less than the present use (1964), and for this study it was assumed to equal two-thirds of the present use. The figures for consumptive use in table 3 are crude approximations, but they are considered satisfactory for this study because they represent only a small part of the natural runoff.

The 33-year average annual runoff figures in table 3 have been obtained by a series of runoff correlations involving short-term stations with longer records. Some of the short-term stations used have been in operation only a few years. Runoff estimates, however carefully made, that are based on short periods of observation are subject to considerable error, but their inclusion is justified because the records are needed now for use in preliminary project planning.

AVERAGE ANNUAL WATER LOSS AND EVAPORATION FROM WATER SURFACES

As considered in this report, the average annual water loss from a drainage basin is the difference between the 33-year mean annual precipitation over the basin and the 33-year mean annual runoff. The use of long-term average figures in this computation minimizes the effect of changes in surface or underground storage. Computed average annual water loss for each watershed under consideration is listed in table 3. Because basinwide precipitation totals for the area are considered index figures, rather than absolute values, the computed annual water loss figures should also be considered as indexes (of annual water loss or evapotranspiration).

Variations in average annual water loss between basins are caused by variations in the factors that influence evapotranspiration, namely: (1) Temperature and other climatic elements, (2) precipitation, (3) soil, (4) vegetation, (5) topography, and (6) geologic factors. The climatic factors—temperature, humidity, windspeed, and solar radiation—fix the upper limit of loss, or the potential evapotranspiration. An index of potential evapotranspiration is the evaporation from the surface of bodies of water such as lakes and reservoirs. A study by the U.S. Weather Bureau (Kohler and others, 1959, pl. 2) produced a generalized map of average annual lake evaporation in the United

States, and a part of this map is reproduced on plate 1. Not enough evaporation stations and first-order Weather Bureau stations are present in the area to permit refinement of the isopleths shown. Plate 1 indicates that lake evaporation, and therefore potential evapotranspiration, increases with distance inland from the humid and often foggy coast.

Potential evapotranspiration cannot be attained in a basin unless the basin affords the opportunity for evaporation. Evaporation opportunity is related, therefore, to the available moisture supply and is influenced laregly by the volume and time distribution of precipitation; it is influenced to a lesser degree by such basin characteristics as soil, vegetation, and geology. Because all watersheds in the study area have the same pattern of monthly precipitation and because the annual volume of precipitation is generally equal to or greater than the annual value of potential evapotranspiration, variation in average annual water loss in the region is closely related to variation in average annual potential evapotranspiration. Inspection of plate 1 and of the tabulation of water loss in table 3 shows that average annual water loss from any basin in the study area is equal to about six-tenths of the average basinwide value of the isopleths of lake evaporation shown on the map. Departures from this ratio are to be expected because of variability in the factors that influence annual loss, but some of the variation undoubtedly results from inaccuracies on plate 1 and from discrepancies in the values of water loss computed for this report. These discrepancies reflect the complexity of estimating basinwide precipitation in mountainous terrain.

FLOW DURATION AND REGIMEN OF FLOW

The basic factors that affect the distribution of streamflow with respect to time are topography, tributary pattern, hydrogeology, soil, vegetation, and meteorological conditions. The flow-duration curve is the simplest means of expressing the time distribution of discharge—it shows the percentage of time, for a given period, that any specified discharge is equaled or exceeded. It thus provides a useful device for analyzing the availability and variability of streamflow.

Flow-duration curves of daily discharge were prepared for 23 gaging stations that have 5 or more years of complete record of daily discharge not seriously affected by regulation or diversion. Included in the 23 station records are those for stations on the East Fork and the main Russian River for the years prior to regulation by Lake Mendocino. The Russian River records were adjusted to natural flow conditions by subtracting the measured daily importations of Eel River water. Flow-duration curves were also prepared for 10 partial-record stations where low and medium flows have been systematically measured for 5 years. At those 10 stations the measured discharges were considered equivalent to daily mean discharges. Duration percentages for high flows could not be computed for the partial-record stations, however, because of the lack of high-water data for those sites.

The information given by the 33 flow-duration curves is summarized in table 5, where discharges equaled or exceeded during specified percentages of time are tabulated both in cubic feet per second and in cubic feet per second per square mile. All discharges have been placed on a common basis for comparison by being adjusted to the base period 1931–63. To do this, the shorter records were extended by the use of correlation procedures. Some personal judgment was required in the extrapolation of short-term flow-duration curves to the lower discharges; consequently, the low-flow values given in table 5 are, to a considerable degree, subjective estimates. The number of significant figures used in the discharge columns of table 5, therefore, do not imply great precision; they were included to enable the user of the table to conveniently reconstruct smooth flow-duration curves on logarithmic normal-probalility paper from the tabulated values.

Duration curves for three gaging stations, selected for broad areal coverage in the area, have been plotted on logarithmic normal-probability paper in figure 3. Streamflow is shown as a ratio to mean annual discharge to facilitate comparison of the runoff characteristics indicated by the curves. Flow-duration curves, however, present an incomplete picture of the distribution of discharge, as they ignore the chronology of streamflow. The value of a flow-duration curve is enhanced, therefore, when it is supplemented by a knowledge of the regimen, or time distribution, of flow. The average monthly distribution of runoff in the area is summarized in table 6, which lists mean monthly runoff, in percentage of the annual total, at the three gaging stations shown in figure 3. The regimen of the Napa River near St. Helena (sta. 4560) is representative of streams in the southern part of the area, and the regimen of the Mattole River near Petrolia (sta. 4690) is representative of those in the northern part.

Examination of figure 3 and table 6 shows that all three streams have runoff patterns that are closely similar. Table 6 shows that about 80 percent of the runoff occurs during the 4 rainy months December through March. The rains of November, falling on fairly dry ground, generaly contribute little runoff. Flow in the summer and early fall is poorly sustained, particularly in the southern part of the area, where many small streams often go dry. The southern basins not only receive the smallest amount of annual precipitation,

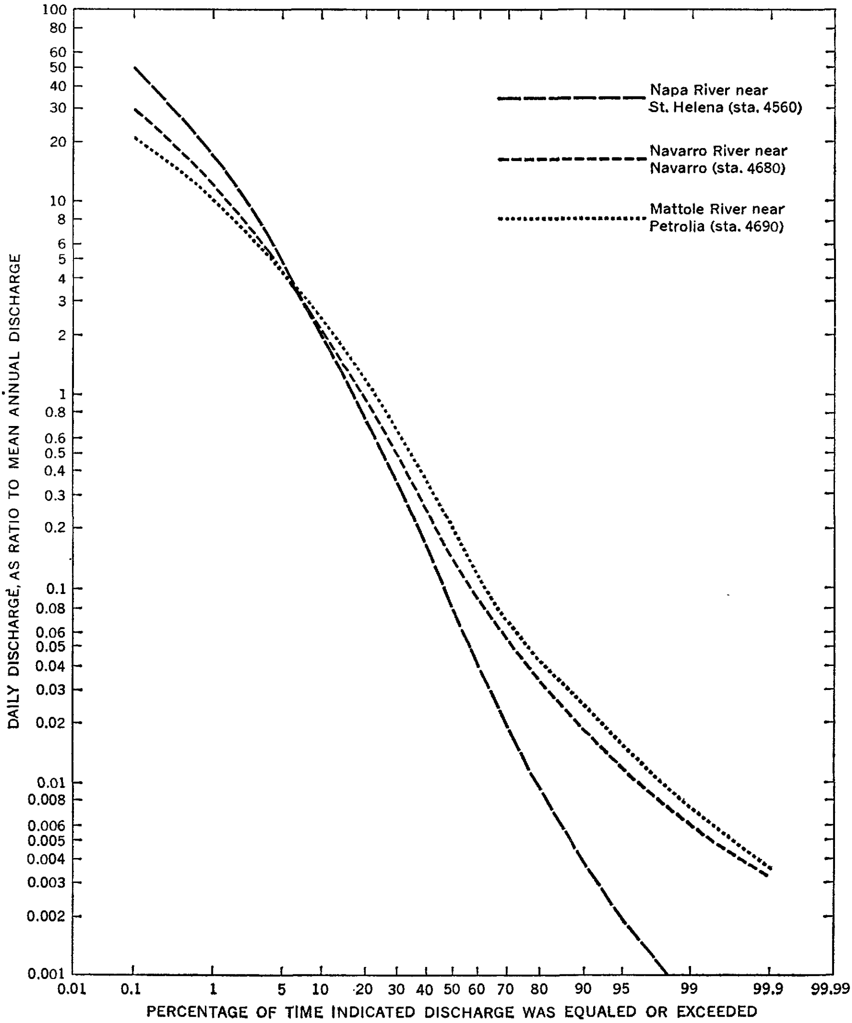

FIGURE 3.—Flow-duration curves of daily discharge for selected gaging stations for period 1931–63.

but they also are less likely than the northern basins to receive occasional summer and early fall rains. Pumping of water from wells and streams is partly responsible for the low summer flow in some sectors. In those places, hydraulic continuity generally exists between the stream and adjacent groundwater body, and the natural movement of ground water is toward the stream. Wells adjacent to the stream channel may temporarily reverse the hydraulic gradient;

wells farther from the channel may intercept water that would otherwise be discharged to the stream.

In figure 3, the steep slopes of the three curves show that flow is highly variable; that is, the streams have a wide range of discharge. This usually indicates that there is little lag between rainfall and runoff; in this area this condition is due to the shallowness and low permeability of the soil and surficial rock, to the absence of lakes or large marshy areas, and to the lack of mountain snowpacks where precipitation might be stored for delayed runoff. The low-water end of the flow-duration curve for Napa River at St. Helena is steeper than that of the curves for the other two streams, and this relation indicates that low flows of the Napa River are the least sustained of the three.

The general characteristics of the flow-duration curves for the 33 gaging stations can be related to the mean discharges at the stations. Key points that were examined on the curves are Q_{10}, Q_{50}, Q_{90}, Q_{mean}, and P_{mean}, where

Q_{10}=discharge equaled or exceeded 10 percent of the time during the period 1931–63,

Q_{50}=median discharge for the period 1931–63,

Q_{90}=discharge equaled or exceeded 90 percent of the time during the period 1931–63,

Q_{mean}=mean discharge for the period 1931–63, and

P_{mean}=percentage of time, in the 1931–63 period, during which Q_{mean} was equaled or exceeded.

Values of Q_{10}, Q_{50}, and Q_{90}, are given in table 5; values of Q_{mean} are given in table 3; and values of P_{mean} are obtained from the individual station flow-duration curves.

In the graphical analyses that follow in figures 4–7, discharges of each of the 33 stations are expressed in cubic feet per second per square mile. For clarity, identifying station numbers are not shown with the plotted points on the graphs.

Figure 4 shows the relation of P_{mean} to Q_{mean}. For the range of mean discharge in the area, values of duration time (P_{mean}) range from 10 percent of the time for low mean discharge to 22 percent of the time for high mean discharge. The values of P_{mean} offer a comparative index to the skewness of the distribution of daily discharges at a station—the lower the value of P_{mean}, the greater the skew in the distribution of flows. Skewness reflects the fact that much of the runoff occurs during rather short periods of high flow. Figure 5 shows the relation of Q_{10}, Q_{mean}, and figure 6, the relation of Q_{50}, to Q_{mean}.

Figure 7, which shows the relation of Q_{90} to Q_{mean}, indicates that for mean discharges less than 1.3 cubic feet per second per square

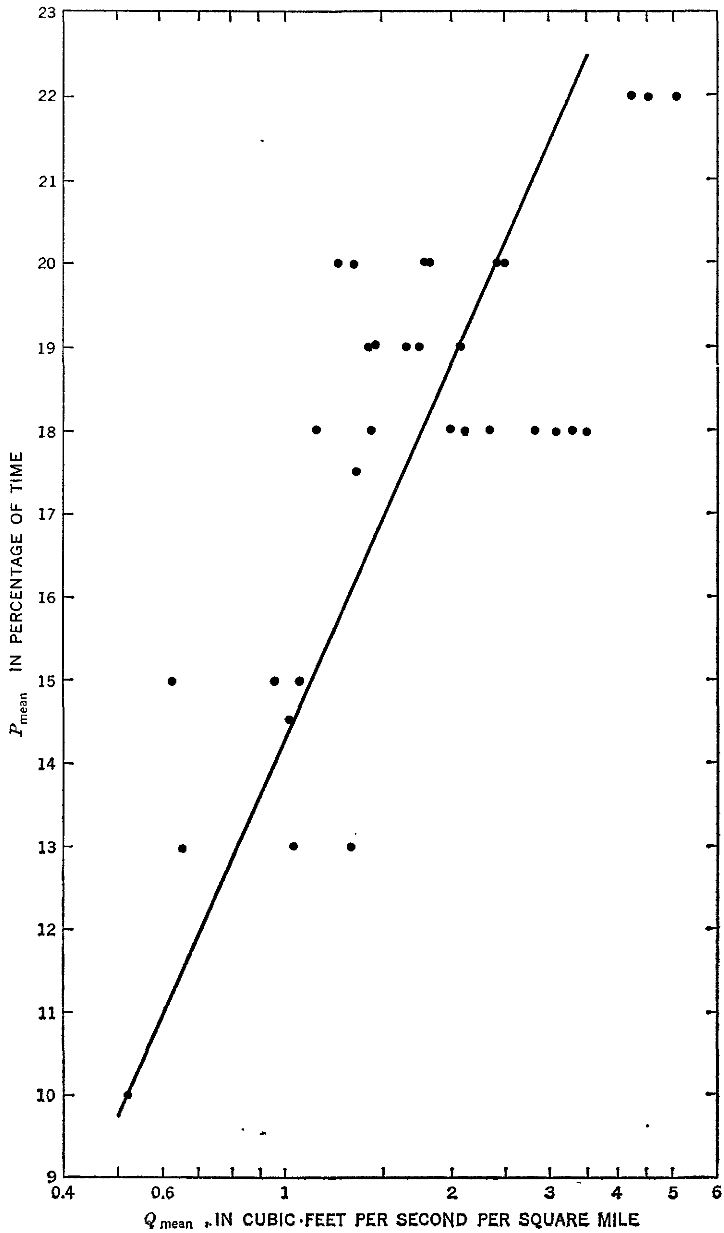

FIGURE 4.—Relation of P_{mean} to Q_{mean}.

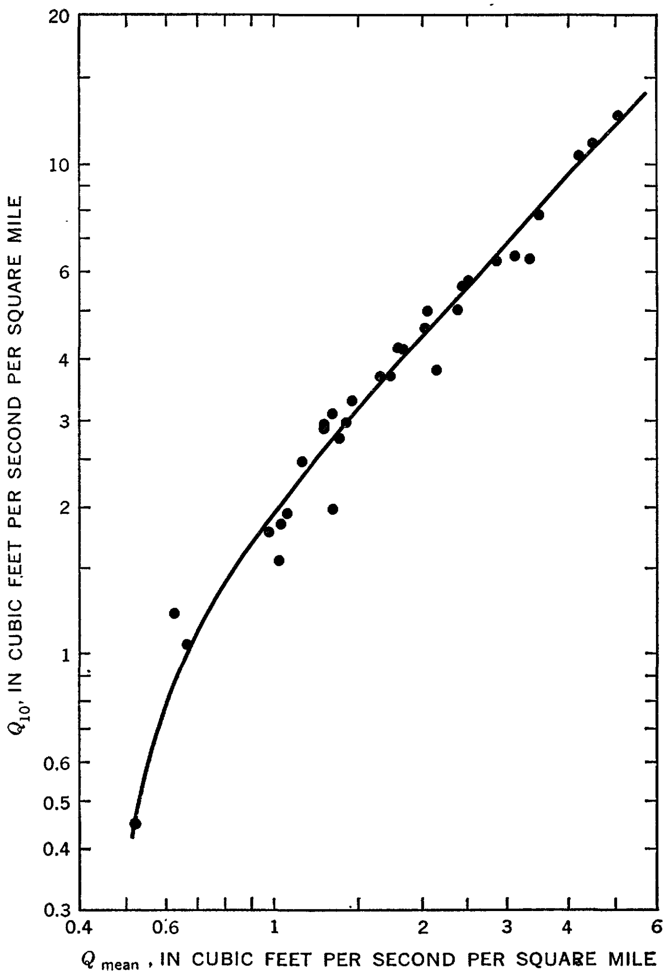

FIGURE 5.—Relation of Q_{10} to Q_{mean}.

mile (940 acre-feet per year square mile), Q_{90} is usually zero. Q_{90} is a significant index in water resources studies in areas of perennial streamflow—for example, in the northern part of the study area. In such places Q_{90} is often considered an appropriate measure of the quantity of water available for continuous use, without resorting to surface storage and without permanently depleting water in underground storage.

The scatter of plotted points on the graphs in figures 4–7 indicates that for the percentile flows investigated, only a part of the variation in discharge is explained by variation in mean discharge. A large

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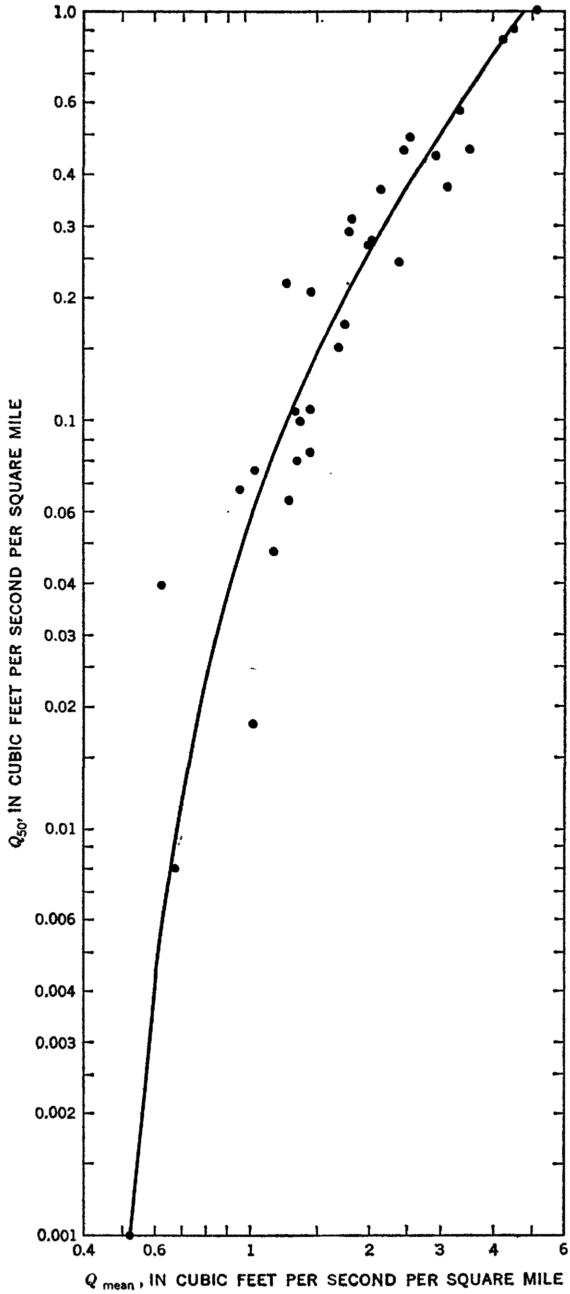


FIGURE 6.—Relation of Q_{50} to Q_{mean}.

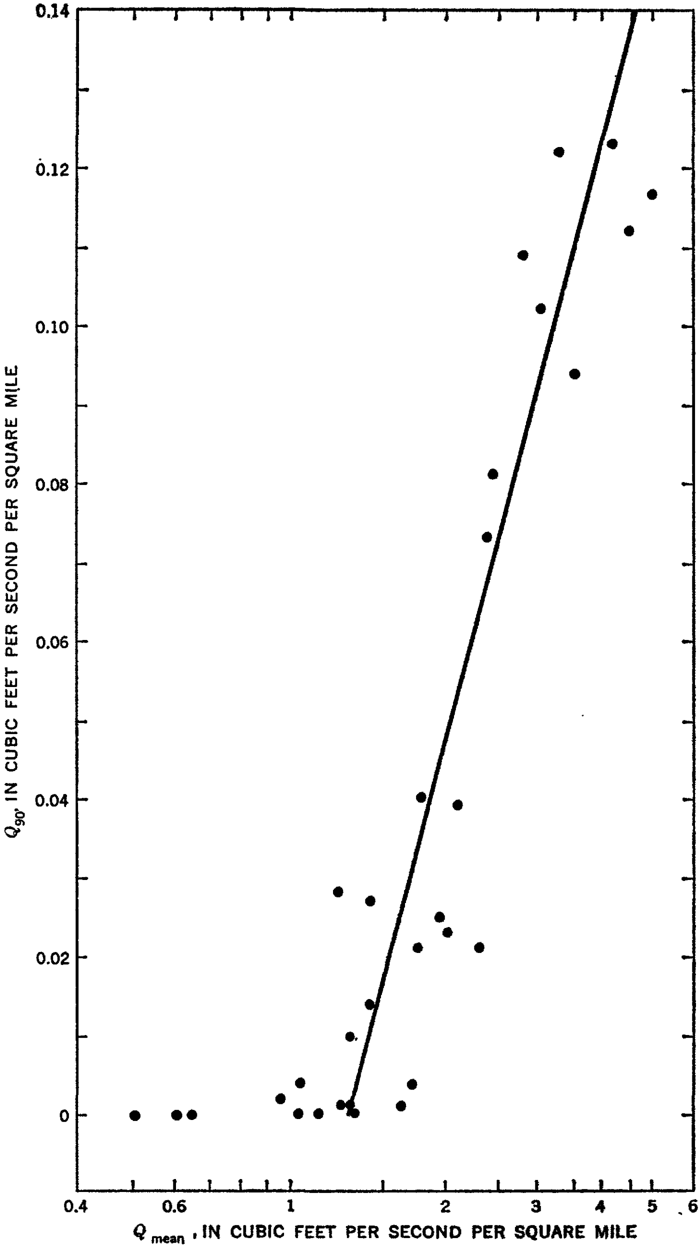


FIGURE 7.—Relation of Q_{90} to Q_{mean}.

part of the variation in Q_{50} and Q_{90} is related to variation in the geology of the basins, and, consequently, there is relatively poor correlation with Q_{mean} alone. Nevertheless, figures 4–7 are helpful in providing a generalized picture of the characteristics of flow-duration curves in the report area.

Although it is common practice to compute indexes of streamflow variability when analyzing the characteristics of flow-duration curves, it was not done for this report. An index of variability, such as that introduced by Lane and Lei (1950) or that used by Rantz (1964, p. 43–45), is significant for perennial streams but is meaningless for streams that go dry or for streams of highly variable discharge whose low flows are minute. Many streams in the southern part of the area are not perennial, so the computation of index figures of variability was not warranted.

LOW FLOW—MAGNITUDE, DURATION, AND FREQUENCY

A prerequisite for any study involving water supply during periods of critically low runoff is a knowledge of the magnitude, duration, and frequency of deficient flow. To fill the need for this information, low-flow frequency graphs and tables were prepared for 31 sites to show the probable recurrence interval of low flows of various magnitudes and durations. The 31 sites included all 23 complete-record gaging stations and 8 of the 10 partial-record stations that were used in the flow-duration analysis. The gaging stations are those having 5 or more years of discharge record that was not seriously affected by regulation or diversion, or having a discharge record (such as that for the Russian River stations) that could be adjusted to natural flow conditions from a record of measured diversions. The duration periods used in this analysis were 1, 7, 14, 30, 60, 90, 120, 183, and 274 days. A 3-day duration period was not included because the lowest mean discharge for 3 consecutive days during each year was almost identical with the minimum daily discharge of each year. The base period used was April 1, 1931, to March 31, 1963. Using March 31 as the closing day of each year eliminated the possibility of a period of sustained low flow starting in one year and extending into the next.

Low-flow frequency graphs for a gaging station were constructed by applying the following procedure:

1. The smallest mean discharges of each year for each of the nine duration periods (1, 7, 14 . . . 274 days) were listed and ranked in ascending order of magnitude, starting with "1" for smallest discharge in the array.

2. The plotting position of each discharge was computed by use of the formula

$$\text{Recurrence interval} = \frac{N+1}{M}$$

where N is the number of years of record (32 yrs), and M is the rank or order number.
3. The discharges and their corresponding recurrence intervals were plotted on logarithmic extreme-value probability paper, and smooth curves were fitted to the plotted points.

Because no station in the report area had a complete array of dischare data for the 32-year base period, it was necessary to estimate many of the discharges needed for the analysis. In making these estimates, discharges at each gaging station for each of the nine duration periods were correlated graphically with concurrent discharges at a nearby station in or near the report area. It was practical to include 8 of the 10 partial-record stations in this analysis because their periodically measured discharges correlated linearly with discharges at complete-record gaging stations, and therefore the correlation equations were valid for discharges averaged over each of the 9 duration periods. The two remaining partial-record stations—Garcia River near Point Arena and Greenwood Creek at Elk—were not used because their discharges did not correlate linearly with those for nearby complete-record stations.

Figure 8 is an example of the low-flow frequency curves derived in this study; the flat roughly parallel curves are typical of those for streams in the northern, or more humid, part of the report area. The nine low-flow frequency curves for streams in the southern, or less humid, part of the area are much steeper because the low flows of these streams are poorly sustained. The spacing of the curves in figure 8 is typical, however, of all streams in the area. The curves are closely spaced for durations of 1 to 120 days because virtually no runoff-producing rain occurs in the region for at least 4 consecutive months in each year. The curves for durations of 183 and 274 days are spaced farther apart because these longer durations include periods of storm runoff.

Table 7 lists the discharges at each station corresponding to selected recurrence intervals on the frequency curves for each of the 31 study sites. Personal judgment was required in the extrapolation of discharges to the higher recurrence intervals, and, consequently, the smaller discharges in table 7 are rather subjective estimates. The number of significant figures shown in the discharge columns of the table, therefore, do not imply great precision, but were included to enable the

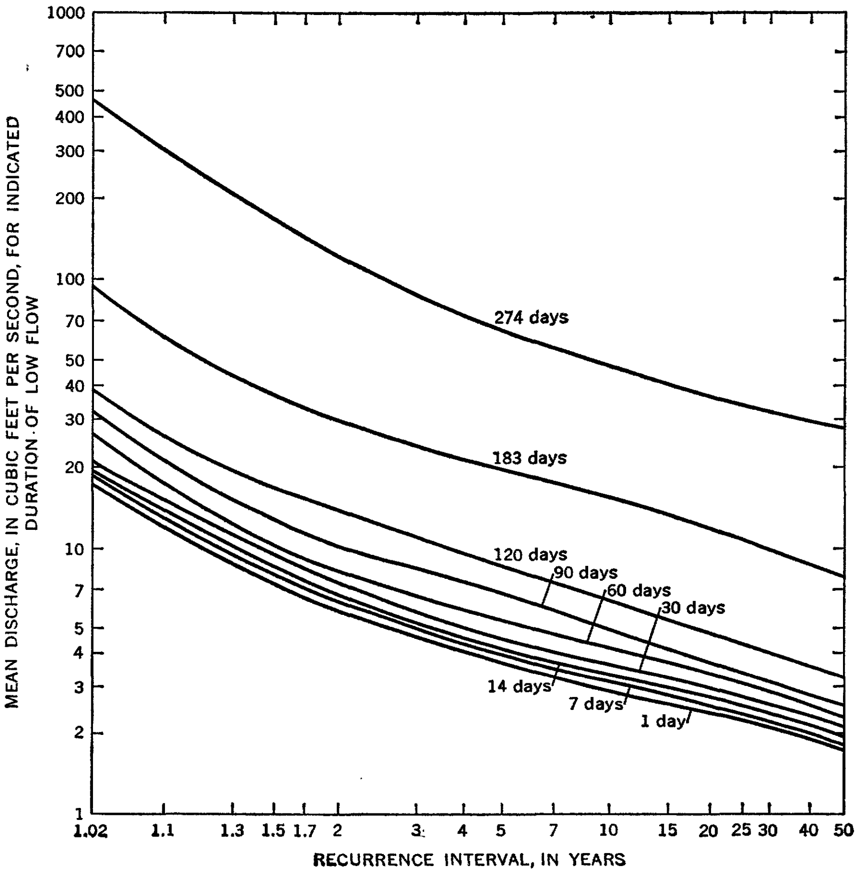


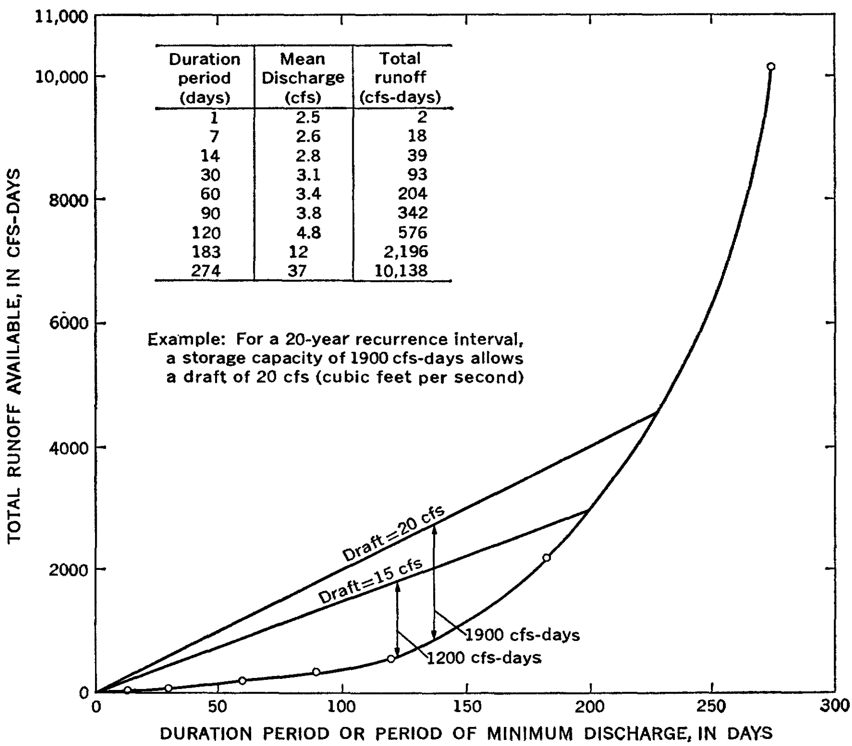
FIGURE 8.—Low-flow frequency curves for Navarro River near Navarro (sta. 4680.)

user of the table to reconstruct smooth low-flow frequency curves on logarithmic extreme-value probability paper.

Examination of the low-flow frequency curves and the flow-duration curves indicates that the two sets of data are fairly closely related. This is not surprising because all streams in the area have similar regimens. It was possible, therefore, to prepare a composite low-flow-frequency table (table 8) for the area; in this table the discharges are replaced by corresponding percentiles from the flow-duration curves. For example, table 8 indicates that for any station the 1-day discharge with a 10-year recurrence interval is about equivalent to the discharge at that station that is equaled or exceeded 99 percent of the time (Q_{99}). To carry this example further, if we check this relationship for Navarro River near Navarro, we find that the 1-day discharge with a 10-

year recurrence interval is 2.9 cfs (from table 7), whereas Q_{99} is 3.1 cfs (from table 5). In general, the composite percentiles listed in table 8 are slightly smaller than the percentiles for individual stations in the northern, or more humid, part of the report area, and somewhat larger than the percentiles for individual stations in the southern, or less humid, part of the area.

The data in table 7 are in convenient form for use in studies of water supply, water power, and pollution control during periods of critically low flow, in those situations where the construction of storage facilities is not contemplated. Where the need for within-year storage is apparent and economic considerations govern the design of the storage facility, the data in these tables may be used to construct a frequency-mass curve that represents the total runoff available for a critical period of specified recurrence interval. The traditional mass-curve method of analyzing the storage required to maintain given draft rates may then be applied (Linsley and Franzini, 1964, p. 154–157). An example of this method of analysis, shown in figure 9, is self-explanatory. The curve



Duration period (days)	Mean Discharge (cfs)	Total runoff (cfs-days)
1	2.5	2
7	2.6	18
14	2.8	39
30	3.1	93
60	3.4	204
90	3.8	342
120	4.8	576
183	12	2,196
274	37	10,138

FIGURE 9.—Frequency-mass curve and storage-draft lines for Navarro River near Navarro (sta. 4680) for 20-year recurrence interval. Mean discharge from table 7.

of total available runoff, corresponding to a 20-year recurrence interval, is obtained by plotting the volume of runoff, for various durations of minimum flow, against the duration period. Water stored in a reservoir may be depleted by evaporation or seepage; thus, the amount of storage required for a given draft must be increased accordingly.

FLOOD FREQUENCY

The magnitude and frequency of floods are essential elements in studies involving flood-control design or the economics of structures within the reach of flood waters. Accordingly, this report provides regional flood-frequency relations that may be used as guides in determining "design" flood flows for streams, both gaged and ungaged, in the coastal basins discussed in this report. The method of analysis used in deriving the regional relationships is only briefly described here; it was discussed in detail by Benson (1962) and by Cruff and Rantz (1965). The regional concept of flood-frequency analysis is used because flood-frequency curves for individual stations, particularly for those stations with short records, are considered inadequate for establishing flood criteria for design purposes. The flood series for a single station is a random sample and therefore may not be representative of the long-term average distribution of flood events at the gaging station.

The stations used in this study were those that had 10 or more years of record of momentary peak discharge not seriously affected by regulation or diversion. If a stream, for example, is now regulated by a reservoir, but had at least 10 years of record before construction of the reservoir, it was included in the analysis; only the years of record before construction of the reservoir were used as basic data. For the preceding sections of this report, the latest data used were those for the 1963 water year. For the flood-frequency analysis, however, the time base was extended to include the disastrous floods of December 1964. The 17 stations listed in table 9 were the only ones in the area that met the criterion of 10 or more years of unaffected peak discharge record.

METHOD OF ANALYSIS

The first step in the regional analysis of flood frequency was the preparation of individual flood-frequency curves for the 17 stations. Because a time base of at least 35 years was desired, it was necessary to obtain a value of maximum peak discharge at each station for each year of the period, 1931–65. No station had a complete array of 35 annual peak discharges, and the gaps in the arrays were filled by graphical correlation of concurrent peak discharges at nearby stations in or contiguous to the report area. At each station the completed array of 35 peak discharges was ranked in order of magnitude, starting with "1" for the greatest discharge and ending with "35" for the smallest. Next, the plotting position or recurrence interval, T, for each discharge was computed by use of the formula:

$$T=\frac{N+1}{M},$$

where N is the number of years of record (35 yrs), and M is the rank or order number. Thus, the computed recurrence interval at each station for the greatest flood discharge since 1930 was 36 years, a value that is consistent with qualitative information concerning historic floods in the region.

Individual station flood-frequency curves were then prepared by plotting peak discharge against recurrence interval on extreme-value probability graph paper. Only those peak discharges that were observed were plotted; the peak discharges computed by correlation were used only to rank the observed discharges and thereby obtain more meaningful values of recurrence interval. A straight line or gentle curve was fitted to the plotted points and extrapolated to a recurrence interval of 50 years, as shown in the example in figure 10.

The individual flood-frequency curves were used to obtain regional flood-frequency equations that relate the peak discharge for selected recurrence intervals to basin and climatic parameters. The recurrence intervals selected for study were 2.33, 5, 10, 25, and 50 years. The 2.33-year recurrence interval was included because of its widespread use in statistical analyses of flood frequency that involve the extreme-value

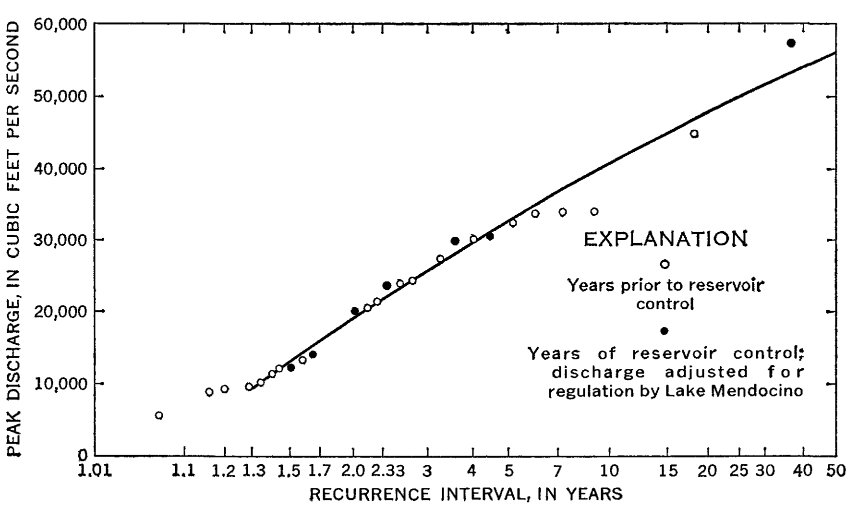


FIGURE 10.—Flood-frequency curve for Russian River near Hopland (sta. 4625).

probability distribution. Investigation of numerous basin and climatic parameters showed the most significant ones to be drainage area and mean annual basinwide precipitation. The relation between peak discharge and drainage area is obvious—in almost all humid environments, the greater the area contributing runoff, the greater the peak flow. The relation between peak discharge and mean annual basinwide precipitation is less obvious, but it can be explained rationally. Mean annual precipitation is an excellent index of the relative magnitude of storms of any given frequency because of the bulk of the annual precipitation in the study area occurs during several general storms each year, and the same number of general storms occur at all stations in any given year. The multiple-regression equations relating peak discharge for each of the five recurrence intervals to drainage area and to mean annual basinwide precipitation are listed in table 10. The constancy of the exponent of drainage area in the equations is noteworthy.

The coefficients of multiple correlation listed in table 10 show a high statistical significance and the listed standard errors of estimate are reasonably low for a regional flood-frequency study. Table 9 summarizes the results of the analysis. The drainage areas of the stations used in developing the regression equations ranged from 17 to 1,340 square miles; mean annual basinwide precipitation ranged from 31 to 92 inches. Table 9 shows that values of peak discharge computed from the regression equations compare reasonably well with those obtained from individual station flood-frequency curves.

APPLICATION OF REGIONAL FLOOD-FREQUENCY RELATIONS

The regional flood-frequency equations that were derived may be used to construct flood-frequency curves for ungaged sites or for sites with short records of peak discharge in the study area. The first step in the process is to determine the drainage area upstream from the site. The next step is to obtain the mean annual basinwide precipitation from plate 1 of this report. Those values of drainage basin area and precipitation are then used in the equations in table 10 to obtain the peak discharges corresponding to recurrence intervals of 2.33, 5, 10, 25, and 50 years. The computed discharges are plotted against recurrence interval on extreme-value probability graph paper, and the desired flood-frequency curve is obtained by drawing a smooth curve through the plotted points. The regression equations in table 10 should be used with caution when it is necessary to apply them to watersheds whose drainage basin area or mean annual basinwide precipitation lie outside the ranges of values given in the preceding paragraph.

MAXIMUM RECORDED PEAK DISCHARGES

In this section of the report the maximum recorded peak discharges at gaging stations in the study area are examined and compared with the theoretical peak discharge for a 50-year recurrence interval as computed by the flood-frequency regression equation. In the years following 1931, major floods occurred on the following dates: February 1940, December 1955, February 1958, February 1960, February 1962, January 1963, and December 1964. No single flood of this group of seven events produced the maximum recorded peak discharge at all gaging stations in the area. In many of the coastal basins south of the Russian River, six of the seven floods were of nearly equal magnitude. In the Russian River basin the flood of December 1964 was generally the maximum event, but in the coastal basins north and west of the Russian River the flood of December 1955 generally produced the greatest peak discharges.

Another notable flood occurred in northern California in 1937, but it has been excluded from this discussion because it was not the maximum event at either of the two stations at which its peak discharge is known. At the station on Conn Creek near St. Helena, where records of natural flow terminated in 1945 with the construction of Conn Dam, the peak discharge of December 1937 was greatly exceeded by that of February 1940. At the station on the Russian River near Guerneville, the peak discharge of December 1937 was exceeded in four of the seven floods listed above.

Relatively few gaging stations were operated during the entire 25-year period (1940–64) that includes all seven floods. However, because no single flood peak predominated in the entire area, it is interesting to examine, with respect to recurrence interval, the maximum peak discharge that occurred at each station whose record includes at least one of the seven floods. Those stations are listed in table 11. Stations whose recorded maximum peak discharge was appreciably affected by reservoir regulation have been omitted, but the lower Russian River stations were included because their recorded peak flows could be adjusted for the effect of regulation by Lake Mendocino.

The maximum discharge (Q_{max}) for each of the 37 stations in table 11 was compared with the theoretical peak discharge for a 50-year recurrence interval (Q_{50}), as computed from the last equation given in table 10. The ratios of Q_{max} to Q_{50} are shown in the last column of table 11. From qualitative historical records we expect the largest flood of the past 25 years to have a recurrence interval of about 35 years. On the basis of the average slope of the flood-frequency curves prepared for this study, the 35-year flood is approximately equal to 93 percent of Q_{50}. Therefore, we expect the largest flood of the past

25 years to be roughly equal to 0.93 (Q_{50}). The ratios of Q_{max} to Q_{50} in the last column of table 11 are centered about a value of 0.85, and half the ratios lie between 0.65 and 1.05. The results of this comparison are therefore consistent with the assumptions made concerning the recurrence interval of maximum observed floods.

HIGH FLOW—MAGNITUDE, DURATION, AND FREQUENCY

Studies involving the storage of flood waters require a knowledge of the magnitude, duration, and frequency of high flows. To fill the need for this information, high-flow frequency curves were prepared for the 17 stations used in the flood-frequency analysis. The stations, listed in table 12, are again those having 10 or more years of discharge record that was not seriously affected by regulation or diversion, or having a discharge record (such as that for the Russian River stations) that could be adjusted to natural flow conditions from a record of measured diversions.

The high flows selected for analysis were the maximum average rates of discharge each year for the following duration periods: 1, 3, 7, 15, 30, 60, 90, 120, 150, 183, and 274 days. The maximum 24-hour flow would have been much more significant than maximum flow for 1 calendar day. The users of Geological Survey streamflow data, however, seldom have maximum 24-hour flow rates available to them, and, in addition, the maximum flow for so short a time interval is generally not a critical factor in reservoir design. For these reasons, the rather artificial duration period of 1 calendar day was adopted for use in this study. The results obtained for discharge of this duration were surprisingly consistent.

The method of analyzing the high-flow data closely paralleled that described in the flood-frequency section of this report. This method is most appropriate for use on streams having one major high-water period per year, and its principal advantage is that it allows estimates of required storage to be made for ungaged streams. In the analysis each of the 11 duration periods was studied separately, and the 33-year base period October 1930–September 1963 was used. For each station and each duration period the data were arrayed in order of magnitude, after first filling gaps in the arrays by graphical correlation of concurrent discharges at nearby stations in or near the report area. The recurrence interval of each observed discharge in each array was computed and then plotted with its corresponding discharges on extreme-value probability paper, and the plotted points were fitted with a straight line or smooth curve.

The individual-station frequency curves for each of the 11 duration periods were used to relate the magnitude of sustained high flows for selected recurrence intervals to regional basin and climatic parameters. A regional analysis of this type reduces the statistical sampling error that might be introduced by treating each station individually in a time series. The recurrence intervals selected for study were 2.33, 5, 10, 25, and 50 years; table 12 lists the discharge indicated by the individual station frequency curves for each of these recurrence intervals. The basin and climatic parameters selected for correlation with these discharges were drainage-basin area and mean annual basinwide precipitation. These parameters, too, are listed in table 12. The multiple-regression equations relating discharge to the 2 parameters for each of the 5 recurrence intervals and for each of the 11 duration periods are summarized in table 13.

The coefficients of multiple correlation listed in table 13 show an extremely high statistical significance, and the listed standard errors of estimate are low for a regional high-flow frequency study. Examination of the regression constants shows that the drainage-area exponent, b, closely approximates unity for all but the smaller duration periods, and the small range of variation of this exponent about the value of unity suggests that the variations may be random.

The regression equations in table 13 may be used to construct frequency curves for various duration periods of high flow at ungaged sites in the study area. The procedure that would be followed in this construction is similar to that for constructing flood-frequency curves for ungaged sites. The user of the equations is reminded that the equations were developed from records for watersheds whose drainage areas range from 17 to 1,342 square miles and whose mean annual basinwide precipitation ranges from 31 to 92 inches. The equations therefore should be used with caution if it is necessary to apply them to a watershed whose drainage area or mean annual precipitation lies outside these ranges of values.

The information furnished by magnitude-duration-frequency curves is useful in studying the hydrologic and economic aspects of reservoir design for flood control. Data picked from the curves can be used to construct a frequency-mass curve that represents the total flood volume produced, for a specified recurrence interval, within duration periods of various lengths. The traditional mass-curve method of analyzing the storage required to limit reservoir outflow rates to some given value would then be applied. This method of analysis is similar to the method explained and illustrated in the closing part of the low-flow analysis section of this report.

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TABLES

TABLE 1.—*Mean monthly distribution of precipitation at selected stations*

Station	Mean annual precipitation 1931–63 (in.)	Mean monthly distribution of precipitation, as percentage of mean annual precipitation											
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Kentfield (No. 16)	46.4	5.3	10	20	22	18	13	6.9	3.2	0.7	0	0.1	0.8
Healdsburg (No. 26)	39.6	5.4	10	20	21	19	12	7.0	3.2	1.2	0	.3	.9
Fort Bragg (No. 42)	37.9	6.9	11	19	20	16	13	7.1	3.9	1.7	.1	.3	1.0
Upper Mattole (No. 43)	79.7	7.3	12	19	20	16	13	6.0	4.0	1.3	.2	.2	1.0

TABLE 2.—*Mean annual precipitation for period 1931–63 at stations in north coastal California*

No. (pl. 1)	Station	Latitude (N)	Longitude (W)	Altitude (ft)	Period of record	Estimated 33-year mean annual precipitation (in.)
1	Angwin Pacific Union College	38°34′	122°26′	1,815	1939–63	37.8
2	Calistoga	38°35′	122°35′	365	1931–63	36.1
3	Saint Helena	38°30′	122°28′	255	1907–63	33.1
4	Saint Helena 4 WSW	38°30′	122°32′	1,792	1940–63	39.8
5	Oakville 1 WNW	38°27′	122°25′	160	1953–62	31.2
6	Oakville 4 SW	38°23′	122°28′	1,465	1943–62	37.3
7	Napa	38°18′	122°17′	16	1945–63	23.2
8	Napa State Hospital	38°17′	122°16′	60	1877–1963	23.8
9	Duttons Landing	38°12′	122°18′	20	1955–63	20.0
10	Sonoma	38°17′	122°27′	20	1952–63	27.2
11	Petaluma 1 N	38°15′	122°38′	30	1943–63	22.7
12	Petaluma Fire Station 2	38°14′	122°38′	16	1871–1963	23.9
13	Novato 8 NW	38°08′	122°43′	350	1943–63	30.6
14	Hamilton Air Force Base	38°04′	122°31′	3	1934–63	25.2
15	San Rafael	37°58′	122°32′	31	1947–63	36.6
16	Kentfield	37°57′	122°33′	45	1888–1963	46.4
17	Muir Woods	37°54′	122°34′	171	1940–63	35.7
18	Sebastopol 4 SSE	38°21′	122°49′	145	1942–63	30.6
19	Santa Rosa	38°27′	122°42′	167	1888–1963	28.9
20	Graton 1 W	38°26′	122°53′	210	1896–1963	40.6
21	Occidental	38°25′	122°59′	1,000	1940–63	50.9
22	Guerneville	38°30′	123°00′	115	1939–63	45.8
23	Fort Ross	38°31′	123°15′	116	1875–1963	39.0
24	Cazadero	38°32′	123°08′	1,040	1939–63	71.1
25	Venado	38°37′	123°01′	1,260	1939–63	56.1
26	Healdsburg	38°37′	122°52′	102	1877–1963	39.6
27	Healdsburg 2 E	38°37′	122°52′	102	1952–63	36.3
28	Kellogg	38°38′	122°39′	1,360	1943–63	42.7
29	Skaggs Springs Los Lomas Ranch	38°41′	123°08′	1,930	1939–63	57.4
30	Cloverdale 11 W	38°46′	123°13′	1,820	1940–63	59.6
31	Cloverdale 3 SSE	38°46′	122°59′	320	1887–1963	39.3
32	The Geysers	38°48′	122°49′	1,600	1939–63	53.9
33	Point Arena	38°55′	123°42′	197	1940–63	39.3
34	Point Arena USCG	38°55′	123°43′	235	1938–57	32.9
35	Yorkville	38°55′	123°16′	1,100	1941–54	46.0
36	Hopland Largo Station	39°01′	123°07′	550	1943–63	34.9
37	Ukiah	39°09′	123°12′	623	1877–1963	35.6
38	Ukiah 4 SW	39°09′	123°16′	1,550	1940–63	49.5
39	Redwood Valley	39°16′	123°12′	718	1939–63	34.6
40	Potter Valley Powerhouse	39°22′	123°08′	1,014	1909–63	43.9
41	Fort Bragg Airway	39°24′	123°49′	61	1940–63	38.5
42	Fort Bragg	39°27′	123°48′	80	1896–1963	37.9
43	Upper Mattole	40°15′	124°11′	255	1886–1963	79.7

TABLE 3.—*Hydrologic budget for watersheds upstream from key stream-gaging stations, for base period 1931–63*

Gaging station		Drainage area (sq mi)	Average annual basinwide values				
No. (pl. 1)	Name		Consumptive use of applied water (acre-ft)	Precipitation (in.)	Natural runoff		Water loss (in.)
					Thousands of acre-feet	Inches	
	Napa River basin						
4560	Napa River near St. Helena	81.4	1,200	43	63.1	14.5	28
4565	Conn Creek near St. Helena	53.2	[1]	37	23.9	8.4	29
4570	Dry Creek near Napa	17.4	[1]	44	13.0	14.0	30
4580	Napa River near Napa	218	5,000	41	135.0	11.6	29
	Sonoma Creek basin						
4585	Sonoma Creek at Boyes Hot Springs	62.2	500	45	43.8	13.2	32
	Petaluma River basin						
4590	Petaluma River at Petaluma	30.9	500	31	11.5	7.0	24
	Novato Creek basin						
4595	Novato Creek near Novato	17.5	[1]	30	8.4	9.0	21
	Corte Madera Creek basin						
4600	Corte Madera Creek at Ross	18.1	[1]	40	17.2	17.8	22
	Lagunitas Creek basin						
	Lagunitas Creek above Nicasio Creek [2]	42.5	[1]	48	44.0	19.4	29
4605	Nicasio Creek near Point Reyes Station	36.2	[1]	38	27.0	14.0	24
	Walker Creek basin						
4608	Walker Creek near Tomales	37.1	[1]	40	31.1	15.7	24
	Russian River basin						
4610	Russian River near Ukiah	99.7	250	46	121.0	22.8	23
4615	East Fork Russian River near Calpella	93.0	4,500	40	77.5	15.6	24
4625	Russian River near Hopland	362	8,000	45	332.0	17.2	28
4627	Feliz Creek near Hopland	31.1	[1]	47	30.4	18.3	29
4629	Cummisky Creek near Cloverdale	13.4	100	44	13.2	18.5	26
4630	Russian River near Cloverdale	502	10,000	44	476.0	17.8	26
4632	Big Sulphur Creek near Cloverdale	82.3	[1]	52	126.0	28.7	23
4637	Sausal Creek near Healdsburg	11.2	[1]	47	13.7	22.9	24
4639	Maacama Creek near Kellogg	43.4	1,300	56	58.7	25.4	31
4639.4	Franz Creek near Kellogg	15.7	400	42	13.4	16.0	26
4640	Russian River near Healdsburg	793	18,000	45	808.0	19.1	26
4645	Dry Creek near Cloverdale	87.8	[1]	50	110.0	23.5	26
4648.8	Warm Springs Creek at Skaggs Springs	32.7	[1]	54	49.9	28.6	25
4652	Dry Creek near Geyserville	162	200	50	198.0	22.9	27
4653	Mill Creek near Healdsburg	11.8	[1]	50	14.8	23.5	26
4658	Santa Rosa Creek near Santa Rosa	12.5	100	48	12.9	19.4	29
4670	Russian River near Guerneville	1,340	31,000	45	1,367.0	19.1	26
4670.5	Big Austin Creek at Cazadero	26.5	[1]	70	68.2	48.3	22
4672	Austin Creek near Cazadero	63.1	[1]	65	135.0	40.1	25
	Gualala River basin						
4675	South Fork Gualala River near Annapolis	161	[1]	58	272.0	31.7	26
4675.5	North Fork Gualala River near Gualala	39.2	[1]	67	100.0	47.8	19
	Garcia River basin						
4676	Garcia River near Point Arena	98.5	[1]	64	238.0	45.3	19

See footnotes at end of table.

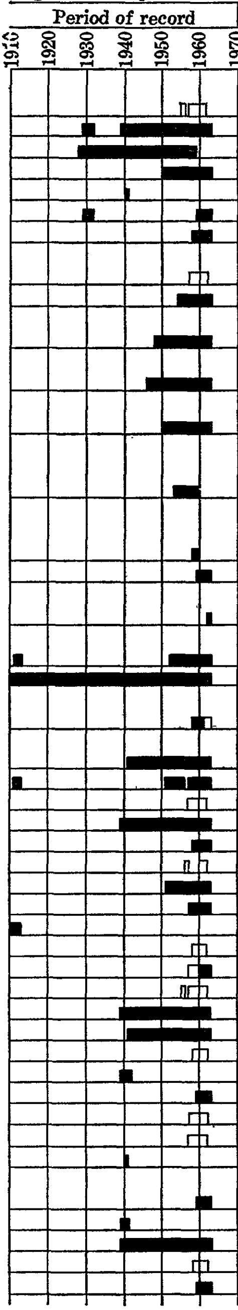
TABLE 3.—*Hydrologic budget for watersheds upstream from key stream-gaging stations, for base period 1931–63*—Continued

Gaging station		Drainage area (sq mi)	Average annual basinwide values				
No. (pl. 1)	Name		Consumptive use of applied water (acre-ft)	Precipitation (in.)	Natural runoff		Water loss (in.)
					Thousands of acre-feet	Inches	
	Alder Creek basin						
4676.5	Alder Creek near Manchester	26.6	(1)	60	58.6	41.3	19
	Elk Creek basin						
4677	Elk Creek near Elk	24.8	(1)	58	51.0	38.6	19
	Greenwood Creek basin						
4677.5	Greenwood Creek at Elk	24.2	(1)	54	34.8	27.0	27
	Navarro River basin						
4678	Rancheria Creek near Boonville	65.6	100	52	96.5	27.6	24
4680	Navarro River near Navarro	303	500	53	322.0	19.9	33
	Big River basin						
4680.7	South Fork Big River near Comptche	36.2	(1)	50	35.2	18.2	32
4681	Big River near Mendocino	152	(1)	52	138.0	17.0	35
	Noyo River basin						
4685	Noyo River near Fort Bragg	106	(1)	56	138.0	24.4	32
	Ten Mile River basin						
4686	Middle Fork Ten Mile River near Fort Bragg	33.3	(1)	58	60.0	33.8	24
4686.5	North Fork Ten Mile River near Fort Bragg	39.1	(1)	58	68.0	32.6	25
4687	South Fork Ten Mile River near Fort Bragg	26.5	(1)	54	34.2	24.2	30
	Mattole River basin						
4690	Mattole River near Petrolia	240	(1)	92	874.0	68.3	24
4695	North Fork Mattole River at Petrolia	37.6	(1)	82	122.0	60.8	21
	Bear River basin						
4695.5	Bear River at Capetown	78.3	(1)	75	237.0	56.8	18

[1] Negligible
[2] No gaging stations in basin; estimate of runoff furnished by Marin Municipal Water District.

TABLE 4.—*Bar chart of records for stream-gaging stations in north coastal California*

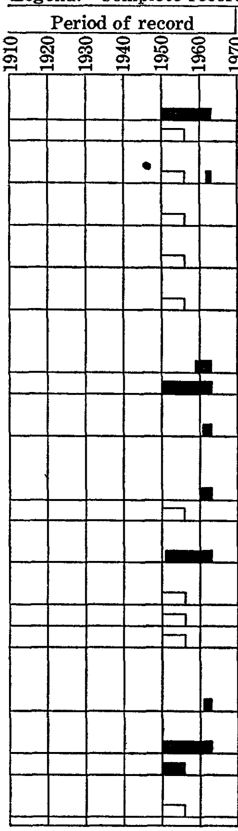
Legend: Complete-record station ▬ Partial-record station ▭



Gaging station	Drainage area (sq mi)	Station No.
Napa River basin:		
Sulphur Creek near St. Helena	4.49	4559.5
Napa River near St. Helena	81.4	4560
Conn Creek near St. Helena	53.2	4565
Dry Creek near Napa	17.4	4570
Dry Creek near Yountville	18.8	4575
Napa River near Napa	218	4580
Redwood Creek near Napa	9.81	4582
Sonoma Creek basin:		
Sonoma Creek near Kenwood	6.06	4584
Sonoma Creek at Boyes Hot Springs	62.2	4585
Petaluma River basin:		
Petaluma River at Petaluma	30.9	4590
Novato Creek basin:		
Novato Creek near Novato	17.5	4595
Corte Madera Creek basin:		
Corte Madera Creek at Ross	18.1	4600
Lagunitas Creek basin:		
Lagunitas Creek:		
Nicasio Creek near Point Reyes Station	36.2	4605
Walker Creek basin:		
Walker Creek:		
Arroyo Sausal near Marshall	19.2	4607
Walker Creek near Tomales	37.1	4608
Salmon Creek basin:		
Salmon Creek at Bodega	15.7	4609.2
Russian River basin:		
Russian River near Ukiah	99.7	4610
Potter Valley powerhouse tailrace near Potter Valley	------	4710
East Fork Russian River tributary near Potter Valley	.15	4614
East Fork Russian River near Calpella	93.0	4615
East Fork Russian River near Ukiah	105	4620
Robinson Creek near Ukiah	19.9	4621
Russian River near Hopland	362	4625
Feliz Creek near Hopland	31.1	4627
Cummisky Creek near Cloverdale	13.4	4629
Russian River near Cloverdale	502	4630
Big Sulphur Creek near Cloverdale	82.3	4632
Russian River at Geyserville	656	4635
Sausal Creek near Healdsburg	11.2	4637
Maacama Creek near Kellogg	43.4	4639
Franz Creek near Kellogg	15.7	4639.4
Russian River near Healdsburg	793	4640
Dry Creek near Cloverdale	87.8	4645
Warm Springs Creek at Skaggs Springs	32.7	4648.8
Dry Creek near Healdsburg	131	4650
Dry Creek near Geyserville	162	4652
Mill Creek near Healdsburg	11.8	4653
Mark West Creek at Mark West Springs	30.5	4654.5
Mark West Creek near Windsor	42.8	4655
Laguna de Santa Rosa:		
Santa Rosa Creek near Santa Rosa	12.5	4658
Santa Rosa Creek at Santa Rosa	56.4	4662
Russian River near Guerneville	1,340	4670
Big Austin Creek at Cazadero	26.5	4670.5
Austin Creek near Cazadero	63.1	4672

TABLE 4.—*Bar chart of records for stream-gaging stations in north coastal California*—Continued

Legend: Complete-record station ▬ Partial-record station ▭



Gaging station	Drainage area (sq mi)	Station No.
Gualala River basin:		
South Fork Gualala River near Annapolis	161	4675
North Fork Gualala River near Gualala	39.2	4675.5
Garcia River basin:		
Garcia River near Point Arena	98.5	4676
Alder Creek basin:		
Alder Creek near Manchester	26.6	4676.5
Elk Creek basin:		
Elk Creek near Elk	24.8	4677
Greenwood Creek basin:		
Greenwood Creek at Elk	24.2	4677.5
Navarro River basin:		
Navarro River:		
Rancheria Creek near Boonville	65.6	4678
Navarro River near Navarro	303	4680
Albion River basin:		
Albion River near Comptche	14.4	4680.1
Big River basin:		
Big River:		
South Fork Big River near Comptche	36.2	4680.7
Big River near Mendocino	152	4681
Noyo River basin.		
Noyo River near Fort Bragg	106	4685
Ten Mile River basin:		
Middle Fork Ten Mile River near Fort Bragg	33.3	4686
North Fork Ten Mile River near Fort Bragg	39.1	4686.5
South Fork Ten Mile River near Fort Bragg	26.5	4687
Cottoneva Creek basin:		
Cottoneva Creek:		
Dunn Creek near Rockport	1.88	4688.5
Mattole River basin:		
Mattole River near Petrolia	240	4690
North Fork Mattole River at Petrolia	37.6	4695
Bear River basin:		
Bear River at Capetown	78.3	4695.5

TABLE 5.—*Flow-duration summary of daily discharge for selected stream-gaging stations*

Gaging station	Napa River basin						Sonoma Creek at Boyes Hot Springs (4585)		Petaluma River at Petaluma (4590)	
	Napa River near St. Helena (4560)		Conn Creek near St. Helena (4565)		Dry Creek near Napa (4570)					
Period of record	1929–32, 1939–63		1929–59		1951–63		1955–63		1948–63	
Drainage area	81.4 sq mi		53.2 sq mi		17.4 sq mi		62.2 sq mi		30.9 sq mi	
	Dischage that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63									
Time (percent)	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi
99.9	0	0	0	0	0	0	0	0	0	0
99.5	0	0	0	0	0	0	0	0	0	0
99	.05	.0006	0	0	0	0	0	0	0	0
98	.08	.0010	0	0	0	0	0	0	0	0
95	.15	.0018	0	0	0	0	.03	.0005	0	0
90	.30	.0037	0	0	0	0	.12	.0019	0	0
80	.75	.0092	0	0	.06	.0034	.46	.0074	0	0
70	1.5	.0184	.02	.0004	.21	.0121	1.0	.0161	0	0
60	2.9	.0356	.30	.0056	.54	.0310	2.0	.0322	0	0
50	6.2	.0762	2.1	.0395	1.3	.0747	4.2	.0675	.03	.0010
40	13	.160	4.7	.0883	2.7	.155	9.1	.146	.16	.0052
30	25	.307	9.3	.175	5.2	.299	17	.275	.58	.0188
20	55	.676	21	.395	11	.632	38	.611	2.4	.0777
10	158	1.94	64	1.20	32	1.84	110	1.77	14	.453
5	380	4.67	162	3.05	77	4.43	270	4.34	56	1.81
2	900	11.1	405	7.61	182	10.5	640	10.3	210	6.80
1	1,450	17.8	660	12.4	300	17.2	1,050	16.9	380	12.3
0.5	2,030	24.9	950	17.9	420	24.1	1,460	23.5	550	17.8
0.1	4,200	51.6	2,000	37.6	850	48.9	2,950	47.4	1,100	35.6

TABLE 5.—*Flow-duration summary of daily discharge for selected stream-gaging stations*—Continued

Gaging station	Novato Creek near Novato (4595)		Corte Madera Creek at Ross (4600)		Nicasio Creek near Point Reyes Station (4605)		Russian River basin			
							Russian River near Ukiah (4610)		East Fork Russian River near Calpella (4615)	
Period of record	1946–63		1951–63		1953–60		1911–13, 1952–63		1941–63	
Drainage area	17.5 sq mi		18.1 sq mi		36.2 sq mi		99.7 sq mi		93.0 sq mi	
Time (percent)	Discharge that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63									
	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sp mi	cfs	cfs per sq mi
99.9	0	0	0	0	0	0	0	0	0	0
99.5	0	0	0	0	0	0	0	0	0	0
99	0	0	0	0	0	0	0	0	0	0
98	0	0	.05	.0028	0	0	0	0	0	0
95	0	0	.10	.0055	0	0	.04	.0004	0	0
90	0	0	.18	.0099	0	0	.11	.0011	0	0
80	0	0	.36	.0199	.06	.0017	.43	.0043	.04	.0004
70	0	0	.60	.0331	.10	.0028	1.4	.0140	.25	.0027
60	.02	.0011	1.0	.0552	.18	.0050	5.2	.0522	1.1	.0118
50	.14	.0080	1.9	.105	.66	.0182	15	.151	4.5	.0484
40	.62	.0354	3.3	.182	2.8	.0773	33	.331	15	.161
30	1.9	.109	5.5	.304	6.0	.166	65	.652	37	.398
20	5.5	.314	11	.608	16	.442	155	1.55	93	1.00
10	18	1.03	36	1.99	56	1.55	360	3.61	230	2.47
5	50	2.86	94	5.19	155	4.28	700	7.02	470	5.05
2	135	7.71	235	13.0	400	11.0	1,390	13.9	960	10.3
1	230	13.1	390	21.5	650	18.0	2,040	20.5	1,450	15.6
0.5	350	20.0	540	29.8	970	26.8	2,850	28.6	2,050	22.0
0.1	810	46.3	1,200	66.3	1,900	52.5	5,250	52.7	3,900	41.9

TABLE 5.—*Flow-duration summary of daily discharge for selected stream-gaging stations*—Continued

	Russian River basin—Continued									
Gaging station	Russian River near Hopland (4625)		Feliz Creek near Hopland (4627)		Russian River near Cloverdale (4630)		Big Sulphur Creek near Cloverdale (4632)		Russian River near Healdsburg (4640)	
Period of record	1939–63		1958–63		1951–63		1957–63		1939–63	
Drainage area	362 sq mi		31.1 sq mi		502 sq mi		82.3 sq mi		793 sq mi	
Time (percent)	Discharge that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63									
	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi
99.9	0	0	0	0	0	0	1.0	0.0122	3.0	0.0038
99.5	0	0	0	0	0	0	1.2	.0146	4.3	.0054
99	0	0	0	0	0	0	1.4	.0170	5.2	.0066
98	0.05	.0001	0	0	.08	.0002	1.7	.0207	6.2	.0078
95	0.1	.0003	0	0	.15	.0003	2.2	.0267	8.5	.0107
90	.2	.0006	0	0	.3	.0006	3.2	.0389	11	.0139
80	.5	.0014	0	0	.8	.0016	5.2	.0632	16	.0202
70	1.7	.0047	.06	.0019	3.0	.0060	8.0	.0972	25	.0315
60	5.5	.0152	1.1	.0354	10	.0199	14	.170	39	.0492
50	23	.0635	3.2	.103	40	.0797	30	.365	86	.108
40	88	.243	7.2	.232	135	.269	53	.644	230	.290
30	203	.561	14	.450	275	.548	87	1.06	490	.618
20	470	1.30	36	1.16	650	1.29	165	2.00	1,100	1.39
10	1,050	2.90	86	2.77	1,510	3.01	310	3.77	2,400	3.03
5	2,000	5.52	170	5.47	2,950	5.88	620	7.53	4,600	5.80
2	3,750	10.4	415	13.3	5,850	11.7	1,290	15.7	8,500	10.7
1	5,400	14.9	640	20.6	8,600	17.1	1,920	23.3	12,000	15.1
0.5	7,400	20.4	870	28.0	12,100	24.1	2,700	32.8	17,000	21.4
0.1	13,300	36.7	1,350	43.4	22,200	44.2	5,100	62.0	30,000	37.8

TABLE 5.—*Flow-duration summary of daily discharge for selected stream-gaging stations*—Continued

	Russian River basin—Continued				Gualala River basin					
Gaging station	Dry Creek near Cloverdale (4645)		Russian River near Guerneville (4670)		South Fork Gualala River near Annapolis (4675)		North Fork Gualala River near Gualala [1] (4675.5)		Garcia River near Point Arena [1] (4676)	
Period of record	1941–63		1939–63		1950–63		1951–56		1951–56, 1962–63	
Drainage area	87.8 sq mi		1,340 sq mi		161 sq mi		39.2 sq mi		98.5 sq mi	
	Discharge that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63									
Time (percent)	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi
99.9	0.03	0.0003	6.0	0.0045	0.3	0.0019	0.9	0.0230	4.0	0.0406
99.5	.05	.0006	8.0	.0060	.6	.0037	1.4	.0357	5.0	.0508
99	.06	.0007	9.5	.0071	.8	.0050	1.7	.0434	6.0	.0609
98	.09	.0010	11	.0082	1.2	.0075	2.1	.0536	7.0	.0711
95	.16	.0018	15	.0112	2.1	.0130	2.8	.0714	9.0	.0914
90	.37	.0042	19	.0142	3.4	.0211	3.7	.0944	12	.122
80	1.3	.0148	26	.0194	6.7	.0416	5.6	.143	17	.173
70	3.1	.0353	38	.0284	12	.0745	7.7	.196	24	.244
60	6.8	.0774	55	.0410	23	.142	12	.306	37	.376
50	15	.171	110	.0821	40	.248	18	.459	55	.558
40	34	.387	310	.231	76	.472	30	.765	90	.914
30	66	.752	720	.537	140	.870	53	1.35	150	1.52
20	145	1.65	1,700	1.27	320	1.99	120	3.06	280	2.84
10	320	3.64	4,000	2.99	810	5.03	300	7.65	630	6.40
5	660	7.52	8,000	5.97	1,600	9.94				
2	1,280	14.6	15,000	11.2	3,200	19.9				
1	1,880	21.4	21,000	15.7	5,000	31.1				
0.5	2,620	29.8	29,000	21.6	7,100	44.1				
0.1	4,600	52.4	48,000	35.8	12,600	78.3				

See footnote at end of table.

TABLE 5.—*Flow-duration summary of daily discharge for selected stream-gaging stations*—Continued

Gaging station	Alder Creek near Manchester [1] (4676.5)		Elk Creek near Elk [1] (4677)		Greenwood Creek at Elk [1] (4677.5)		Navarro River basin: Rancheria Creek near Boonville (4678)		Navarro River basin: Navarro River near Navarro (4680)	
Period of record	1951–56		1951–56		1951–56		1959–63		1950–63	
Drainage area	26.6 sq mi		24.8 sq mi		24.2 sq mi		65.6 sq mi		303 sq mi	
Time (percent)	**Discharge that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63**									
	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi
99.9	0.9	0.0338	0.9	0.0363	0	0	0.3	0.0046	2.0	0.0066
99.5	1.2	.0451	1.2	.0484	0	0	.4	.0061	2.6	.0086
99	1.4	.0526	1.4	.0565	.10	.0041	.5	.0076	3.1	.0102
98	1.6	.0602	1.6	.0645	.15	.0062	.6	.0091	3.7	.0122
95	2.1	.0789	2.1	.0847	.3	.0124	.9	.0137	5.3	.0175
90	2.7	.102	2.7	.109	.6	.0248	1.5	.0229	8.2	.0271
80	3.7	.139	3.8	.153	1.3	.0537	3.0	.0457	14	.0462
70	4.7	.177	5.1	.206	2.3	.0950	5.5	.0838	23	.0759
60	6.8	.256	7.4	.298	3.9	.161	10	.152	38	.125
50	10	.376	11	.444	6.4	.264	18	.274	63	.208
40	17	.639	18	.726	11	.455	34	.518	110	.363
30	31	1.17	32	1.29	21	.868	63	.960	195	.644
20	69	2.59	64	2.58	44	1.82	130	1.98	400	1.32
10	172	6.47	155	6.25	107	4.42	330	5.03	990	3.27
5							640	9.75	1,900	6.27
2							1,200	18.3	3,550	11.7
1							1,760	26.8	5,300	17.5
0.5							2,470	37.6	7,400	24.4
0.1							4,500	68.6	13,500	44.6

See footnote at end of table.

TABLE 5.—*Flow-duration summary of daily discharge for selected steam-gaging stations*—Continued

Gaging station	Big River near Mendocino [1] (4681)		Noyo River near Fort Bragg (4685)		Ten Mile River basin: Middle Fork Ten Mile River near Fort Bragg [1] (4686)		Ten Mile River basin: North Fork Ten Mile River near Fort Bragg [1] (4686.5)		Ten Mile River basin: South Fork Ten Mile River near Fort Bragg [1] (4687)	
Period of record	1951–56		1951–63		1951–56		1951–56		1951–56	
Drainage area	152 sq mi		106 sq mi		33.3 sq mi		39.1 sq mi		26.5 sq mi	
Time (percent)	Discharge that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63									
	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi
99.9	0.6	0.0039	0.6	0.0057	0.3	0.0090	0.3	0.0077	0	0
99.5	1.0	.0066	1.0	.0094	.5	.0150	.6	.0153	.05	.0019
99	1.3	.0086	1.3	.0123	.7	.0210	.8	.0205	.08	.0030
98	1.7	.0112	1.7	.0160	1.0	.0300	1.1	.0281	.13	.0049
95	2.7	.0178	2.7	.0255	1.7	.0511	1.9	.0486	.30	.0113
90	4.2	.0276	4.2	.0396	2.7	.0811	3.1	.0728	.55	.0208
80	7.5	.0493	7.5	.0708	4.7	.141	5.4	.138	1.4	.0528
70	12	.0789	12	.113	7.0	.210	8.0	.205	2.5	.0943
60	21	.138	21	.198	11	.330	12	.307	4.8	.181
50	33	.217	33	.311	16	.480	18	.460	7.8	.294
40	56	.368	56	.528	26	.781	30	.767	14	.528
30	95	.625	95	.896	42	1.26	48	1.23	23	.868
20	190	1.25	190	1.79	83	2.49	95	2.43	47	1.77
10	440	2.89	440	4.15	190	5.71	217	5.55	110	4.15
5			810	7.64						
2			1,500	14.2						
1			2,200	20.8						
0,5			3,000	28.3						
0.1			5,400	50.9						

See footnote at end of table.

TABLE 5.—*Flow-duration summary of daily discharge for selected steam-gaging stations*—Continued

Gaging station	Mattole River basin				Bear River at Capetown[1] (4695.5)	
	Mattole River near Petrolia (4690)		North Fork Mattole River at Petrolia (4695)			
Period of record	1950–63		1951–57		1951–56	
Drainage area	240 sq mi		37.6 sq mi		78.3 sq mi	
Time (percent)	Discharge that is equaled or exceeded during percent of time indicated, adjusted to base period 1931–63					
	cfs	cfs per sq mi	cfs	cfs per sq mi	cfs	cfs per sq mi
99.9	4.5	0.0188	0.7	0.0186	2.8	0.0358
99.5	7.2	.0300	1.1	.0293	3.6	.0460
99	9.0	.0375	1.4	.0372	4.2	.0536
98	12	.0500	1.8	.0479	5.0	.0638
95	18	.0750	2.8	.0745	6.9	.0881
90	28	.117	4.2	.112	9.6	.123
80	49	.204	7.4	.197	16	.204
70	81	.338	12	.319	25	.319
60	138	.575	20	.532	40	.511
50	240	1.00	34	.904	67	.856
40	420	1.75	59	1.57	115	1.47
30	710	2.96	99	2.63	192	2.45
20	1,420	5.92	200	5.32	388	4.96
10	2,950	12.3	413	11.0	800	10.2
5	4,950	20.6	693	18.4		
2	8,600	35.8	1,200	31.9		
1	12,100	50.4	1,700	45.2		
0.5	16,000	66.7	2,240	59.6		
0.1	25,000	104	3,500	93.1		

[1] Partial-record station.

TABLE 6.—*Mean monthly distribution of runoff at selected gaging stations*

Gaging station	Mean annual runoff 1931–63 (thousands of acre-ft)	Mean monthly distribution of runoff, as percentage of mean annual runoff											
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Napa River near St. Helena (sta. 4560)	63.1	0.3	1.7	20.2	27.5	27.1	12.6	7.6	2.1	0.6	0.2	0.06	0.04
Navarro River near Navarro (sta. 4680)	322	1.2	2.4	17.4	28.7	25.6	13.3	7.1	2.6	.9	.4	.2	.2
Mattole River near Petrolia (sta. 4690)	874	2.5	6.4	17.8	27.1	20.9	11.3	7.0	4.5	1.4	.5	.3	.3

TABLE 7.—*Low-flow frequency table for selected stream-gaging stations*

[Discharge adjusted to base period Apr. 1, 1931–Mar. 31, 1963]

Station No.	Gaging station	Number of consecutive days	Ordinates of low-flow frequency curves, in cubic feet per second, for indicated recurrence intervals, in years								
			1.02	1.10	1.3	2.0	5.0	10	20	30	50
4560	Napa River near St. Helena.	1	1.1	0.80	0.45	0.15	0.02	0	0	0	0
		7	1.2	.90	.55	.22	.03	.01	0	0	0
		14	1.3	1.0	.65	.30	.06	.02	0	0	0
		30	1.5	1.1	.80	.40	.11	.05	.02	.01	0
		60	1.7	1.3	1.0	.55	.23	.12	.07	.05	.03
		90	2.2	1.6	1.2	.70	.33	.19	.11	.08	.05
		120	3.2	2.2	1.6	.90	.40	.24	.14	.11	.07
		183	9.5	6.4	4.5	2.5	1.0	.55	.32	.23	.15
		274	120	86	53	19	6.3	3.8	2.5	2.1	1.8
4565	Conn Creek near St. Helena.	1	0	0	0	0	0	0	0	0	0
		7	0	0	0	0	0	0	0	0	0
		14	0	0	0	0	0	0	0	0	0
		30	0	0	0	0	0	0	0	0	0
		60	.25	.10	.03	0	0	0	0	0	0
		90	.45	.22	.07	0	0	0	0	0	0
		120	.75	.45	.22	.01	0	0	0	0	0
		183	3.3	2.1	1.3	.55	.03	0	0	0	0
		274	50	34	20	7.0	2.1	1.0	.55	.40	.30
4570	Dry Creek near Napa.	1	0	0	0	0	0	0	0	0	0
		7	0	0	0	0	0	0	0	0	0
		14	0	0	0	0	0	0	0	0	0
		30	0	0	0	0	0	0	0	0	0
		60	0	0	0	0	0	0	0	0	0
		90	.45	.32	.24	.12	.02	0	0	0	0
		120	.65	.45	.32	.17	.04	0	0	0	0
		183	2.0	1.3	.90	.50	.20	.08	.02	0	0
		274	24	17	11	4.0	1.3	.80	.50	.42	.36
4585	Sonoma Creek at Boyes Hot Springs.	1	0.85	0.60	0.30	0.03	0	0	0	0	0
		7	.90	.70	.40	.09	0	0	0	0	0
		14	1.0	.80	.48	.16	0	0	0	0	0
		30	1.1	.85	.60	.26	.01	0	0	0	0
		60	1.3	1.0	.80	.40	.10	.02	0	0	0
		90	1.6	1.2	.90	.50	.20	.06	.01	0	0
		120	2.3	1.6	1.2	.70	.26	.10	.03	.01	0
		183	6.6	4.5	3.2	1.8	.80	.40	.18	.10	.03
		274	84	60	37	13	4.4	2.7	1.8	1.6	1.4
4590	Petaluma River at Petaluma.	1	0	0	0	0	0	0	0	0	0
		7	0	0	0	0	0	0	0	0	0
		14	0	0	0	0	0	0	0	0	0
		30	0	0	0	0	0	0	0	0	0
		60	0	0	0	0	0	0	0	0	0
		90	.01	0	0	0	0	0	0	0	0
		120	.03	.01	0	0	0	0	0	0	0
		183	.35	.15	.07	.01	0	0	0	0	0
		274	28	16	7.0	1.3	.15	.05	.01	0	0

TABLE 7.—*Low-flow frequency table for selected stream-gaging stations*—Continued

Station No.	Gaging station	Number of consecutive days	Ordinates of low-flow frequency curves, in cubic feet per second, for indicated recurrence intervals, in years								
			1.02	1.10	1.3	2.0	5.0	10	20	30	50
4595	Novato Creek near Novato.	1	0	0	0	0	0	0	0	0	0
		7	0	0	0	0	0	0	0	0	0
		14	.01	0	0	0	0	0	0	0	0
		30	.02	0	0	0	0	0	0	0	0
		60	.03	.01	0	0	0	0	0	0	0
		90	.05	.02	0	0	0	0	0	0	0
		120	.10	.05	.02	0	0	0	0	0	0
		183	.56	.33	.18	.06	0	0	0	0	0
		274	20	12	6.4	1.5	.30	.13	.06	.04	.03
4600	Corte Madera Creek at Ross.	1	0.55	0.45	0.30	0.10	0	0	0	0	0
		7	.58	.50	.35	.15	0	0	0	0	0
		14	.62	.53	.38	.20	.04	0	0	0	0
		30	.65	.55	.45	.27	.07	.02	0	0	0
		60	.75	.62	.53	.35	.16	.08	.03	.01	0
		90	.87	.70	.58	.40	.23	.13	.07	.04	.01
		120	1.1	.87	.70	.50	.27	.17	.10	.07	.04
		183	2.6	1.9	1.4	.95	.53	.35	.22	.16	.10
		274	31	22	13	4.7	1.8	1.3	.97	.87	.79
4605	Nicasio Creek near Point Reyes Station.	1	0.09	0.07	0.05	0.01	0	0	0	0	0
		7	.09	.08	.06	.02	0	0	0	0	0
		14	.10	.09	.07	.03	0	0	0	0	0
		30	.11	.10	.08	.04	0	0	0	0	0
		60	.12	.11	.09	.06	.02	0	0	0	0
		90	.14	.12	.10	.07	.03	.01	0	0	0
		120	.22	.15	.11	.08	.04	.02	.01	0	0
		183	1.6	.80	.36	.16	.09	.06	.04	.02	.01
		274	55	35	18	4.5	.75	.28	.16	.14	.13
4610	Russian River near Ukiah.	1	0.78	0.31	0.14	0.05	0.01	0	0	0	0
		7	.84	.36	.16	.06	.02	0	0	0	0
		14	.92	.43	.20	.07	.02	.01	0	0	0
		30	1.1	.50	.23	.09	.03	.01	0	0	0
		60	2.0	.78	.31	.12	.04	.02	.01	0	0
		90	3.0	1.2	.54	.20	.06	.03	.02	.01	0
		120	4.7	2.0	1.0	.44	.14	.06	.03	.02	.01
		183	26	12	6.2	2.8	1.0	.61	.32	.21	.11
		274	180	117	75	38	14	7.4	4.3	3.3	2.4
4615	East Fork Russian River near Calpella.	1	0.10	0.02	0	0	0	0	0	0	0
		7	.11	.03	.01	0	0	0	0	0	0
		14	.13	.04	.01	0	0	0	0	0	0
		30	.17	.05	.02	0	0	0	0	0	0
		60	.40	.10	.03	0	0	0	0	0	0
		90	.67	.19	.05	.01	0	0	0	0	0
		120	1.1	.38	.14	.04	.01	0	0	0	0
		183	10	4.0	1.8	.56	.13	.07	.02	.01	0
		274	110	68	41	18	4.5	2.0	1.0	.72	.49
4625	Russian River near Hopland.	1	0.85	0.38	0.21	0.11	0.05	0.03	0.02	0.01	0
		7	.90	.42	.24	.12	.06	.04	.02	.02	.01
		14	1.0	.50	.28	.14	.07	.04	.03	.02	.01
		30	1.2	.58	.31	.16	.08	.05	.04	.03	.02
		60	2.2	.85	.38	.19	.10	.07	.05	.03	.02
		90	3.4	1.3	.60	.28	.14	.09	.06	.04	.03
		120	5.5	2.2	1.0	.50	.21	.13	.08	.06	.04
		183	58	17	7.5	3.0	1.0	.69	.40	.29	.18
		274	530	350	230	105	22	9.5	5.0	3.7	2.6
4627	Feliz Creek near Hopland.	1	.08	0	0	0	0	0	0	0	0
		7	.10	0	0	0	0	0	0	0	0
		14	.12	.01	0	0	0	0	0	0	0
		30	.16	.02	0	0	0	0	0	0	0
		60	.40	.08	0	0	0	0	0	0	0
		90	.70	.19	.03	0	0	0	0	0	0
		120	1.2	.40	.14	.01	0	0	0	0	0
		183	7.6	3.3	1.6	.64	.14	.04	0	0	0
		274	52	34	22	11	4.0	2.0	1.1	.78	.52

TABLE 7.—*Low-flow frequency table for selected stream-gaging stations*—Continued

Station No.	Gaging station	Number of consecutive days	Ordinates of low-flow frequency curves, in cubic feet per second, for indicated recurrence intervals, in years								
			1.02	1.10	1.3	2.0	5.0	10	20	30	50
4630	Russian River near Cloverdale.	1	1.4	0.58	0.32	0.17	0.08	0.05	0.03	0.02	0.01
		7	1.5	.65	.36	.18	.09	.06	.04	.03	.02
		14	1.7	.78	.42	.21	.11	.07	.05	.03	.02
		30	2.1	.91	.47	.24	.13	.08	.06	.04	.03
		60	4.0	1.4	.59	.29	.15	.11	.08	.06	.04
		90	6.4	2.3	.94	.42	.21	.14	.09	.07	.05
		120	10	4.0	1.7	.78	.32	.20	.13	.09	.06
		183	92	30	12	5.2	1.8	1.1	.60	.44	.27
		274	730	480	320	155	38	17	9.4	6.9	4.8
4632	Big Sulphur Creek near Cloverdale.	1	7.0	5.0	3.9	2.9	2.0	1.6	1.3	1.1	0.90
		7	7.2	5.2	4.1	3.0	2.1	1.7	1.4	1.2	1.0
		14	7.5	5.6	4.4	3.2	2.2	1.8	1.5	1.3	1.1
		30	7.8	6.0	4.6	3.4	2.4	2.0	1.6	1.4	1.2
		60	9.2	6.6	4.9	3.7	2.7	2.2	1.8	1.6	1.3
		90	11	7.6	5.6	4.1	3.0	2.5	2.1	1.8	1.4
		120	14	9.2	7.3	5.3	3.8	3.0	2.5	2.2	1.8
		183	37	22	14	9.8	6.7	5.7	4.6	3.9	3.1
		274	160	112	80	48	24	16	11	10	9.0
4640	Russian River near Healdsburg.	1	19	14	11	8.6	6.2	4.9	3.8	3.3	2.8
		7	20	15	12	9.0	6.7	5.4	4.2	3.6	3.1
		14	21	16	13	9.5	7.2	5.8	4.7	4.1	3.4
		30	22	17	14	10	7.7	6.2	5.3	4.6	3.8
		60	27	19	15	11	8.4	7.2	6.0	5.2	4.2
		90	32	22	17	13	9.5	8.0	6.8	6.0	4.9
		120	40	27	20	15	11	9.2	7.6	6.8	5.6
		183	170	72	46	31	20	18	15	13	10
		274	1,200	810	550	270	85	52	38	33	29
4645	Dry Creek near Cloverdale.	1	2.0	0.92	0.45	0.18	0.08	0.06	0.04	0.03	0.02
		7	2.1	1.0	.52	.21	.09	.07	.05	.04	.03
		14	2.3	1.2	.60	.24	.10	.08	.05	.04	.03
		30	2.6	1.4	.67	.28	.12	.09	.06	.05	.04
		60	3.9	1.9	.92	.38	.16	.11	.07	.06	.04
		90	5.0	2.8	1.5	.60	.23	.14	.09	.07	.05
		120	7.5	4.0	2.4	1.2	.44	.22	.13	.10	.07
		183	26	12	7.5	4.8	2.4	1.7	.98	.64	.36
		274	175	115	75	38	14	8.4	6.2	5.4	4.4
4670	Russian River near Guerneville.	1	31	24	19	15	11	9.5	7.4	6.6	5.8
		7	32	25	20	16	12	10	8.0	7.1	6.2
		14	34	27	22	17	13	11	9.0	8.0	6.8
		30	36	29	24	18	14	12	10	9.0	7.5
		60	43	32	26	19	15	13	11	10	8.2
		90	51	36	28	23	17	14	12	11	9.4
		120	63	43	33	25	19	16	14	13	11
		183	250	110	72	49	33	30	25	22	18
		274	1,900	1,230	800	390	115	81	60	52	46
4675	South Fork Gualala River near Annapolis.	1	8.8	5.5	3.7	2.2	1.2	0.78	0.53	0.38	0.22
		7	9.4	6.0	4.1	2.5	1.4	.95	.61	.42	.26
		14	9.8	6.6	4.5	2.7	1.5	1.0	.70	.53	.32
		30	11	7.2	4.8	3.0	1.7	1.2	.86	.69	.43
		60	15	9.0	5.5	3.4	2.1	1.5	1.0	.77	.49
		90	19	11	7.3	4.5	2.8	1.9	1.3	.94	.61
		120	23	15	10	6.5	3.6	2.6	1.8	1.4	1.0
		183	72	41	28	18	9.8	7.9	5.6	4.6	3.3
		274	420	275	180	97	46	31	24	20	16
4675.5	North Fork Gualala River near Gualala.	1	6.5	4.9	3.8	2.9	2.1	1.6	1.3	1.0	0.73
		7	6.8	5.1	4.1	3.1	2.3	1.8	1.4	1.1	.80
		14	7.0	5.4	4.3	3.3	2.4	1.9	1.5	1.3	.92
		30	7.5	5.7	4.6	3.5	2.6	2.1	1.7	1.5	1.1
		60	9.1	6.5	4.9	3.7	2.8	2.4	1.9	1.6	1.2
		90	11	7.5	5.8	4.3	3.3	2.7	2.2	1.8	1.4
		120	12	9.1	7.1	5.4	3.8	3.2	2.6	2.3	1.9
		183	29	18	14	10	7.0	6.0	5.0	4.4	3.6
		274	150	100	67	38	20	15	12	11	9.5

TABLE 7.—*Low-flow frequency table for selected stream-gaging stations*—Continued

Station No.	Gaging station	Number of consecutive days	Ordinates of low-flow frequency curves, in cubic feet per second, for indicated recurrence intervals, in years								
			1.02	1.10	1.3	2.0	5.0	10	20	30	50
4676.5	Alder Creek near Manchester.	1	4.1	3.3	2.7	2.2	1.6	1.4	1.1	1.0	0.80
		7	4.2	3.4	2.9	2.3	1.7	1.5	1.2	1.0	.85
		14	4.4	3.6	3.0	2.4	1.8	1.5	1.3	1.1	.93
		30	4.6	3.8	3.1	2.5	1.9	1.6	1.4	1.3	1.0
		60	5.4	4.2	3.3	2.7	2.1	1.8	1.5	1.4	1.1
		90	6.1	4.6	3.8	3.0	2.4	2.0	1.7	1.5	1.2
		120	6.9	5.4	4.4	3.6	2.7	2.3	2.0	1.8	1.5
		183	16	10	7.9	6.0	4.4	3.9	3.4	3.1	2.6
		274	90	60	40	22	11	8.5	7.1	6.3	5.6
4677	Elk Creek near Elk.	1	4.3	3.4	2.8	2.2	1.6	1.4	1.2	1.0	0.80
		7	4.5	3.5	2.9	2.3	1.8	1.5	1.2	1.1	.86
		14	4.7	3.7	3.1	2.4	1.8	1.5	1.3	1.2	.95
		30	4.9	3.9	3.2	2.5	1.9	1.6	1.4	1.3	1.1
		60	5.9	4.4	3.4	2.7	2.1	1.8	1.5	1.4	1.2
		90	6.8	4.9	3.9	3.1	2.4	2.0	1.7	1.5	1.3
		120	7.7	5.9	4.7	3.7	2.8	2.4	2.0	1.8	1.5
		183	18	12	8.7	6.6	4.7	4.1	3.4	3.1	2.6
		274	80	54	38	23	12	9.4	7.9	7.0	6.1
4678	Rancheria Creek near Boonville.	1	4.1	2.7	1.8	1.1	0.62	0.45	0.38	0.33	0.27
		7	4.4	2.9	2.0	1.2	.68	.51	.41	.36	.28
		14	4.7	3.2	2.2	1.3	.74	.55	.44	.39	.30
		30	5.2	3.5	2.4	1.4	.81	.61	.50	.42	.33
		60	6.7	4.1	2.7	1.7	1.0	.74	.55	.46	.36
		90	8.6	5.2	3.5	2.1	1.3	.90	.64	.51	.40
		120	11	6.8	4.7	3.2	1.8	1.2	.90	.72	.55
		183	27	18	13	8.0	4.7	3.8	2.7	2.1	1.6
		274	147	100	66	37	19	14	10	8.6	7.4
4680	Navarro River near Navarro.	1	17	12	8.6	5.7	3.7	2.9	2.5	2.2	1.8
		7	18	13	9.4	6.3	4.0	3.2	2.6	2.3	1.9
		14	19	14	10	6.7	4.2	3.4	2.8	2.5	2.0
		30	21	15	11	7.3	4.6	3.7	3.1	2.7	2.2
		60	26	17	12	8.2	5.5	4.3	3.4	2.9	2.4
		90	32	21	15	10	6.9	5.0	3.8	3.2	2.6
		120	38	26	19	14	8.6	6.5	4.8	4.2	3.4
		183	94	60	43	30	19	16	12	10	7.9
		274	450	310	208	120	65	47	37	32	28
4681	Big River near Fort Bragg.	1	9.2	6.2	4.4	2.9	1.7	1.2	0.90	0.70	0.46
		7	9.6	6.6	4.8	3.2	1.9	1.4	1.0	.75	.52
		14	10	7.2	5.2	3.4	2.0	1.5	1.1	.90	.62
		30	11	7.8	5.5	3.7	2.3	1.7	1.3	1.1	.76
		60	14	9.2	6.2	4.2	2.8	2.1	1.5	1.2	.85
		90	17	11	8.0	5.2	3.5	2.5	1.8	1.4	1.0
		120	20	14	10	7.2	4.4	3.3	2.4	2.0	1.5
		183	48	31	23	16	10	8.4	6.4	5.3	4.0
		274	215	147	101	62	34	25	20	17	15
4685	Noyo River near Fort Bragg.	1	9.2	6.2	4.4	2.9	1.7	1.2	0.90	0.70	0.46
		7	9.6	6.6	4.8	3.2	1.9	1.4	1.0	.75	.52
		14	10	7.2	5.2	3.4	2.0	1.5	1.1	.90	.62
		30	11	7.8	5.5	3.7	2.3	1.7	1.3	1.1	.76
		60	14	9.2	6.2	4.2	2.8	2.1	1.5	1.2	.85
		90	17	11	8.0	5.2	3.5	2.5	1.8	1.4	1.0
		120	20	14	10	7.2	4.4	3.3	2.4	2.0	1.5
		183	48	31	23	16	10	8.4	6.4	5.3	4.0
		274	215	147	101	62	34	25	20	17	15
4686	Middle Fork Ten Mile River near Fort Bragg.	1	5.5	3.8	2.8	1.8	1.0	0.67	0.48	0.35	0.22
		7	5.7	4.1	3.0	2.0	1.1	.79	.54	.39	.25
		14	6.0	4.4	3.2	2.1	1.2	.85	.60	.47	.31
		30	6.5	4.8	3.4	2.3	1.4	1.0	.73	.60	.38
		60	7.9	5.5	3.8	2.6	1.7	1.2	.85	.66	.44
		90	9.3	6.5	4.9	3.3	2.2	1.5	1.0	.79	.54
		120	11	7.9	6.0	4.4	2.7	2.0	1.5	1.2	.85
		183	23	15	12	8.9	6.0	5.0	4.0	3.3	2.5
		274	95	65	46	29	17	13	10	9.2	8.4

TABLE 7.—*Low-flow frequency table for selected stream-gaging stations*—Continued

Station No.	Gaging station	Number of consecutive days	Ordinates of low-flow frequency curves, in cubic feet per second, for indicated recurrence intervals, in years								
			1.02	1.10	1.3	2.0	5.0	10	20	30	50
4686.5	North Fork Ten Mile River near Fort Bragg.	1	6.3	4.3	3.2	2.1	1.1	0.76	0.55	0.39	0.22
		7	6.5	4.7	3.4	2.3	1.2	.90	.62	.44	.26
		14	6.8	5.0	3.6	2.4	1.4	.97	.68	.54	.33
		30	7.4	5.5	3.9	2.6	1.6	1.1	.83	.68	.43
		60	9.0	6.3	4.3	3.0	1.9	1.4	.97	.75	.50
		90	11	7.4	5.6	3.8	2.5	1.7	1.1	.90	.62
		120	13	9.0	6.8	5.0	3.1	2.3	1.7	1.4	.97
		183	26	17	14	10	6.8	5.7	4.6	3.8	2.8
		274	108	74	52	33	19	15	12	11	9.0
4687	South Fork Ten Mile River near Fort Bragg.	1	1.8	1.0	0.63	0.33	0.13	0.07	0.04	0.02	0
		7	1.9	1.1	.72	.39	.16	.09	.05	.03	.01
		14	2.0	1.2	.80	.43	.18	.11	.06	.04	.02
		30	2.2	1.4	.87	.48	.23	.14	.08	.06	.03
		60	3.0	1.7	1.0	.59	.31	.20	.11	.07	.04
		90	3.7	2.2	1.5	.82	.44	.26	.15	.10	.05
		120	4.5	3.0	2.0	1.3	.62	.40	.24	.18	.11
		183	12	7.4	5.2	3.5	2.0	1.6	1.1	.82	.55
		274	53	36	25	15	8.0	5.7	4.5	3.8	3.3
4690	Mattole River near Petrolia.	1	61	41	29	20	12	8.9	6.7	5.3	3.8
		7	63	44	31	21	13	9.5	7.2	5.7	4.2
		14	65	47	34	23	14	10	8.3	6.7	4.8
		30	70	50	36	25	16	12	9.3	7.7	5.6
		60	92	61	41	28	19	14	10	8.5	6.5
		90	111	73	51	35	23	17	13	10	7.4
		120	135	90	65	47	30	22	17	14	10
		183	370	220	160	105	65	55	42	35	27
		274	1,650	1,150	810	490	250	170	130	112	98
4695	North Fork Mattole River at Petrolia.	1	9.1	6.2	4.4	3.0	1.8	1.4	1.0	0.83	0.60
		7	9.4	6.7	4.7	3.2	2.0	1.5	1.1	.89	.66
		14	9.7	7.2	5.1	3.5	2.2	1.6	1.3	1.0	.76
		30	11	7.7	5.5	3.8	2.5	1.9	1.4	1.2	.87
		60	13	9.1	6.2	4.2	2.9	2.2	1.6	1.3	1.0
		90	16	11	7.7	5.3	3.5	2.6	2.0	1.6	1.1
		120	20	13	9.6	7.2	4.5	3.4	2.6	2.2	1.6
		183	52	31	23	15	9.7	8.3	6.3	5.3	4.1
		274	230	160	110	69	35	25	19	16	14
4695.5	Bear River at Capetown.	1	19	13	10	7.3	5.0	4.2	3.5	3.1	2.7
		7	20	14	11	7.7	5.4	4.4	3.7	3.2	2.8
		14	21	15	12	8.3	5.8	4.7	4.0	3.5	3.0
		30	23	16	13	8.8	6.3	5.2	4.2	3.8	3.2
		60	27	19	14	9.6	7.1	5.7	4.6	4.0	3.4
		90	32	22	16	12	8.3	6.5	5.4	4.6	3.6
		120	40	27	20	15	10	8.1	6.5	5.7	4.6
		183	102	61	46	30	21	18	14	12	9.4
		274	445	310	215	133	69	50	38	32	28

TABLE 8.—*Composite low-flow frequency table*

Number of consecutive days	Ordinates of composite low-flow frequency curves, expressed as percentiles of flow duration, for indicated recurrence intervals, in years								
	1.02	1.10	1.3	2.0	5.0	10	20	30	50
1	75	82	88	94	98.0	99.0	99.6	99.8	*a*
7	74	81	87	93	97.5	98.7	99.5	99.7	*b*
14	73	80	85	92	97.0	98.4	99.3	99.6	99.9
30	71	78	84	91	96.0	98.0	99.0	99.3	99.8
60	67	75	82	89	95.0	97.0	98.5	99.1	99.6
90	63	71	77	85	92.0	95.3	97.5	98.5	99.4
120	59	67	72	80	89.0	93.0	95.5	97.0	98.5
183	43	51	57	64	73.0	78.0	84.0	87.0	91.0
274	16	21	27	37	49.0	55.5	61.0	63.0	66.0

NOTE.—Symbols *a* and *b* indicate percentiles greater than 99.9. Ordinates represented by *a* and *b* are discharges in cubic feet per second, where $a=0.90(Q_{99.9})$ and $b=0.95(Q_{99.9})$.

TABLE 9.—*Summary of results of flood-frequency analysis*

Station No.	Gaging station	Drainage area (sq mi)	Mean annual basin-wide precipitation (in.)	Peak discharge for indicated recurrence intervals: Recurrence interval (years)	Peak discharge, in cfs: Q_c (from individual station frequency curves)	Peak discharge, in cfs: Q_r (from regression equation)	Percent difference $\frac{100(Q_c-Q_r)}{Q_r}$
4560	Napa River near St. Helena.	81.4	43	2.33	6,400	5,660	+13
				5	9,200	8,250	+12
				10	11,000	10,100	+9
				25	12,700	12,300	+3
				50	13,800	13,900	−1
4565	Conn Creek near St. Helena.	53.2	37	2.33	3,200	3,280	−2
				5	5,200	4,720	+10
				10	6,800	5,720	+19
				25	8,600	6,810	+26
				50	9,900	7,540	+31
4570	Dry Creek near Napa	17.4	44	2.33	1,220	1,700	−28
				5	1,980	2,520	−21
				10	2,510	3,100	−19
				25	3,080	3,770	−18
				50	3,500	4,260	−18
4585	Sonoma Creek at Boyes Hot Springs.	62.2	45	2.33	4,300	4,870	−12
				5	6,200	7,150	−13
				10	7,700	8,830	−13
				25	9,600	10,800	−11
				50	11,000	12,200	−10
4590	Petaluma River at Petaluma.	30.9	31	2.33	1,080	1,660	−35
				5	1,410	2,360	−40
				10	1,630	2,810	−42
				25	1,820	3,260	−44
				50	1,930	3,530	−45
4600	Corte Madera Creek at Ross.	18.1	40	2.33	2,020	1,540	+31
				5	2,740	2,250	+22
				10	3,180	2,750	+16
				25	3,600	3,300	+9
				50	3,880	3,690	+5
4610	Russian River near Ukiah.	99.7	46	2.33	9,900	7,320	+35
				5	13,500	10,700	+26
				10	16,200	13,300	+22
				25	19,800	16,300	+21
				50	22,000	18,500	+19
4615	East Fork Rnssian River near Calpella.	93.0	40	2.33	7,670	5,710	+34
				5	10,600	8,260	+28
				10	12,800	10,100	+27
				25	15,600	12,200	+28
				50	17,500	13,600	+29
4625	Russian River near Hopland.	362	45	2.33	21,800	20,000	+9
				5	33,000	29,000	+14
				10	40,500	35,800	+13
				25	50,000	43,900	+14
				50	56,000	49,600	+13
4630	Russian River near Cloverdale.	502	44	2.33	24,200	25,100	−4
				5	36,800	36,300	+1
				10	47,000	44,800	+5
				25	59,000	54,800	+8
				50	68,000	61,800	+10
4640	Russian River near Healdsburg.	793	45	2.33	35,800	37,400	−4
				5	50,000	54,000	−7
				10	60,500	66,700	−9
				25	72,000	81,900	−12
				50	80,000	92,600	−14
4645	Dry Creek near Cloverdale.	87.8	50	2.33	10,100	7,430	+36
				5	15,200	11,000	+38
				10	18,000	13,700	+31
				25	22,000	17,000	+29
				50	25,500	19,500	+31

TABLE 9.—*Summary of results of flood-frequency analysis*—Continued

Station No.	Gaging station	Drainage area (sq mi)	Mean annnal basin-wide precipitation (in.)	Peak discharge for indicated recurrence intervals			Percent difference $\frac{100(Q_c-Q_r)}{Q_r}$
				Recurrence interval (years)	Peak discharge, in cfs: Q_c (from individual station frequency curves)	Peak discharge, in cfs: Q_r (from regression equation)	
4670	Russian River near Guerneville.	1,340	45	2.33	50,200	56,900	−12
				5	68,000	82,000	−17
				10	80,000	101,000	−21
				25	93,000	125,000	−26
				50	102,000	141,000	−28
4675	South Fork Gualala River near Annapolis.	161	58	2.33	25,500	14,800	+72
				5	35,400	22,200	+59
				10	43,000	28,100	+53
				25	52,200	35,600	+47
				50	59,000	41,600	+42
4680	Navarro River near Navarro.	303	53	2.33	16,800	21,800	−23
				5	29,000	32,200	−10
				10	41,000	40,400	+1
				25	57,000	50,600	+13
				50	71,500	58,400	+22
4685	Noyo River near Fort Bragg.	106	56	2.33	7,300	10,000	−27
				5	11,500	15,000	−23
				10	15,900	18,900	−16
				25	22,400	23,900	−6
				50	28,000	27,700	+1
4690	Mattole River near Petrolia.	240	92	2.33	30,800	38,900	−21
				5	46,000	61,000	−25
				10	58,700	80,800	−27
				25	74,700	109,000	−31
				50	89,000	134,000	−34

TABLE 10.—*Multiple-regression equations and associated statistics for peak discharges at selected recurrence intervals*

Recurrence interval (years)	Multiple-regression equation	Coefficient of multiple correlation	Standard error of estimate	
			Logarithmic units	Percent
2.33	$Q_{2.33}=0.922\,A^{0.800}\,P^{1.38}$	0.972	0.128	30
5	$Q_5=0.929\,A^{0.794}\,P^{1.49}$	.976	.119	28
10	$Q_{10}=0.793\,A^{0.794}\,P^{1.59}$	.978	.115	26
25	$Q_{25}=0.580\,A^{0.796}\,P^{1.72}$	.977	.119	28
50	$Q_{50}=0.416\,A^{0.795}\,P^{1.84}$	.976	.124	29

NOTE.—Q=discharge, in cubic feet per second.
A=drainage area, in square miles.
P=mean annual basinwide precipitation, in inches.

TABLE 11.—*Comparison of maximum recorded peak discharge and* Q_{50} *computed from regression equation*

Station No.	Gaging Station	Drainage area (sq mi)	Mean annual basinwide precipitation (in.)	Period of record	Maximum discharge during period of record: Date	Maximum discharge during period of record: Q_{max} (cfs)	Q_{50} from regression equation (cfs)	Ratio, Q_{max}/Q_{50}
4560	Napa River near St. Helena.	81.4	43	1929–32, 1939–65	Dec. 22, 1955	12,600	13,900	0.91
4565	Conn Creek near St. Helena.	53.2	37	[1] 1929–45	Feb. 27, 1940	7,700	7,540	1.02
4570	Dry Creek near Napa.	17.4	44	1951–65	Feb. 28, 1958	3,460	4,260	.81
4580	Napa River near Napa.	218	41	1929–32, 1959–65	Jan. 31, 1963	16,900	27,900	.61
4582	Redwood Creek near Napa.	9.81	35	1958–65	Jan. 31, 1963	1,330	1,770	.75
4585	Sonoma Creek at Boyes Hot Springs.	62.2	45	1955–65	Dec. 22, 1955	8,880	12,200	.73
4590	Petaluma River at Petaluma.	30.9	31	1948–63	Dec. 22, 1955	1,860	3,530	.53
4600	Corte Madera Creek at Ross.	18.1	40	1951–65	Dec. 22, 1955	3,620	3,690	.98
4605	Nicasio Creek near Point Reyes Station.	36.2	38	1953–60	Dec. 22, 1955	9,010	5,830	1.55
4608	Walker Creek near Tomales.	37.1	40	1959–65	Feb. 13, 1962	3,430	6,510	.53
4609.2	Salmon Creek at Bodega.	15.7	36	1962–65	Jan. 31, 1963	1,430	2,710	.53
4610	Russian River near Ukiah.	99.7	46	1911–13 1952–65	Dec. 22, 1964	19,500	18,500	1.05
4615	East Fork Russian River near Calpella.	93.0	40	1941–65	Dec. 22, 1964	18,800	13,600	1.38
4625	Russian River near Hopland.	362	45	1939–65	Dec. 22, 1964	[2] 57,500	49,600	1.16
4627	Feliz Creek near Hopland.	31.1	47	1958–65	Dec. 22, 1964	6,080	7,620	.80
4630	Russian River near Cloverdale.	502	44	1951–65	Dec. 22, 1964	[2] 67,100	61,800	1.09
4632	Big Sulphur Creek near Cloverdale.	82.3	52	1957–65	Dec. 22, 1955	20,000	19,900	1.00
4639	Maacama Creek near Kellogg.	43.4	56	1958–65	Dec. 22, 1964	8,920	13,700	.65
4639.4	Franz Creek near Kellogg.	15.7	42	1955–65	Dec. 22, 1955	4,130	3,600	1.15
4640	Russian River near Healdsburg.	793	45	1939–65	Dec. 22, 1964	[2] 81,400	92,600	.88
4645	Dry Creek near Cloverdale.	87.8	50	1941–65	Dec. 22, 1964	18,100	19,500	.93
4652	Dry Creek near Geyserville.	162	50	1959–65	Dec. 22, 1964	32,900	31,800	1.03
4658	Santa Rosa Creek near Santa Rosa.	12.5	48	1959–65	Feb. 8, 1960	3,200	3,840	.83
4670	Russian River near Guerneville.	1,340	45	1939–65	Dec. 23, 1964	[2] 101,000	141,000	0.72
4672	Austin Creek near Cazadero.	63.1	65	1959–65	Feb. 13, 1962	15,100	24,300	.62
4675	South Fork Gualala River near Annapolis.	161	58	1950–65	Dec. 22, 1955	55,000	41,600	1.32
4675.5	North Fork Gualala River near Gualala.	39.2	67	1951–56	Dec. 22, 1955	11,900	17,600	.68
4676	Garcia River near Point Arena.	98.5	64	1951–56, 1962–65	Dec. 22, 1955	26,300	33,600	.78
4678	Rancheria Creek near Boonville.	65.6	52	1959–65	Dec. 22, 1964	20,000	16,600	1.20
4680	Navarro River near Navarro.	303	53	1950–65	Dec. 22, 1955	64,500	58,400	1.10
4680.1	Albion River near Comptche.	14.4	57	1961–65	Dec. 21, 1964	2,050	5,900	.35
4680.7	South Fork Big River near Comptche.	36.2	50	1960–65	Dec. 22, 1964	8,200	9,650	0.85

See footnotes at end of table.

TABLE 11.—*Comparison of maximum recorded peak discharge and* Q_{50} *computed from regression equation*—Continued

Station No.	Gaging Station	Drainage area (sq mi)	Mean annual basinwide precipitation (in.)	Period of record	Maximum discharge during period of record		Q_{50} from regression equation (cfs)	Ratio, Q_{max}/Q_{50}
					Date	Q_{max} (cfs)		
4681	Big River near Mendocino.	152	52	1951–56	Dec. 22, 1955	31,300	32,400	0.97
4685	Noyo River near Fort Bragg.	106	56	1951–65	Dec. 22, 1964	24,000	27,700	.87
4686	Middle Fork Ten Mile River near Fort Bragg.	33.3	58	1964–65	Dec. 21, 1964	5,670	11,800	.48
4690	Mattole River near Petrolia.	240	92	1911–13, 1950–65	Dec. 22, 1955	90,400	134,000	.67
4695	North Fork Mattole River at Petrolia.	37.6	82	1951–57	Dec. 22, 1955	9,600	24,700	.39

[1] Regulated by Lake Hennessey after 1945.
[2] Adjusted for reservoir regulation by Lake Mendocino on the basis of provisional computations by U.S. Army Corps of Engineers.

TABLE 12.—*High-flow frequency data for selected stream-gaging stations*

[Discharge, in cubic feet per second, from individual station frequency curves]

Station No.	Gaging station	Drainage area (sq mi)	Mean annual basin-wide precipitation (in.)	Recurrence interval (years)	Mean discharge, at selected recurrence intervals, for indicated number of consecutive days										
					1	3	7	15	30	60	90	120	150	183	274
4560	Napa River near St. Helena	81.4	43	2.33	3,410	2,030	1,200	810	510	380	270	215	185	150	102
				5	5,190	3,170	1,880	1,250	810	590	440	370	310	260	177
				10	6,610	4,080	2,410	1,600	1,070	770	610	510	425	355	240
				25	8,420	5,210	3,100	2,050	1,420	980	830	680	560	470	320
				50	9,780	6,090	3,640	2,380	1,700	1,150	1,020	810	670	560	380
4565	Conn Creek near St. Helena	53.2	37	2.33	1,330	800	520	330	220	140	110	85	70	58	42
				5	2,090	1,260	820	530	350	250	200	165	140	102	74
				10	2,700	1,710	1,050	690	450	350	295	245	210	143	101
				25	3,470	2,270	1,360	900	590	480	415	360	310	202	140
				50	4,060	2,690	1,580	1,060	690	575	500	450	400	247	172
4570	Dry Creek near Napa	17.4	44	2.33	620	380	240	170	110	74	59	44	38	32	22
				5	980	590	390	260	170	120	96	76	66	56	38
				10	1,260	760	520	335	220	157	132	107	92	76	52
				25	1,600	970	690	425	285	203	180	152	126	101	70
				50	1,870	1,130	830	495	330	238	220	190	154	120	84
4285	Sonoma Creek at Boyes Hot Springs	62.2	45	2.33	1,960	1,180	800	560	350	245	190	155	130	110	73
				5	3,000	1,860	1,250	850	550	390	320	250	210	175	120
				10	3,980	2,400	1,670	1,090	740	515	435	335	285	235	163
				25	5,400	3,100	2,290	1,400	990	675	575	450	395	320	215
				50	6,760	3,630	2,830	1,620	1,170	790	685	535	480	390	255
4590	Petaluma River at Petaluma	30.9	31	2.33	660	410	260	178	118	70	52	41	30	26	18
				5	960	630	410	287	194	125	95	76	57	49	33
				10	1,210	800	535	370	258	172	135	107	83	69	46
				25	1,520	1,020	690	470	344	235	182	148	121	94	66
				50	1,760	1,200	800	550	410	282	220	181	150	113	81
4600	Corte Madera Creek at Ross	18.1	40	2.33	880	550	350	220	135	93	68	56	47	40	28
				5	1,340	840	530	350	225	140	114	96	80	68	47
				10	1,710	1,080	680	450	295	180	157	130	109	90	63
				25	2,180	1,380	900	580	380	235	213	172	145	119	83
				50	2,540	1,600	1,070	680	450	280	255	204	170	140	97

TABLE 12.—*High-flow frequency data for selected stream-gaging stations*—Continued

Station No.	Gaging station	Drainage area (sq mi)	Mean annual basin-wide precipitation (in.)	Recurrence interval (years)	Mean discharge, at selected recurrence intervals, for indicated number of consecutive days: 1	3	7	15	30	60	90	120	150	183	274
4610	Russian River near Ukiah	99.7	46	2.33	4,240	2,890	2,010	1,330	970	640	540	450	370	320	208
				5	6,180	3,990	2,900	1,850	1,380	920	800	650	530	465	296
				10	7,820	4,950	3,630	2,280	1,750	1,140	1,010	820	660	580	368
				25	10,400	6,420	4,600	2,820	2,250	1,470	1,280	1,020	830	730	457
				50	12,800	7,900	5,380	3,240	2,700	1,750	1,480	1,170	950	840	525
4615	East Fork Russian River near Calpella	93.0	40	2.33	3,300	2,050	1,320	880	640	460	360	300	250	215	140
				5	5,050	3,050	1,990	1,330	930	680	535	460	375	320	207
				10	6,280	3,780	2,500	1,620	1,160	840	680	585	475	410	264
				25	7,400	4,530	3,030	1,830	1,460	1,040	860	745	600	520	335
				50	8,000	4,950	3,340	1,900	1,680	1,170	1,000	870	700	600	386
4625	Russian River near Hopland	362	45	2.33	12,000	7,750	5,000	3,480	2,480	1,770	1,500	1,250	1,040	845	576
				5	19,500	12,300	7,620	5,010	3,710	2,550	2,200	1,860	1,570	1,300	880
				10	25,100	15,600	9,800	6,200	4,700	3,180	2,760	2,340	1,980	1,660	1,120
				25	32,300	19,200	12,600	7,420	5,820	3,970	3,490	2,890	2,470	2,050	1,400
				50	37,500	21,200	14,600	8,200	6,600	4,560	4,040	3,250	2,830	2,300	1,590
4630	Russian River near Cloverdale	502	44	2.33	18,000	12,000	7,500	5,100	3,800	2,500	2,060	1,710	1,480	1,210	820
				5	25,200	17,000	10,600	7,020	5,380	3,550	3,000	2,630	2,160	1,820	1,280
				10	31,300	21,300	13,100	8,600	6,600	4,400	3,750	3,270	2,670	2,290	1,660
				25	38,800	26,200	16,200	10,400	8,100	5,500	4,680	3,920	3,240	2,840	2,120
				50	44,500	29,800	18,600	11,600	9,170	6,320	5,410	4,250	3,550	3,190	2,470
4640	Russian River near Healdsburg	793	45	2.33	26,500	18,600	12,400	8,500	6,000	4,330	3,620	2,710	2,400	1,900	1,300
				5	39,900	28,500	17,800	12,200	8,800	6,400	5,300	4,400	3,750	3,240	2,050
				10	50,000	36,000	22,400	14,600	11,000	7,850	6,600	5,700	4,710	4,140	2,600
				25	62,200	44,300	28,000	17,000	13,600	9,290	8,200	7,200	5,780	4,870	3,210
				50	70,500	49,400	32,400	18,200	15,300	10,100	9,250	8,120	6,350	5,240	3,560
4645	Dry Creek near Cloverdale	87.8	50	2.33	4,800	3,630	2,000	1,270	860	610	490	410	340	285	195
				5	7,300	5,580	2,990	1,800	1,280	900	720	617	498	413	285
				10	9,000	7,100	3,790	2,250	1,620	1,120	910	780	625	520	356
				25	10,700	8,810	4,800	2,790	2,050	1,420	1,150	987	790	653	448
				50	11,600	9,990	5,550	3,220	2,370	1,640	1,340	1,140	910	755	517

4670	Russian River near Guerneville	1,340	45	2.33	39,200	30,290	20,400	14,000	9,700	7,360	5,810	4,600	3,900	3,200	2,160
				5	57,000	45,200	30,600	20,000	14,500	10,600	8,650	7,180	6,000	5,000	3,300
				10	71,100	57,500	39,500	25,000	18,600	13,300	11,200	9,400	7,910	6,550	4,350
				25	86,200	73,000	51,300	31,300	24,000	16,700	14,400	12,600	10,500	8,480	5,800
				50	95,100	84,900	61,000	36,000	28,200	19,200	17,000	15,000	12,600	9,900	6,900
4675	South Fork Gualala River near Annapolis	161	58	2.33	11,600	7,060	4,500	3,100	2,090	1,500	1,170	990	860	720	498
				5	17,500	10,200	6,620	4,100	2,910	2,010	1,630	1,380	1,190	1,000	673
				10	21,700	12,800	8,210	4,800	3,580	2,440	2,000	1,680	1,450	1,240	815
				25	25,600	16,000	10,200	5,650	4,400	2,960	2,450	2,020	1,780	1,580	990
				50	27,500	18,400	11,500	6,300	5,000	3,370	2,800	2,230	2,040	1,840	1,130
4680	Navarro River near Navarro	303	53	2.33	12,200	8,700	5,580	3,600	2,520	1,710	1,500	1,250	1,060	880	565
				5	19,200	12,100	7,810	4,830	3,600	2,400	2,140	1,740	1,480	1,260	800
				10	25,600	14,800	9,700	5,810	4,500	3,000	2,640	2,120	1,830	1,560	1,000
				25	34,500	18,200	12,000	7,090	5,600	3,540	3,290	2,610	2,270	1,940	1,270
				50	41,500	20,800	13,800	8,020	6,420	4,260	3,900	3,000	2,600	2,220	1,480
4685	Noyo River near Fort B agg	106	56	2.33	5,100	3,320	2,150	1,410	1,040	720	580	540	430	372	250
				5	8,100	4,950	3,020	1,950	1,530	1,030	810	760	628	530	360
				10	10,800	6,220	3,750	2,380	1,880	1,260	1,000	940	782	660	448
				25	14,400	7,720	4,650	2,940	2,260	1,520	1,250	1,130	980	820	542
				50	17,100	8,750	5,320	3,360	2,500	1,680	1,430	1,260	1,130	940	610
4690	Mattole River near Petrolia	240	92	2.33	18,200	16,200	11,800	7,900	5,750	4,450	3,670	3,020	2,630	2,140	1,600
				5	24,600	22,100	15,800	10,600	7,800	5,750	4,700	3,940	3,390	2,770	2,020
				10	30,200	26,500	19,000	12,600	9,350	6,570	5,390	4,600	3,910	3,300	2,370
				25	38,500	32,000	23,200	14,800	11,200	7,400	6,120	5,380	4,600	3,950	2,800
				50	45,000	36,200	26,300	16,200	12,500	7,980	6,610	5,950	5,130	4,450	3,140

TABLE 13.—*Multiple-regression equations and associated statistics for high flows of various durations at selected recurrence intervals*

Number of consecutive days	Recurrence interval T (years)	Values of constants in multiple-regression equation: $Q_T=aA^bP^c$ [1]			Coefficient of multiple correlation	Standard error of estimate		Range of percentage differences between individual station discharges and discharges computed from regression equations
		a	*b*			Logarithmic units	Percent	
1	2.33	0.341	0.928	1.327	0.991	0.080	18	−20 to +40
	5	.657	.920	1.272	.990	.083	19	−23 to +30
	10	1.054	.915	1.222	.989	.087	20	−25 to +38
	25	1.041	.908	1.292	.992	.076	18	−26 to +28
	50	1.172	.898	1.311	.992	.075	17	−26 to +28
3	2.33	.070	.960	1.591	.992	.080	19	−25 to +40
	5	.171	.953	1.473	.992	.078	18	−22 to +44
	10	.284	.949	1.407	.992	.078	18	−21 to +46
	25	.438	.941	1.363	.992	.077	18	−19 to +44
	50	.557	.934	1.347	.992	.077	18	−18 to +42
7	2.33	.032	.968	1.671	.994	.070	16	−21 to +39
	5	.087	.952	1.534	.994	.066	15	−18 to +35
	10	.148	.946	1.466	.995	.064	15	−17 to +33
	25	.236	.937	1.419	.994	.065	15	−17 to +35
	50	.308	.932	1.394	.994	.067	16	−18 to +37
15	2.33	.022	.975	1.655	.995	.065	15	−21 to +32
	5	.070	.952	1.480	.995	.063	15	−18 to +35
	10	.123	.940	1.406	.995	.061	14	−17 to +35
	25	.196	.926	1.356	.995	.060	14	−16 to +36
	50	.258	.913	1.334	.994	.064	15	−15 to +37
30	2.33	.0109	1.002	1.705	.995	.068	16	−23 to +29
	5	.032	.982	1.554	.995	.063	15	−20 to +31
	10	.058	.974	1.473	.995	.061	14	−21 to +32
	25	.110	.965	1.381	.995	.060	14	−21 to +30
	50	.162	.959	1.325	.995	.065	15	−21 to +31
60	2.33	.0039	1.018	1.857	.994	.073	17	−24 to +31
	5	.0177	.993	1.601	.996	.059	14	−19 to +21
	10	.042	.981	1.451	.997	.051	12	−18 to +18
	25	.104	.966	1.294	.997	.051	12	−20 to +17
	50	.167	.958	1.218	.997	.051	12	−15 to +20
90	2.33	.0022	1.039	1.919	.995	.071	16	−22 to +31
	5	.0122	1.008	1.626	.996	.059	14	−16 to +26
	10	.036	.988	1.439	.997	.053	12	−14 to +25
	25	.090	.972	1.284	.997	.051	12	−15 to +25
	50	.155	.964	1.193	.997	.050	11	−15 to +24
120	2.33	.00130	1.036	2.011	.994	.078	18	−25 to +34
	5	.0085	1.015	1.664	.996	.064	15	−21 to +29
	10	.024	.997	1.485	.996	.057	13	−20 to +26
	25	.063	.980	1.320	.996	.054	12	−19 to +23
	50	.109	.965	1.234	.996	.055	13	−18 to +20
150	2.33	.00078	1.046	2.084	.994	.080	18	−24 to +33
	5	.0053	1.016	1.740	.996	.062	14	−20 to +31
	10	.0161	.996	1.542	.997	.054	12	−18 to +28
	25	.043	.976	1.380	.997	.048	11	−16 to +24
	50	.072	.961	1.303	.997	.048	11	−16 to +21
183	2.33	.00071	1.032	2.078	.993	.084	19	−26 to +36
	5	.0044	1.019	1.736	.994	.071	16	−24 to +33
	10	.0105	1.008	1.591	.995	.064	15	−21 to +31
	25	.021	.988	1.498	.996	.057	13	−16 to +28
	50	.030	.972	1.468	.996	.054	12	−15 to +25
274	2.33	.00040	1.024	2.141	.994	.079	18	−23 to +35
	5	.0025	1.005	1.801	.995	.066	15	−20 to +34
	10	.0062	.996	1.643	.996	.060	14	−19 to +34
	25	.0154	.988	1.479	.996	.055	13	−18 to +31
	50	.024	.981	1.408	.997	.052	12	−17 to +28

[1] Where Q_T=Discharge, in cubic feet per second, corresponding to recurrence interval of *T* years;
A=Drainage area, in square miles;
P=Mean annual basinwide precipitation, in inches;
a, *b*, and *c* are constants.