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# OW-FLOW CHARACTERISTICS OF STREAMS IN THE PUGET SOUND REGION, WASHINGTON

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## CONTENTS


| | Page |
|---|---|
| Abstract | 1 |
| Introduction | 2 |
| Physical and hydrologic environment | 2 |
| Topography | 2 |
| Geology | 4 |
| Climate | 4 |
| Glaciers | 5 |
| Basic data used in analysis | 8 |
| Occurrence of low flows | 9 |
| Low-flow-frequency curves | 11 |
| Indexes of low-flow characteristics | 13 |
| Low-flow-yield index | 13 |
| Base-flow index | 13 |
| Slope index | 14 |
| Spacing index | 14 |
| Factors affecting low flows by basins | 20 |
| Elwha-Dungeness basins | 20 |
| West Sound basins | 21 |
| Nisqually-Deschutes basins | 22 |
| Puyallup basin | 23 |
| Cedar-Green basins | 24 |
| Snohomish basin | 25 |
| Stillaguamish basin | 26 |
| Skagit basin | 27 |
| Nooksack basin | 30 |
| Summary | 30 |
| References cited | 31 |

# ILLUSTRATIONS

Page

FIGURE 1. Map showing drainage basins, Puget Sound region .............. 3

2. Graph showing average monthly precipitation at two stations, 1931-60 .............. 6

3. Map showing mean annual precipitation, 1930-57 .............. 7

4. Graph showing monthly distribution of runoff for selected streams .............. 10

5. Graph showing low-flow-frequency curves for Dungeness River near Sequim, 1946-64 .............. 12

6. Map showing gaging stations and generalized areal variations in low-flow-yield indexes for streams in the Puget Sound region .............. (in pocket)

7. Graph showing frequency curves for annual 7-day minimum discharges at selected gaging stations, 1946-64, and variations in slope index .............. 15

8-11. Graphs showing low-flow-frequency curves and spacing indexes during 1946-64 for:

8. Huge Creek near Wauna .............. 16
9. Skookum Creek near Wickersham .............. 17
10. Day Creek near Lyman .............. 18
11. Pilchuck Creek near Bryant .............. 19

# TABLES

Page

TABLE 1. Gaging-station records used in analysis .............. 32

2. Low-flow-frequency data for selected gaging stations in the Puget Sound region .............. 36

3. Distribution of low-flow indexes in the Puget Sound region .............. 51

4. Low-flow characteristics of streams in the Puget Sound region .............. 52

# LOW-FLOW CHARACTERISTICS OF STREAMS IN THE PUGET SOUND REGION, WASHINGTON

By F. T. Hidaka

## ABSTRACT

Periods of low streamflow are usually the most critical factor in relation to most water uses. The purpose of this report is to present data on low-flow characteristics of streams in the Puget Sound region, Washington, and to briefly explain some of the factors that influence low flow in the various basins.

Presented are data on low-flow frequencies of streams in the Puget Sound region, as gathered at 150 gaging stations. Four indexes were computed from the low-flow-frequency curves and were used as a basis to compare the low-flow characteristics of the streams. The indexes are the (1) low-flow-yield index, expressed in unit runoff per square mile; (2) base-flow index, or the ratio of the median 7-day low flow to the average discharge; (3) slope index, or slope of annual 7-day low-flow-frequency curve; and (4) spacing index, or spread between the 7-day and 183-day low-flow-frequency curves. The indexes showed a wide variation between streams due to the complex interrelation between climate, topography, and geology.

The largest low-flow-yield indexes determined—greater than 1.5 cfs (cubic feet per second) per square mile—were for streams that head at high altitudes in the Cascade and Olympic Mountains and have their sources at glaciers. The smallest low-flow-yield indexes—less than 0.5 cfs per square mile—were for the small streams that drain the lowlands adjacent to Puget Sound. Indexes between the two extremes were for nonglacial streams that head at fairly high altitudes in areas of abundant precipitation.

The base-flow index has variations that can be attributed to a basin's hydrogeology, with very little influence from climate. The largest base-flow indexes were obtained for streams draining permeable unconsolidated glacial and alluvial sediments in parts of the lowlands adjacent to Puget Sound. Large volume of ground water in these materials sustain flows during late summer. The smallest indexes were computed for streams draining areas underlain by relatively impermeable igneous, sedimentary, and metamorphic rocks or by relatively impermeable glacial till. Melt water from snow and ice influences the index for streams which originate at glaciers, and result in fairly large indexes—0.25 or greater.

The slope index is influenced principally by the character of the geologic materials that underlie the basin. The largest slope indexes were computed for small streams that drain areas underlain by compact glacial till or consolidated sedimentary rocks. In contrast, lowland streams that flow through areas underlain by unconsolidated alluvial and glacial deposits have the smallest indexes. Small slope indexes also are characteristic of glacial streams and show the moderating effect of the snow and ice storage in the high mountain basins.

The spacing indexes are similar to the slope indexes in that they are affected by the character of the geologic materials underlying a basin. The largest spacing indexes are characteristic of small streams whose basins are underlain by glacial till or by consolidated sedimentary rocks. The smallest indexes were computed for some lowland streams draining areas underlain by permeable glacial and alluvial sediments.

The indexes do not appear to have a definite relation to each other. The low-flow-yield indexes are not related to either the slope or spacing indexes because snow and ice storage has a great influence on the low-flow-yield index, while the character of the geologic materials influences the slope and spacing indexes. A relation exists between the slope and spacing indexes but many anomalies occur that cannot be explained by the geology of the basins.

# INTRODUCTION

In the Puget Sound region abundant surface-water supplies are generally available. The limiting factors in the development of these supplies are the quantity, distribution, and duration of critical periods of low flow, as well as the chemical, physical, and biological properties of these waters. In this report streamflow data are analyzed only for the quantity, distribution, and duration of low flow.

Periods of low streamflow are usually the most critical factor in relation to water use, not only from the standpoint of quantity available for diversion but for uses of the stream itself, such as for fish propagation. In addition, and most important for some streams, during low flow the stream is more susceptible to rises in temperature and to a higher degree of pollution from industrial, municipal, and agricultural wastes.

The purpose of this report is to present data on the low-flow characteristics of streams in the Puget Sound region and to relate these characteristics to the climatic, geologic, and topographic environment. Low-flow characteristics are described from indexes computed from low-flow-frequency curves. Variations in the indexes and factors responsible for the variations —such as the permeability of geologic materials and extent of ground-water storage, the climatic factors such as precipitation and temperature, and the effects of surface storage in glaciers and perennial snowfields —are discussed and explained. Low-flow characteristics of streams at 150 sites in the Puget Sound region are given.

Streamflow records used in the analysis for this report were collected over a period of years by the U.S. Geological Survey in cooperation with many Federal, State, and municipal agencies. The study was made under the terms of a cooperative agreement between the Geological Survey and the State of Washington Department of Water Resources (now Department of Ecology). The report was prepared by the Geological Survey under the supervision of L. B. Laird, district chief.

Grateful acknowledgment is made to the National Weather Service for the climatic data furnished by their Seattle office. Technical reviews of the manuscript by S. E. Rantz, K. L. Walters, and H. C. Riggs of the Geological Survey were of benefit to the final report.

# PHYSICAL AND HYDROLOGIC ENVIRONMENT

The Puget Sound region covers about 15,780 square miles in the northwestern part of Washington (fig. 1). As delineated in this study, the region is bounded on the north by Canada, on the east by the crest of the Cascade Range, on the west by the drainage divide of the Olympic Mountains, and on the south by the drainage divide of the Chehalis River. Puget Sound, other inland marine waterways, and the adjacent lowlands occupy a trough about 50 miles wide between the Cascade Range and Olympic Mountains.

## Topography

The Puget Sound region of this report is made up of the Puget Sound lowland and the bordering mountains. The Puget Sound lowland includes the marine waters—of which Puget Sound and Hood Canal are the principal channels—and the low-altitude glacial drift plains and their remnants, along with the broad river valleys that separate the drift-plain remnants. The drift plains are referred to as "uplands" relative to the marine waters and the broad alluviated river valleys. These valleys, with broad floors bordered by steep bluffs, are important physiographic features of the Puget Sound lowland. The valleys are separated by the uplands whose gently rolling surfaces are remnants of a former, nearly continuous, glacial drift plain. The terrain of the uplands is diversified by terraces, lakes, and marshy depressions. The transition between the uplands and the mountains is usually abrupt in much of the area.

Drift-plain remnants also form the Kitsap Peninsula and adjacent islands between Hood Canal on the west and Puget Sound proper on the east. The peninsula covers an area of 582 square miles and lies mostly below an altitude of 500 feet.

The periphery of the Puget Sound lowland, beyond which lies the bordering foothills and mountains, is defined herein as the general limit of coverage by a significant thickness of glacial drift. The foothills of the Cascade Range and Olympic Mountains generally rise abruptly from the drift plains but in some places the rise is so gradual that the line of distinction must be based on a change in lithology.

In the Cascade Range, the higher ridges generally reach an altitude of 8,000 feet in the north and 5,000 feet in the south. Dormant volcanoes—Mount Baker (10,778 ft), Glacier Peak (10,541 ft), and Mount

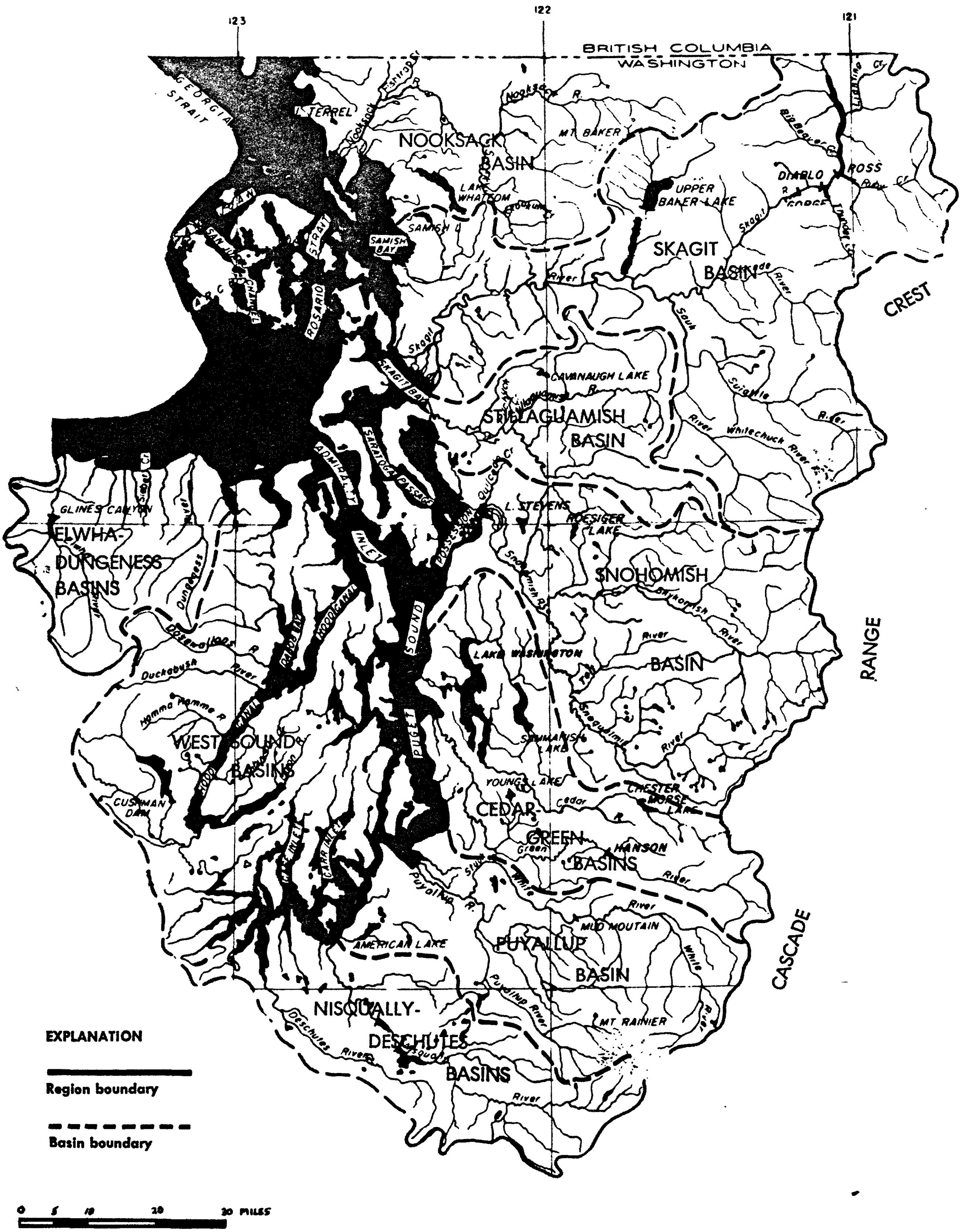


**FIGURE 1.—Drainage basins studied in Puget Sound region, Washington.**

Rainier (14,410 ft)—rise prominently above the rather uniform summit level of the range. The principal rivers and numerous tributaries head at high altitudes in the range and flow in deep, steep-walled valleys. The combination of high ridge crests and steep-walled valleys produces a very irregular and rugged topography.

The Olympic Mountains are generally at lower altitudes than the Cascades but are similarly rugged. Many deep valleys and canyons are separated by ridges and peaks that attain altitudes of 6,000 feet. The mountains rise rather abruptly above the Puget Sound lowland on the east, but a relatively narrow piedmont on the north separates the Olympic Mountains from the Strait of Juan de Fuca.

The Black Hills and Bald Hills, in the southern part of the study area, rise to altitudes generally less than 2,500 feet and 3,500 feet, respectively. The two areas are separated by a lowland generally less than 400 feet above sea level.

## Geology

The character of the geologic materials in the region has a major influence on its hydrologic environment. Runoff, infiltration, ground-water occurrence, and water quality are influenced by the permeability and types of rock materials underlying the area.

The Puget Sound lowland occupies a broad north-trending structural trough formed toward the close of the Tertiary Period. The east and west flanks of the trough are composed of consolidated rocks that were uplifted during the Pliocene Epoch to form the Cascade Range and Olympic Mountains. During the Quaternary Period, the Cascades and Olympics were eroded to their present relief. During this time, intermittent volcanic activity formed the prominent cones —Mount Rainier, Glacier Peak, and Mount Baker— that rise above the older peaks of the Cascade Range.

During the Pleistocene "Ice Age" of the Quaternary Period continental glaciers originating in the mountains of British Columbia advanced into, and receded from, the study area at least four times. These glaciers were several thousand feet thick, and had the power to erode, transport, and deposit large volumes of rock materials to form the broad drift plains of the lowland. Materials incorporated in the ice mass were laid down as unstratified, concretelike, till deposits (locally known as "hardpan"). As the glacier advanced and retreated, sand and gravel of the advance and recessional outwash were deposited in stratified layers by melt-water streams. Finer grained sand, silt and clay were deposited in glacier-dammed lakes. Other lakes and swamps, formed in depressions left by melting blocks of ice buried in the outwash plains and terraces, were sites for accumulation of organic materials which were later transformed into peat.

The most recent glaciation—the Fraser Glaciation —ended in the Puget Sound region about 10,000 years ago. The drift plains and their eroded remnants and other land features resulting from this glaciation are relatively intact, although normal erosional processes continue to the present day. The present terrain is characterized by numerous lakes and swales, deranged drainage patterns, and broad, deeply incised valleys.

The valley floors are underlain by alluvial deposits associated with flood plains and deltas of the present-day drainage system. Composition and texture of the alluvium are not uniform and are influenced by stream gradient and by silt from glacial melt water. The water-bearing characteristics of the alluvium vary not only from one valley to the next but also with depth and location within a particular valley.

Many of the drift-plain remnants (herein called uplands) between the major valleys are underlain by glacial till which, because of its compact character, impedes infiltration and favors surface runoff. In low-lying areas adjacent to, and in depressions on, the till-covered uplands, recessional outwash composed mostly of sand and gravel covers the till in many places. Areas covered by this loose, unconsolidated material characteristically have rather high rates of infiltration. Many of the streams that drain the outwash have significantly less seasonal and year-to-year variation in discharge than do streams that drain lands underlain by finer materials.

Quaternary units older than the most recent till comprise a complex assortment of lake, stream, and glacial deposits. These older materials underlie the till and surface exposures are small in areal extent and occur principally along bluffs that border the larger valleys and inlets. The largest and most dependable supplies of ground water are contained in these deposits.

## Climate

The Puget Sound region has a characteristically maritime climate. The airmasses that reach the region originate over the Pacific Ocean and have a moderating influence, with relatively short, cool, dry summers and prolonged, rather mild but wet winters. Only occasionally does dry, cold continental air from the north or east extend across the Cascade Mountains to reach the Puget Sound region.

Some of the factors that influence the climate are topography, position, and intensity of the high- and low-pressure systems in the North Pacific, wind direction, and distance from the ocean. The Olympic Mountains on the west and the mountains of Vancouver Island on the north protect the area from more intense winter storms. On the other hand, the Straits of Juan de Fuca and Georgia on the north, and the range of low hills on the south provide low-level passages for maritime air moving inland.

The Puget Sound region has a well-defined dry season in the summer and a wet season in the winter. Precipitation is light in the summer, increases in the fall, reaches a maximum in the winter, then decreases in the spring. Very often, a slight increase in precipitation is recorded in May and June and is followed by a sharp decline in July. About 75 percent of the annual precipitation falls during the 6-month period October through March, whereas less than 5 percent occurs during July and August. Seasonal variations in precipitation are shown for two representative weather stations in figure 2.

Precipitation varies widely across the study area. Figure 3 shows the areal variations in mean annual precipitation within the Puget Sound region. The driest part of the region, often referred to as being in the "rain shadow" of the Olympic Mountains and extending eastward from Port Angeles almost to Everett and northward into the San Juan Islands, receives 18 to 30 inches of precipitation a year. Annual precipitation ranges from 35 to 50 inches over most of the Puget Sound lowland, then increases to 75 inches in the foothills and from 100 to 200 inches on the wettest slopes of the Cascade and Olympic Mountains.

During most years winter precipitation falls as rain at altitudes less than 1,500 feet, as rain and snow between 1,500 and 2,500 feet, and as snow at higher altitudes. In the mountains snow can be expected in October and it generally remains on the ground from November to June or July. Total winter snowfall over the lowlands near Puget Sound ranges from a trace to 30 inches, in the foothills it ranges between 75 and 100 inches, and in the mountains it ranges between 350 and 500 inches.

## Glaciers

Glaciers are an integral part of the water resources of the Puget Sound region and significantly affect the low-flow regimen. Glaciers in the area cover about 116 square miles—this represents about two-thirds of the glacier area in Washington. The Skagit River basin has the greatest number of glaciers and the largest total area of glacial ice—233 glaciers covering 63.3 square miles.

Almost all glaciers occur at altitudes where annual precipitation exceeds 100 inches, and they produce an average of about 9,000 acre-feet of streamflow per square mile of glacier each year, or an average flow of about 1,440 cfs (cubic feet per second) in the study area. The total amount of water stored as glacier ice in the region is estimated to be about 19 million acre-feet.

Distinctive characteristics of glaciers include the following: (1) winter precipitation is retained and released during the summer, usually in July and August; (2) runoff from glaciers approximately equals precipitation when averaged over a long period of time; but in warm, dry years runoff can greatly exceed precipitation and in cool, wet years runoff can be considerably less than precipitation; (3) daily fluctuations in melt-water discharge from a glacier in midsummer is pronounced; and (4) evaporation losses are small.

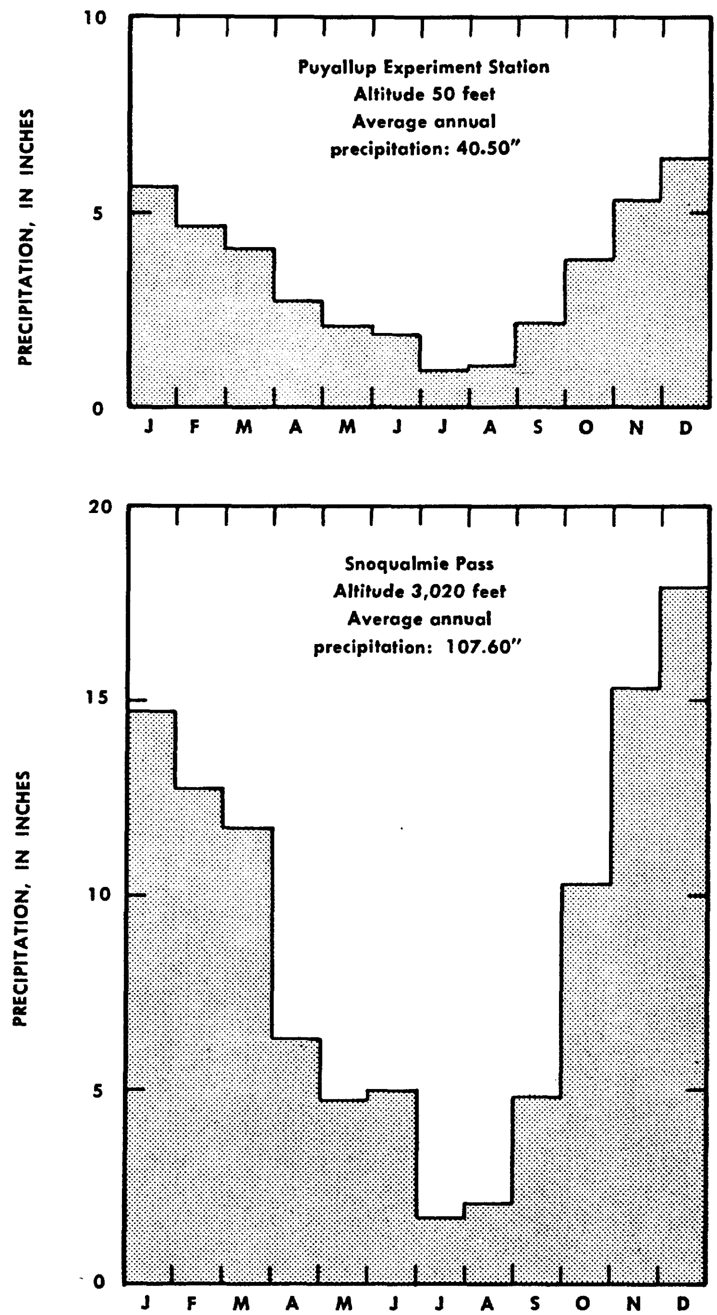


**FIGURE 2.—Average monthly precipitation at two representative weather stations, 1931-60.**

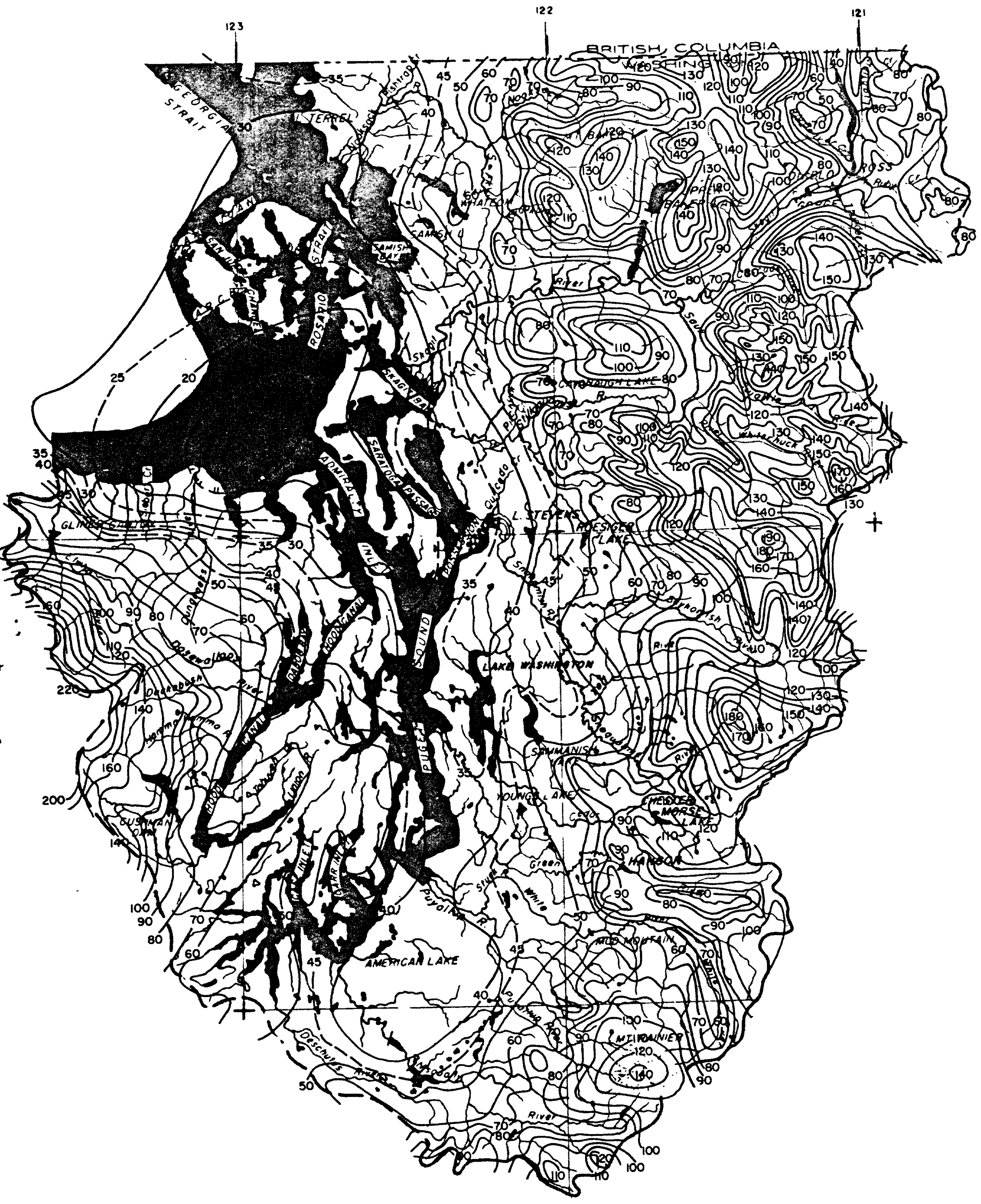


**FIGURE 3.—Mean annual precipitation in the Puget Sound region, 1930-57. Isohyetals connect points of equal precipitation, in inches. From U. S. Weather Bureau.**

# BASIC DATA USED IN ANALYSIS

Streamflow data for 150 gaging stations in the Puget Sound region were available for analysis in this report. So that low-flow characteristics of one stream could be compared to those of another, all data were adjusted to a common reference period of 19 years, 1946-64, with the climatic year designated as the year beginning April 1 and ending the following March 31. This period of moderate length was chosen because the more numerous records give a better definition of the areal relationship of low flows. Longer records are available, such as the 69-year period 1896-1964 for Cedar River near Landsburg and the 51-year period 1914-64 for South Fork Skykomish River near Index, but extending the shorter term records to any of the longer records was not feasible.

All gaging stations at which low-flow characteristics were determined, and their period of record, are listed in table 1 (p. 32). Low-flow data are available for each gaging station that had 5 years or more of usable records prior to March 31, 1965.

The numbers assigned to each station (table 1 and fig. 6) are part of a nationwide coding system adopted by the Geological Survey in 1958 and their sequence corresponds to the downstream order of the station. Since all the gaging stations numbered are in area 12 (the Pacific slope basins in Washington and upper Columbia River basins), the prefix 12 has been omitted from the station numbers in the tables and maps.

# OCCURRENCE OF LOW FLOWS

The occurrence of low-flow periods for individual streams in the Puget Sound region vary during the year, depending upon the altitudes and climatic influences in their basins. For most streams minimum discharges usually occur during the period July-October and coincide with the period of minimum precipitation. For some high-altitude streams that originate at glaciers or drain basins with perennial snowfields, minimum flows may occur only during the winter when low temperatures freeze up these sources of supply.

Low flows of low-altitude streams occur during late summer. Minimum flows of these streams are dependent largely upon ground-water effluent as almost all the winter precipitation falls as rain and no snow or ice is stored for summer runoff. The extent to which ground water supports streamflow is a function of the amount of ground water in storage and the rate of movement toward surface streams.

Streams with winter low-flow periods drain basins at high altitudes and their summer flows are sustained by melt water from glaciers and perennial snowfields. Because winter precipitation is largely in the form of snow there is little contribution to streamflow during this period.

Climatic influences on some streams, particularly those at high altitude, may cause low-flow periods to occur both during the summer and winter. During most years cold winter temperatures allow very little melting to occur, and water stored as snow is available for release during the spring and summer. However, occasionally a part of the winter precipitation may fall as rain, resulting in an increase in the winter streamflows. The amount of water stored as snow is thus reduced and this snow may be entirely gone by late spring or early summer. The low-flow period then will occur in late summer with the major part of the streamflow consisting of ground-water effluent.

To illustrate the occurrence of the low-flow period for streams in the Puget Sound region, hydrographs showing the monthly distribution of streamflow are presented in figure 4. For example, the graph for the Samish River near Burlington shows that the low-flow period occurs during the summer and the distribution of streamflow during the year closely follows that of precipitation (fig. 2). The Samish basin drains a low-lying area which receives very little snow during the winter.

The graph for Thunder Creek near Newhalem shows the low flow occurring during the period January-March. The basin is at a high altitude and contains numerous glaciers and snowfields that store precipitation during the winter and contribute large quantities of melt water during the summer.

Low-flow periods that can occur either in late summer or winter are shown by the graph for Cascade River at Marblemount. Low flows have been experienced in September or October and also between January and March. Although the basin is located at high altitudes and contains glaciers and snowfields, temperatures have had a definite bearing on the occurrence of low flows. Unusually cold temperatures in winter can cause the low-flow period to occur in the winter, whereas, warm winter temperatures can cause the low-flow period to occur in the summer.

Because the season during which low-flow periods occur may have an effect on the low-flow characteristics, streams in the Puget Sound region were divided into three classes: summer low-flow period; winter low-flow period; and mixed (summer or winter) low-flow period. The normal low-flow season is listed in table 4 (p. 52) for stations not affected by regulation or diversions.

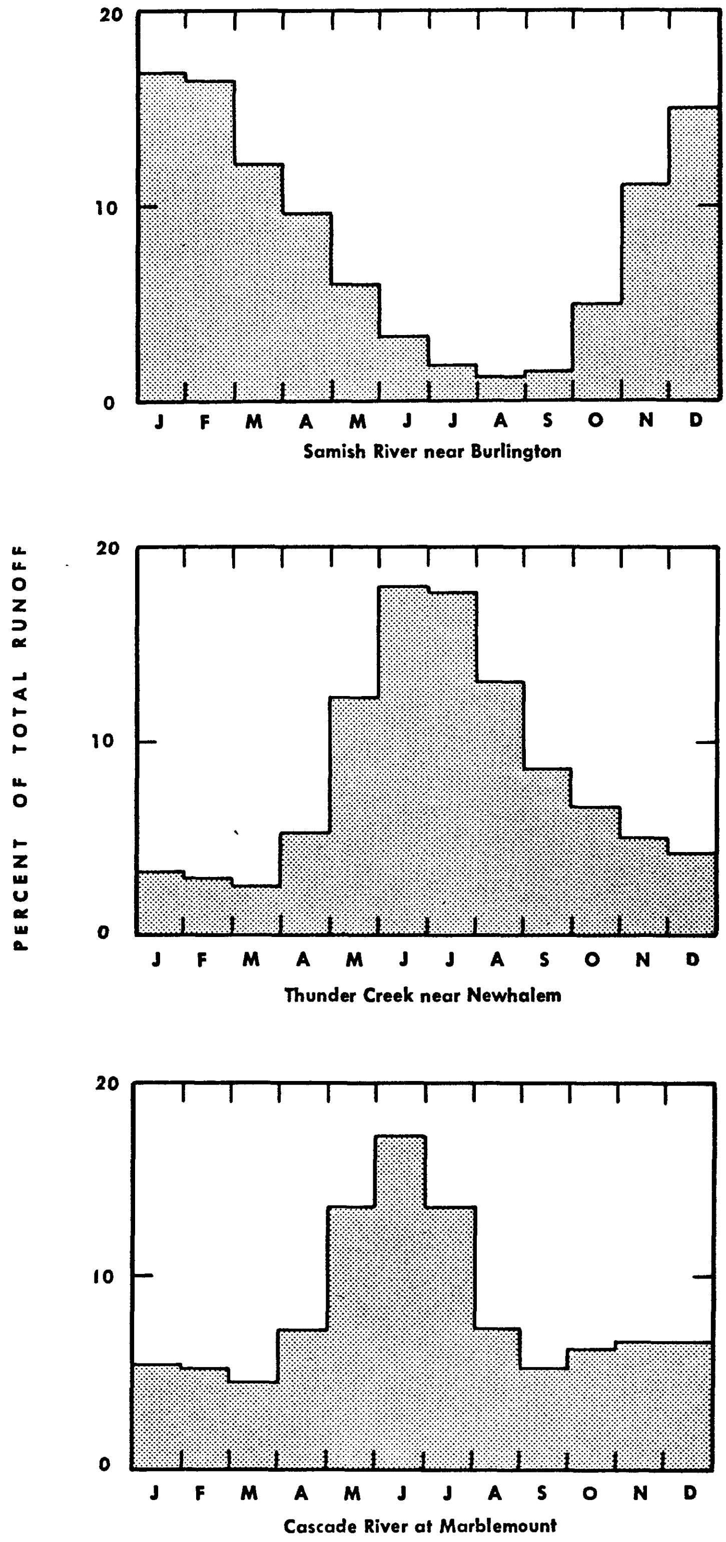


**FIGURE 4.—Monthly distribution of runoff from selected streams.**

# LOW-FLOW-FREQUENCY CURVES

Low-flow-frequency curves show the magnitude and frequency of low flows for various periods of consecutive days. The periods selected for use in this report are 7, 30, 90, and 183 days. For each period for each climatic year (year beginning April 1 and ending March 31), the minimum average flow was computed and arranged in order of magnitude. These data were related to recurrence interval and plotted on a frequency graph. Figure 5 shows an example of a family of low-flow-frequency curves for periods of 7, 30, 90, and 183 consecutive days.

Low-flow-frequency data for some of the short-term gaging stations had to be extended to the base reference period. Estimates were based on correlation of concurrent discharge data with those of a long-term station. Table 2 (p. 36) presents low-flow-frequency data for 150 gaging stations in Puget Sound region. These data can be plotted and the curves would be similar to those of figure 4.

Frequency curves relate the magnitude of annual low flows to recurrence interval or return period. The recurrence interval of low flow is the average interval of time between occurrences of flows equal to or less than a particular magnitude of annual low flow.

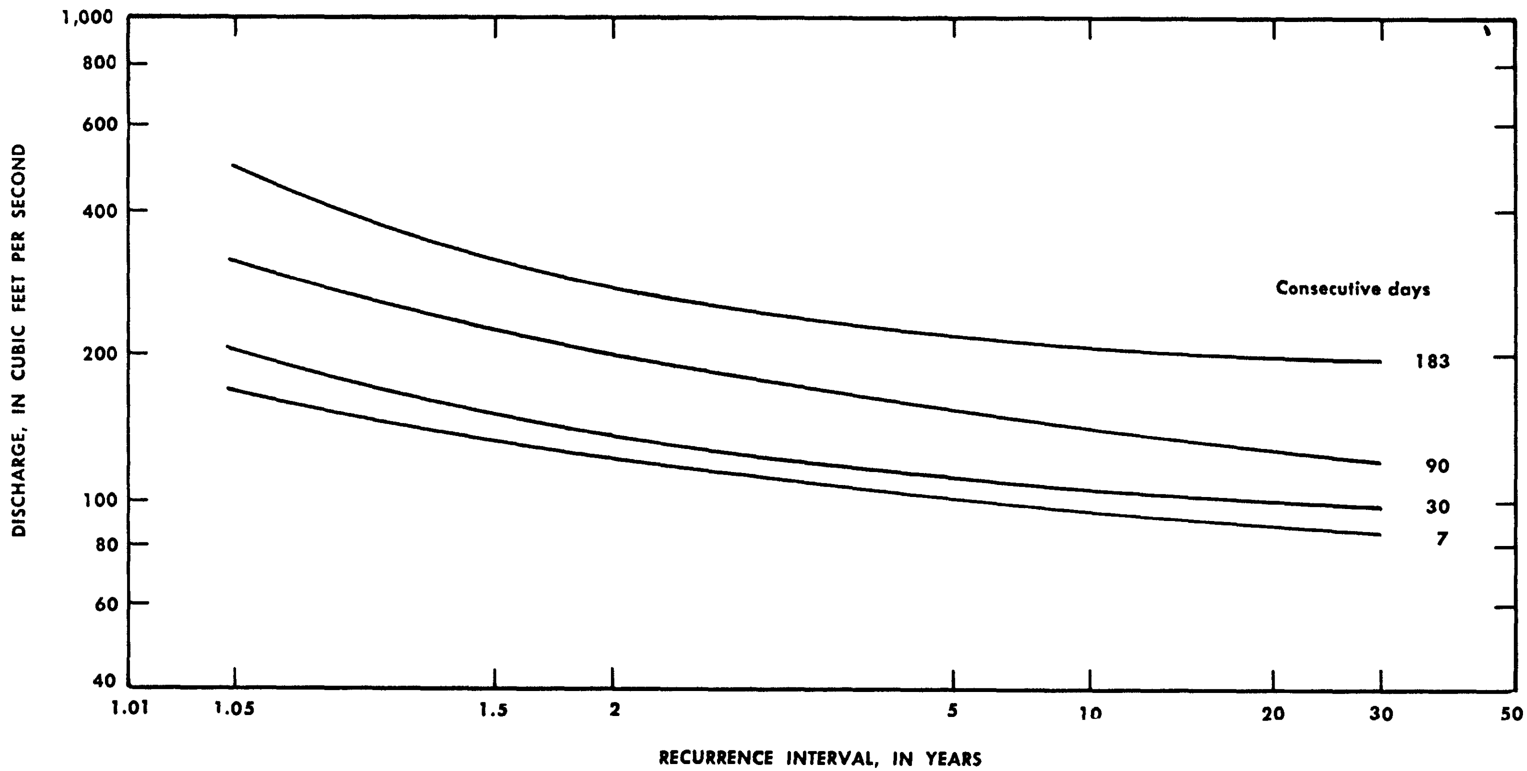


FIGURE 5.—Low-flow-frequency curves for Dungeness River near Sequim, 1946-64.

# INDEXES OF LOW-FLOW CHARACTERISTICS

To describe the low-flow characteristics of streams in the Puget Sound region, indexes were determined from data obtained from low-flow-frequency curves and from the average discharge at 150 gaging stations. The four indexes computed were the low-flow-yield, base-flow, slope, and spacing indexes. Because the indexes showed wide variations, extrapolation to ungaged sites was not attempted in this study.

## Low-Flow-Yield Index

The median (2-year recurrence interval) value of the annual 7-day minimum flow taken from the frequency curve, and expressed in cfs per square mile of drainage area, is used as a measure of the low-flow yield of a stream. This value, called "low-flow-yield index" in this report, has been determined for the 150 gaging stations for the 1946-64 reference period. The low-flow-yield index makes possible a quick appraisal of the normal low-flow yield of streams and permits direct comparison of flows of streams with various-size drainage areas.

Areal variations in the low-flow-yield indexes were delineated by use of arbitary classifications as shown in figure 6. The indexes are largest in the mountainous areas, whereas they are smallest in the lowland area adjacent to Puget Sound. In the entire area of study, the low-flow-yield indexes range from 0.03 cfs per square mile for Dubuque Creek, a tributary of the Snohomish River, to 2.75 cfs per square mile for Baker River in the Skagit River basin.

## Base-Flow Index

Geologic conditions generally are considered to have a major influence on low-flow yields. To isolate the geologic effect on low flows, a second value called the base-flow index was computed as the ratio of the discharge at the 2-year recurrence interval of the annual 7-day minimum-flow-frequency curve to the mean annual discharge. Differences in this value can be attributed to differences in basin hydrogeology with very little influence from climate. The index indicates the amount of storage available in the basin, as ground water and (or) surface water in the form of ice and snow.

The effect of geology on low flows can be appraised by the use of this index, but only if the streams originating at glaciers or draining perennial snowfields are excluded. It is not possible to separate influences of snow and ice storage from the geologic influences. Glacial streams such as the Nisqually, Puyallup, and Suiattle Rivers have fairly high indexes—0.31, 0.35, and 0.29, respectively—indicating the influence of the melt water.

In the Puget Sound region the base-flow indexes range from 0.01 for Dubuque Creek to 0.48 for Burley Creek. Both of these streams drain low-lying areas with minimum flows consisting entirely of ground-water inflow. The small index for Dubuque Creek indicates that ground water contributes very little to low flows and the ground-water storage is small. Compact and poorly permeable glacial till covers most of the basin, causing precipitation to run off rapidly without recharging the ground-water reservior. Burley Creek, on the other hand, drains an area underlain by permeable glacial outwash materials that allow precipitation to infiltrate readily. The materials support a large ground-water reservoir that naturally regulates the discharge of ground water and sustains low flows at a relatively high level, as shown by the large index.

## Slope Index

The slope index, which was computed for each station in the study area, is the ratio of the discharges at 2-year- and 20-year-recurrence intervals from the 7-day minimum frequency curve. A small value of the slope index indicates a nearly flat slope of the curve and small year-to-year differences in low flow, whereas a large value indicates a steep slope and large variations in low flow. The slope index also shows the ability of the geologic materials to transmit ground water. In general, areas underlain by highly permeable unconsolidated sediments have large quantities of ground water in storage and frequency curves for streams draining these areas will normally have nearly flat slopes. Small slope indexes also can characterize streams that drain areas underlain by materials of low transmissibility, where ground water from these materials contributes to streamflow very slowly. Low-flow-frequency curves with steep slopes are indicative of basins with small amounts of storage that can be drained rapidly. Another factor that influences the slope index is the regulating effect of snow and ice storage in the basin. In the Puget Sound region the slope indexes range from 1.16 for Bear Creek, a tributary to Sammamish River, to 8.33 for Dubuque Creek, but most are less than 2.00. Figure 7 shows some examples of variations in the slopes of 7-day low-flow-frequency curves.

## Spacing Index

The spacing index is the ratio between the discharges at the 2-year-recurrence intervals of the 183- and 7-day frequency curves. The same basin characteristics that affect the slope index influence the spacing index. If a basin is underlain by relatively impermeable materials, precipitation will not readily infiltrate into the ground and the frequency curves will be widely spaced. In contrast, curves for streams draining permeable materials are more closely spaced. The spacing indexes for streams in the study area range from a minimum of 1.30 for Huge Creek on Kitsap Peninsula to a maximum of 22.2 for Pilchuck Creek, a tributary to the Stillaguamish River. Figures 8-11 illustrate variations in the spacing of the frequency curves for four gaging stations.

The distribution of indexes used to describe low-flow characteristics of streams in the Puget Sound region are summarized in table 3 (p. 51). The table gives the maximum, minimum, upper 25 percent, lower 25 percent, and median values for each of the four indexes. Table 4 (p. 52) lists the indexes for all the gaging stations in the study area, as in figure 1.

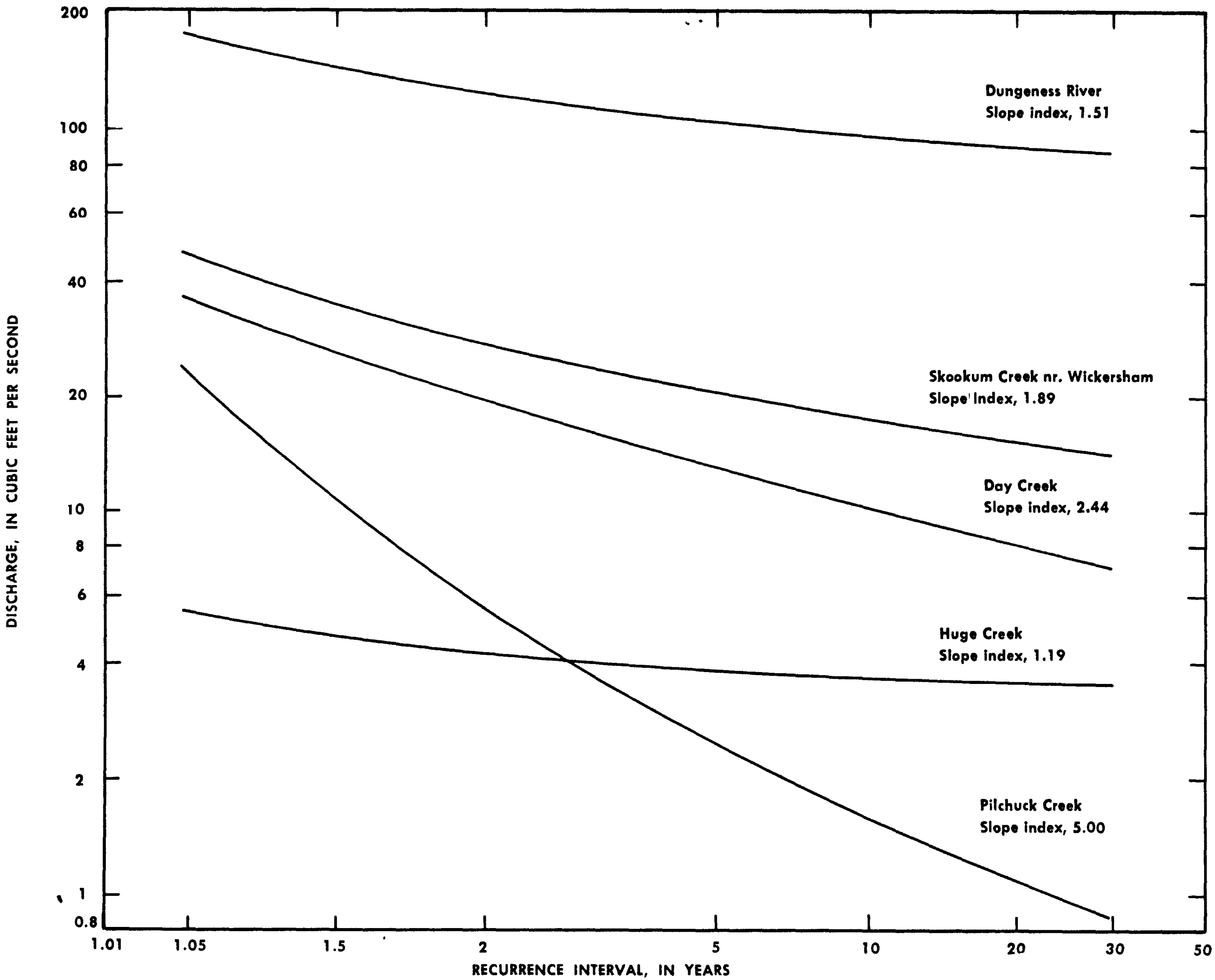


**FIGURE 7.—Frequency curves for annual 7-day minimum discharges at selected gaging stations, 1946-64, showing variations in slope index.**

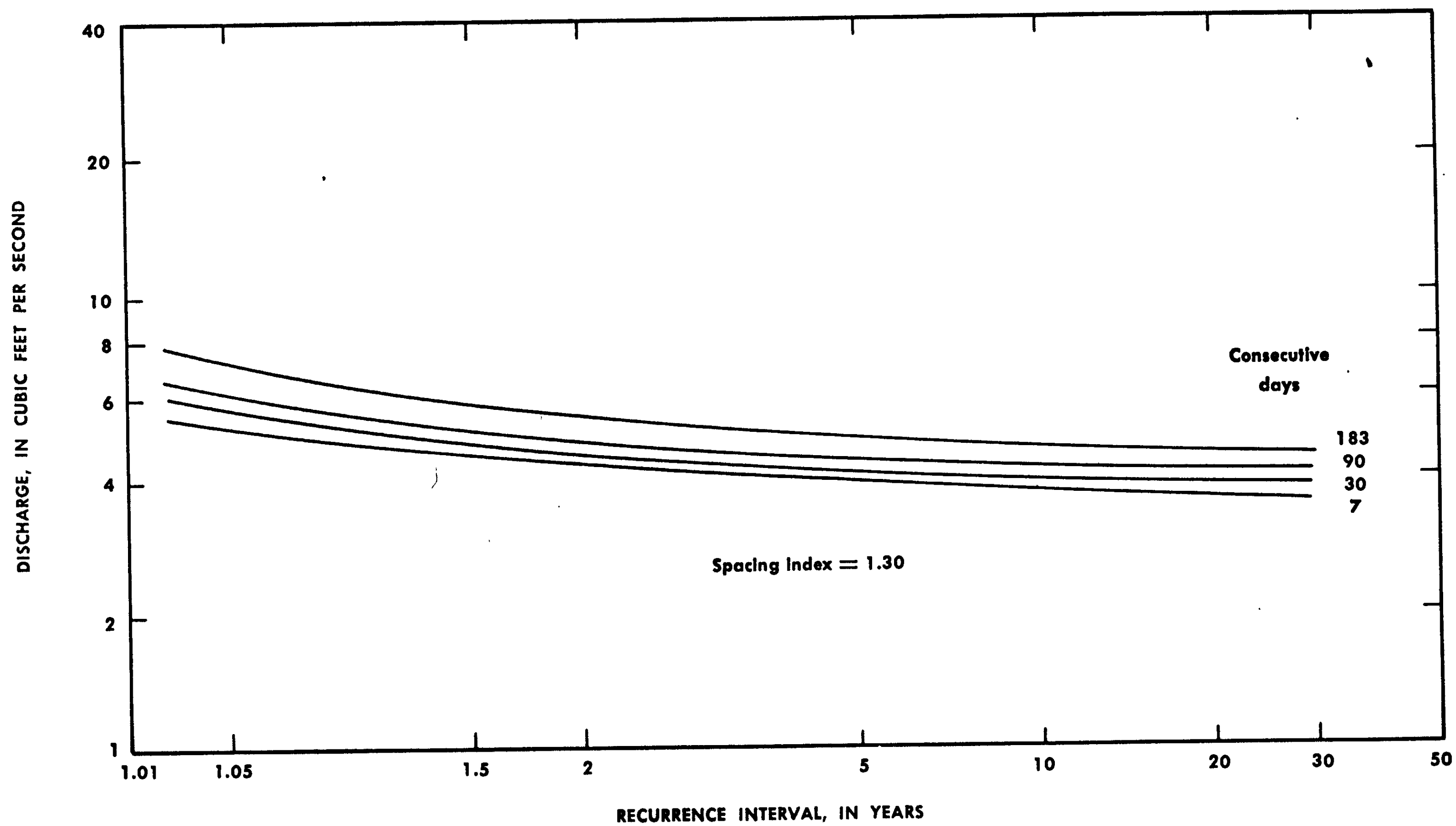


FIGURE 8.—Low-flow-frequency curves for Huge Creek near Wauna, 1946-64, showing spacing index.

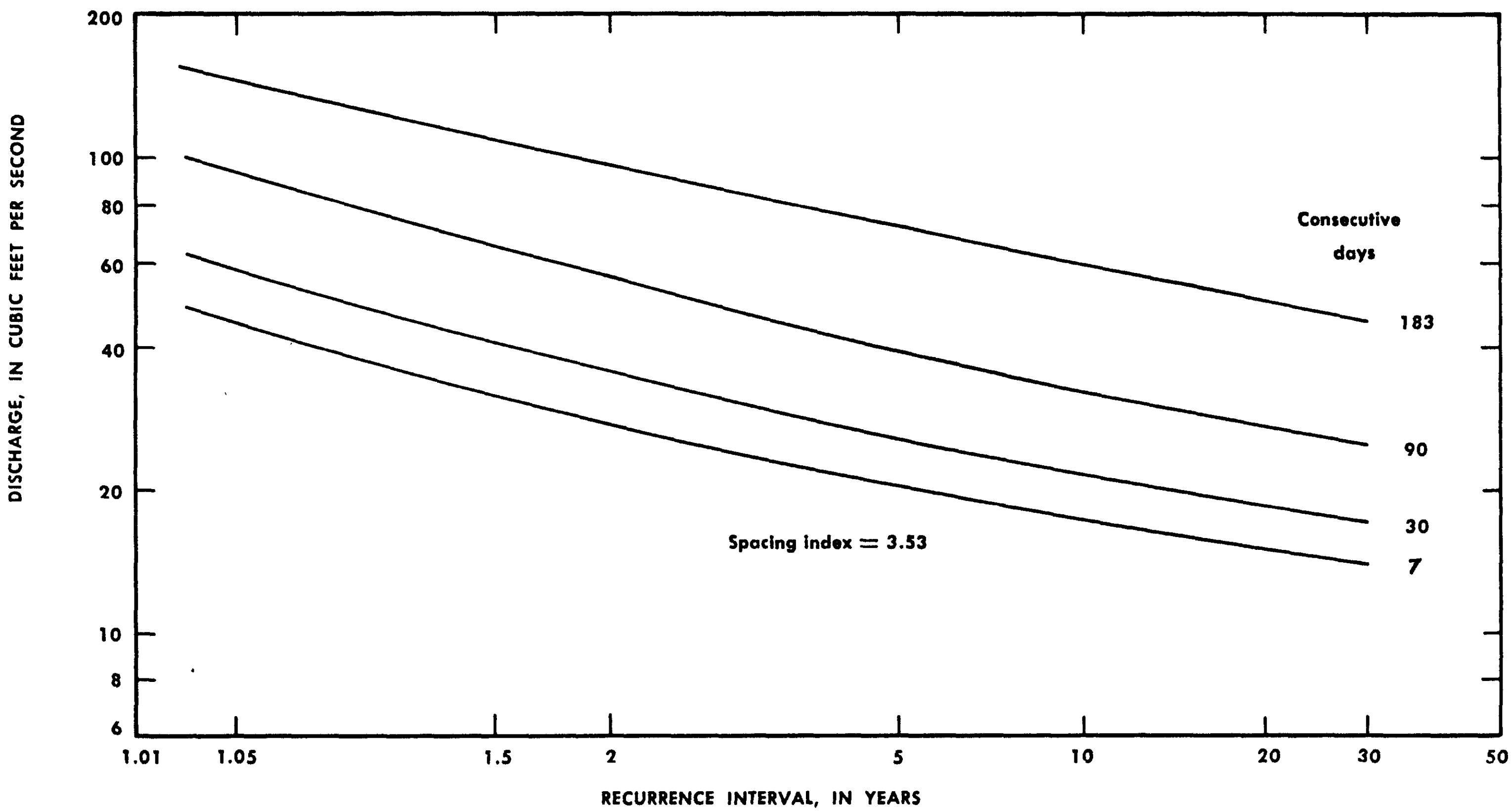


FIGURE 9.—Low-flow-frequency curves for Skookum Creek near Wickersham, 1946-64, showing spacing index.

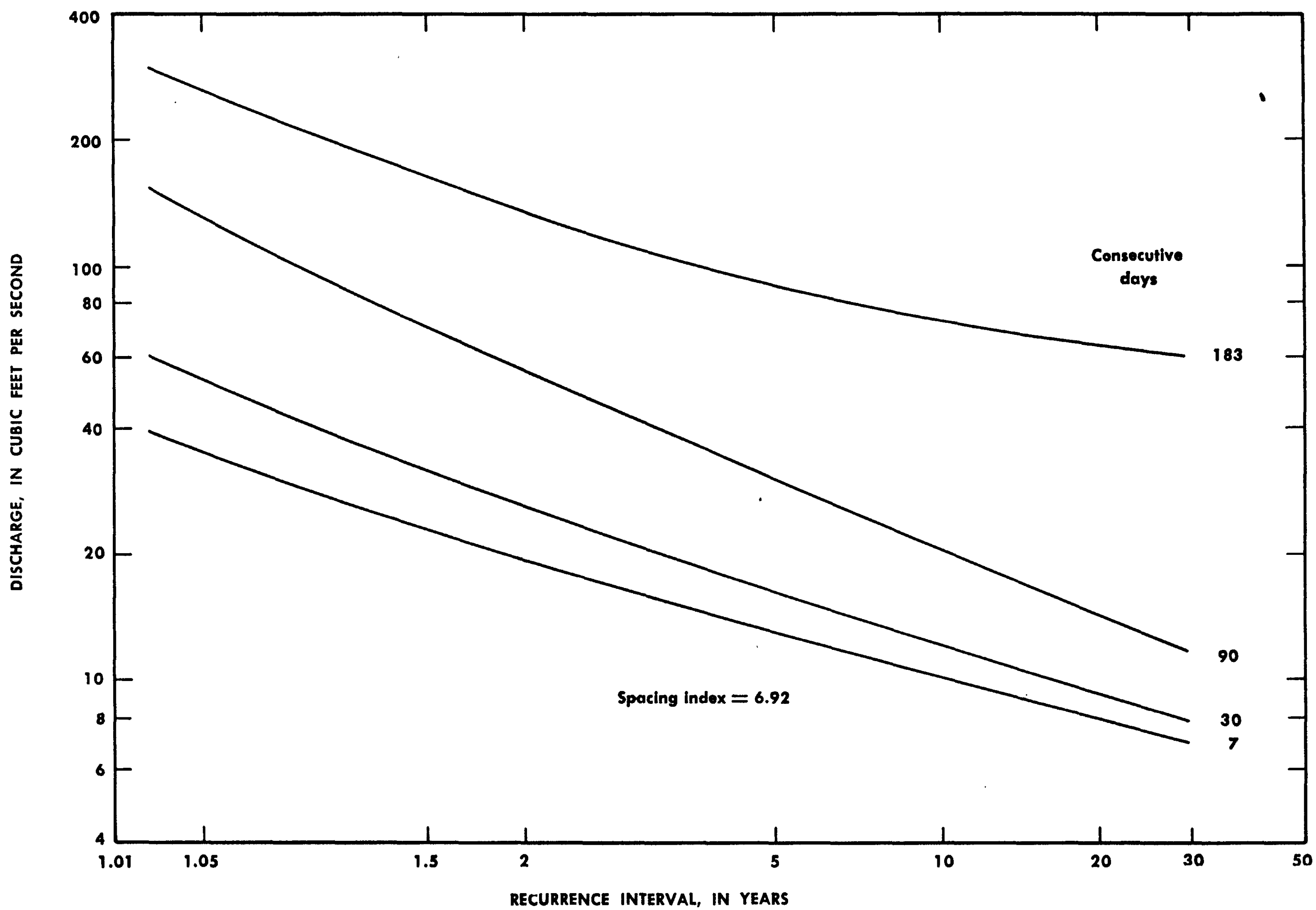


FIGURE 10.—Low-flow-frequency curves for Day Creek near Lyman, 1946-64, showing spacing index.

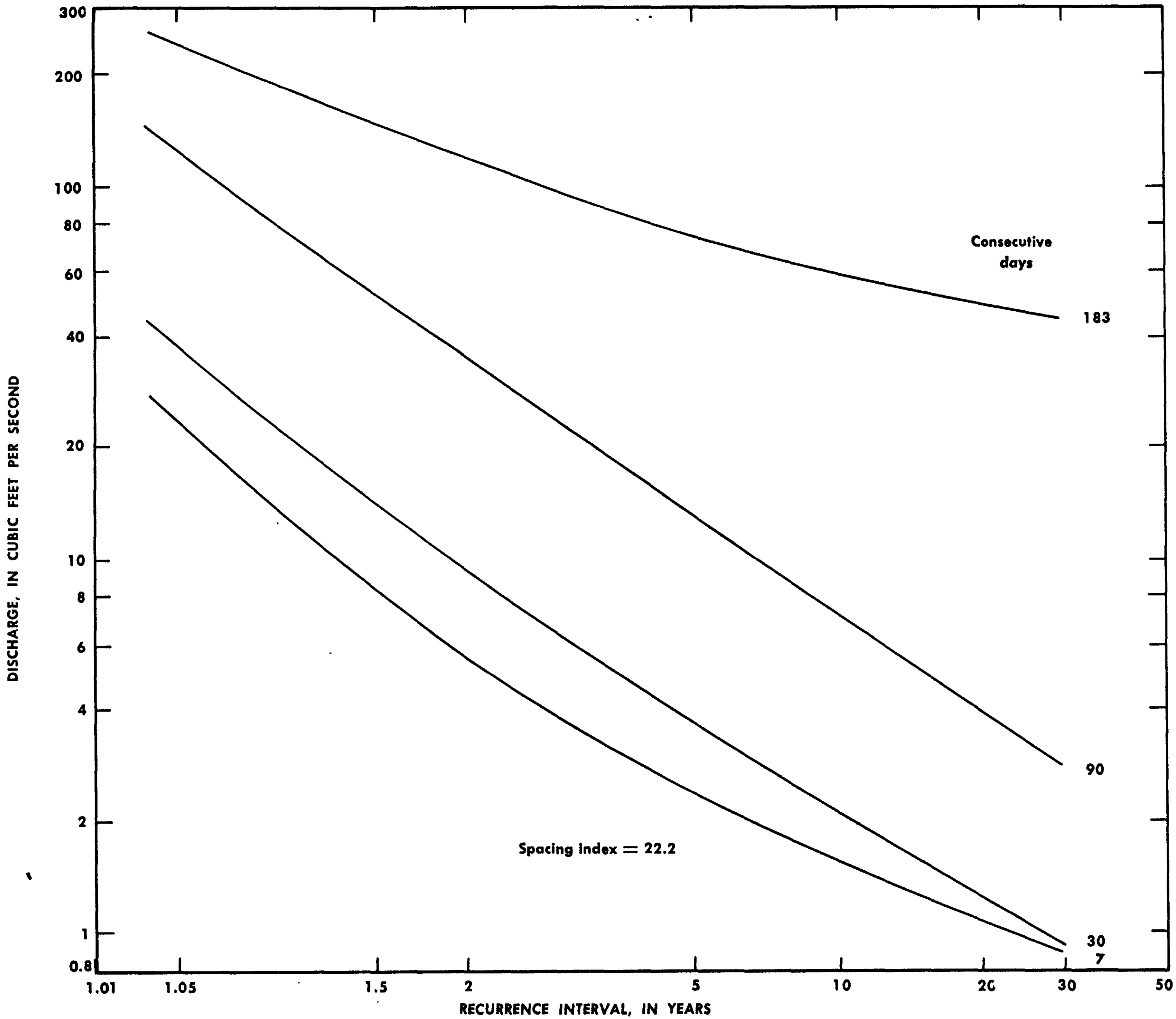


**FIGURE 11.—Low-flow-frequency curves for Pilchuck Creek near Bryant, 1946-64, showing spacing index.**

# FACTORS AFFECTING LOW FLOW BY BASINS

Water that sustains flows of streams during periods of no precipitation comes from prior precipitation that has been temporarily diverted. The natural diversion of this water is through storage below the land surface as ground water and on the surface as lakes, reservoirs, snow, and ice. The low flows of streams are governed by the release of this storage.

The natural low flows of some streams in the study area may have been modified by man's activities. Water withdrawn from streams for irrigation, industrial, or municipal uses and storage reservoirs that are regulated for electric-power production have a decided effect on low flows. Heavy pumping of ground water close to a stream may lower the ground-water table and either decrease the ground-water contribution to the stream or permit some of the streamflow to be lost to adjacent aquifers. Channel improvements such as dredging also may increase or decrease the natural low flows of streams. The effect of these artificial changes limits the interpretation that can be made on the relation between low flows and the natural environment.

Low-flow characteristics differ from stream to stream and may vary from one reach to the next on the same stream. The indexes provide a means of comparing these characteristics and a basis for studying the factors that affect low flows. For convenience in describing the low-flow characteristics of streams in the Puget Sound region, the area is divided into nine basins, as outlined in figure 1.

## Elwha-Dungeness Basins

As defined herein the Elwha-Dungeness basins (fig. 1) cover 690 square miles in the extreme northwestern part of the Puget Sound region. The Elwha and Dungeness Rivers drain areas of 321 and 198 square miles, respectively, while several small independent streams drain 171 square miles. Most of the drainage area of the two streams is heavily forested and very rugged. The rivers flow northward from the Olympic Mountains and descend across lowlands to their outlets at the Strait of Juan de Fuca. The headwaters and high tributaries of the Elwha originate at glaciers and snowfields on the higher peaks of the Olympic Mountains. The small independent streams drain the foothills and coastal plain between the two major basins.

The low-flow-yield index for the Elwha River, a regulated stream, is 1.56 cfs per square mile. Regulation for power production at Aldwell Lake and Lake Mills and snow and ice storage in some of the tributary basins are factors contributing to the large index. The lower index of 0.85 cfs per square mile for Dungeness River is partly due to the relatively small amount of precipitation received by the basin in comparison to that in nearby basins in the Olympic Mountains (fig. 3). The effect of geology on the index is not apparent. Siebert Creek, a foothills-and-lowland stream, has a low-flow-yield index of 0.16 cfs per square mile. The small index is attributed to the small amount of precipitation and to the lack of ground-water storage in the poorly permeable sedimentary and volcanic rocks that underlie the upper part of the basin.

The base-flow index for these streams range from 0.16 for Siebert Creek to 0.30 for Dungeness River. The low-flow period occurs during the summer in Siebert Creek and the index reflects the moderate amount of ground-water storage available. The index for Siebert Creek is equal to the median value for the Puget Sound region and, though the upper part of the basin is underlain by impermeable materials, some ground water is contributed to low flows from the glacial outwash materials in the lower basin. The fairly large index for Dungeness River is attributed to the contribution of melt water from ice and snow, and possibly of ground water from the unconsolidated sediments in the lower reaches of the drainage area.

Both the slope and spacing indexes for the three streams vary within narrow ranges. Slope indexes range from 1.39 for Siebert Creek to 1.62 for Elwha River, while spacing indexes range from 2.16 for Dungeness River to 2.81 for Elwha River. The similarity in the geology of these basins may be responsible for the small variation in the indexes.

## West Sound Basins

The West Sound basins (fig. 1) are bounded on the east by the main channel of Puget Sound and on the west by the Olympic Mountains. Hood Canal divides the West Sound basins into two topographically and geologically distinct areas—the mountainous Olympic Peninsula and the lowland Kitsap Peninsula.

Because of the striking differences in climate, topography, and geology between the Olympic and Kitsap Peninsulas, streams draining the former are large whereas those draining the latter are rather small. From south to north, the principal rivers draining the eastern slope of Olympic Peninsula are the Skokomish, Hamma Hamma, Duckabush, and Dosewallips Rivers; all head in the rugged forested areas of Olympic National Park and Forest and flow into Hood Canal. Only the Skokomish River passes through a broad flood plain before emptying into Hood Canal.

The Kitsap Peninsula is drained by hundreds of small streams—only 12 have drainage areas of more than 10 square miles. Almost all of the streams originate in and flow across the glacial drift plains that are characteristic of the Puget Sound lowland.

The larger streams originating in the Olympic Mountains have low-flow-yield indexes that are the largest in the West Sound basins, being between 1.0 and 1.5 cfs per square mile. Most of the lowland area is drained by streams with indexes between 0.5 to 1.0 cfs per square mile. Small areas in the southern part of Kitsap Peninsula and the extreme northern and southwestern part of Olympic Peninsula have streams with indexes of less than 0.5 cfs per square mile.

Low-flow-yield indexes range from 0.05 cfs per square mile for Mission Creek to 1.41 cfs per square mile for Dosewallips River. The areas of extremely small indexes receive relatively little precipitation and are underlain by poorly permeable bedrock. The indexes for the larger Olympic Mountain streams are all greater than 1.0 cfs per square mile and, even though the drainage areas are relatively impermeable, the indexes are influenced by the large amount of winter precipitation falling as snow in the high-altitude areas. Some basins located in the Kitsap Peninsula have low-flow-yield indexes between 0.56 and 1.27 cfs per square mile. The permeable alluvial and glacial sediments that generally underlie these basins readily transmit ground water to streams at low flow. The influence of this ground-water contribution is shown by the low-flow-yield index of 1.27 cfs per square mile for Burley Creek. Another example is the increase in the index for the Union River between Bremerton (0630) and Belfair (0635), from 0.19 to 0.87 cfs per square mile. The basin above the Bremerton station is underlain by relatively impermeable igneous rocks that do not contribute to streamflow. Between the two stations the river flows through permeable glacial drift containing a large amount of ground-water storage.

The base-flow index ranges from 0.02 for Mission Creek and Tahuya River to 0.48 for Burley Creek, all on the Kitsap Peninsula. Mission Creek and Tahuya River drain an area underlain by poorly permeable glacial till which accounts for their small indexes. Burley Creek has a large base-flow index and also a large yield index, the combination of which shows the influence of highly permeable geologic materials underlying the basin. The geologic influence also is shown in the Union River basin where the base-flow index increases from 0.05 near Bremerton to 0.32 near Belfair.

Most of the streams draining the east slope of the Olympic Mountains have base-flow indexes less than 0.26. Though the low-flow-yield indexes are greater than 1.0 cfs per square mile for many of these streams, the base-flow indexes are relatively small and indicate that ground-water contributes very little to low flows.

Slope indexes range from 1.19 for Huge Creek to 3.71 for Tahuya River, both on the Kitsap Peninsula. The large difference in the slope indexes is due to variations in infiltration capabilities of the geologic materials and the amount of ground-water storage; in much of its length Tahuya River flows across poorly permeable glacial till that impedes percolation of precipitation to underlying aquifers, whereas the lower reach of Huge Creek flows across sand deposits that are permeable and maintain large volumes of ground-water storage. The character of the geologic materials within the basin is the most important factor influencing the slope index of low-lying streams, but the Olympic Mountain streams also are affected by the snow storage at high altitudes. The effect of snow storage tends to decrease the variability of low flows from year to year as shown by the fairly small values of slope index, 1.30 to 1.67, for the mountain streams.

Spacing indexes range from 1.30 for Huge Creek to 8.18 for Tahuya River. These indexes show about the same areal variations as the slope indexes and are primarily influenced by the permeability of the geologic materials drained by the streams. The small spacing indexes for Huge Creek and many other small streams on Kitsap Peninsula are attributed to the permeable unconsolidated sediments that are drained by the streams. On the other hand, the relatively impervious materials over which the Tahuya River flows in much of its length prevent large quantities of the streamflow from infiltrating to become ground water in storage and result in the large spacing index for this stream. Although the Olympic Mountain streams also drain impermeable materials, some of the precipitation falls as snow and, therefore, the spacing indexes—2.27 to 4.62—are not as large as that for Tahuya River.

## Nisqually-Deschutes Basins

The Nisqually-Deschutes basins (fig. 1) are located in the southern part of the Puget Sound region and comprise an area of 1,016 square miles of land and inland water. The principal rivers in the area are the Nisqually, with a drainage area of 712 square miles, and the Deschutes, with an area of 162 square miles.

The Nisqually River originates at the glaciers on the southwestern slope of Mount Rainier and has a length of 81 miles. From its source at Nisqually Glacier to La Grande, the Nisqually flows westerly for 40 miles through a steep-sided mountain valley. From La Grande, halfway to McKenna, the river flows northwesterly about 10 miles over a benchland of glacial materials resting on older relatively impermeable deposits. It then flows about 30 miles across the glacial drift plain of the Puget Sound lowland to where it enters Puget Sound midway between Tacoma and Olympia.

The Deschutes River heads in the low hills southeast of Yelm and flows across the lowland to discharge into Budd Inlet at Olympia. The river parallels the lower part of Nisqually River and occupies part of the benchland common to both streams.

In the Nisqually River basin, streamflow at the main-stem stations below Alder Lake and La Grande Reservoir is affected by regulation and (or) diversion. Discharge of the Nisqually River at the stations at La Grande and near McKenna is affected by regulation and that at the station at McKenna is affected by both regulation and diversion.

The low-flow-yield indexes in the Nisqually River basin range from 0.04 cfs per square mile for Tanwax Creek to 1.88 cfs per square mile for the Nisqually River near National. The large contribution to low flows in the upper basin, principally from snow and glaciers, and regulation by Alder and La Grande Reservoirs result in fairly large indexes for all Nisqually River main-stem stations except that at McKenna where some streamflow is diverted around the station. Tanwax Creek, Ohop Creek, and Mashel River, which are tributary to the Nisqually River from the north, have the smallest indexes—less than 0.20 cfs per square mile. They drain bedrock and unconsolidated deposits that are compacted or poorly sorted. These materials are not capable of storing much water and hence cannot sustain low flows in any appreciable quantity. The tributaries from the south, Mineral Creek and Little Nisqually River, have slightly larger indexes—about 0.40 cfs per square mile.

In contrast to most basins where the low-flow-yield indexes are larger in the upper reaches, the Deschutes River basin has smaller values in the upper part of the basin than in the lower part. The index increases from 0.36 cfs per square mile near Rainier to 0.60 cfs per square mile near Olympia. The permeable glacial drift through which the river flows in its lower reaches probably acts as a large ground-water reservoir and contributes an appreciable amount of water to the stream at low flows.

The base-flow indexes in the Nisqually-Deschutes basins range from 0.03 for Tanwax Creek to 0.44 for Woodland Creek. The base flows past upper Nisqually River stations near National and near Alder, with indexes of 0.31 and 0.28, respectively, are influenced primarily by melt water from snow and ice storage on Mount Rainier.

In general, those streams with small low-flow yields have small base-flow indexes. For example, Tanwax Creek has a yield index of 0.04 cfs per square mile and drains materials not capable of storing much ground water. Although the yield index—0.51 cfs per square mile—for Woodland Creek is not very large, the large base-flow index indicates a basin with a large amount of ground water stored in the permeable glacial outwash materials.

Slope indexes for all but one station in the Nisqually River basin range from 1.33 for the Nisqually River at La Grande to 1.92 for the Mashel River. The extremely large slope index of 6.67 for the Nisqually River at McKenna is due to diversion a short distance upstream. Regulation during low flows for power development is responsible for the small index for the Nisqually River at La Grande. The fairly large value for Mashel River is attributed to a small volume of ground-water storage in the basin. In general, smaller slope indexes are characteristic of streams whose drainage areas lie at high altitudes because of the moderating influence of snow and ice storage.

Low flows in the Deschutes River basin vary little from year to year, indicating the influence of the large ground-water reservoir in the glacial materials underlying most of the basin. The slope index of 1.56 for Woodland Creek near Olympia is comparable to the value for many of the low-lying streams.

Spacing indexes in the Nisqually River basin have the same general areal variations as the slope indexes. The smallest and largest indexes—2.00 and 6.40—were determined for Nisqually River at La Grande and Mashel River at La Grande, respectively. The main-stem stations on the Nisqually River have smaller indexes than those for its tributaries because precipitation is stored as snow at high altitudes and does not immediately contribute to surface runoff. The poor permeability at the igneous rocks underlying the Mashel River basin is reflected in the large spacing index for this stream.

In the Deschutes River basin the spacing indexes for the Deschutes are 2.56 at Rainier and 1.67 at Olympia, while Woodland Creek has an index of 1.36. The larger index at Rainier indicates that the geologic materials in the upper basin are less permeable than the glacial deposits in the drainage area between the two stations—the precipitation infiltrates more readily into the glacial deposits and delays surface runoff. Woodland Creek drains the most permeable materials as shown by its small spacing index.

## Puyallup Basin

The Puyallup basin (fig. 1) is located in the southeastern part of the Puget Sound region and comprises an area of 1,217 square miles of land and inland water. The largest and most important river, the Puyallup, drains 927 square miles and begins at the glaciers on Mount Rainier. From its source the river flows northwesterly about 46 miles to Commencement Bay at Tacoma. For the first 20 miles the river flows through a rugged mountainous country with deep canyons after which it flows out onto a flat valley. White River, the principal tributary, also rises at glaciers on Mount Rainier and enters the Puyallup River about 10.5 miles upstream from the mouth. The Carbon and Mowich Rivers, two other large tributaries, head at glaciers and flow through steep rugged canyons through most of their lengths before joining the Puyallup River.

Chambers Creek and its tributaries drain most of the remaining area outside the Puyallup drainage. This area is flat-topped drift plain that slopes gently westward toward Puget Sound and is generally below an altitude of 1,000 feet.

The low-flow-yield indexes for the Puyallup, White, and Carbon Rivers increase in an upstream direction, and range from 0.12 cfs per square mile for White River near Sumner to 2.10 cfs per square mile for Puyallup River near Electron. The upper watersheds have excellent low-flow-yield indexes, greater than 1.5 cfs per square mile. For streams in the middle part of the basin, the indexes are between 0.5 and 1.0 cfs per square mile, and for those in the lowlands, the indexes are less than 0.5 cfs per square mile.

Melt water from glaciers on Mount Rainier contributes to the Puyallup, White, and Carbon Rivers and is responsible for large indexes for these streams. The indexes decrease downstream along the Puyallup River from 2.10 cfs per square mile near Electron to 1.24 cfs per square mile at Puyallup. This decrease shows the smaller contribution to low flows from the lower part of the basin. The extremely small value for White River near Sumner does not represent natural flow conditions because a large part of the streamflow is diverted around the station. Greenwater River and South Prairie Creek drain areas about the same size as that of Carbon River, but because they do not have glacial sources, their low-flow-yield indexes are much smaller; 0.56 and 0.52 cfs per square mile, respectively. Kapowsin Creek has the smallest index (without diversion) in the basin—0.15 cfs per square mile. Ohop and Tanwax Creeks in the adjacent Nisqually-Deschutes basins have similarly small indexes.

The low-flow-yield index for Chambers Creek is 0.39 cfs per square mile, much smaller than would be expected from the drainage area which is underlain by permeable recessional outwash and alluvium containing large volumes of ground water. However, because the creek is perched the main ground-water body contributes little to low flow and most of the inflow comes from perched shallow aquifers.

The base-flow indexes for streams in the Puyallup basin range from 0.07 for Kapowsin Creek to 0.36 for the White River at Greenwater. Because the White, Carbon, and Puyallup Rivers are of glacial origin their indexes are fairly large, ranging from 0.30 to 0.36. However, regulation of flow at Mud Mountain Dam affects the flows of the White River downstream and also the Puyallup River as measured at Puyallup.

The small base-flow value for Kapowsin Creek is attributed to the impermeable bedrock underlying the basin. An index of 0.34 for Chambers Creek indicates a fairly sizable contribution from the semi-perched aquifer, even though, as noted earlier, the main ground-water storage is in aquifers below the level of the creek. However, because precipitation infiltrates rapidly into the permeable materials underlying the basin, very little is available for surface runoff and almost all of the flow of the creek is ground-water effluent which is responsible for the fairly high index. The base-flow and yield indexes for Greenwater River and South Prairie Creek are very nearly the same, indicating that geologic and climatic influences are similar in the two basins.

Slope indexes for the streams in the basin range from 1.32 for Chambers Creek to 2.94 for Kapowsin Creek. Except for the large index for Kapowsin Creek, all other streams have indexes less than 1.61. The ground-water conditions in the Chambers Creek basin, as explained above, are responsible for the small index and the small variation in low flows of this creek from year to year. The large index for Kapowsin Creek is probably the result of seepage out of the drainage area and the evaporation losses in Kapowsin Lake. The fairly uniform and small indexes for the other streams is probably due to the influence of snow and ice storage at the high altitudes in these drainages.

Spacing indexes range from 1.52 for Chambers Creek to 4.47 for Kapowsin Creek. The permeability of the underlying rocks probably has the greatest influence on the spacing index. Because the unconsolidated sediments in the Chambers Creek watershed allow rainfall to infiltrate readily, precipitation does not generally result in significant surface runoff and therefore, the spacing index is small. In the Kapowsin Creek drainage area, the large spacing index reflects surface conditions that favor rapid runoff and little infiltration. Glaciers also influence the spacing between the frequency curves, as shown by the fairly small spacing indexes for glacial streams. These streams have values that range from 2.06 for White River at Greenwater to 2.80 for Carbon River. Nonglacial Greenwater River and South Prairie Creek have the somewhat larger values of 2.92 and 3.37, respectively.

## Cedar-Green Basins

The Cedar-Green basins (fig. 1) are located in the east-central part of the Puget Sound region and consist of two important watersheds, Lake Washington and the Green-Duwamish River. The area includes 1,151 square miles of land and inland water. The Lake Washington watershed covers 607 square miles and the Green-Duwamish watershed consists of 483 square miles.

The two principal tributaries to Lake Washington are the Cedar and Sammamish Rivers. The Cedar River has a drainage area of 188 square miles and heads in the Cascade Range. The river flows northwesterly for 50 miles from its source to Lake Washington at Renton. The City of Seattle has developed the upper Cedar River for municipal water supply and hydroelectric power. The Sammamish River is the outlet of Sammamish Lake and drains 240 square miles. Streams tributary to Sammamish Lake are small and drain foothills below an altitude of 3,000 feet.

The Green River also heads on the west slope of the Cascade Range and flows westerly and northerly about 60 miles to Tukwila, where it becomes the Duwamish River. The Duwamish flows northerly an additional 12 miles and enters Elliott Bay at Seattle. The upper Green River basin is the main watershed for the city of Tacoma's municipal water supply. Within the watershed Howard A. Hanson Dam provides storage to control floods and to augment summer low flows downstream.

In the Cedar-Green basins the only area where the low-flow-yield index is greater than 1.5 cfs per square mile is between Cedar Falls and Landsburg on the Cedar River. Three small basins, North Fork Cedar River, Taylor Creek, and Charley Creek have indexes between 1.0 and 1.5 cfs per square mile. The streams in the remaining part of the upper basin have indexes that are between 0.5 and 1.0 cfs per square mile. The lowland creeks tributary to Lake Washington and Sammamish Lake have the smallest indexes, less than 0.5 cfs per square mile.

The low-flow-yield indexes in the Lake Washington watershed range from 0.19 cfs per square mile for May Creek to 2.22 for Cedar River near Landsburg. The large index for the latter station is due partly to upstream regulation and partly to seepage return from Chester Morse Lake and Masonry Pool. Large ground-water contributions from unconsolidated alluvial and outwash sediments that underlie the Taylor Creek watershed account for the fairly large value of 1.37 cfs per square mile for this stream. In the upper Cedar River basin near Lester the low-flow-yield indexes vary greatly, from 1.11 cfs per square mile for North Fork Cedar River to 0.68 cfs per square mile for South Fork Cedar River. The two watersheds drain similar geologic units but the orientation of the drainage basin in respect to the prevailing storms may be the major influencing factor for the difference. May Creek and other lowland tributaries to Lake Washington and Sammamish Lake have small indexes, the largest being 0.56 cfs per square mile for Issaquah Creek. Though most of these streams drain areas that consist of unconsolidated sediments and glacial till, their watersheds receive smaller amounts of precipitation, and recharge of the ground-water reservoir is not sufficient to sustain large low-flow yields.

An increase in low-flow-yield indexes between Green River near Lester and Palmer (table 4) is due to ground-water discharge from the alluvium and recessional outwash in the North Fork Green River and Charley Creek watersheds. A decrease between Palmer and Black Diamond (table 4) is due mostly to Tacoma's diversion but an appreciable amount of ground water contributes to the low flow in this reach. Downstream from Black Diamond, aquifers contained in the alluvial and glacial deposits of the broad flood plain add a considerable amount of ground water to the stream. Tributaries to the Green River have indexes that range from 0.40 to 0.96 cfs per square mile, except for Charley Creek. The larger values for the upper tributaries probably result from the greater amount of precipitation in the upper watershed.

In the Lake Washington basin, the base-flow indexes range from 0.09 for Rex River near Cedar Falls to 0.35 for both Cedar River near Landsburg and Cottage Lake Creek near Redmond. The streams in the upper Cedar River basin, such as the North and South Forks Cedar River, the Rex River, and Cedar River below Bear Creek and near Cedar Falls, have base-flow indexes that are relatively small—0.09 to 0.14. Relatively impermeable igneous and metamorphic rocks underlie these basins and are not capable of storing large quantities of ground water. However, the low-flow-yield indexes are fairly large—0.68 to 1.11 cfs per square mile—indicating some contribution by melt water from snowfields. The large base-flow index for Cedar River near Landsburg is attributed to regulation, seepage, and ground-water contribution. The basins of the creeks tributary to Lake Washington and Sammamish Lake are underlain by unconsolidated alluvial and outwash sediments and contain large ground-water reservoirs that sustain low flows, resulting in fairly large base-flow indexes.

The geology and climate of the upper Green and Cedar River basins are quite similar and result in low base-flow indexes, such as 0.07 for Bear Creek near Eagle Gorge, but higher low-flow-yield indexes, such as 1.06 cfs per square mile for Charley Creek near Eagle Gorge. Farther downstream, Big Soos Creek and Newaukum Creek drain low-lying areas with a large part of their basins underlain by permeable glacial and alluvial sediments which sustain low flows as shown by the magnitude of the base-flow index.

The slope indexes in the Lake Washington watershed range from 1.16 for Bear Creek at Redmond to 3.78 for Cedar River at Cedar Falls. The index for Bear Creek is the smallest determined for the entire Puget Sound region. Extremely small values were obtained for all the low-lying streams tributary to Lake Washington. The extensive ground-water aquifers contained in the unconsolidated alluvial and outwash sediments drained by these streams sustain low flows and variations are small from year to year.

On the Cedar River main stem the slope index increases from 1.64 at the station near Cedar Falls to 3.78 at Cedar Falls and decreases to 1.52 near Landsburg. The index increases again to 3.45 at Renton. The large index at Cedar Falls is caused by regulation at low flows by Chester Morse Lake and Masonry Pool. In the reach between Cedar Falls and Landsburg seepage from the two upstream reservoirs and ground water from the Taylor Creek basin are responsible for the decrease in the slope index near Landsburg. The increase shown at Renton is due largely to the large diversion by Seattle for municipal use below Landsburg; this overshadows the effect of ground-water effluent within this reach. The Cedar River tributaries above Landsburg have indexes between 1.47 and 1.96; in general, the tributaries with larger low-flow-yield indexes have the smaller slope indexes.

In the Green River basin the slope indexes do not vary as widely as those in the Lake Washington basin—from 1.49 for Big Soos Creek near Auburn and Green River near Palmer to 2.22 for Green River near Black Diamond. Large amounts of ground-water storage in the unconsolidated sediments underlying the North Fork Green River basin tend to regulate low flow, thereby reducing the year-to-year variability of flow in the Green River near Palmer. Tacoma's municipal diversion is responsible for the increase to 2.22 near Black Diamond. The gradual decrease in the indexes below Black Diamond is due to the large ground-water reservoir contained in the broad flood plain. Indexes for tributary streams are all fairly small except for Friday Creek, which has an index of 2.13.

The spacing indexes in the Lake Washington watershed range from 1.50 for Cottage Lake Creek to 6.73 for Rex River. Streams draining the lowlands, such as Cottage Lake Creek, generally have small indexes because the unconsolidated sediments that underlie these areas allow precipitation to infiltrate readily and impede surface runoff. The large spacing indexes for Rex River and other upper Cedar River tributaries reflect the impervious character of the geologic units that allows rainfall to immediately form surface runoff.

In the Green River basin the spacing indexes range from 1.57 for Big Soos Creek to 6.23 for Bear Creek. As in the Lake Washington watershed, the principal factor that influences the index is the composition of the surface materials. In general the lowland streams have smaller indexes than the streams draining higher altitudes. The main-stem stations show the same variations as the slope indexes—decreasing between Lester and Palmer, increasing to Black Diamond, and decreasing again below Black Diamond.

## Snohomish Basin

The Snohomish basin (fig. 1) is located in the east-central part of the Puget Sound region and comprises an area of 1,900 square miles of land and inland water. The Snohomish River drains 1,780 square miles and flows into Possession Sound at Everett. The river is formed by the confluences of the Skykomish River which drains 844 square miles and of the Snoqualmie River which drains 693 square miles. Both the Skykomish and Snoqualmie Rivers head in the Cascade Range. The mountain valleys are narrow and steep and characterized by many swift-flowing streams. Downstream, the valleys of the Skykomish and Snoqualmie Rivers widen and the surrounding hills decrease in altitude. The Snohomish River flows down a flood plain that is from 1 to 3 miles wide. Marshes and tidal lowlands characterize the lower reaches of the river and tides affect the streamflow in its lowermost 12-mile reach.

The low flow of the Snoqualmie River near Carnation is affected by regulation at Snoqualmie Falls for power generation. Since 1966, diversion from the South Fork Tolt River by the City of Seattle for municipal supply also affects the streamflow. The records analyzed for this station were collected prior to the diversion and, therefore, do not represent present conditions. Diversions for domestic use occur in some of the smaller streams, but the amount is so small that the records represent virtually natural flow conditions.

The low-flow-yield indexes are greater than 1.5 cfs per square mile in the watersheds of the upper South Fork Skykomish River and North Fork Tolt River. In the drainage area above the three forks of the Snoqualmie River, South Fork Tolt River, and Sultan River, the low-flow-yield indexes are between 1.0 and 1.5 cfs per square mile. Streams draining lowland areas close to Puget Sound are less than 0.5 cfs per square mile.

The low-flow-yield indexes in the basin range from 0.03 cfs per square mile for Dubuque Creek to 1.69 cfs per square mile for North Fork Tolt River. Dubuque Creek and other lowland streams—Little Pilchuck, Woods, Griffin, and Quilceda Creeks—have small indexes that are typical of lowland streams. The extremely small indexes for Dubuque and Little Pilchuck Creeks may be the result of both the impermeable till across which the streams flow and the small rainfall in these basins. Much of the area drained by the North Fork Tolt River is underlain by igneous rocks that normally are not capable of storing much ground water. The reason for the large index (1.69 cfs per sq mi) for this watershed is not known but a part can be attributed to the large amounts of precipitation. The snow and ice storage in the upper South Fork Skykomish River basin above Skykomish influences the runoff pattern and the low-flow-yield index is large (1.63 cfs per sq mi). Those streams in the Snohomish River basin whose indexes range from 1.0 to 1.5 cfs per square mile drain areas of high precipitation and are located at fairly high altitudes. In such areas much of the winter precipitation falls as snow and the slow melting of the snowpack helps to maintain the summer low flows at higher rates. The smaller low-flow-yield indexes of Beckler River, Wallace River, and Olney Creek may be due to smaller amounts of rainfall and snow storage.

The base-flow indexes in the Snohomish basin range from 0.01 for Dubuque Creek near Lake Stevens to 0.27 for Patterson Creek near Fall City. Almost all the indexes are less than 0.20 with many less than 0.10. The small index for Dubuque Creek is attributed to the small amount of ground water available from the glacial till underlying the basin. Patterson Creek drains part of the flood plain of the Snoqualmie River and the unconsolidated alluvial sediments store appreciable amounts of ground water which is reflected in the relatively high base-flow index. The index of 0.24 for South Fork Skykomish River near Skykomish is probably due to the contribution of melt water from ice and snow in the higher mountains of the basin. The lack of ground-water storage in the consolidated sedimentary and igneous rocks in the Wallace River, Sultan River, and Olney Creek basins is shown by the small base-flow indexes of 0.10, 0.13, and 0.09, respectively. Glacial till covers much of the low-lying area drained by Dubuque Creek, Little Pilchuck Creek, and Raging River and, because of the compact character of the till, it does not contain much ground water. The base-flow indexes are correspondingly small. The high low-flow-yield indexes for the North Fork Tolt River and Sultan River appear to be inconsistent with their small base-flow indexes. Factors other than geologic characteristics must influence the low-flow yields in these basins.

The slope indexes in the basin range from 1.30 for Patterson Creek to 8.33 for Dubuque River. Patterson Creek drains the area directly east of Bear and Cottage Lake Creeks in the Cedar-Green basins and has similarly small slope index. The unconsolidated alluvial and glacial sediments in this basin maintain a large amount of ground-water storage that regulates the low flow. The extremely large index for Dubuque Creek can be attributed to the small amount of storage in the basin. Fairly large slope indexes (greater than 2.0) were determined for Olney Creek, McCoy Creek, North Fork Snoqualmie River, South Fork Tolt River, and Little Pilchuck Creek. Most of the high-altitude streams have indexes that are larger than those of the streams of the lowlands. The presence of a greater amount of alluvium and glacial outwash in the lowlands accounts for the smaller values of the low-altitude streams. The smaller index of 1.56 for the South Fork Snoqualmie River, in comparison to indexes of 1.89 and 2.22 for the Middle and North Forks, respectively, may be the result of seepage from Chester Morse Lake and Masonry Pool in the Cedar River basin. The small slope index of 1.52 for Snoqualmie River near Carnation is due mainly to the influence of regulation at low flow by the Snoqualmie Falls powerplant.

The spacing indexes in the basin vary through a wide range—1.68 for Patterson Creek to 14.5 for Dubuque Creek. Further evidence of the presence of permeable unconsolidated alluvial and glacial sediments is shown by the small spacing index for Patterson Creek. The extremely large index for Dubuque Creek results from the impermeability of the surface materials that allows immediate surface runoff and very little infiltration. Lowland streams such as Woods, Griffin, Stossel, Little Pilchuck, and Quilceda Creeks have values less than 4.0—mostly because of the greater permeability of the unconsolidated sediments drained by these streams. Snow and ice storage also is a factor, as shown by the small index of 2.86 for South Fork Skykomish River near Skykomish. Wallace River and Olney Creek drain fairly low-altitude areas that do not receive large amounts of snowfall and are underlain by impermeable sedimentary rocks, with the result that their spacing indexes are large, 7.25 and 7.71, respectively.

## Stillaguamish Basin

The Stillaguamish basin (fig. 1) is located between the Skagit basin to the north and the Snohomish basin to the south. The Stillaguamish River, the only major stream in the area, drains an area of 684 square miles. Two main tributaries, the North and South Forks, rise in the Cascade Mountains and flow through steep narrow mountain valleys in the upper drainages. The North Fork emerges from its narrow valley below Darrington and flows westerly in a wide valley about 30 miles to its confluence with the South Fork. The South Fork heads above Silverton and flows through a gradually widening valley flanked by high mountains and ridges to the mouth of Canyon Creek. Below Canyon Creek the river flows through a canyon cut in glacial deposits and enters a broad flood plain about 4 miles above its confluence with the North Fork. The two forks join near Arlington and from there the main stem meanders down a broad flood plain to Puget Sound.

The low-flow-yield indexes are between 1.0 and 1.5

cfs per square mile for the South Fork Stillaguamish River stations and between 0.5 and 1.5 cfs per square mile in most of the North Fork Basin. Similar to other basins in the Puget Sound region, lowland streams adjacent to Puget Sound have indexes less than 0.5 cfs per square mile. The rather small values in this basin, when compared to those in the adjacent Skagit basin, probably are due to the absence of glaciers to provide melt water during the low-flow season. The larger values in the South Fork and Squire Creek basins may be attributed to their fairly large areas of highly permeable recessional outwash and the abundance of precipitation over these basins. The small low-flow-yield index for Pilchuck Creek may be due to the smaller amount of precipitation and the low permeability of the consolidated sedimentary rocks that underlie most of the basin. Both Armstrong and Fish Creeks drain lowlands underlain by glacial till; their indexes are similar—0.16 and 0.11 cfs per square mile, respectively.

The lowland streams in the Stillaguamish basin have small base-flow indexes. Pilchuck Creek has an index of 0.02; Fish Creek, 0.01; and Armstrong Creek, 0.02. Low-flow yields also are small for these streams, indicating very little ground water available from the impermeable sedimentary rocks and compact glacial till that underlie the basins. The base-flow indexes for the North Fork and South Fork Stillaguamish Rivers also are small and ground-water inflow is very limited in these basins. Large parts of both basins are underlain by sedimentary and igneous rocks which do not support large ground-water reservoirs. However, for the North Fork Stillaguamish River between Darrington and Arlington, the base-flow index increases from 0.10 to 0.14. The river flows from a narrow mountain valley above Darrington through a fairly wide flood plain between the two sites. The ground water in the alluvial sediments of the flood plain discharges to the river during the low-flow period to cause the increase in the base-flow index.

The slope indexes, indicative of the variability of low flows from year to year, range from 1.61 for North Fork Stillaguamish River to 5.00 for Pilchuck Creek. All the indexes are greater than the regional average of 1.60. The lack of any appreciable snow and ice storage in the Stillaguamish basin may be responsible for the larger values. In the Pilchuck River watershed, the wide variability in low flows indicates the presence of only a very small amount of ground-water storage which is rapidly depleted during periods of little or no precipitation. Squire Creek near Darrington (station 1650 in figs. 1 and 7) has a slope index of 2.38. The wide flood plain through which the North Fork Stillaguamish River flows below Darrington is underlain by sedimentary deposits which contain a fairly large volume of ground water that sustains low flows.

The North and South Fork Stillaguamish Rivers have larger spacing indexes than those for most of the major streams in the region. Because of the low altitude of their watersheds, most of the winter precipitation falls as rain and very little is in storage as snow.

The spacing index ranges from 2.12 for Armstrong Creek to 22.2 for Pilchuck Creek, the latter value being the largest computed in the entire Puget Sound region. The indexes for Armstrong Creek and nearby Fish Creek are small for this basin but are large when compared to the indexes for streams in other basins. The extremely large index for Pilchuck Creek is attributed to the impermeable rocks in the basin and the large amount of precipitation falling on the area.

## Skagit Basin

The Skagit basin within Washington (fig. 1) consists of 2,705 square miles of land and inland water. The Skagit River drains 3,105 square miles, of which 400 square miles is in Canada. The lower, western part of the Skagit basin lies between the Nooksack and Stillaguamish basins and the higher eastern part widens toward the Cascade Range crest between the Canadian border and the upper Snohomish basin. The headwaters of the Skagit and its main tributaries (Baker, Cascade, and Sauk Rivers) are at glaciers in the northern Cascade Range, and a part of the surface runoff from these rivers is derived from glacial melt water. The Skagit River valley is relatively narrow above Marblemount, but below that point the valley widens and the river flows down a broad, mountain-flanked flood plain to the lowlands near Sedro Woolley. From there, the river meanders for several miles until about 8 miles from Puget Sound where it branches into two major distributaries to the Sound.

The Samish River is the only other stream of any importance in the Skagit basin and drains a 106-square-mile area immediately north of the lower Skagit River. The river heads in the low hills south of Bellingham and descends to a broad alluvial and glacial outwash plain. Below the mouth of Friday Creek, its main tributary, the river flows about 8 miles in a southerly direction and then flows west and north to its outlet at Samish Bay.

Low-flow-yield indexes in the Skagit basin are greater than 1.5 cfs per square mile for streams tributary to the Skagit River in the middle part of the basin, such as the Baker, Cascade, and Sauk Rivers. Big Beaver, Thunder, and Stetattle Creeks have indexes between 1.0 and 1.5 cfs per square mile and the upper Skagit basin and part of the lower basin have indexes between 0.5 and 1.0 cfs per square mile. The lowland streams close to Puget Sound have indexes less than 0.5 cfs per square mile.

The low-flow-yield indexes range from 0.06 cfs per square mile for Friday Creek in the lowland to 2.75 cfs per square mile for Baker River in the mountains. Small indexes (less than 0.5 cfs per square mile) are characteristic of streams that drain the lowlands adjacent to Puget Sound. Friday Creek flows through an area underlain by consolidated sedimentary rocks. The combined effect of the low permeability of these rocks and small amount of precipitation contribute to the extremely small value for this creek. East Fork Nookachamps Creek drains similar materials and has correspondingly small index—0.11 cfs per square mile. Samish River, Day Creek, and Alder Creek have larger indexes because they flow through areas that are underlain mostly by unconsolidated sediments and some glacial till.

The index for Baker River is the largest determined in the Puget Sound region; this is attributed to the large amount of precipitation received by the basin, much of which falls as snow, and to the large ground-water reservoir contained in the extensive glacial deposits underlying most of its lower valley. The large indexes determined for Sauk and Cascade Rivers also are due to basin characteristics similar to those of the Baker River. Much of the variations in the low-flow-yield indexes for streams in the area upstream from Newhalem can be accounted for, in part, by the variations in precipitation. This area is partly shielded from the prevailing storms by Mounts Baker and Shuksan. Precipitation becomes progressively smaller in an easterly direction and the same pattern is reflected by the low-flow-yield index.

On the main stem of the Skagit River in the Canadian watershed, the low-flow-yield index is fairly small—0.57 cfs per square mile—and increases as the river flows south into Washington. Near Newhalem, the index is 0.96 cfs per square mile and becomes 1.66 at Newhalem, 2.37 at Concrete, and then decreases slightly to 2.33 near Mount Vernon. The large increases in the indexes are due partly to the large contributions from the upper glacier-fed tributaries—Big Beaver Creek, Thunder Creek, Cascade, Sauk, and Baker Rivers—and partly to the regulation for power development at Ross and Diablo Dams. The smaller inflow from the lower tributaries is responsible for the slight decrease between Concrete and Mount Vernon.

The Skagit River at its main-stem stations below Newhalem has a base-flow index ranging between 0.40 and 0.43. These values are among the largest computed for streams in the Puget Sound region and are due to regulation for hydroelectric power production and to the contribution from the major tributary streams. Downstream, for the tributaries to the Skagit River between Newhalem and Concrete, base-flow indexes range from 0.19 for the Sauk River above its confluence with the Whitechuck River to 0.29 for Suiattle River. The low-flow periods for these rivers occur either in the winter or summer, with the base-flow index probably being influenced by melt water from snow or ice. Streams in the lower part of the basin and in the Samish River basin have base-flow indexes ranging from 0.03 for East Fork Nookachamps Creek to 0.25 for Alder Creek. Geologic conditions in these two basins vary: the low-index East Fork Nookachamps Creek basin is underlain by impermeable sedimentary rocks that support very small volumes of ground water, whereas the larger index for Alder Creek is attributed to larger ground-water inflow from the permeable unconsolidated glacial and alluvial sediments in that basin.

Slope indexes in the basin vary through a fairly wide range and show the influences of climate, basin characteristics, and manmade changes. The indexes range from 1.33 for the Skagit River 4 miles north of the border and upstream from the head of Ross Lake (station Skagit River near Hope, B.C.) to 2.86 for East Fork Nookachamps Creek. The heavy snowpack and glacier cover of the watershed probably accounts for a fairly stable summer runoff. On the other hand, the rather large index for low-altitude East Fork Nookachamps Creek probably is due to the inability of the consolidated sedimentary rocks to store much water. Similarly large values were determined for Finney, Day, and Friday Creeks; all are streams draining areas underlain by relatively impermeable rocks. No consistency in the slope indexes could be found for the upper tributaries to the Skagit River. The combination of the areal variations in precipitation, amount of snow and ice storage, and character of the underlying geologic materials have varying influences on the year-to-year changes in low flows. The slope index of 2.04 for Cascade River could possibly be the result of the low flows occurring during the winter months for some years and during the summer months in other years. On the main stem of the Skagit River below Newhalem, the indexes are generally small due to regulation at upstream reservoirs.

The spacing indexes in the Skagit basin range from 1.89 for Alder Creek to 13.5 for East Fork Nookachamps Creek. Unconsolidated glacial sediments underlie most of the Alder Creek basin and allow precipitation to infiltrate readily; this is the principal factor responsible for the small value. In contrast, the poorly permeable materials underlying the East Fork Nookachamps Creek basin do not allow precipitation to infiltrate and, consequently, the index is large. In addition to the impermeability of the surface materials, the low altitude of the Finney, Day, and Friday Creek watersheds is the primary characteristic accountable for the rather large values—6.73, 6.92, and 7.08, respectively. Most of the upper tributaries have indexes that are less than 3.0; these values are influenced greatly by the effect of winter precipitation falling as snow. The spacing indexes for the Skagit main-stem stations are all small and vary within a very narrow range of 1.96 and 2.11 except for 2.45 for the Skagit River upstream from Ross Lake (station 1705). These small values are the result of storage in Ross and Diablo Lakes and in the Baker River watershed.

# Nooksack Basin

The Nooksack basin (fig. 1) is located in the extreme northeastern part of the Puget Sound region, between the Canadian border and the Skagit basin. The basin is comprised of 1,262 square miles of land and inland water. The Nooksack River has a drainage area of 826 square miles, of which 49 square miles is in Canada. The three major tributaries of the river head in the Mounts Baker and Shuksan and converge near the town of Deming. From Deming the main stem flows 37 miles across the lowland to its outlet in Bellingham Bay.

Included in the discussion of the Nooksack basin are the Sumas and Chilliwack Rivers whose headwaters lie between the Nooksack River basin and the Canadian border and which flow northward to the Fraser River in British Columbia. The Sumas River drains some of the foothills and lowlands in the western part of the basin. The Chilliwack River heads on the northern slope of the Picket Range of the North Cascades and drains 170 square miles in Washington.

The low-flow-yield indexes in the Nooksack basin range from 0.22 cfs per square mile for Fishtrap Creek to 1.90 cfs per square mile for Nooksack River below Cascade Creek. The indexes in the main stem and North Fork Nooksack basins are greater than 1.5 cfs per square mile, and between 1.0 and 1.5 cfs per square mile in the South Fork basin. The low-lying streams adjacent to Puget Sound have indexes less than 0.5 cfs per square mile.

Snow and glacial melt water augments the late-summer flow in the North Fork Nooksack River below Cascade Creek, resulting in a large low-flow-yield index for this stream. Because less snow and ice are stored in the South Fork basin, the index is smaller than that for the North Fork even though the basins receive approximately the same amount of precipitation. At Deming, below the confluences of the North, Middle and South Forks, an index of 1.81 cfs per square mile was determined. No gaging station records are available on the Middle Fork, but climatic and geologic conditions would suggest that the Middle Fork probably would have a value greater than 1.5.

The small low-flow-yield index for Fishtrap Creek is representative of the lowland streams in the basin. The small amount of precipitation available to recharge the ground-water aquifers in the lowlands, as well as the diversion of water for irrigation and domestic use may account for the small index in the lowlands.

The base-flow indexes for the two Nooksack mainstem stations at Deming and near Lynden are 0.30 and 0.31, respectively. These values are influenced by the melt water from snowfields and glaciers in the basin's headwater areas. Because low winter temperatures reduce runoff from the upper parts of the basin, the low-flow period may occur at this time or in the summer when low flows are augmented by some summer melt water.

The smallest base-flow index in the basin is 0.13 for Fishtrap Creek, a low-lying stream. Most of this basin is underlain by glacial drift capable of supporting large volumes of ground water. However, because the index may be affected by diversion for irrigation during the summer, it is not representative of natural conditions.

The slope indexes in the Nooksack basin range from 1.59 for Nooksack River at Deming to 1.92 for Fishtrap Creek. The indexes show little variation and are nearly the average value determined for the entire Puget Sound region. As mentioned earlier, however, the slope index for Fishtrap Creek may not represent natural conditions because diversions are made from the stream for irrigation. Although the climate and basin characteristics vary widely between the Nooksack River below Cascade Creek and the South Fork Nooksack River near Wickersham, their slope indexes are nearly identical—1.69 and 1.67, respectively. The smallest index, that for the Nooksack River at Deming (1.59), probably results from the stabilizing influence of melt water from snow and ice in the upper part of the basin.

The spacing indexes show a greater variation than do the slope indexes; they range from 2.40 for Fishtrap Creek to 4.54 for South Fork Nooksack River. The glacial and alluvial sediments drained by Fishtrap Creek are fairly permeable and permit rainfall to infiltrate the ground; this may account for the small index. A large part of the South Fork basin consists of relatively impermeable igneous and metamorphic rocks, and precipitation results in immediate surface runoff. Skookum Creek, a tributary to the South Fork, has similar basin characteristics and a correspondingly large spacing index of 3.53.

# SUMMARY

This study of the low-flow characteristics of streams in the Puget Sound region has been made to guide the efficient use and development of the available water resources. As the demand for water for industrial, agricultural, and municipal uses continues to expand, the results of this study can be used as a guide in the planning and development of the resource so that future needs for water in the area can be met.

Low-flow characteristics of the streams in the region were compared on the basis of indexes computed from the (1) median 7-day low flow expressed as unit runoff per square mile, (2) ratio of median 7-day low flow and average discharge, (3) slope of the annual 7-day low-flow-frequency curve, and (4) spacing between the annual 7-day and 183-day low-flow-frequency curves. The streams show a wide variation in the indexes owing to the complex interrelation between low flow of streams and climatic and geologic characteristics.

Some general observations of the low-flow characteristics of streams in the Puget Sound region are as follows:

1. Low-flow-yield indexes are largest for streams that head at high altitudes in the Cascade and Olympic Mountains and have their sources at glaciers. The low-flow yields of streams in these areas are benefitted principally by such perennial snow and ice storage which regulates streamflow naturally, with melt water augmenting late-summer flows.
2. Low-flow-yield indexes are smallest for streams that drain lowland areas adjacent to Puget Sound, where the precipitation is less than in the higher foothills and mountains. Although the lowlands are underlain generally by highly permeable materials that retain greater quantities of ground-water storage for maintenance of late-summer streamflows, the lesser precipitation in the lowlands causes the smaller yields there.
3. Low-flow-yield indexes between the extreme values are representative of streams that head at fairly high altitudes but do not have their sources at glaciers. Although the relatively impermeable rocks underlying these mountainous areas do not support large ground-water reservoirs, the large amount of precipitation at these high altitudes contributes to the fairly large low-flow-yield indexes for these streams.
4. Variations in the base-flow index can be attributed both to the character of the geologic material underlying the basin and to the amount of melt water originating at glaciers or perennial snowfields. The influence of the geologic environment on low flows of nonglacial streams can be appraised from this index. The study of base-flow indexes of streams receiving melt water from snow and ice is far more complex. The largest base-flow indexes were obtained for streams draining areas of the Puget Sound lowland underlain by permeable unconsolidated glacial and alluvial sediments. These materials contain large volumes of ground water that sustain flows during late summer. The smallest indexes were obtained for nonglacial streams draining areas underlain by poorly permeable glacial till and relatively impermeable igneous, sedimentary, and metamorphic bedrock—only small amounts of ground water are available in these materials to contribute to low flows. Base-flow indexes for streams of glacial origin are among the larger indexes computed and indicate that melt water from snow and ice has an appreciable effect.
5. The slope indexes are influenced by the character of the geologic materials to a greater extent than are the low-flow-yield indexes. Slope indexes were largest for small streams that drain areas underlain by relatively impermeable consolidated rocks and at fairly low altitudes where very little precipitation falls as snow. Slope indexes were smallest for streams in the lowlands close to Puget Sound, where ground water stored in aquifers in unconsolidated alluvial and glacial deposits tends to regulate low flows from year to year. Slope indexes also were small for glacial streams, showing the moderating effect of snow and ice storage in these basins.
6. The spacing indexes, like the slope indexes, are affected mainly by the geologic character of the materials underlying the basin; the ability of the materials to accept infiltration from precipitation is the principal factor causing the variations in the spacing indexes. The largest indexes are characteristic of the small streams whose basins are underlain by consolidated igneous, sedimentary, or metamorphic rocks. The impermeability of these rocks allows precipitation to run off readily, thereby increasing appreciably the 183-day low-flow and the spacing index. The unconsolidated glacial and alluvial sediments, through which most of the lowland streams flow, produce the smallest spacing indexes because these materials permit much of the precipitation to infiltrate into the ground-water reservoir, for naturally regulated discharge to streams throughout the year.
7. The four indexes herein used to define low-flow characteristics of streams in the region do not appear to have any consistent relation to each other. Streams with large low-flow indexes would normally be expected to have large base-flow indexes and small slope and spacing indexes. Presumably large low-flow yields would indicate a substantial ground-water reservoir that is easily recharged and that sustains low flows from year to year. However, no relation could be established between the low-flow-yield index and the other three indexes because the storage of water as snow and ice and wide areal variation of precipitation has a great influence on the low-flow yield. Most of the effect of the variation of precipitation was

removed by the base-flow index, and, for streams not benefitting from melt water from glaciers or snowfields, this index shows the influence of geology in the basin. The slope and spacing index also are influenced by the geologic materials. An apparent relation exists between the three indexes—streams with small base-flow indexes usually have large slope and spacing indexes and those with large base-flow indexes usually have small slope and spacing indexes—but many anomalies occur that cannot be explained by the geology of the basin.

This report attempts to present low-flow data in a usable form and to explain their meaning and limitations. Careful application of the data may help solve many problems in the planning, development, and design of various water-resources projects. The low-flow characteristics defined by the indexes are for natural-flow conditions for most of the streams in the region and can provide a basis for evaluating the effect of future changes in the stream systems on the low-flow regimen. Further studies are needed to develop techniques for analyzing low-flow data so that low-flow characteristics can be determined for many ungaged sites.

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# TABLE 1.—Gaging-station records used in low-flow analysis

| Station no.[1] | Station name and basin | Drainage area (sq mi) | Mean annual discharge (cfs) | Period of record |
|---|---|---|---|---|
| | Elwha-Dungeness Basins | | | |
| 0455 | Elwha River at McDonald Bridge, near Port Angeles | 269 | 1,615 | 1897-1901; 1918-64. |
| 0475 | Siebert Creek near Port Angeles | 15.5 | 15.5 | 1952-64. |
| 0480 | Dungeness River near Sequim | 156 | 418 | 1923-30; 1937-64. |
| | West Sound Basins | | | |
| 0505 | Snow Creek near Maynard | 11.2 | 15.3 | 1952-64. |
| 0520 | Little Quilcene River near Quilcene | 23.7 | 51.5 | 1926-27; 1951-57. |
| 0530 | Dosewallips River near Brinnon | 93.5 | 507 | 1930-49. |
| 0540 | Duckabush River near Brinnon | 66.5 | 437 | 1910-11; 1938-64. |
| 0545 | Hamma Hamma River near Eldon | 51.3 | 361 | 1951-64. |
| 0546 | Jefferson Creek near Eldon | 21.6 | 153 | 1957-64. |
| 0565 | North Fork Skokomish River below Staircase Rapids, near Hoodsport | 57.2 | 543 | 1924-64. |
| 0600 | South Fork Skokomish River near Potlatch | 63.4 | 644 | 1923-32; 1946-64. |
| 0605 | South Fork Skokomish River near Union | 76.3 | 765 | 1931-64. |
| 0615 | Skokomish River near Potlatch | 227 | 1,246 | 1943-64. |
| 0630 | Union River near Bremerton | 3.16 | 12.1 | 1945-59. |
| 0635 | Union River near Belfair | 19.8 | 53.8 | 1947-59. |
| 0650 | Mission Creek near Belfair | 4.43 | 12.2 | 1945-53. |
| 0655 | Gold Creek near Bremerton | 1.51 | 5.95 | 1945-64. |
| 0660 | Tahuya River near Bremerton | 5.99 | 21.3 | 1945-56. |
| 0685 | Dewatto River near Dewatto | 18.4 | 68.1 | 1947-54; 1958-64. |
| 0700 | Dogfish Creek near Poulsbo | 5.01 | 8.70 | 1947-64. |
| 0730 | Burley Creek at Burley | 10.7 | 28.3 | 1947-50; 1959-64. |
| 0735 | Huge Creek near Wauna | 6.47 | 11.7 | 1947-64. |
| 0765 | Goldsborough Creek near Shelton | 39.3 | 120 | 1951-64. |
| 0780 | Skookum Creek at Kamilche | 16.1 | 56.8 | 1951-58. |
| 0784 | Kennedy Creek near Kamilche | 17.4 | 60.6 | 1960-64. |
| | Nisqually-Deschutes Basins | | | |
| 0790 | Deschutes River near Rainier | 89.8 | 265 | 1949-64. |
| 0800 | Deschutes River near Olympia | 160 | 408 | 1945-54; 1957-64. |
| 0810 | Woodland Creek near Olympia | 24.6 | 28.2 | 1949-64. |
| 0825 | Nisqually River near National | 133 | 801 | 1942-64. |
| 0830 | Mineral Creek near Mineral | 75.2 | 395 | 1942-64. |
| 0840 | Nisqually River near Alder | 249 | 1,270 | 1931-44. |
| 0845 | Little Nisqually River near Alder | 28.0 | 137 | 1920-43. |
| 0865 | Nisqually River at LaGrande | 289 | 1,577 | 1906-11; 1919-31; 1943-64. |
| 0870 | Mashel River near LaGrande | 80.7 | 248 | 1940-57. |
| 0880 | Ohop Creek near Eatonville | 34.5 | 72.5 | 1927-32; 1941-64. |
| 0885 | Nisqually River near McKenna | 445 | 1,950 | 1941-63. |
| 0890 | Tanwax Creek near McKenna | 26.0 | 31.0 | 1944-50. |
| 0895 | Nisqually River at McKenna | 517 | 1,480 | 1947-64. |

| Station no.[1] | Station name and basin | Drainage area (sq mi) | Mean annual discharge (cfs) | Period of record |
|---|---|---|---|---|
| | **Puyallup Basin** | | | |
| 0915 | Chambers Creek below Leach Creek, near Steilacoom | 104 | 120 | 1937-40; 1943-64. |
| 0920 | Puyallup River near Electron | 92.8 | 561 | 1908-33; 1944-49; 1957-64. |
| 0930 | Kapowsin Creek near Kapowsin | 25.9 | 52.6 | 1927-32; 1941-57. |
| 0935 | Puyallup River near Orting | 172 | 737 | 1931-64. |
| 0940 | Carbon River near Fairfax | 78.9 | 448 | 1910-12; 1929-64. |
| 0950 | South Prairie Creek at South Prairie | 79.5 | 249 | 1949-64. |
| 0965 | Puyallup River at Alderton | 438 | 1,733 | 1914-27; 1943-57. |
| 0970 | White River at Greenwater | 216 | 927 | 1929-64. |
| 0975 | Greenwater River at Greenwater | 73.5 | 228 | 1929-64. |
| 0985 | White River near Buckley | 401 | 1,573 | 1928-33; 1938-64. |
| 1005 | White River near Sumner | 470 | 625 | 1945-64. |
| 1015 | Puyallup River at Puyallup | 948 | 3,674 | 1914-64. |
| | **Cedar-Green Basins** | | | |
| 1035 | Snow Creek near Lester | 11.5 | 68.5 | 1945-64. |
| 1040 | Friday Creek near Lester | 4.67 | 27.6 | 1945-64. |
| 1045 | Green River near Lester | 96.2 | 422 | 1945-64. |
| 1047 | Green Canyon Creek near Lester | 3.23 | 13.7 | 1960-64. |
| 1050 | Smay Creek near Lester | 8.56 | 52.4 | 1946-64. |
| 1055 | Charley Creek near Eagle Gorge | 11.3 | 72.8 | 1946-55. |
| 1060 | Bear Creek near Eagle Gorge | 4.10 | 25.7 | 1946-55. |
| 1065 | Green River near Palmer | 230 | 1,164 | 1931-63. |
| 1075 | Green River near Black Diamond | 285 | 1,215 | 1939-48. |
| 1085 | Newaukum Creek near Black Diamond | 27.4 | 65.3 | 1944-50; 1952-64. |
| 1125 | Big Soos Creek near Auburn | 59.2 | 123 | 1944-49; 1952-56. |
| 1130 | Green River near Auburn | 399 | 1,458 | 1936-64. |
| 1133.5 | Green River at Tukwila | 440 | 1,588 | 1960-64. |
| 1135 | North Fork Cedar River near Lester | 9.30 | 71.9 | 1944-63. |
| 1140 | South Fork Cedar River near Lester | 6.00 | 40.2 | 1944-64. |
| 1145 | Cedar River below Bear Creek, near Cedar Falls | 25.4 | 181 | 1945-63. |
| 1150 | Cedar River near Cedar Falls | 40.7 | 279 | 1945-64. |
| 1155 | Rex River near Cedar Falls | 13.4 | 106 | 1945-64. |
| 1165 | Cedar River at Cedar Falls | 84.2 | 357 | 1914-64. |
| 1167 | Middle Fork Taylor Creek near Selleck | 5.17 | 37.3 | 1956-63. |
| 1168 | North Fork Taylor Creek near Selleck | 3.77 | 21.9 | 1956-64. |
| 1170 | Taylor Creek near Selleck | 17.2 | 106 | 1956-64. |
| 1175 | Cedar River near Landsburg | 117 | 738 | 1895-1964. |
| 1185 | Rock Creek near Maple Valley | 12.6 | 18.2 | 1945-64. |
| 1190 | Cedar River at Renton | 186 | 709 | 1945-64. |
| 1195 | May Creek near Renton | 12.5 | 20.0 | 1945-50; 1955-58; 1963-64. |
| 1200 | Mercer Creek near Bellevue | 12.0 | 20.2 | 1955-64. |
| 1210 | Issaquah Creek near Issaquah | 27.0 | 69.6 | 1945-63. |
| 1225 | Bear Creek near Redmond | 13.9 | 27.8 | 1945-49. |
| 1230 | Cottage Lake Creek near Redmond | 10.7 | 13.8 | 1955-64. |
| 1240 | Evans Creek above mouth, near Redmond | 130 | 22.0 | 1955-64. |
| 1245 | Bear Creek at Redmond | 48.2 | 78.4 | 1945-50; 1955-58. |
| 1250 | Sammamish River near Redmond | 150 | 309 | 1939-57. |
| 1260 | North Creek near Bothell | 24.6 | 35.4 | 1945-64. |
| 1265 | Sammamish River at Bothell | 212 | 391 | 1939-62. |

## TABLE 1.—Gaging-station records used in low-flow analysis—continued

| Station no.[1] | Station name and basin | Drainage area (sq mi) | Mean annual discharge (cfs) | Period of record |
|---|---|---|---|---|
| | Snohomish Basin | | | |
| 1305 | South Fork Skykomish River near Skykomish | 135 | 924 | 1929-31; 1946-50. |
| 1310 | Beckler River near Skykomish | 96.5 | 649 | 1929-33; 1946-49. |
| 1330 | South Fork Skykomish River near Index | 355 | 2,647 | 1911-64. |
| 1340 | North Fork Skykomish River at Index | 146 | 1,359 | 1910-22; 1929-38; 1946-48. |
| 1345 | Skykomish River near Gold Bar | 535 | 4,251 | 1928-64. |
| 1350 | Wallace River at Gold Bar | 19.0 | 166 | 1928-33; 1946-64. |
| 1355 | Olney Creek near Gold Bar | 8.31 | 80.3 | 1946-50. |
| 1375 | Sultan River near Startup | 74.5 | 859 | 1934-64. |
| 1385 | McCoy Creek near Sultan | 5.87 | 27.5 | 1946-50. |
| 1410 | Woods Creek near Monroe | 56.4 | 155 | 1946-64. |
| 1415 | Middle Fork Snoqualmie River near North Bend | 169 | 1,348 | 1907-26; 1929-32. |
| 1420 | North Fork Snoqualmie River near Snoqualmie Falls | 64.0 | 552 | 1929-49; 1961-64. |
| 1430 | North Fork Snoqualmie River near North Bend | 95.7 | 772 | 1907-26; 1929-38; 1960-64. |
| 1440 | South Fork Snoqualmie River at North Bend | 81.7 | 583 | 1907-26; 1929-38; 1945-50; 1960-64. |
| 1455 | Raging River near Fall City | 30.6 | 142 | 1945-50; 1963-64. |
| 1460 | Patterson Creek near Fall City | 15.5 | 31.2 | 1947-50; 1955-64. |
| 1470 | Griffin Creek near Carnation | 17.1 | 42.3 | 1945-64. |
| 1475 | North Fork Tolt River near Carnation | 39.2 | 384 | 1952-63. |
| 1480 | South Fork Tolt River near Carnation | 19.7 | 199 | 1952-63. |
| 1485 | Tolt River near Carnation | 81.4 | 667 | 1928-32; 1937-64. |
| 1487 | Stossel Creek near Carnation | 5.58 | 17.8 | 1957-63. |
| 1490 | Snoqualmie River near Carnation | 603 | 4,065 | 1928-64. |
| 1525 | Pilchuck River near Granite Falls | 54.5 | 349 | 1943-57. |
| 1530 | Little Pilchuck Creek near Lake Stevens | 17.0 | 31.0 | 1947-50; 1953-64. |
| 1545 | Dubuque Creek near Lake Stevens | 5.33 | 17.0 | 1946-50. |
| 1570 | Quilceda Creek near Marysville | 15.4 | 25.3 | 1946-64. |
| | Stillaquamish Basin | | | |
| 1610 | South Fork Stillaguamish River near Granite Falls | 119 | 1,146 | 1928-64. |
| 1625 | South Fork Stillaguamish River above Jim Creek, near Arlington | 199 | 1,743 | 1936-57. |
| 1640 | Jim Creek near Arlington | 46.2 | 225 | 1937-50; 1953-57. |
| 1650 | Squire Creek near Darrington | 20.0 | 190 | 1950-64. |
| 1655 | North Fork Stillaguamish River near Darrington | 82.2 | 625 | 1950-57. |
| 1670 | North Fork Stillaguamish River near Arlington | 262 | 2,024 | 1928-64. |
| 1675 | Armstrong Creek near Arlington | 7.33 | 15.2 | 1950-57. |
| 1685 | Pilchuck Creek near Bryant | 52.0 | 288 | 1929-31; 1950-64. |
| 1695 | Fish Creek near Arlington | 7.52 | 9.0 | 1950-53. |

| Station no.[1] | Station name and basin | Drainage area (sq mi) | Mean annual discharge (cfs) | Period of record |
|---|---|---|---|---|
| | Skagit Basin | | | |
| 1705 | Skagit River near Hope, B.C. | 357 | 1,163 | 1915-22; 1934-55. |
| 1710 | Lightning Creek near Newhalem | 129 | 422 | 1943-48. |
| 1720 | Big Beaver Creek near Newhalem | 63.2 | 466 | 1940-48; 1963-64. |
| 1725 | Skagit River near Newhalem | 780 | 2,970 | 1929-40. |
| 1735 | Ruby Creek below Panther Creek, near Newhalem | 206 | 705 | 1948-56; 1963-64. |
| 1755 | Thunder Creek near Newhalem | 105 | 638 | 1930-64. |
| 1775 | Stetattle Creek near Newhalem | 22.0 | 196 | 1933-64. |
| 1780 | Skagit River at Newhalem | 1,175 | 4,893 | 1908-14; 1920-64. |
| 1790 | Skagit River above Alma Creek, near Marblemount | 1,274 | 5,770 | 1950-64. |
| 1800 | Bacon Creek near Marblemount | 50.9 | 492 | 1943-50. |
| 1810 | Skagit River at Marblemount | 1,381 | 6,670 | 1946-51. |
| 1825 | Cascade River at Marblemount | 168 | 1,105 | 1928-64. |
| 1860 | Sauk River above Whitechuck River, near Darrington | 152 | 1,232 | 1917-22; 1928-64. |
| 1890 | Suiattle River near Mansford | 335 | 2,104 | 1938-49. |
| 1895 | Sauk River near Sauk | 714 | 4,657 | 1928-64. |
| 1915 | Baker River below Anderson Creek, near Concrete | 211 | 2,010 | 1910-25; 1928-31; 1955-59. |
| 1935 | Baker River at Concrete | 297 | 2,725 | 1910-15; 1943-64. |
| 1940 | Skagit River near Concrete | 2,737 | 16,210 | 1924-64. |
| 1945 | Finney Creek near Concrete | 51.6 | 322 | 1943-48. |
| 1960 | Alder Creek near Hamilton | 10.7 | 36.7 | 1943-64. |
| 1965 | Day Creek near Lyman | 34.2 | 277 | 1943-62. |
| 2000 | East Fork Nookachamps Creek near Clear Lake | 20.5 | 91.2 | 1943-50; 1961-23. |
| 2005 | Skagit River near Mount Vernon | 3,093 | 17,420 | 1940-64. |
| 2010 | Friday Creek near Burlington | 37.1 | 82.1 | 1943-48. |
| 2015 | Samish River near Burlington | 87.8 | 250 | 1943-64. |
| | Nooksack Basin | | | |
| 2050 | Nooksack River below Cascade Creek, near Glacier | 105 | 800 | 1937-64. |
| 2090 | South Fork Nooksack River near Wickersham | 103 | 772 | 1933-64. |
| 2095 | Skookum Creek near Wickersham | 23.1 | 136 | 1948-64. |
| 2105 | Nooksack River at Deming | 584 | 3,535 | 1935-56. |
| 2115 | Nooksack River near Lynden | 648 | 3,733 | 1944-64. |
| 2120 | Fishtrap Creek at Lynden | 22.3 | 37.6 | 1948-64. |

[1] For convenience, prefix "12" is deleted from all station numbers.

TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]

| Station no.1/ | Station name and basin | Number of consecu-tive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Elwha-Dungeness Basins | | | | | | |
| 0455 | Elwha River at McDonald Bridge, near Port Angeles | 7 | 420 | 340 | 300 | 260 | 245 |
| | | 30 | 500 | 415 | 375 | 340 | 330 |
| | | 90 | 740 | 560 | 490 | 440 | 420 |
| | | 183 | 1,180 | 930 | 840 | 760 | 720 |
| 0475 | Siebert Creek near Port Angeles | 7 | 2.5 | 2.0 | 1.9 | 1.8 | 1.7 |
| | | 30 | 2.8 | 2.3 | 2.2 | 2.1 | 2.0 |
| | | 90 | 3.7 | 2.9 | 2.6 | 2.4 | 2.3 |
| | | 183 | 5.7 | 4.5 | 4.1 | 4.0 | 3.9 |
| 0480 | Dungeness River near Sequim | 7 | 123 | 104 | 95 | 88 | 84 |
| | | 30 | 141 | 120 | 109 | 101 | 97 |
| | | 90 | 203 | 160 | 141 | 126 | 119 |
| | | 183 | 287 | 232 | 210 | 200 | 193 |
| | West Sound Basins | | | | | | |
| 0505 | Snow Creek near Maynard | 7 | 1.9 | 1.5 | 1.3 | 1.2 | 1.2 |
| | | 30 | 2.4 | 1.8 | 1.6 | 1.5 | 1.4 |
| | | 90 | 3.5 | 2.5 | 2.1 | 1.8 | 1.7 |
| | | 183 | 6.6 | 4.8 | 4.1 | 3.6 | 3.3 |
| 0520 | Little Quilcene River near Quilcene | 7 | 11 | 8.4 | 7.3 | 6.6 | 6.3 |
| | | 30 | 13 | 9.6 | 8.4 | 7.5 | 7.0 |
| | | 90 | 14 | 11 | 9.9 | 9.3 | 9.0 |
| | | 183 | 25 | 19 | 18 | 17 | 16 |
| 0530 | Dosewallips River near Brinnon | 7 | 132 | 114 | 106 | 100 | 96 |
| | | 30 | 154 | 132 | 123 | 118 | 114 |
| | | 90 | 222 | 184 | 170 | 160 | 156 |
| | | 183 | 350 | 300 | 280 | 268 | 260 |
| 0540 | Duckabush River near Brinnon | 7 | 78 | 64 | 58 | 53 | 51 |
| | | 30 | 97 | 79 | 70 | 64 | 61 |
| | | 90 | 160 | 120 | 108 | 100 | 96 |
| | | 183 | 300 | 245 | 224 | 212 | 209 |
| 0545 | Hamma Hamma River near Eldon | 7 | 59 | 47 | 43 | 40 | 39 |
| | | 30 | 69 | 55 | 50 | 46 | 45 |
| | | 90 | 113 | 85 | 76 | 70 | 68 |
| | | 183 | 220 | 188 | 177 | 170 | 168 |
| 0546 | Jefferson Creek near Eldon | 7 | 13 | 10.6 | 9.6 | 8.9 | 8.6 |
| | | 30 | 16 | 12.7 | 11.5 | 10.8 | 10.3 |
| | | 90 | 28 | 20.5 | 18 | 16 | 15 |
| | | 183 | 60 | 50 | 46 | 44 | 43 |
| 0565 | North Fork Skokomish River below Staircase Rapids, near Hoodsport | 7 | 75 | 62 | 56 | 54 | 52 |
| | | 30 | 94 | 74 | 67 | 62 | 60 |
| | | 90 | 160 | 120 | 107 | 98 | 95 |
| | | 183 | 335 | 270 | 252 | 240 | 235 |

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) 2.0 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|---|---|
| | West Sound Basins--Con. | | | | | | |
| 0600 | South Fork Skokomish River near Potlatch | 7 | 89 | 76 | 70 | 66 | 64 |
| | | 30 | 99 | 83 | 77 | 73 | 71 |
| | | 90 | 140 | 110 | 98 | 90 | 86 |
| | | 183 | 280 | 230 | 210 | 200 | 190 |
| 0605 | South Fork Skokomish River near Union | 7 | 94 | 80 | 75 | 72 | 70 |
| | | 30 | 105 | 88 | 82 | 77 | 74 |
| | | 90 | 153 | 121 | 108 | 99 | 94 |
| | | 183 | 308 | 250 | 226 | 210 | 204 |
| 0615 | Skokomish River near Potlatch | 7 | 178 | 160 | 151 | 144 | 140 |
| | | 30 | 200 | 176 | 168 | 160 | 158 |
| | | 90 | 250 | 218 | 205 | 197 | 190 |
| | | 183 | 480 | 380 | 350 | 325 | 315 |
| 0630 | Union River near Bremerton | 7 | .6 | .46 | .40 | .35 | .32 |
| | | 30 | .65 | .50 | .43 | .38 | .35 |
| | | 90 | .8 | .7 | .55 | .50 | .48 |
| | | 183 | 1.8 | 1.4 | 1.2 | 1.1 | 1.0 |
| 0635 | Union River near Belfair | 7 | 17.2 | 15 | 14 | 13.3 | 13 |
| | | 30 | 18.8 | 16 | 15 | 14 | 13.7 |
| | | 90 | 20 | 17.6 | 16.5 | 15.8 | 15.5 |
| | | 183 | 24.4 | 21.2 | 20 | 19 | 18 |
| 0650 | Mission Creek near Belfair | 7 | .23 | .15 | .11 | .09 | .08 |
| | | 30 | .28 | .18 | .14 | .11 | .10 |
| | | 90 | .36 | .25 | .20 | .16 | .15 |
| | | 183 | .98 | .66 | .52 | .43 | .39 |
| 0655 | Gold Creek near Bremerton | 7 | .51 | .40 | .36 | .32 | .30 |
| | | 30 | .57 | .45 | .40 | .36 | .34 |
| | | 90 | .71 | .56 | .49 | .43 | .40 |
| | | 183 | 1.3 | 1.0 | .88 | .78 | .73 |
| 0660 | Tahuya River near Bremerton | 7 | .33 | .17 | .12 | .09 | .08 |
| | | 30 | .42 | .22 | .16 | .12 | .10 |
| | | 90 | .73 | .40 | .29 | .22 | .18 |
| | | 183 | 2.7 | 1.7 | 1.3 | 1.0 | .90 |
| 0685 | Dewatto River near Dewatto | 7 | 12 | 10.9 | 10.2 | 9.9 | 9.7 |
| | | 30 | 13.7 | 12.2 | 11.8 | 11.4 | 11.2 |
| | | 90 | 15.2 | 13.9 | 13.2 | 13 | 12.7 |
| | | 183 | 22 | 19 | 18 | 16.8 | 16 |
| 0700 | Dogfish River near Poulsbo | 7 | 2.8 | 2.6 | 2.4 | 2.3 | 2.2 |
| | | 30 | 3.1 | 2.8 | 2.6 | 2.5 | 2.4 |
| | | 90 | 3.4 | 3.1 | 2.9 | 2.8 | 2.7 |
| | | 183 | 4.5 | 4.0 | 3.8 | 3.6 | 3.5 |

## TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) 2.0 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|---|---|
| | West Sound Basins--Con. | | | | | | |
| 0730 | Burley Creek at Burley | 7 | 13.6 | 12 | 11.1 | 10.4 | 10 |
| | | 30 | 14.7 | 13 | 12.3 | 11.9 | 11.6 |
| | | 90 | 15.7 | 14 | 13.4 | 13 | 12.6 |
| | | 183 | 18.2 | 16 | 15 | 14.4 | 14 |
| 0735 | Huge Creek near Wauna | 7 | 4.3 | 3.9 | 3.7 | 3.6 | 3.5 |
| | | 30 | 4.6 | 4.1 | 4.0 | 3.9 | 3.8 |
| | | 90 | 4.8 | 4.4 | 4.2 | 4.1 | 4.0 |
| | | 183 | 5.6 | 4.9 | 4.7 | 4.5 | 4.4 |
| 0765 | Goldsborough Creek near Shelton | 7 | 20 | 17.3 | 16 | 15.2 | 14.9 |
| | | 30 | 22 | 19 | 17.8 | 16.8 | 16 |
| | | 90 | 25 | 21.2 | 19.5 | 18 | 17.2 |
| | | 183 | 40 | 33 | 29 | 21 | 19.5 |
| 0780 | Skookum Creek near Kamilche | 7 | 2.1 | 1.7 | 1.6 | 1.5 | 1.5 |
| | | 30 | 2.5 | 2.2 | 2.1 | 2.0 | 2.0 |
| | | 90 | 3.0 | 2.4 | 2.2 | 2.1 | 2.1 |
| | | 183 | 8.6 | 5.7 | 4.4 | 3.4 | 2.9 |
| 0784 | Kennedy Creek near Kamilche | 7 | 2.8 | 2.3 | 2.1 | 1.9 | 1.8 |
| | | 30 | 3.1 | 2.6 | 2.3 | 2.1 | 2.0 |
| | | 90 | 3.7 | 3.0 | 2.8 | 2.6 | 2.5 |
| | | 183 | 9.1 | 6.4 | 5.1 | 4.2 | 3.7 |
| | Nisqually-Deschutes Basins | | | | | | |
| 0790 | Deschutes River near Rainier | 7 | 32 | 28 | 26 | 25 | 24 |
| | | 30 | 35 | 31 | 29 | 27 | 26 |
| | | 90 | 41 | 35 | 32 | 30 | 29 |
| | | 183 | 82 | 62 | 52 | 44 | 40 |
| 0800 | Deschutes River near Olympia | 7 | 96 | 85 | 80 | 75 | 72 |
| | | 30 | 101 | 89 | 83 | 79 | 76 |
| | | 90 | 110 | 96 | 88 | 82 | 79 |
| | | 183 | 160 | 130 | 115 | 102 | 96 |
| 0810 | Woodland Creek near Olympia | 7 | 12.5 | 9.9 | 8.8 | 8.0 | 7.6 |
| | | 30 | 13.5 | 10.9 | 9.7 | 8.9 | 8.5 |
| | | 90 | 14.5 | 11.5 | 10.2 | 9.2 | 8.9 |
| | | 183 | 17 | 13.2 | 11.7 | 10.3 | 9.8 |
| 0825 | Nisqually River near National | 7 | 250 | 202 | 178 | 156 | 147 |
| | | 30 | 320 | 250 | 213 | 188 | 173 |
| | | 90 | 445 | 380 | 350 | 330 | 320 |
| | | 183 | 600 | 475 | 420 | 380 | 370 |
| 0830 | Mineral Creek near Mineral | 7 | 33 | 26 | 24 | 22 | 21 |
| | | 30 | 38 | 30 | 27 | 25 | 24 |
| | | 90 | 54 | 38 | 32 | 28 | 27 |
| | | 183 | 145 | 96 | 76 | 62 | 55 |

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Nisqually-Deschutes Basins--Con. | | | | | | |
| 0840 | Nisqually River near Alder | 7 | 350 | 290 | 263 | 240 | 230 |
| | | 30 | 445 | 375 | 340 | 310 | 290 |
| | | 90 | 630 | 540 | 505 | 480 | 465 |
| | | 183 | 820 | 680 | 610 | 560 | 530 |
| 0845 | Little Nisqually River near Alder | 7 | 10 | 7.3 | 6.4 | 5.8 | 5.5 |
| | | 30 | 12.7 | 9.0 | 7.7 | 6.8 | 6.4 |
| | | 90 | 20 | 13.9 | 11.4 | 9.7 | 9.0 |
| | | 183 | 44 | 30.5 | 25 | 21 | 19.5 |
| 0865 | Nisqually River at La Grande | 7 | 520 | 430 | 410 | 390 | 380 |
| | | 30 | 660 | 520 | 470 | 440 | 420 |
| | | 90 | 800 | 640 | 560 | 500 | 470 |
| | | 183 | 1,040 | 880 | 820 | 780 | 750 |
| 0870 | Mashel River near La Grande | 7 | 14.7 | 10 | 8.6 | 7.7 | 7.3 |
| | | 30 | 18.5 | 12 | 10 | 8.8 | 8.3 |
| | | 90 | 30.5 | 17.8 | 13.8 | 11.3 | 10 |
| | | 183 | 94 | 54 | 38 | 27.5 | 22.8 |
| 0880 | Ohop Creek near Eatonville | 7 | 6.5 | 4.9 | 4.3 | 3.9 | 3.7 |
| | | 30 | 8.9 | 6.6 | 5.7 | 5.0 | 4.6 |
| | | 90 | 13 | 9.2 | 7.6 | 6.4 | 5.8 |
| | | 183 | 27 | 18 | 14.4 | 12 | 10.8 |
| 0885 | Nisqually River near McKenna | 7 | 540 | 445 | 405 | 375 | 360 |
| | | 30 | 690 | 560 | 500 | 455 | 430 |
| | | 90 | 830 | 660 | 590 | 540 | 510 |
| | | 183 | 1,190 | 990 | 900 | 840 | 800 |
| 0890 | Tanwax Creek near McKenna | 7 | 1.05 | .76 | .66 | .60 | .58 |
| | | 30 | 1.4 | .95 | .80 | .70 | .66 |
| | | 90 | 2.3 | 1.5 | 1.2 | 1.0 | .92 |
| | | 183 | 6.0 | 3.6 | 2.8 | 2.2 | 1.9 |
| 0895 | Nisqually River at McKenna | 7 | 167 | 72 | 42 | 25 | 19 |
| | | 30 | 280 | 132 | 83 | 53 | 42 |
| | | 90 | 415 | 255 | 195 | 150 | 130 |
| | | 183 | 750 | 540 | 480 | 460 | 450 |
| | Puyallup Basin | | | | | | |
| 0915 | Chambers Creek below Leach Creek, near Steilacoom | 7 | 41 | 34 | 32 | 31 | 30 |
| | | 30 | 45 | 38 | 35 | 33 | 32 |
| | | 90 | 49 | 41 | 38 | 36 | 35 |
| | | 183 | 62 | 51 | 46 | 42 | 40 |
| 0920 | Puyallup River near Electron | 7 | 195 | 158 | 146 | 132 | 125 |
| | | 30 | 260 | 200 | 183 | 165 | 155 |
| | | 90 | 390 | 315 | 290 | 265 | 250 |
| | | 183 | 500 | 400 | 375 | 350 | 330 |

## TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued

| Station no.[1/] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Puyallup Basin--Con. | | | | | | |
| 0930 | Kapowsin Creek near Kapowsin | 7 | 3.8 | 2.3 | 1.7 | 1.3 | 1.1 |
| | | 30 | 4.7 | 2.9 | 2.2 | 1.7 | 1.5 |
| | | 90 | 6.6 | 3.9 | 3.0 | 2.4 | 2.1 |
| | | 183 | 17 | 10.7 | 8.2 | 6.4 | 5.6 |
| 0935 | Puyallup River near Orting | 7 | 255 | 210 | 188 | 170 | 162 |
| | | 30 | 335 | 285 | 260 | 240 | 225 |
| | | 90 | 460 | 410 | 380 | 360 | 350 |
| | | 183 | 600 | 520 | 490 | 470 | 460 |
| 0940 | Carbon River near Fairfax | 7 | 134 | 110 | 98 | 89 | 85 |
| | | 30 | 170 | 133 | 118 | 105 | 99 |
| | | 90 | 260 | 220 | 197 | 177 | 167 |
| | | 183 | 375 | 300 | 265 | 240 | 225 |
| 0950 | South Prairie Creek at South Prairie | 7 | 41 | 34 | 30 | 28 | 26 |
| | | 30 | 48 | 39 | 35 | 31 | 30 |
| | | 90 | 68 | 49 | 41 | 35 | 33 |
| | | 183 | 138 | 96 | 77 | 62 | 56 |
| 0965 | Puyallup River at Alderton | 7 | 520 | 440 | 400 | 360 | 335 |
| | | 30 | 710 | 580 | 510 | 445 | 410 |
| | | 90 | 980 | 820 | 740 | 650 | 610 |
| | | 183 | 1,350 | 1,100 | 990 | 860 | 800 |
| 0970 | White River at Greenwater | 7 | 330 | 280 | 260 | 240 | 225 |
| | | 30 | 390 | 330 | 300 | 280 | 265 |
| | | 90 | 500 | 440 | 410 | 390 | 380 |
| | | 183 | 680 | 530 | 480 | 450 | 440 |
| 0975 | Greenwater River at Greenwater | 7 | 41 | 34 | 32 | 30 | 29 |
| | | 30 | 47 | 38 | 35 | 33 | 32 |
| | | 90 | 60 | 47 | 42 | 39 | 37 |
| | | 183 | 120 | 81 | 66 | 56 | 51 |
| 0985 | White River near Buckley | 7 | 480 | 390 | 340 | 300 | 280 |
| | | 30 | 600 | 500 | 440 | 400 | 375 |
| | | 90 | 740 | 640 | 580 | 540 | 510 |
| | | 183 | 1,140 | 910 | 820 | 770 | 740 |
| 1005 | White River near Sumner | 7 | 58 | 47 | 41 | 37 | 34 |
| | | 30 | 70 | 56 | 50 | 46 | 44 |
| | | 90 | 102 | 76 | 64 | 55 | 50 |
| | | 183 | 280 | 140 | 100 | 73 | 62 |
| 1015 | Puyallup River at Puyallup | 7 | 1,180 | 1,010 | 910 | 820 | 770 |
| | | 30 | 1,440 | 1,250 | 1,150 | 1,050 | 1,000 |
| | | 90 | 1,900 | 1,590 | 1,440 | 1,300 | 1,230 |
| | | 183 | 2,700 | 2,200 | 2,000 | 1,800 | 1,700 |

| Station no. 1/ | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Cedar-Green Basins | | | | | | |
| 1035 | Snow Creek near Lester | 7 | 6.2 | 4.7 | 4.1 | 3.6 | 3.3 |
| | | 30 | 7.2 | 5.4 | 4.7 | 4.0 | 3.7 |
| | | 90 | 11.9 | 7.4 | 6.0 | 4.9 | 4.4 |
| | | 183 | 35 | 21 | 15.5 | 11.3 | 9.6 |
| 1040 | Friday Creek near | 7 | 2.9 | 1.9 | 1.6 | 1.4 | 1.3 |
| | Lester | 30 | 3.5 | 2.5 | 2.1 | 1.8 | 1.7 |
| | | 90 | 5.4 | 3.4 | 2.7 | 2.2 | 2.0 |
| | | 183 | 15 | 9.4 | 7.1 | 5.6 | 4.8 |
| 1045 | Green River near | 7 | 38 | 30 | 27 | 24.7 | 23.5 |
| | Lester | 30 | 44 | 34 | 30 | 26.5 | 25 |
| | | 90 | 65 | 45 | 38 | 33 | 31 |
| | | 183 | 200 | 120 | 86 | 63 | 53 |
| 1047 | Green Canyon Creek | 7 | 2.0 | 1.6 | 1.4 | 1.2 | 1.2 |
| | near Lester | 30 | 2.2 | 1.8 | 1.5 | 1.4 | 1.3 |
| | | 90 | 3.1 | 2.2 | 1.8 | 1.5 | 1.4 |
| | | 183 | 6.4 | 4.4 | 3.4 | 2.8 | 2.4 |
| 1050 | Smay Creek near Lester | 7 | 8.2 | 6.4 | 5.6 | 5.0 | 4.7 |
| | | 30 | 9.1 | 7.0 | 6.2 | 5.6 | 5.3 |
| | | 90 | 12.5 | 8.9 | 7.6 | 6.6 | 6.2 |
| | | 183 | 30.5 | 20 | 15.8 | 12.5 | 11 |
| 1055 | Charley Creek near | 7 | 12 | 9.9 | 8.8 | 7.9 | 7.4 |
| | Eagle Gorge | 30 | 14 | 11.1 | 9.9 | 8.9 | 8.3 |
| | | 90 | 18 | 13 | 11.1 | 9.9 | 9.3 |
| | | 183 | 40 | 27 | 21.5 | 17.5 | 15.5 |
| 1060 | Bear Creek near | 7 | 1.8 | 1.3 | 1.1 | 1.0 | .9 |
| | Eagle Gorge | 30 | 2.2 | 1.6 | 1.3 | 1.1 | 1.0 |
| | | 90 | 4.1 | 2.6 | 2.0 | 1.6 | 1.4 |
| | | 183 | 11.2 | 7.3 | 5.5 | 4.2 | 3.6 |
| 1065 | Green River near Palmer | 7 | 150 | 120 | 107 | 100 | 95 |
| | | 30 | 175 | 135 | 120 | 110 | 103 |
| | | 90 | 233 | 170 | 150 | 135 | 129 |
| | | 183 | 580 | 400 | 330 | 280 | 250 |
| 1075 | Green River near | 7 | 110 | 76 | 60 | 49 | 44 |
| | Black Diamond | 30 | 135 | 89 | 70 | 57 | 51 |
| | | 90 | 208 | 130 | 101 | 82 | 72 |
| | | 183 | 550 | 335 | 255 | 200 | 175 |
| 1085 | Newaukum Creek near | 7 | 16.3 | 13 | 11.3 | 10 | 9.2 |
| | Black Diamond | 30 | 18.2 | 14.5 | 12.7 | 11.1 | 10.5 |
| | | 90 | 21 | 16.1 | 14 | 12 | 11 |
| | | 183 | 29.6 | 22 | 18.7 | 16.2 | 15 |

**TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued**

| Station no.1/ | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) 2.0 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|---|---|
| | Cedar-Green Basins--Con. | | | | | | |
| 1125 | Big Soos Creek near Auburn | 7 | 30 | 25 | 22 | 20 | 18.7 |
| | | 30 | 32 | 26.5 | 23.5 | 21 | 20 |
| | | 90 | 36 | 29 | 25.5 | 22.5 | 21 |
| | | 183 | 47 | 37 | 32.5 | 29 | 27.5 |
| 1130 | Green River near Auburn | 7 | 176 | 130 | 107 | 90 | 82 |
| | | 30 | 208 | 147 | 118 | 96 | 86 |
| | | 90 | 295 | 198 | 156 | 125 | 110 |
| | | 183 | 670 | 430 | 335 | 270 | 240 |
| 1133.5 | Green River at Tukwila | 7 | 220 | 168 | 140 | 120 | 110 |
| | | 30 | 250 | 185 | 155 | 130 | 120 |
| | | 90 | 335 | 235 | 195 | 166 | 150 |
| | | 183 | 770 | 490 | 380 | 295 | 260 |
| 1135 | North Fork Cedar River near Lester | 7 | 10.3 | 8.2 | 7.2 | 6.3 | 5.8 |
| | | 30 | 11.8 | 9.0 | 7.8 | 6.8 | 6.3 |
| | | 90 | 16.4 | 11.4 | 9.6 | 8.5 | 7.9 |
| | | 183 | 42 | 29 | 24 | 20 | 18.5 |
| 1140 | South Fork Cedar River near Lester | 7 | 4.1 | 2.9 | 2.4 | 2.1 | 1.9 |
| | | 30 | 4.7 | 3.3 | 2.7 | 2.3 | 2.1 |
| | | 90 | 7.4 | 4.4 | 3.4 | 2.7 | 2.4 |
| | | 183 | 22.5 | 14 | 10.6 | 8.1 | 6.9 |
| 1145 | Cedar River below Bear Creek, near Cedar Falls | 7 | 24 | 18 | 16 | 14.2 | 13.5 |
| | | 30 | 27 | 20 | 17.5 | 15.8 | 15 |
| | | 90 | 42 | 28 | 23 | 19.5 | 18 |
| | | 183 | 107 | 71 | 55 | 44 | 38 |
| 1150 | Cedar River near Cedar Falls | 7 | 36 | 28 | 24.5 | 22 | 21 |
| | | 30 | 41 | 31 | 27 | 25 | 24 |
| | | 90 | 63 | 42 | 35 | 31 | 29 |
| | | 183 | 168 | 110 | 88 | 70 | 62 |
| 1155 | Rex River near Cedar Falls | 7 | 9.2 | 6.7 | 5.8 | 5.2 | 5.0 |
| | | 30 | 11.3 | 7.8 | 6.7 | 5.9 | 5.6 |
| | | 90 | 21 | 12.7 | 9.7 | 7.8 | 7.0 |
| | | 183 | 62 | 43 | 37 | 32 | 30 |
| 1165 | Cedar River at Cedar Falls | 7 | 43.5 | 24 | 16.5 | 11.5 | 9.3 |
| | | 30 | 61 | 34 | 23.3 | 16.5 | 13.5 |
| | | 90 | 88 | 49 | 38.5 | 31.5 | 29 |
| | | 183 | 178 | 101 | 80 | 68 | 63 |
| 1167 | Middle Fork Taylor Creek near Selleck | 7 | 7.3 | 5.1 | 4.4 | 4.0 | 3.8 |
| | | 30 | 8.6 | 5.8 | 4.8 | 4.3 | 4.0 |
| | | 90 | 10.6 | 6.8 | 5.4 | 4.6 | 4.2 |
| | | 183 | 20.5 | 13.8 | 11 | 9.2 | 8.4 |

| Station no.1/ | Station name and basin | Number of consecu-tive days | Streamflow (cfs) for indicated recurrence intervals (years) 2.0 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|---|---|
| | Cedar-Green Basins--Con. | | | | | | |
| 1168 | North Fork Taylor Creek near Selleck | 7 | 2.1 | 1.1 | 0.8 | 0.6 | 0.5 |
| | | 30 | 2.7 | 1.5 | 1.0 | .8 | .6 |
| | | 90 | 4.8 | 2.4 | 1.6 | 1.2 | 1.0 |
| | | 183 | 13 | 7.6 | 5.3 | 3.8 | 3.2 |
| 1170 | Taylor Creek near Selleck | 7 | 23.5 | 19 | 17 | 15.8 | 15 |
| | | 30 | 26.5 | 21.5 | 19.3 | 18 | 17 |
| | | 90 | 36 | 26.5 | 22 | 19.2 | 18 |
| | | 183 | 66 | 46 | 36 | 29 | 26 |
| 1175 | Cedar River near Landsburg | 7 | 260 | 210 | 184 | 170 | 160 |
| | | 30 | 295 | 235 | 210 | 190 | 180 |
| | | 90 | 335 | 265 | 230 | 210 | 200 |
| | | 183 | 470 | 360 | 320 | 285 | 270 |
| 1185 | Rock Creek near Maple Valley | 7 | 5.4 | 4.1 | 3.4 | 2.9 | 2.6 |
| | | 30 | 6.0 | 4.6 | 3.9 | 3.4 | 3.1 |
| | | 90 | 6.8 | 5.3 | 4.6 | 4.0 | 3.7 |
| | | 183 | 9.3 | 7.0 | 5.8 | 4.9 | 4.5 |
| 1190 | Cedar River at Renton | 7 | 101 | 56 | 40 | 29 | 24 |
| | | 30 | 138 | 75 | 52 | 36 | 30 |
| | | 90 | 187 | 100 | 66 | 44 | 35 |
| | | 183 | 370 | 210 | 148 | 103 | 85 |
| 1195 | May Creek near Renton | 7 | 2.4 | 2.1 | 1.8 | 1.7 | 1.6 |
| | | 30 | 2.8 | 2.4 | 2.1 | 1.9 | 1.8 |
| | | 90 | 3.2 | 2.6 | 2.2 | 2.0 | 1.9 |
| | | 183 | 4.7 | 3.3 | 2.8 | 2.4 | 2.2 |
| 1200 | Mercer Creek near Bellevue | 7 | 3.8 | 3.2 | 3.0 | 2.8 | 2.7 |
| | | 30 | 4.7 | 4.0 | 3.6 | 3.4 | 3.3 |
| | | 90 | 5.4 | 4.4 | 4.0 | 3.7 | 3.6 |
| | | 183 | 8.0 | 6.4 | 5.5 | 5.0 | 4.6 |
| 1210 | Issaquah Creek near Issaquah | 7 | 15 | 12.6 | 11.7 | 11 | 10.7 |
| | | 30 | 16.5 | 14 | 12.7 | 11.7 | 11.2 |
| | | 90 | 19 | 15.5 | 14 | 12.7 | 12 |
| | | 183 | 29 | 21 | 18 | 15 | 13.5 |
| 1225 | Bear Creek near Redmond | 7 | 5.0 | 4.2 | 3.8 | 3.6 | 3.4 |
| | | 30 | 5.5 | 4.6 | 4.1 | 3.9 | 3.7 |
| | | 90 | 6.6 | 5.2 | 4.6 | 4.2 | 3.9 |
| | | 183 | 9.8 | 7.0 | 5.9 | 5.1 | 4.7 |
| 1230 | Cottage Lake Creek near Redmond | 7 | 4.8 | 4.2 | 4.0 | 3.9 | 3.8 |
| | | 30 | 5.4 | 4.7 | 4.4 | 4.2 | 4.1 |
| | | 90 | 5.8 | 5.0 | 4.7 | 4.5 | 4.3 |
| | | 183 | 7.2 | 6.0 | 5.4 | 4.9 | 4.7 |

TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued

| Station no.1/ | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) 2.0 | 5 | 10 | 20 | 30 |
|---|---|---|---|---|---|---|---|
| | Cedar-Green Basins--Con. | | | | | | |
| 1240 | Evans Creek above mouth, near Redmond | 7 | 6.6 | 6.0 | 5.7 | 5.4 | 5.3 |
| | | 30 | 7.0 | 6.4 | 6.2 | 6.0 | 5.8 |
| | | 90 | 8.0 | 7.1 | 6.8 | 6.6 | 6.4 |
| | | 183 | 10 | 8.6 | 7.9 | 7.4 | 7.1 |
| 1245 | Bear Creek at Redmond | 7 | 18.6 | 17 | 16.5 | 16 | 15.7 |
| | | 30 | 20.2 | 18.5 | 17.8 | 17 | 16.6 |
| | | 90 | 24 | 21.5 | 20.3 | 19.5 | 19 |
| | | 183 | 34 | 28 | 26 | 24 | 23 |
| 1250 | Sammamish River near Redmond | 7 | 70 | 55 | 49 | 46 | 44 |
| | | 30 | 74 | 59 | 53 | 48 | 46 |
| | | 90 | 85 | 67 | 60 | 55 | 53 |
| | | 183 | 125 | 97 | 83 | 73 | 67 |
| 1260 | North Creek near Bothell | 7 | 6.2 | 5.4 | 5.2 | 4.9 | 4.8 |
| | | 30 | 7.0 | 6.0 | 5.6 | 5.3 | 5.2 |
| | | 90 | 8.3 | 7.2 | 6.7 | 6.4 | 6.2 |
| | | 183 | 12.6 | 10.2 | 9.0 | 8.3 | 7.9 |
| 1265 | Sammamish River at Bothell | 7 | 96 | 78 | 72 | 66 | 63 |
| | | 30 | 102 | 83 | 75 | 70 | 67 |
| | | 90 | 113 | 93 | 84 | 77 | 74 |
| | | 183 | 162 | 130 | 118 | 107 | 100 |
| | Snohomish Basin | | | | | | |
| 1305 | South Fork Skykomish River near Skykomish | 7 | 220 | 182 | 163 | 150 | 140 |
| | | 30 | 260 | 210 | 182 | 165 | 155 |
| | | 90 | 380 | 280 | 235 | 200 | 185 |
| | | 183 | 630 | 480 | 420 | 360 | 330 |
| 1310 | Beckler River near Skykomish | 7 | 86 | 70 | 64 | 59 | 57 |
| | | 30 | 107 | 82 | 72 | 65 | 62 |
| | | 90 | 178 | 120 | 100 | 85 | 78 |
| | | 183 | 380 | 270 | 220 | 180 | 160 |
| 1330 | South Fork Skykomish River near Index | 7 | 440 | 360 | 340 | 320 | 310 |
| | | 30 | 540 | 430 | 390 | 360 | 340 |
| | | 90 | 890 | 620 | 520 | 440 | 400 |
| | | 183 | 1,800 | 1,300 | 1,100 | 940 | 860 |
| 1340 | North Fork Skykomish River at Index | 7 | 190 | 150 | 132 | 119 | 112 |
| | | 30 | 260 | 190 | 161 | 140 | 130 |
| | | 90 | 430 | 290 | 235 | 200 | 180 |
| | | 183 | 930 | 630 | 500 | 390 | 340 |
| 1345 | Skykomish River near Gold Bar | 7 | 740 | 570 | 490 | 430 | 390 |
| | | 30 | 950 | 700 | 580 | 500 | 450 |
| | | 90 | 1,540 | 1,010 | 780 | 620 | 550 |
| | | 183 | 3,100 | 2,150 | 1,700 | 1,380 | 1,220 |

| Station no.1/ | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Snohomish Basin--Con. | | | | | | |
| 1350 | Wallace River at Gold Bar | 7 | 16 | 11 | 9.4 | 8.2 | 7.5 |
| | | 30 | 23.5 | 15 | 12 | 10.4 | 9.6 |
| | | 90 | 46 | 28 | 24 | 21.5 | 20.5 |
| | | 183 | 116 | 86 | 70 | 59 | 53 |
| 1355 | Olney Creek near Gold Bar | 7 | 7.0 | 4.8 | 4.1 | 3.5 | 3.2 |
| | | 30 | 10.8 | 6.5 | 5.3 | 4.5 | 4.2 |
| | | 90 | 24 | 13.8 | 10.3 | 8.3 | 7.5 |
| | | 183 | 54 | 39 | 32 | 26.5 | 24 |
| 1375 | Sultan River near Startup | 7 | 108 | 77 | 64 | 55 | 52 |
| | | 30 | 143 | 100 | 80 | 66 | 60 |
| | | 90 | 300 | 190 | 150 | 120 | 106 |
| | | 183 | 600 | 420 | 340 | 280 | 250 |
| 1385 | McCoy Creek near Sultan | 7 | 2.4 | 1.5 | 1.2 | 1.0 | .9 |
| | | 30 | 3.1 | 1.8 | 1.4 | 1.2 | 1.1 |
| | | 90 | 4.2 | 2.6 | 2.0 | 1.7 | 1.5 |
| | | 183 | 10 | 6.4 | 4.8 | 3.7 | 3.1 |
| 1410 | Woods Creek near Monroe | 7 | 18 | 14 | 12.5 | 11.5 | 11 |
| | | 30 | 20.5 | 15.4 | 13.7 | 12.6 | 12 |
| | | 90 | 25 | 18 | 16 | 14.4 | 13.8 |
| | | 183 | 50 | 34 | 27 | 22 | 19.5 |
| 1415 | Middle Fork Snoqualmie River near North Bend | 7 | 240 | 163 | 140 | 128 | 120 |
| | | 30 | 315 | 213 | 180 | 160 | 150 |
| | | 90 | 480 | 320 | 270 | 240 | 225 |
| | | 183 | 1,000 | 700 | 560 | 450 | 400 |
| 1420 | North Fork Snoqualmie River near Snoqualmie Falls | 7 | 64 | 40 | 32 | 26 | 24 |
| | | 30 | 86 | 54 | 42 | 33 | 29 |
| | | 90 | 165 | 95 | 68 | 50 | 43 |
| | | 183 | 370 | 270 | 225 | 190 | 170 |
| 1430 | North Fork Snoqualmie River near North Bend | 7 | 96 | 61 | 50 | 43 | 39 |
| | | 30 | 128 | 80 | 62 | 50 | 44 |
| | | 90 | 235 | 138 | 102 | 81 | 74 |
| | | 183 | 490 | 360 | 290 | 245 | 220 |
| 1440 | South Fork Snoqualmie River at North Bend | 7 | 119 | 94 | 83 | 76 | 73 |
| | | 30 | 132 | 103 | 92 | 84 | 81 |
| | | 90 | 185 | 136 | 120 | 110 | 103 |
| | | 183 | 400 | 285 | 230 | 185 | 165 |
| 1455 | Raging River near Fall City | 7 | 10 | 7.7 | 6.9 | 6.3 | 6.0 |
| | | 30 | 12 | 9.7 | 8.6 | 8.0 | 7.7 |
| | | 90 | 18 | 13 | 11.3 | 10.2 | 9.7 |
| | | 183 | 48 | 34 | 29 | 25 | 24 |

TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued

| Station no.1/ | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Snohomish Basin--Con. | | | | | | |
| 1460 | Patterson Creek near Fall City | 7 | 8.3 | 7.1 | 6.6 | 6.4 | 6.2 |
| | | 30 | 9.0 | 7.6 | 7.0 | 6.7 | 6.4 |
| | | 90 | 9.9 | 8.3 | 7.6 | 7.0 | 6.8 |
| | | 183 | 13.9 | 10.7 | 9.0 | 7.8 | 7.2 |
| 1470 | Griffin Creek near Carnation | 7 | 3.2 | 2.4 | 2.1 | 1.8 | 1.7 |
| | | 30 | 3.6 | 2.7 | 2.3 | 2.0 | 1.9 |
| | | 90 | 4.9 | 3.5 | 3.0 | 2.6 | 2.4 |
| | | 183 | 12 | 7.6 | 6.0 | 5.0 | 4.5 |
| 1475 | North Fork Tolt River near Carnation | 7 | 66 | 47 | 40 | 35 | 33 |
| | | 30 | 86 | 60 | 49 | 40 | 37 |
| | | 90 | 138 | 85 | 66 | 54 | 48 |
| | | 183 | 260 | 190 | 155 | 128 | 115 |
| 1480 | South Fork Tolt River near Carnation | 7 | 24 | 16 | 13 | 11 | 10 |
| | | 30 | 33 | 22.5 | 18 | 14.8 | 13 |
| | | 90 | 66 | 39 | 28.5 | 22 | 19 |
| | | 183 | 130 | 94 | 78 | 68 | 62 |
| 1485 | Tolt River near Carnation | 7 | 103 | 75 | 64 | 56 | 52 |
| | | 30 | 130 | 91 | 75 | 63 | 57 |
| | | 90 | 220 | 138 | 102 | 80 | 70 |
| | | 183 | 430 | 305 | 245 | 200 | 180 |
| 1487 | Stossel Creek near Carnation | 7 | 1.4 | 1.0 | .9 | .8 | .7 |
| | | 30 | 1.8 | 1.2 | 1.0 | .9 | .8 |
| | | 90 | 2.3 | 1.6 | 1.3 | 1.2 | 1.1 |
| | | 183 | 5.5 | 3.3 | 2.6 | 2.2 | 2.0 |
| 1490 | Snoqualmie River near Carnation | 7 | 640 | 500 | 450 | 425 | 410 |
| | | 30 | 820 | 600 | 510 | 450 | 430 |
| | | 90 | 1,370 | 900 | 710 | 570 | 510 |
| | | 183 | 2,750 | 1,900 | 1,530 | 1,250 | 1,100 |
| 1525 | Pilchuck River near Granite Falls | 7 | 46 | 35 | 30 | 26 | 24 |
| | | 30 | 54 | 39 | 33 | 29 | 27 |
| | | 90 | 87 | 56 | 46 | 40 | 37 |
| | | 183 | 177 | 126 | 104 | 87 | 79 |
| 1530 | Little Pilchuck Creek near Lake Stevens | 7 | 1.4 | .9 | .7 | .5 | .4 |
| | | 30 | 1.6 | 1.2 | 1.0 | .9 | .8 |
| | | 90 | 2.2 | 1.6 | 1.4 | 1.3 | 1.2 |
| | | 183 | 6.3 | 3.5 | 2.5 | 1.8 | 1.6 |
| 1545 | Dubuque Creek near Lake Stevens | 7 | .2 | .1 | 0 | 0 | 0 |
| | | 30 | .3 | .2 | .1 | .04 | 0 |
| | | 90 | .5 | .3 | .2 | .1 | .1 |
| | | 183 | 2.9 | 1.3 | .8 | .5 | .4 |
| 1570 | Quilceda Creek near Marysville | 7 | 4.1 | 3.4 | 3.1 | 2.8 | 2.7 |
| | | 30 | 4.5 | 3.7 | 3.3 | 3.0 | 2.9 |
| | | 90 | 5.3 | 4.5 | 4.1 | 3.8 | 3.6 |
| | | 183 | 8.8 | 6.7 | 5.8 | 5.0 | 4.6 |

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | <u>Stillaguamish Basin</u> | | | | | | |
| 1610 | South Fork Stillaguamish River near Granite Falls | 7 | 145 | 110 | 94 | 82 | 75 |
| | | 30 | 200 | 140 | 112 | 94 | 84 |
| | | 90 | 390 | 260 | 205 | 165 | 147 |
| | | 183 | 760 | 550 | 440 | 360 | 325 |
| 1625 | South Fork Stillaguamish River above Jim Creek, near Arlington | 7 | 215 | 154 | 130 | 113 | 105 |
| | | 30 | 300 | 204 | 163 | 135 | 120 |
| | | 90 | 550 | 350 | 290 | 260 | 250 |
| | | 183 | 1,140 | 830 | 680 | 560 | 500 |
| 1640 | Jim Creek near Arlington | 7 | 15 | 11 | 9.5 | 8.6 | 8.2 |
| | | 30 | 20 | 13.2 | 11 | 9.6 | 9.0 |
| | | 90 | 38 | 25 | 21 | 18 | 17 |
| | | 183 | 94 | 67 | 54 | 46 | 41 |
| 1650 | Squire Creek near Darrington | 7 | 26 | 17.5 | 13.7 | 10.8 | 9.4 |
| | | 30 | 40 | 26 | 20 | 16 | 14 |
| | | 90 | 79 | 45 | 34.5 | 28 | 25 |
| | | 183 | 140 | 99 | 80 | 65 | 58 |
| 1655 | North Fork Stillaguamish River near Darrington | 7 | 64 | 45 | 38 | 33 | 30 |
| | | 30 | 82 | 56 | 46 | 38 | 35 |
| | | 90 | 162 | 108 | 83 | 65 | 56 |
| | | 183 | 355 | 240 | 185 | 148 | 130 |
| 1670 | North Fork Stillaguamish River near Arlington | 7 | 290 | 225 | 200 | 180 | 173 |
| | | 30 | 375 | 280 | 240 | 215 | 200 |
| | | 90 | 630 | 410 | 350 | 310 | 300 |
| | | 183 | 1,270 | 890 | 700 | 570 | 510 |
| 1675 | Armstrong Creek near Arlington | 7 | 3.4 | 2.6 | 2.3 | 2.0 | 1.9 |
| | | 30 | 3.8 | 3.0 | 2.7 | 2.5 | 2.4 |
| | | 90 | 4.5 | 3.6 | 3.4 | 3.2 | 3.1 |
| | | 183 | 7.2 | 5.8 | 5.3 | 4.9 | 4.7 |
| 1685 | Pilchuck Creek near Bryant | 7 | 5.4 | 2.4 | 1.6 | 1.1 | .9 |
| | | 30 | 9.8 | 3.8 | 2.1 | 1.3 | 1.0 |
| | | 90 | 36 | 13.5 | 7.1 | 3.9 | 2.7 |
| | | 183 | 120 | 74 | 58 | 48 | 44 |
| 1695 | Fish Creek near Arlington | 7 | .79 | .59 | .49 | .40 | .36 |
| | | 30 | .91 | .70 | .58 | .49 | .44 |
| | | 90 | 1.1 | .86 | .74 | .66 | .61 |
| | | 183 | 1.9 | 1.4 | 1.2 | 1.1 | 1.0 |

TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Skagit Basin | | | | | | |
| 1705 | Skagit River near Hope, B.C. | 7 | 200 | 163 | 152 | 145 | 140 |
| | | 30 | 230 | 190 | 175 | 165 | 160 |
| | | 90 | 320 | 240 | 218 | 200 | 190 |
| | | 183 | 490 | 350 | 290 | 250 | 230 |
| 1710 | Lightning Creek near Newhalem | 7 | 78 | 60 | 50 | 42 | 38 |
| | | 30 | 88 | 65 | 55 | 48 | 44 |
| | | 90 | 111 | 80 | 66 | 55 | 52 |
| | | 183 | 170 | 125 | 108 | 96 | 90 |
| 1720 | Big Beaver Creek near Newhalem | 7 | 90 | 70 | 61 | 55 | 52 |
| | | 30 | 116 | 85 | 72 | 63 | 58 |
| | | 90 | 175 | 128 | 108 | 91 | 84 |
| | | 183 | 265 | 205 | 176 | 152 | 140 |
| 1725 | Skagit River near Newhalem | 7 | 750 | 590 | 520 | 460 | 430 |
| | | 30 | 860 | 690 | 620 | 560 | 530 |
| | | 90 | 1,200 | 930 | 820 | 730 | 680 |
| | | 183 | 1,580 | 1,170 | 1,000 | 880 | 820 |
| 1735 | Ruby Creek below Panther Creek, near Newhalem | 7 | 94 | 72 | 64 | 59 | 57 |
| | | 30 | 116 | 87 | 78 | 72 | 68 |
| | | 90 | 195 | 138 | 110 | 89 | 80 |
| | | 183 | 315 | 220 | 180 | 150 | 132 |
| 1755 | Thunder Creek near Newhalem | 7 | 107 | 84 | 73 | 65 | 62 |
| | | 30 | 122 | 94 | 85 | 80 | 76 |
| | | 90 | 180 | 130 | 113 | 104 | 100 |
| | | 183 | 320 | 245 | 210 | 190 | 180 |
| 1775 | Stetattle Creek near Newhalem | 7 | 29 | 23 | 21 | 19 | 18 |
| | | 30 | 40 | 30 | 26 | 24 | 23 |
| | | 90 | 77 | 50 | 42 | 39 | 38 |
| | | 183 | 132 | 102 | 90 | 79 | 74 |
| 1780 | Skagit River at Newhalem | 7 | 1,950 | 1,400 | 1,200 | 1,100 | 1,020 |
| | | 30 | 2,800 | 2,000 | 1,600 | 1,300 | 1,130 |
| | | 90 | 3,500 | 2,550 | 2,100 | 1,750 | 1,600 |
| | | 183 | 4,100 | 3,200 | 2,700 | 2,300 | 2,100 |
| 1790 | Skagit River above Alma Creek, near Marblemount | 7 | 2,500 | 1,850 | 1,550 | 1,300 | 1,170 |
| | | 30 | 3,200 | 2,400 | 2,000 | 1,700 | 1,500 |
| | | 90 | 4,100 | 3,400 | 3,000 | 2,700 | 2,500 |
| | | 183 | 4,900 | 4,000 | 3,500 | 3,100 | 2,900 |
| 1800 | Bacon Creek near Marblemount | 7 | 97 | 76 | 67 | 61 | 58 |
| | | 30 | 122 | 91 | 80 | 74 | 72 |
| | | 90 | 240 | 152 | 130 | 116 | 110 |
| | | 183 | 390 | 290 | 255 | 235 | 225 |

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Skagit Basin--Con. | | | | | | |
| 1810 | Skagit River at Marblemount | 7 | 2,850 | 2,200 | 2,000 | 1,800 | 1,700 |
| | | 30 | 3,700 | 2,850 | 2,400 | 2,100 | 1,900 |
| | | 90 | 4,700 | 3,600 | 3,000 | 2,500 | 2,150 |
| | | 183 | 5,600 | 4,250 | 3,550 | 3,000 | 2,700 |
| 1825 | Cascade River at Marblemount | 7 | 280 | 200 | 165 | 137 | 122 |
| | | 30 | 350 | 240 | 190 | 155 | 138 |
| | | 90 | 520 | 370 | 300 | 240 | 215 |
| | | 183 | 780 | 620 | 530 | 460 | 420 |
| 1860 | Sauk River above Whitechuck River, near Darrington | 7 | 230 | 190 | 175 | 163 | 158 |
| | | 30 | 300 | 245 | 220 | 200 | 190 |
| | | 90 | 520 | 405 | 360 | 320 | 300 |
| | | 183 | 890 | 670 | 570 | 490 | 440 |
| 1890 | Suiattle River near Mansford | 7 | 620 | 510 | 450 | 390 | 360 |
| | | 30 | 750 | 600 | 510 | 440 | 400 |
| | | 90 | 990 | 820 | 730 | 670 | 630 |
| | | 183 | 1,400 | 1,120 | 1,000 | 900 | 850 |
| 1895 | Sauk River near Sauk | 7 | 1,300 | 1,010 | 860 | 730 | 660 |
| | | 30 | 1,600 | 1,220 | 1,050 | 900 | 820 |
| | | 90 | 2,450 | 1,960 | 1,700 | 1,500 | 1,400 |
| | | 183 | 3,550 | 2,700 | 2,370 | 1,940 | 1,800 |
| 1915 | Baker River below Anderson Creek, near Concrete | 7 | 580 | 440 | 390 | 350 | 330 |
| | | 30 | 690 | 500 | 440 | 390 | 360 |
| | | 90 | 1,100 | 780 | 670 | 600 | 580 |
| | | 183 | 1,700 | 1,300 | 1,100 | 990 | 920 |
| 1935 | Baker River at Concrete | 7 | 770 | 580 | 500 | 440 | 405 |
| | | 30 | 1,180 | 950 | 840 | 750 | 700 |
| | | 90 | 1,700 | 1,370 | 1,200 | 1,050 | 980 |
| | | 183 | 2,200 | 1,840 | 1,650 | 1,490 | 1,400 |
| 1940 | Skagit River near Concrete | 7 | 6,500 | 5,300 | 4,700 | 4,200 | 3,900 |
| | | 30 | 7,800 | 6,300 | 5,500 | 4,900 | 4,600 |
| | | 90 | 9,900 | 8,000 | 7,200 | 6,600 | 6,300 |
| | | 183 | 13,000 | 10,500 | 9,400 | 8,500 | 8,000 |
| 1945 | Finney Creek near Concrete | 7 | 24.5 | 17 | 13.5 | 11 | 10 |
| | | 30 | 33 | 21 | 16.2 | 13 | 11 |
| | | 90 | 65 | 37 | 26 | 18.5 | 15 |
| | | 183 | 165 | 115 | 96 | 81 | 75 |
| 1960 | Alder Creek near Hamilton | 7 | 9.0 | 7.0 | 6.1 | 5.4 | 5.0 |
| | | 30 | 9.7 | 7.6 | 6.6 | 5.8 | 5.4 |
| | | 90 | 11.4 | 9.0 | 7.7 | 6.7 | 6.2 |
| | | 183 | 17 | 12.8 | 10.7 | 9.0 | 8.2 |

TABLE 2.—Low-flow-frequency data for selected gaging stations in the Puget Sound region [Discharge adjusted to base flow April 1, 1946-March 31, 1964]—continued

| Station no.[1] | Station name and basin | Number of consecutive days | Streamflow (cfs) for indicated recurrence intervals (years) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2.0 | 5 | 10 | 20 | 30 |
| | Skagit Basin--Con. | | | | | | |
| 1965 | Day Creek near Lyman | 7 | 19.5 | 13 | 10.2 | 8.0 | 7.0 |
| | | 30 | 26 | 16 | 12 | 9.1 | 7.8 |
| | | 90 | 55 | 30 | 20.5 | 14 | 11.6 |
| | | 183 | 135 | 88 | 74 | 65 | 62 |
| 2000 | East Fork Nookachamps Creek near Clear Lake | 7 | 2.3 | 1.4 | 1.0 | .8 | .6 |
| | | 30 | 3.7 | 2.0 | 1.4 | 1.0 | .8 |
| | | 90 | 13 | 5.3 | 3.0 | 1.7 | 1.3 |
| | | 183 | 42 | 23.5 | 18.5 | 16 | 14.8 |
| 2005 | Skagit River near Mount Vernon | 7 | 7,200 | 5,800 | 5,100 | 4,600 | 4,300 |
| | | 30 | 8,300 | 6,700 | 5,800 | 5,200 | 4,900 |
| | | 90 | 10,500 | 8,500 | 7,700 | 7,000 | 6,600 |
| | | 183 | 14,200 | 11,600 | 10,100 | 9,000 | 8,300 |
| 2010 | Friday Creek near Burlington | 7 | 2.4 | 1.7 | 1.4 | 1.2 | 1.1 |
| | | 30 | 2.9 | 2.0 | 1.6 | 1.3 | 1.2 |
| | | 90 | 4.4 | 2.6 | 2.0 | 1.6 | 1.4 |
| | | 183 | 17 | 9.4 | 6.2 | 4.2 | 3.3 |
| 2015 | Samish River near Burlington | 7 | 26 | 21.5 | 19.5 | 17.8 | 16.8 |
| | | 30 | 29 | 24 | 21 | 19 | 18 |
| | | 90 | 37 | 27 | 23 | 20 | 19 |
| | | 183 | 83 | 57 | 46 | 37 | 33 |
| | Nooksack Basin | | | | | | |
| 2050 | Nooksack River below Cascade Creek, near Glacier | 7 | 200 | 148 | 130 | 118 | 110 |
| | | 30 | 235 | 173 | 150 | 130 | 120 |
| | | 90 | 370 | 270 | 238 | 210 | 200 |
| | | 183 | 570 | 450 | 390 | 350 | 330 |
| 2090 | South Fork Nooksack River near Wickersham | 7 | 119 | 91 | 79 | 71 | 66 |
| | | 30 | 152 | 110 | 92 | 80 | 74 |
| | | 90 | 275 | 170 | 138 | 120 | 112 |
| | | 183 | 540 | 380 | 310 | 250 | 225 |
| 2095 | Skookum Creek near Wickersham | 7 | 27.5 | 20 | 17 | 14.5 | 13.5 |
| | | 30 | 36 | 26 | 21.5 | 18.5 | 17 |
| | | 90 | 56 | 39 | 32 | 27 | 25 |
| | | 183 | 97 | 72 | 60 | 50 | 45 |
| 2105 | Nooksack River at Deming | 7 | 1,060 | 860 | 760 | 670 | 620 |
| | | 30 | 1,340 | 1,070 | 950 | 850 | 800 |
| | | 90 | 2,000 | 1,600 | 1,400 | 1,260 | 1,200 |
| | | 183 | 2,700 | 2,150 | 1,850 | 1,600 | 1,500 |
| 2115 | Nooksack River near Lynden | 7 | 1,160 | 900 | 760 | 660 | 610 |
| | | 30 | 1,400 | 1,110 | 1,000 | 880 | 830 |
| | | 90 | 2,100 | 1,600 | 1,400 | 1,200 | 1,100 |
| | | 183 | 2,900 | 2,250 | 1,900 | 1,700 | 1,600 |
| 2120 | Fishtrap Creek at Lynden | 7 | 5.0 | 3.7 | 3.1 | 2.6 | 2.4 |
| | | 30 | 5.7 | 4.1 | 3.4 | 2.9 | 2.6 |
| | | 90 | 6.9 | 5.0 | 4.0 | 3.3 | 2.9 |
| | | 183 | 12 | 8.4 | 6.7 | 5.4 | 4.8 |

[1] For convenience, prefix "12" is deleted from all station numbers.

ABLE 3.—Distribution of low-flow indexes in the Puget Sound region

| Index | Maximum value | Upper 25-percent value | Median value | Lower 25-percent value | Minimum value |
|---|---|---|---|---|---|
| Low-flow yield | 2.75 | 1.30 | 0.79 | 0.39 | 0.03 |
| Base flow | .48 | .26 | .16 | .11 | .01 |
| Slope | 8.33 | 1.82 | 1.60 | 1.45 | 1.16 |
| Spacing | 22.2 | 4.40 | 3.25 | 2.40 | 1.30 |

## TABLE 4.—Low-flow characteristics of streams in the Puget Sound region

| Station no.[1] | Station name and basin | Low-flow season | Low-flow characteristic: Yield index | Base-flow index | Slope index | Spacing index |
|---|---|---|---|---|---|---|
| | **Elwha-Dungeness Basins** | | | | | |
| 0455 | Elwha River at McDonald bridge, near Port Angeles | Regulated | 1.56 | 0.26 | 1.62 | 2.81 |
| 0475 | Siebert Creek near Port Angeles | Summer | .16 | .16 | 1.39 | 2.28 |
| 0480 | Dungeness River near Sequim | Mixed | .85 | .30 | 1.51 | 2.16 |
| | **West Sound Basins** | | | | | |
| 0505 | Snow Creek near Maynard | Summer | .17 | .12 | 1.58 | 3.47 |
| 0520 | Little Quilcene River near Quilcene | Summer | .46 | .21 | 1.67 | 2.27 |
| 0530 | Dosewallips River near Brinnon | Mixed | 1.41 | .26 | 1.32 | 2.65 |
| 0540 | Duckabush River near Brinnon | Summer | 1.17 | .18 | 1.47 | 3.85 |
| 0545 | Hamma Hamma River near Eldon | Summer | 1.13 | .16 | 1.47 | 2.73 |
| 0546 | Jefferson Creek near Eldon | Summer | .60 | .08 | 1.45 | 4.62 |
| 0565 | North Fork Skokomish River below Staircase Rapids, near Hoodsport | Summer | 1.31 | .14 | 1.39 | 4.46 |
| 0600 | South Fork Skokomish River near Potlatch | Summer | 1.40 | .14 | 1.35 | 3.15 |
| 0605 | South Fork Skokomish River near Union | Summer | 1.23 | .12 | 1.30 | 3.28 |
| 0615 | Skokomish River near Potlatch | Regulated | .78 | .14 | 1.24 | 2.69 |
| 0630 | Union River near Bremerton | Summer | .19 | .05 | 1.69 | 3.05 |
| 0635 | Union River near Belfair | Summer | .87 | .32 | 1.30 | 1.42 |
| 0650 | Mission Creek near Belfair | Summer | .05 | .02 | 2.56 | 4.26 |
| 0655 | Gold Creek near Bremerton | Summer | .34 | .09 | 1.59 | 2.56 |
| 0660 | Tahuya River near Bremerton | Summer | .06 | .02 | 3.71 | 8.18 |
| 0685 | Dewatto River near Dewatto | Summer | .65 | .18 | 1.21 | 1.84 |
| 0700 | Dogfish Creek near Poulsbo | Summer | .56 | .32 | 1.22 | 1.61 |
| 0730 | Burley Creek at Burley | Summer | 1.27 | .48 | 1.30 | 1.34 |
| 0735 | Huge Creek near Wauna | Summer | .66 | .37 | 1.19 | 1.30 |
| 0765 | Goldsborough Creek near Shelton | Summer | .57 | .17 | 1.32 | 2.00 |
| 0780 | Skookum Creek at Kamilche | Summer | .13 | .04 | 1.39 | 4.10 |
| 0784 | Kennedy Creek near Kamilche | Summer | .16 | .05 | 1.47 | 3.25 |
| | **Nisqually-Deschutes Basins** | | | | | |
| 0790 | Deschutes River near Rainier | Summer | .36 | .12 | 1.28 | 2.56 |
| 0800 | Deschutes River near Olympia | Summer | .60 | .24 | 1.28 | 1.67 |
| 0810 | Woodland Creek near Olympia | Summer | .51 | .44 | 1.56 | 1.36 |
| 0825 | Nisqually River near National | Mixed | 1.88 | .31 | 1.59 | 2.40 |
| 0830 | Mineral Creek near Mineral | Summer | .44 | .08 | 1.43 | 4.40 |
| 0840 | Nisqually River near Alder | Mixed | 1.41 | .28 | 1.45 | 2.34 |
| 0845 | Little Nisqually River near Alder | Summer | .36 | .07 | 1.72 | 4.40 |
| 0865 | Nisqually River at La Grande | Regulated | 1.78 | .33 | 1.33 | 2.00 |
| 0870 | Mashel River near La Grande | Summer | .18 | .06 | 1.92 | 6.40 |
| 0880 | Ohop Creek near Eatonville | Summer | .19 | .09 | 1.67 | 4.15 |
| 0885 | Nisqually River near McKenna | Regulated | 1.21 | .28 | 1.45 | 2.20 |
| 0890 | Tanwax Creek near McKenna | Summer | .04 | .03 | 1.75 | 5.72 |
| 0895 | Nisqually River at McKenna | Diversion | .32 | .11 | 6.67 | 4.49 |

| Station no.[1] | Station name and basin | Low-flow season | Low-flow characteristic | | | |
|---|---|---|---|---|---|---|
| | | | Yield index | Base-flow index | Slope index | Spacing index |
| | **Puyallup Basin** | | | | | |
| 0915 | Chambers Creek below Leach Creek, near Steilacoom | Summer | 0.39 | 0.34 | 1.32 | 1.52 |
| 0920 | Puyallup River near Electron | Winter | 2.10 | .35 | 1.47 | 2.56 |
| 0930 | Kapowsin Creek near Kapowsin | Summer | .15 | .07 | 2.94 | 4.47 |
| 0935 | Puyallup River near Orting | Mixed | 1.48 | .35 | 1.49 | 2.36 |
| 0940 | Carbon River near Fairfax | Mixed | 1.70 | .30 | 1.52 | 2.80 |
| 0950 | South Prairie Creek at South Prairie | Summer | .52 | .16 | 1.46 | 3.37 |
| 0965 | Puyallup River at Alderton | Mixed | 1.19 | .30 | 1.44 | 2.60 |
| 0970 | White River at Greenwater | Mixed | 1.53 | .36 | 1.37 | 2.06 |
| 0975 | Greenwater River at Greenwater | Summer | .56 | .18 | 1.35 | 2.92 |
| 0985 | White River near Buckley | Mixed | 1.19 | .31 | 1.61 | 2.38 |
| 1005 | White River near Sumner | Diversion | .12 | .09 | 1.57 | 4.83 |
| 1015 | Puyallup River at Puyallup | Regulated | 1.24 | .31 | 1.45 | 2.29 |
| | **Cedar-Green Basins** | | | | | |
| 1035 | Snow Creek near Lester | Summer | .54 | .09 | 1.72 | 5.65 |
| 1040 | Friday Creek near Lester | Summer | .62 | .10 | 2.13 | 5.18 |
| 1045 | Green River near Lester | Summer | .40 | .09 | 1.54 | 5.27 |
| 1047 | Green Canyon Creek near Lester | Summer | .62 | .15 | 1.61 | 3.20 |
| 1050 | Smay Creek near Lester | Summer | .96 | .16 | 1.64 | 3.72 |
| 1055 | Charley Creek near Eagle Gorge | Summer | 1.06 | .16 | 1.52 | 3.33 |
| 1060 | Bear Creek near Eagle Gorge | Summer | .43 | .07 | 1.79 | 6.23 |
| 1065 | Green River near Palmer | Summer | .65 | .13 | 1.49 | 3.87 |
| 1075 | Green River near Black Diamond | Diversion | .39 | .09 | 2.22 | 5.00 |
| 1085 | Newaukum Creek near Black Diamond | Summer | .59 | .25 | 1.61 | 1.82 |
| 1125 | Big Soos Creek near Auburn | Summer | .51 | .24 | 1.49 | 1.57 |
| 1130 | Green River near Auburn | Diversion | .44 | .12 | 1.96 | 3.81 |
| 1133.5 | Green River at Tukwila | Diversion | .50 | .14 | 1.82 | 3.50 |
| 1135 | North Fork Cedar River near Lester | Summer | 1.11 | .14 | 1.64 | 4.06 |
| 1140 | South Fork Cedar River near Lester | Summer | .68 | .10 | 1.96 | 6.50 |
| 1145 | Cedar River below Bear Creek, near Cedar Falls | Summer | .95 | .13 | 1.69 | 4.46 |
| 1150 | Cedar River near Cedar Falls | Summer | .88 | .13 | 1.64 | 4.67 |
| 1155 | Rex River near Cedar Falls | Summer | .69 | .09 | 1.75 | 6.73 |
| 1165 | Cedar River at Cedar Falls | Regulated | .52 | .12 | 3.78 | 4.09 |
| 1167 | Middle Fork Taylor Creek near Selleck | Summer | 1.41 | .20 | 1.82 | 2.81 |
| 1168 | North Fork Taylor Creek near Selleck | Summer | .56 | .10 | 3.70 | 6.19 |
| 1170 | Taylor Creek near Selleck | Summer | 1.37 | .22 | 1.47 | 2.81 |
| 1175 | Cedar River near Landsburg | Regulated | 2.22 | .35 | 1.52 | 1.81 |
| 1185 | Rock Creek near Maple Valley | Summer | .44 | .30 | 1.85 | 1.72 |
| 1190 | Cedar River at Renton | Diversion | .54 | .14 | 3.45 | 3.66 |
| 1195 | May Creek near Renton | Summer | .19 | .12 | 1.41 | 1.96 |
| 1200 | Mercer Creek near Bellevue | Summer | .32 | .19 | 1.35 | 2.11 |
| 1210 | Issaquah Creek near Issaquah | Summer | .56 | .22 | 1.35 | 1.93 |
| 1225 | Bear Creek near Redmond | Summer | .36 | .18 | 1.39 | 1.96 |
| 1230 | Cottage Lake Creek near Redmond | Summer | .45 | .35 | 1.22 | 1.50 |
| 1240 | Evans Creek above mouth, near Redmond | Summer | .51 | .30 | 1.22 | 1.52 |

TABLE 4.—Low-flow characteristics of streams in the Puget Sound region—continued

| Station no.[1/] | Station name and basin | Low-flow season | Low-flow characteristic | | | |
|---|---|---|---|---|---|---|
| | | | Yield index | Base-flow index | Slope index | Spacing index |
| | Cedar-Green Basins--Con. | | | | | |
| 1245 | Bear Creek at Redmond | Summer | 0.39 | 0.24 | 1.16 | 1.83 |
| 1250 | Sammamish River near Redmond | Summer | .47 | .23 | 1.52 | 1.79 |
| 1260 | North Creek near Bothell | Summer | .25 | .17 | 1.27 | 2.03 |
| 1265 | Sammamish River at Bothell | Summer | .45 | .25 | 1.45 | 1.69 |
| | Snohomish Basin | | | | | |
| 1305 | South Fork Skykomish River near Skykomish | Mixed | 1.63 | .24 | 1.47 | 2.86 |
| 1310 | Beckler River near Skykomish | Summer | .81 | .13 | 1.47 | 4.42 |
| 1330 | South Fork Skykomish River near Index | Mixed | 1.24 | .17 | 1.37 | 4.09 |
| 1340 | North Fork Skykomish River at Index | Summer | 1.30 | .14 | 1.59 | 4.90 |
| 1345 | Skykomish River near Gold Bar | Summer | 1.38 | .17 | 1.72 | 4.19 |
| 1350 | Wallace River at Gold Bar | Summer | .84 | .10 | 1.92 | 7.25 |
| 1355 | Olney Creek near Gold Bar | Summer | .84 | .09 | 2.00 | 7.71 |
| 1375 | Sultan River near Startup | Summer | 1.45 | .13 | 1.96 | 5.55 |
| 1385 | McCoy Creek near Sultan | Summer | .41 | .09 | 2.38 | 4.17 |
| 1410 | Woods Creek near Monroe | Summer | .32 | .12 | 1.56 | 2.78 |
| 1415 | Middle Fork Snoqualmie River near North Bend | Summer | 1.43 | .18 | 1.89 | 4.17 |
| 1420 | North Fork Snoqualmie River near Snoqualmie Falls | Summer | 1.00 | .12 | 2.44 | 5.78 |
| 1430 | North Fork Snoqualmie River near North Bend | Summer | 1.01 | .12 | 2.22 | 5.11 |
| 1440 | South Fork Snoqualmie River at North Bend | Summer | 1.46 | .20 | 1.56 | 3.36 |
| 1455 | Raging River near Fall City | Summer | .33 | .07 | 1.59 | 4.80 |
| 1460 | Patterson Creek near Fall City | Summer | .54 | .27 | 1.30 | 1.68 |
| 1470 | Griffin Creek near Carnation | Summer | .19 | .08 | 1.78 | 3.75 |
| 1475 | North Fork Tolt River near Carnation | Summer | 1.69 | .17 | 1.89 | 3.94 |
| 1480 | South Fork Tolt River near Carnation | Summer | 1.22 | .12 | 2.18 | 5.42 |
| 1485 | Tolt River near Carnation | Summer | 1.27 | .15 | 1.85 | 4.17 |
| 1487 | Stossel Creek near Carnation | Summer | .25 | .08 | 1.85 | 3.93 |
| 1490 | Snoqualmie River near Carnation | Regulated | 1.06 | .16 | 1.52 | 4.30 |
| 1525 | Pilchuck River near Granite Falls | Summer | .84 | .13 | 1.75 | 3.85 |
| 1530 | Little Pilchuck Creek near Lake Stevens | Summer | .08 | .05 | 2.86 | 4.50 |
| 1545 | Dubuque Creek near Lake Stevens | Summer | .03 | .01 | 8.33 | 14.5 |
| 1570 | Quilceda Creek near Marysville | Summer | .27 | .16 | 1.47 | 2.15 |
| | Stillaquamish Basin | | | | | |
| 1610 | South Fork Stillaguamish River near Granite Falls | Summer | 1.22 | .13 | 1.75 | 5.24 |
| 1625 | South Fork Stillaguamish River above Jim Creek, near Arlington | Summer | 1.08 | .12 | 1.89 | 5.30 |
| 1640 | Jim Creek near Arlington | Summer | .32 | .07 | 1.75 | 6.27 |
| 1650 | Squire Creek near Darrington | Summer | 1.30 | .14 | 2.38 | 5.49 |

| Station no.[1] | Station name and basin | Low-flow season | Low-flow characteristic | | | |
|---|---|---|---|---|---|---|
| | | | Yield index | Base-flow index | Slope index | Spacing index |
| | Stillaguamish Basin--Con. | | | | | |
| 1655 | North Fork Stillaguamish River near Darrington | Summer | 0.78 | 0.10 | 1.89 | 5.55 |
| 1670 | North Fork Stillaguamish River near Arlington | Summer | 1.11 | .14 | 1.61 | 4.38 |
| 1675 | Armstrong Creek near Arlington | Summer | .16 | .02 | 1.69 | 2.12 |
| 1685 | Pilchuck Creek near Bryant | Summer | .10 | .02 | 5.00 | 22.2 |
| 1695 | Fish Creek near Arlington | Summer | .11 | .01 | 1.96 | 2.41 |
| | Skagit Basin | | | | | |
| 1705 | Skagit River near Hope, B.C. | Mixed | .57 | .17 | 1.33 | 2.45 |
| 1710 | Lightning Creek near Newhalem | Mixed | .60 | .18 | 1.85 | 2.18 |
| 1720 | Big Beaver Creek near Newhalem | Mixed | 1.42 | .19 | 1.64 | 2.94 |
| 1725 | Skagit River near Newhalem | Mixed | .96 | .25 | 1.64 | 2.11 |
| 1735 | Ruby Creek below Panther Creek, near Newhalem | Mixed | .46 | .13 | 1.59 | 3.35 |
| 1755 | Thunder Creek near Newhalem | Winter | 1.02 | .17 | 1.64 | 2.99 |
| 1775 | Stetattle Creek near Newhalem | Winter | 1.32 | .15 | 1.54 | 4.56 |
| 1780 | Skagit River at Newhalem | Regulated | 1.66 | .40 | 1.77 | 2.10 |
| 1790 | Skagit River above Alma Creek, near Marblemount | Regulated | 1.96 | .43 | 1.92 | 1.96 |
| 1800 | Bacon Creek near Marblemount | Mixed | 1.90 | .20 | 1.59 | 4.02 |
| 1810 | Skagit River at Marblemount | Regulated | 2.06 | .43 | 1.58 | 1.97 |
| 1825 | Cascade River at Marblemount | Mixed | 1.67 | .25 | 2.04 | 2.78 |
| 1860 | Sauk River above Whitechuck River, near Darrington | Mixed | 1.52 | .19 | 1.41 | 3.87 |
| 1890 | Suiattle River near Mansford | Mixed | 1.85 | .29 | 1.59 | 2.26 |
| 1895 | Sauk River near Sauk | Mixed | 1.82 | .28 | 1.79 | 2.73 |
| 1915 | Baker River below Anderson Creek, near Concrete | Mixed | 2.75 | .29 | 1.67 | 2.93 |
| 1935 | Baker River at Concrete | Regulated | 2.59 | .28 | 1.75 | 2.86 |
| 1940 | Skagit River near Concrete | Regulated | 2.37 | .40 | 1.55 | 2.00 |
| 1945 | Finney Creek near Concrete | Summer | .47 | .08 | 2.22 | 6.73 |
| 1960 | Alder Creek near Hamilton | Summer | .84 | .25 | 1.67 | 1.89 |
| 1965 | Day Creek near Lyman | Summer | .57 | .07 | 2.44 | 6.92 |
| 2000 | East Fork Nookachamps Creek near Clear Lake | Summer | .11 | .03 | 2.86 | 13.5 |
| 2005 | Skagit River near Mount Vernon | Regulated | 2.33 | .41 | 1.56 | 1.97 |
| 2010 | Friday Creek near Burlington | Summer | .06 | .03 | 2.00 | 7.08 |
| 2015 | Samish River near Burlington | Summer | .30 | .10 | 1.47 | 3.19 |
| | Nooksack Basin | | | | | |
| 2050 | North Fork Nooksack River below Cascade Creek, near Glacier | Winter | 1.90 | .25 | 1.69 | 2.85 |
| 2090 | South Fork Nooksack River near Wickersham | Summer | 1.16 | .15 | 1.67 | 4.54 |
| 2095 | Skookum Creek near Wickersham | Summer | 1.19 | .20 | 1.89 | 3.53 |
| 2105 | Nooksack River at Deming | Mixed | 1.81 | .30 | 1.59 | 2.55 |
| 2115 | Nooksack River near Lynden | Mixed | 1.79 | .31 | 1.75 | 2.50 |
| 2120 | Fishtrap Creek at Lynden | Summer | .22 | .13 | 1.92 | 2.40 |

1/ For convenience, prefix "12" is deleted from all station numbers.

72-163

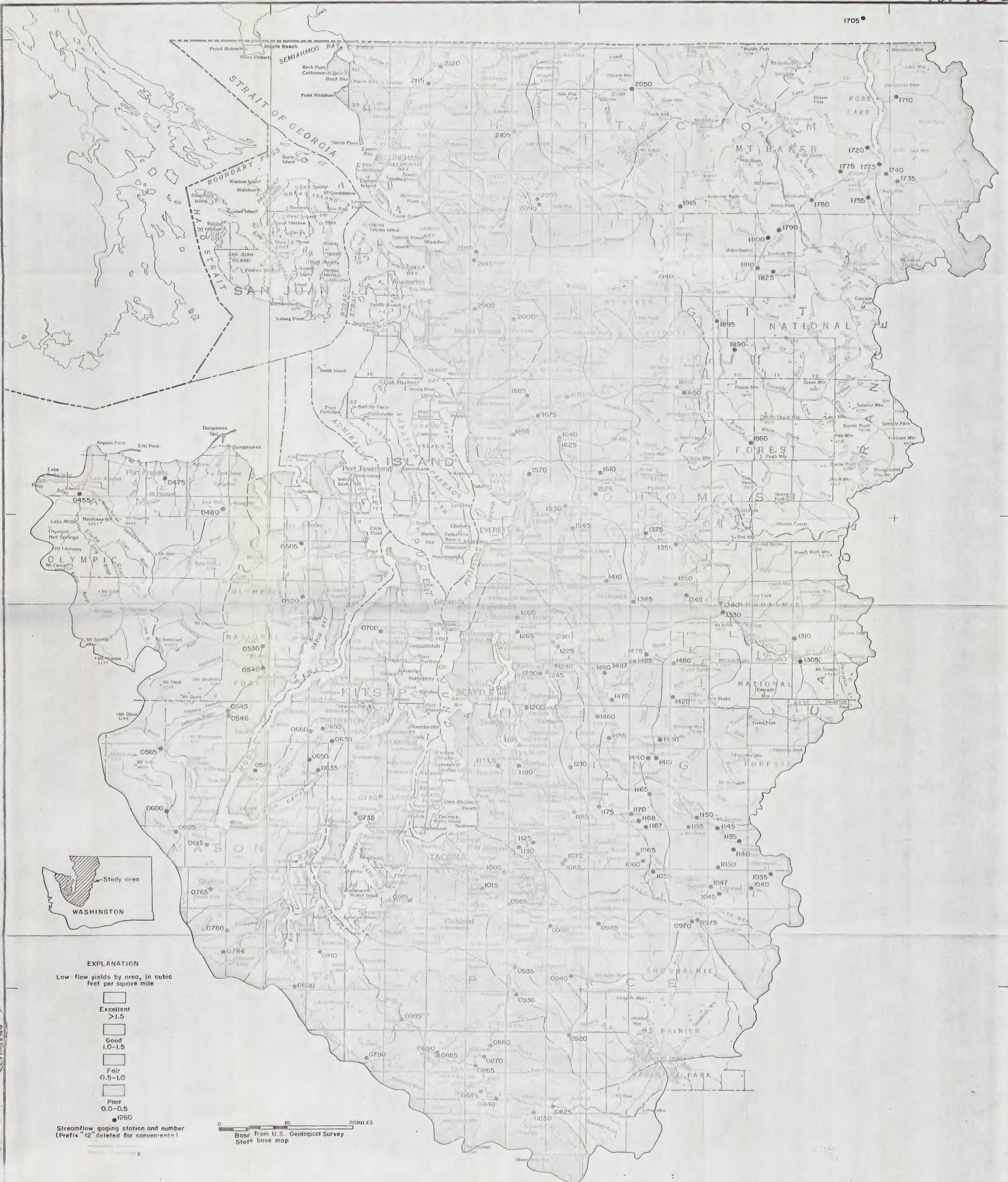


FIGURE 6.—LOCATIONS AND NUMBERS OF GAGING STATIONS AND GENERALIZED AREA VARIATIONS IN LOW-FLOW-YIELD INDEXES FOR STREAMS IN THE PUGET SOUND REGION.