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J. A. Krug, Secretary.

GEOLOGICAL SURVEY W. E. Wrather, Director.

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By

C. C. McDonald and H. C. Riggs

WASHINGTON, D. C.

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The design of hydraulic projects or the planning of a program of water resource development in a basin requires an adequate knowledge of the stream flow. Because of the wide variation in the amount of runoff from year to year in many basins, many years of stream-flow records are necessary to determine adequately the amount and distribution of the discharge and the probable dependable yield of the watershed.

Adequate data on stream flow are rarely available, and some method of estimation of the stream characteristics from the data must be used. If no actual record of discharge from an area is available, it is difficult if not impossible to determine the runoff with any degree of reliability from other data. Having a discharge record of short duration, however, it is often possible to arrive at reasonably reliable estimates of discharge for a longer period. Several methods are available, including rainfall-runoff studies and correlation with the flow of nearby streams. Studies of this kind should be made if it is necessary to utilize a record of very short duration for the design of a water project.

Estimates of annual mean discharge are often possible where the data do not permit reliable estimates of monthly means. Although the annual mean discharge does not provide information as to the seasonal distribution of runoff, it has considerable hydrologic significance. It reflects roughly the runoff characteristics during the year. An annual mean discharge below normal strongly indicates a probability that the flood activity was below normal, and also indicates that the discharge during the low-water period was probably below normal. An examination of precipitation records with relation to normal will assist in making reliable deductions.

This report presents a method of making graphical comparisons between the annual mean discharge of one or more years, and the average for the period 1928-45 in Columbia River Basin. The period 1928-45 has no particular hydrologic significance, but merely represents the period during which a sufficient number of gaging stations were operated to provide fairly satisfactory coverage of the basin. The 25-year period 1921-45 is used in the Water Re-

sources Review ¹/ as a base period, and the median or mid-value is used as a normal. Because of the general diminution of runoff during the past 50 years, the average runoff during the period 1928-45 is slightly less than the average for the period 1921-45. The differences are fairly consistent, and average about 3 percent greater for the period 1921-45. The 18-year averages used in this report are, therefore, not identical with the 25-year normals used in the Water Resources Review.

Although the magnitude of the annual runoff from various parts of the Columbia Basin varies greatly owing to the distribution of precipitation, deviations from the 18-year average are quite consistent. This consistency makes it possible to compare the discharge for corresponding years on different streams in terms of their respective normals. With sufficient coverage by gaging-station records for the entire 18-year period, it is possible to define with a fair degree of accuracy the relative variation with respect to normal throughout the basin.

A map of the Columbia River Basin was prepared for each year from 1928 to 1946 and isograms of percent of mean runoff were plotted. All available discharge records that were representative of natural or fairly consistent conditions were used to define the isograms. Such records are not ideally distributed and are inadequate to define the position of the isograms with great accuracy.

In order to assist in the definition, similar maps were prepared for precipitation, inasmuch as precipitation stations are more uniformly distributed and provide point definition as compared to the large areas represented by gaging stations on the larger streams. The isograms of percent of normal precipitation were particularly useful in ungaged areas. Although most of the precipitation stations were located at a comparatively low elevation, the

¹/Water Resources Review--United States and Canada; a monthly inventory of water supplies, distributed as a news release by the Geological Survey, Department of the Interior, Wash. 25, D. C. and the Dominion Water and Power Bureau, Department of Mines and Resources, Ottawa, Ont.

ratio of each year to the 18-year average is believed representative. There is no evidence that the ratio to the normal is affected by elevation.

Complete agreement between precipitation and runoff patterns would require a better correlation between rainfall and runoff than actually exists. One of the factors that affect the relation is the time distribution of precipitation during the year. In an arid basin a large number of light storms throughout the summer might increase the yearly precipitation to above normal, while producing little or no runoff. Conversely, a heavy winter precipitation or a rapid spring snow melt may produce a greater runoff than would normally be expected from the precipitation record. Ground-water storage in a basin may cause a lag between precipitation and the resultant runoff that makes a direct correlation impossible.

Runoff from small areas should correlate with precipitation better than that from large areas because the characteristics of a small basin are likely to be more uniform. Likewise, the precipitation recorded at one point in the basin will be more representative of that for a small surrounding area than for a large one. Correlation in areas of heavy precipitation will be better than that in arid ones, other things being equal, because of the greater areal uniformity. There appear to be no areas over which the precipitation or runoff pattern is similar from year to year.

Before using the runoff maps to determine the mean flow of a stream with a short-term record, the drainage basin in question should be compared with nearby basins for which records are available, as regards size, topography, vegetal cover, storm exposure, and capacity for ground-water storage. The relation between percent of mean runoff from two similar, proximate basins may be expected to vary according to the lines on the runoff maps.

The history of all basins used in the study should be reviewed to determine whether there have been any changes during the period 1928-45, such as diversions, removal of vegetal cover, irrigation of basin lands, or changes in natural or artificial storage. These changes should be given weight in computing the mean flow.

If there are several years of record on the stream in question, a determination of the mean flow should be made for each year of record and the results averaged to obtain the ratio between the period of record and the 18-year average. It is believed that estimates made by this method will compare favorably with those obtained by other means. By preparing these maps for the whole Columbia River Basin, the work necessary to make a reliable estimate of the average flow of a stream with one or more years of record is much simplified, and duplication of work is avoided.

Following the series of maps for each year is a map showing average annual runoff in inches for the basin, based on the 18-year period 1928-45. This map is intended to show in a general way the distribution of annual runoff from the Columbia River Basin. No attempt was made at precise definition of the lines of equal runoff to reflect the runoff from very small areas. Records of discharge from areas less than 100 square miles were collected at only a few places in the basin during the 18-year period, and even the smaller of the gaged areas usually include a considerable range in elevation. The precise definition of the average runoff for small areas would require a much greater density of gaging stations than exists today. Records used in the definition of the lines of equal runoff usually represent substantially natural conditions. In a few areas where irrigation is practiced, diversions were nearly constant and represent a fairly small percentage of the total annual discharge.







































