Article 164

RESERVOIR STORAGE ON STREAMS HAVING LOG-NORMAL DISTRIBUTIONS OF ANNUAL DISCHARGE

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Abstract.—The standard deviation of the logarithms of annual discharge is used as an index of the required amount and frequency of carryover storage computed by probability routing of annual discharge.

The amount of storage required to augment the yearly flow of streams during drought years depends on the variability of the annual discharge; for a given stream-gaging station this can be computed by probability routing as proposed by Langbein (1958, p. 1811–1817). For stations having the same type of distribution of annual discharge, the amount of required storage is related to the variability and thus can be estimated from standard curves for that distribution. Langbein (1961) used a three-step queuing model to compute curves of required storage for normal distributions of annual discharge and for a slightly skewed distribution. This article presents similar curves for log-normal distributions of annual discharge.

The results presented here are based on probability routing of annual discharge. The method proposed by Langbein (1958) was modified by using a constant rate of draft, by substituting simultaneous equations for the trial-and-error solution, and by using an electronic computer to solve the equations (Hardison and Furness, 1963). The cumulative frequency-distribution curve for each variability index was drawn to cross the 50-percent line at a discharge that would preserve the theoretical relation between the arithmetic and geometric means in a log-normal distribution. The results, which show the percentage chance of deficiency for selected storage capacities and selected draft rates, were used to define curves from which the curves for selected probabilities of deficiency shown in figure 164.1 were obtained.

The results computed by probability routing assume uniform and independent annual discharges. No allowance is made for the within-the-year storage that would be required at the beginning and end of the critical period of drought years or for the effect of serial correlation between years. As both the seasonal storage and serial-correlation effect cause the total storage requirement to be greater than that shown, the curves in figure 164.1 serve primarily as a guide to the minimum amount of storage required at high draft rates where seasonal storage becomes relatively minor.

The variability index used in figure 164.1 is the logarithmic standard deviation of the annual discharge similar to that proposed by Lane and Lei (1950) for daily discharge. For log-normal distributions it can be estimated graphically by plotting arrayed figures of annual discharge on logarithmic probability paper at duration probabilities, in percent, computed by the formula $100\ m\ /\ (n+1)$, in which m is the order number from highest to lowest and n is the number of items in the array. The variability index may then be obtained by drawing a straight line through the points and expressing the vertical component of the distance between the 50-percent duration point and the 84.13-percent duration point as the proportional part of a log cycle.

If the array of annual discharges on logarithmic probability paper tends not to lie on a straight line, the distribution should be replotted on arithmetic probability paper to see if the distribution is more nearly normal than log-normal. If the distribution is normal, the curves given by Langbein (1961) should be used instead of those in figure 164.1. If the distribution departs appreciably from both normal and log-normal,

ART. 164 *IN* U.S. GEOL. SURVEY PROF. PAPER 475–D, PAGES D192–D193. 1964.

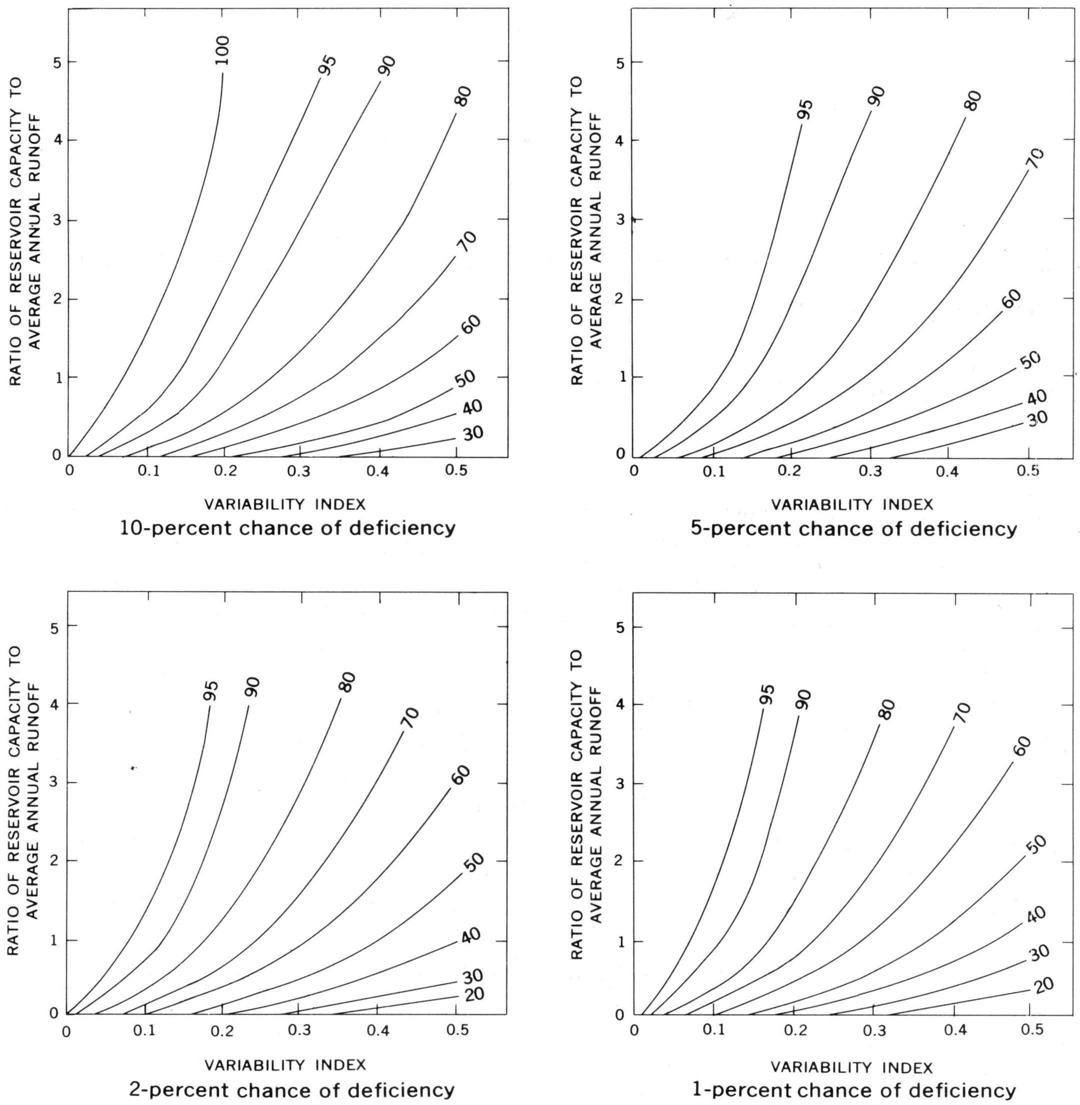

FIGURE 164.1.—Diagrams showing carryover storage requirements for log-normal distributions of annual discharge. Variability index is the logarithmic standard deviation of annual discharge. Parameter is constant-draft rate in percentage of mean flow. Percentage chance of deficiency is the percentage of years that the indicated reservoir capacity would be insufficient.

probability routing of the actual distribution would be required.

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