

water management and salinity control. Errors of prediction in the later stages of development are in the nature of things larger than those in the initial stages of development. A discussion of some of the uncertainties pertaining to estimates of available water as the ultimate level of development is approached is presented in a subsequent section, "Second Level of Development."

The calculations in the water budget are based on hydrological records of relatively short length (less than forty or fifty years) and therefore are subject to random sampling errors, as well as measurement errors. Runoff data for great rivers exhibit long-term trends and large fluctuations that reflect shifts in global meteorological patterns. The mean flow of the Indus River for the ten-year period starting in 1921 was 85 maf/yr, during the next decade it was 91 maf/yr, and in the following decade, 97 maf/yr. The flow for the entire period can be fitted by a regression line

$$Q = 82.3 + 0.6 t$$

where Q is the mean annual flow in the Indus at Kalabagh, and t is the number of years after 1921. While statistical analysis shows that the regression coefficient is significantly greater than zero, it would be unwise to assume that this upward trend will continue during the next decades. Hurst⁽⁶⁾ has investigated long records of hydro-meteorological events and has shown that large long-term fluctuations occur that do not accord with any simple theoretical probability model. Hurst's data for the Nile River are of interest in this connection. From 1871 to 1908 the mean annual flow at Aswan was 104 milliiards of cubic meters; and from 1909 to 1945, 82 milliiards of cubic meters. In the present state of the science of hydrology such fluctuations cannot reliably be predicted.

Estimates of the efficiency of storage provided by dams constructed in accordance with the "Indus Basin Development Fund Agreement" (or "Settlement Plan") and by other projects to provide additional regulation in the flow of the rivers have been based on the assumption that these would be operated with rule curves to utilize the storage capacity for irrigation. The reliability of our predictions of the effect of surface storage in increasing diversion at the canal heads is limited by the following factors: (1) As stated previously the annual flows in the Indus River exhibit an unusually high degree of serial correlation compared to flows in other great rivers; and this impairs the efficiency of the storage. However, the record of streamflows in the Indus Basin is not sufficiently long to provide a basis for accurate calculation of the serial

(6)Hurst, H. E., Methods of Long-Term Storage in Reservoirs, Institution of Civil Engrs., Part I, Vol. 5, 519-590, Sept. 1956.