Analysis Techniques: Flow Duration Analysis

What is it?

The flow duration curve is a plot that shows the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest. For example, it can be used to show the percentage of time river flow can be expected to exceed a design flow of some specified value (e.g., 20 cfs), or to show the discharge of the stream that occurs or is exceeded some percent of the time (e.g., 80% of the time).

How is it calculated?

The basic time unit used in preparing a flow-duration curve will greatly affect its appearance. For most studies, mean daily discharges are used. These will give a steep curve. When the mean flow over a long period is used (such as mean monthly flow), the resulting curve will be flatter due to averaging of short-term peaks with intervening smaller flows during a month. Extreme values are averaged out more and more, as the time period gets larger (e.g., for a flow duration curve based on annual flows at a long-record station).

Step 1: Sort (rank) average daily discharges for period of record from the largest value to the smallest value, involving a total of n values.

Step 2: Assign each discharge value a rank (M), starting with 1 for the largest daily discharge value.

Step 3: Calculate exceedence probability (P) as follows:

$$P = 100 * [M / (n + 1)]$$

P = the probability that a given flow will be equaled or exceeded (% of time)
M = the ranked position on the listing (dimensionless)
n = the number of events for period of record (dimensionless)

What kind of graphs and charts can be generated?

A flow duration curve is a plot of discharge vs. percent of time that a particular discharge was equaled or exceeded. The area under the flow duration curve (with arithmetic scales) gives the average daily flow, and the median daily flow is the 50% value. It is useful to graph the data on probability paper. Graphing software programs, such as Sigma Plot, have the capability to plot on a log vs. probability scale.

What does this particular information tell you about your stream?

A flow duration curve characterizes the ability of the basin to provide flows of various magnitudes. Information concerning the relative amount of time that flows past a site are likely to equal or exceed a specified value of interest is extremely useful for the design of structures on a stream. For example, a structure can be designed to perform well within some range of flows, such as flows that occur between 20 and 80% of the time (or some other selected interval).

The shape of a flow-duration curve in its upper and lower regions is particularly significant in evaluating the stream and basin characteristics. The shape of the curve in the high-flow region indicates the type of flood regime the basin is likely to have, whereas, the shape of the low-flow region characterizes the ability of the basin to sustain low flows during dry seasons. A very steep curve (high flows for short periods) would be expected for rain-caused floods on small watersheds. Snowmelt floods, which last for several days, or regulation of floods with reservoir storage, will generally result in a much flatter curve near the upper limit. In the low-flow region, an intermittent stream would exhibit periods of no flow, whereas, a very flat curve indicates that moderate flows are sustained throughout the year due to natural or artificial streamflow regulation, or due to a large groundwater capacity which sustains the base flow to the stream.

Tutorial | Example

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