Estimating Flow Duration at Regional Scales Using Empirical Models – A Concept

Western States Water Council
WOTUS Regional Technical Pre-Workshop 2

Wyoming Department of Environmental Quality

Flow Duration Curves (FDC)

Plot of discharge versus time to determine the percentage of time that flow is equaled or exceeded

Used to characterize the ability of a stream to provide flows of various magnitudes and duration

Can be derived using mean daily flow or annual flow

A FDC can define both duration of a given flow and the type of flow regime

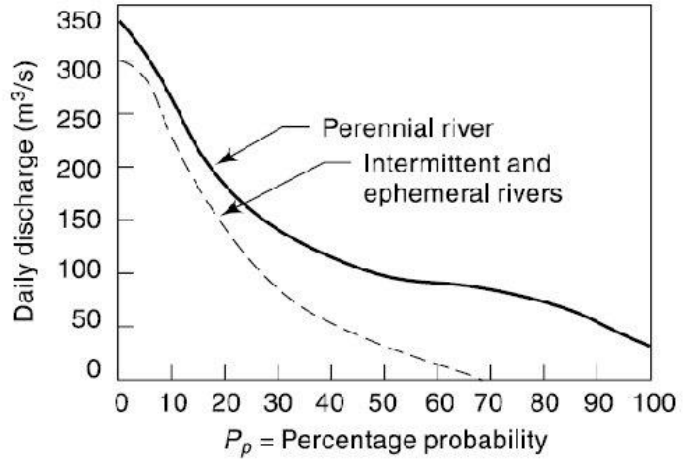

Fig. 5.8 Flow Duration Curve

Flow-Duration Curve for different river types

Conceptual Approach to Estimate Flow Duration at Regional Scales

1. *A priori* selection of homogenous hydrologic regions using other tools (e.g., combined HUC6 or HUC8 watersheds, level IV ecoregions, NHD+V2, etc.)
2. Develop FDCs (Annual FDCs preferred) for all gauged* sites within each hydrologic region
   a) Annual FDCs preferred and can be used to evaluate inter-annual variability and recurrence intervals can be developed. Abnormally wet or dry periods have less weight.
   b) Annual FDCs are representative of a median hypothetical year and not tied to a period of record
3. Use FDCs and other information to define hydrologic metrics for classification of the three flow regimes (ephemeral, intermittent, perennial) within each hydrologic region (e.g., % of year with flow)
   a) Example using % of year with flow: Ephemeral (<25), Intermittent (25-80), Perennial (>80)

*USGS gauges; state-operated gauges; state, federal, local and private stage recorders; university collected flow data; etc.

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4. Use physiographic and climatic variables* (e.g., drainage area, precipitation, evaporation, channel slope) to develop dimensionless empirical regression models that predict each of the three flow regimes within a hydrologic region.
   a) *Can use Bayesian classification methods (random forest, regression trees) to determine the most important variables in prediction of a flow regime class

5. Apply dimensionless models to ungaged sites (catchments) within the hydrologic region to determine flow regime.
   a) Example: **Intermittent (25-80 % of year with flow) = $0.000225A^{0.750}P^{0.838}$** where A (drainage area) and P (annual precipitation)

*Physiographic and climatic variables should be GIS based or readily available from public open-sources (e.g., EPA StreamCat, USGS StreamStats)

Conceptual Approach to Estimate Flow Duration at Regional Scales

6. Establishes regional *quantitative* definitions of “ephemeral”, “intermittent” and “perennial” with respect to WOTUS rule language
7. Uses only hydrologic-based variables (gauged sites, geomorphic, climate and physiographic)
8. Provides a prediction of each hydrologic class for a catchment with statistical significance and levels of confidence. Can develop numeric thresholds from which ground-truthing would be required.
9. Once developed, can be used as desktop application
10. Only applies to lotic systems – not for use with wetlands or lentic waters
11. Recommend application at regional scales smaller than used by SDAM to increase accuracy
12. Can be integrated as part of SDAM applications

Conceptual Approach to Estimate Flow Duration at Regional Scales

Relevant Examples:

Burgan and Aksoy. 2021. Daily flow duration curve model for ungaued subbasins of gauged rivers. Journal of Hydrology 604

Castellarin et al. 2004. Regional flow-duration curves: reliability for ungauged basins. Advances in Water Resources 27:953-965

Castellarin et al. 2007. Predicting annual and long-term flow duration curves in ungauged basins. Advances n Water Resources 30:937-953

Costa et al. 2014. Regional models of flow-duration curves of perennial and intermittent streams and their use for calibrating the parameters of a rainfall-runoff model. Hydrological Sciences Journal 59:262-277

Mohamoud. 2007. Prediction of daily flow duration curves and streamflow for ungauged catchments using regional flow duration curves. Hydrologic Sciences Journal 53:706-724

Sauqet et al. 2021. Predicting flow intermittence in France under climate change. Hydrological Sciences Journal 66:246-2059

Swain and Patra. 2017. Streamflow estimation in ungauged catchments using regional flow duration curve: comparative study. Journal of Hydrologic Enginnering 22

Thomas et al. 2014. Estimation of regional flow-duration curves for Indiana and Illinois. USGS. Scientific Investigation Report 2014-5177.