Status of At-Site Flood-Frequency Analysis Among Federal Agencies

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All federal agencies in the United States currently use Bulletin 17B, *Guidelines for Determining Flood Flow Frequency*, for flood-frequency analyses. The current guidelines, issued in 1982 by the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data, resulted from many years of coordination and discussions among several federal agencies. The evolution of the Bulletin 17B guidelines is briefly summarized, activities of an ongoing Bulletin 17B interagency work group are described, and future directions for flood-frequency analyses among federal agencies are suggested.

The use of Bulletin 17B guidelines is intended to provide a consistent and uniform technique for flood-frequency analyses among the federal agencies. Several engineering and economic reasons dictate the need for a uniform technique. Some of these reasons are as follows:

1. The computation of average annual flood losses for equitable evaluation of flood-control projects.
2. The definition of equitable flood-hazard zones as part of the National Flood Insurance Program.
3. The definition of flood risk required for the economic design of highway drainage structures.

In addition, several federal agencies make estimates of flood magnitude and frequency in fulfilling their agency's mission. A uniform technique facilitates coordination among agencies and permits a more cost-effective use of each agency's budget. Furthermore, a uniform technique minimizes public confusion and discourages litigation that might result from federal agencies' advocating or publishing different flood-frequency estimates for the same location.

Just as important as the engineering and economic motivation is the political motivation for a consistent and uniform technique. In August 1966, the 89th Congress passed House Document 465, entitled *A Unified National Program for Managing Flood Losses*. It recommended the establishment of a panel of the Water Resources Council (WRC) to "present a set of techniques for frequency analyses that are based on the best of known hydrological and statistical procedures." In response to the document, the executive director of WRC assigned the responsibility for developing this set of techniques to the WRC Hydrology Committee. Accordingly, the Hydrology Committee established the Work Group on Flow-Frequency Methods, which comprised members of various federal agencies. The accomplishments of this work group and subsequent work groups are described in the following sections.

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HISTORICAL DEVELOPMENT OF FLOOD-FREQUENCY GUIDELINES

In December 1967, the Work Group on Flow-Frequency Methods published Bulletin 15: *A Uniform Technique for Determining Flood Flow Frequencies* (*1*). Benson (*2*) provided additional details on the analysis and decisions that resulted in the publication of Bulletin 15. The recommendation in the bulletin was to fit the Pearson Type III frequency distribution to the logarithms of the annual peak flows using the sample moments (mean, standard deviation, and skew) to estimate the parameters of the distribution. Benson (*2*) and Thomas (*3*) have described the reasons and motivation for this decision.

The publication of Bulletin 15 was a significant event because for the first time a single method for flood-frequency analysis was recommended for use by all federal agencies. However, it soon became evident that the Bulletin 15 technique was not as consistent and was not being as uniformly applied as conceived because of the latitude for nonuniform treatment of outliers, computation of skewness, and treatment of historical information.

In January 1972, the Hydrology Committee of WRC initiated a review of Bulletin 15 and the need for more consistent and uniform guidelines. In March 1976, WRC published Bulletin 17: *Guidelines for Determining Flood Flow Frequency* (*4*). To correct problems noted with Bulletin 15 techniques, Bulletin 17 included the use of a low-outlier test, generalized (regionalized) skew, and a statistical procedure for incorporating historical information in the analysis. The Bulletin 17 techniques continued the practice of fitting the Pearson Type III distribution to the logarithms of annual peak flows by the method of moments.

Soon after Bulletin 17 was published, it was noted that there was a discrepancy about the order of the historical adjustment and the determination of weighted skew. In June 1977, Bulletin 17A was published, which clarified that the historical adjustment was to be applied before the weighting of station and generalized skew (*5*). This clarification is the only significant difference between Bulletins 17 and 17A. A few editorial corrections were also made.

With time, problems with the application of Bulletin 17A techniques began to surface. These problems can be briefly summarized as follows:

1. The low-outlier test did not adequately identify low outliers.
2. Some confusion existed over the estimation and use of generalized skew.

3. There were inconsistencies in the use of the conditional probability adjustment for low outliers.

In September 1981, Bulletin 17B was published (*6*). Several technical changes were made in Bulletin 17B to correct the problems in Bulletin 17A. The significant differences in the two bulletins are

1. Revised guidelines for estimating and using generalized skew;
2. A new procedure for weighting station and generalized skew;
3. A new test for detecting high outliers and a revised test for detecting low outliers; and
4. Revised guidelines for the application the conditional probability adjustment.

In March 1982, Bulletin 17B was reissued under the auspices of the Interagency Advisory Committee on Water Data (IACWD) (*7*). WRC was disbanded in September 1981, and the Hydrology Committee of WRC became the Hydrology Subcommittee of IACWD. Bulletin 17B was reissued because many typographical errors were discovered in the September 1981 version. There are no technical differences in the September 1981 and the March 1982 versions, and the latter version is still being used as the federal agency guidelines for flood-frequency analysis. Thomas provides a more detailed discussion of the evolution of the Bulletin 17B methodology (*3*).

ACTIVITIES OF CURRENT BULLETIN 17B WORK GROUP

In February 1985, the Hydrology Subcommittee of IACWD undertook a study to determine whether the Bulletin 17B guidelines were meeting the needs of the federal agencies and whether the guidelines should be revised or extended. An ad hoc work group was formed by the Hydrology Subcommittee, and a questionnaire was distributed to all federal agencies on IACWD to identify problems and solicit suggestions for improving the Bulletin 17B methodology.

In December 1987, the ad hoc work group submitted a summary report to the Hydrology Subcommittee describing the results of its study. The main conclusions were that the Bulletin 17B techniques are generally sound, that no substantial problems have been identified that cannot be resolved by means included in the guidelines, and that no clearly superior technical alternatives to the Bulletin 17B methodology have emerged. The study did find that problems are sometimes encountered in using Bulletin 17B and recommended that a new work group be formed to develop a series of pamphlets to supplement Bulletin 17B and to provide additional guidance in solving these problems.

The Hydrology Subcommittee study resulted in the following topics suggested for the pamphlet series:

- Generalized (regional) skew,
- Detection and treatment of outliers,
- Mixed population analysis,
- Multistation comparison,
- Watershed changes and time trends,
- Partial duration analysis, and
- Coincident frequency.

From the study, it was clear that users of Bulletin 17B also wanted more examples of applying the various techniques and more diagnostics and interpretation of the analysis results. Users were most concerned about the use of the Bulletin 17B skew map (i.e., definition of generalized skew). The detection and treatment of outliers was the second most important area of concern. The remaining topics were of about equal importance.

In July 1989, a new work group was formed to prepare supplemental guidance to Bulletin 17B in those areas identified by the Hydrology Subcommittee study. In this work group, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the National Weather Service, the Soil Conservation Service, the Federal Emergency Management Agency, and the U.S. Geological Survey are represented. A member of the Water Resources Branch, Environment Canada, is an observer and adviser to the work group.

On the basis of the topics suggested in the Hydrology Subcommittee study and the needs as perceived by the new work group, the topics identified as important ones to address initially were definition of generalized (regional) skew, detection and treatment of outliers, the effect of watershed changes and time trends, and frequency analysis for regulated watersheds. Progress by 1991 resulted in a draft copy of the report *Evaluating the Effects of Watershed Changes on the Flood-Frequency Curve*, expected to be ready for publication in summer 1992. The report will discuss statistical tests for identifying nonhomogeneity in the annual peak flows resulting from watershed changes and discuss new ways of performing flood-frequency analyses under conditions of watershed change such as urbanization.

It is anticipated that publications of the Bulletin 17B work group will be a combination of lengthy book-type reports and shorter pamphlets. The type of publication will be determined by the nature of the topic and the amount of detail required to discuss it. Current plans are that the work group will prepare supplemental guidance in the four areas noted.

Another related activity of the work group was the support and sponsorship of the development of a hypothesis test to determine if the logarithms or the untransformed values of annual peak flows fit a Pearson Type III distribution. A probability-plot correlation coefficient hypothesis test was developed for the three-parameter Pearson Type III distribution by Vogel and McMartin (*8*). This hypothesis test provides an objective method of evaluating whether the Pearson Type III distribution is an appropriate frequency distribution for flood-frequency analysis in a given region. The applicability of the Pearson Type III distribution should be judged by applying the hypothesis test to several data sets in a region rather than to a single data set.

DIRECTIONS FOR FLOOD-FREQUENCY FUTURE ANALYSIS

Considerable research has been completed in the area of flood-frequency analysis since the 1976 publication of Bulletin 17B. Any attempt to summarize the pertinent research would surely result in omitting some noteworthy contributions. However,

some thoughts and suggestions can be provided on the direction of flood-frequency analysis among federal agencies.

The present Bulletin 17B work group will produce reports and pamphlets in an attempt to enhance and supplement the existing guidelines. This work group does not plan to change or supersede any guidance in the existing guidelines. This means that the base method of flood-frequency analysis for federal agencies will continue to be to fit the Pearson Type III distribution to the logarithms of the annual flood peaks using the sample moments (mean, standard deviation, and skew) to estimate the parameters of the distribution. The supplemental publications will provide needed additional guidance on such topics as how to perform frequency analyses for watersheds undergoing change and for watersheds with major flood-control structures, and how to detect and treat outliers or estimate generalized skew as part of the frequency analysis. This additional guidance is needed, regardless of the base method of frequency analysis.

The study conducted by the Hydrology Subcommittee during 1985–1987 indicated that, for the most part, federal agencies believe that the Bulletin 17B guidelines meet their needs. This, of course, does not mean that Bulletin 17B techniques are superior to all others. The Bulletin 17B method was adopted and developed in the mid-1970s, when access to personal computers was not as prevalent as it is today. The techniques in Bulletin 17B are straightforward, and computations can be performed on a hand-held calculator. This was part of the motivation in adopting the recommended techniques. More complicated and computer-intensive techniques are available today. However, the fact that these techniques are more complicated does not necessarily mean they are superior to the Bulletin 17B methodology. Any study to determine this would take considerable resources that most federal agencies do not have or apparently are not willing to commit.

However, it is the opinion of the author that within the next few years the Bulletin 17B methodology should undergo a major evaluation. Topics to be investigated relate to the appropriate frequency distribution (*9–11*); the appropriate method of parameter estimation (*11–16*); the use of the logarithmic transformation (*17*); and the use and estimation of generalized skew (*18–21*). Recent papers on regional goodness-of-fit tests (*8,11,22–24*) may provide more objective ways of identifying the appropriate frequency distribution.

Appropriate federal agencies need to take an objective look at the considerable research in the last decade to determine whether Bulletin 17B should be revised or replaced. Given the huge expenditures in the construction of flood-control structures, highway drainage structures, and floodplain management, the investment in a comprehensive study of flood-frequency techniques that could take advantage of computational power of today's personal computers appears to be worthwhile.

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