Probabilistic Flood Hazard Assessment Workshop

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Overview and History of Flood Frequency in the United States

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Objective of Presentation

- Provide an overview and brief history of statistical flood frequency analysis in the US

- Describe the evolution of statistical procedures for analyzing gaged streams with observed flood data (at-site analysis)

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Beginnings of Flood Frequency in US

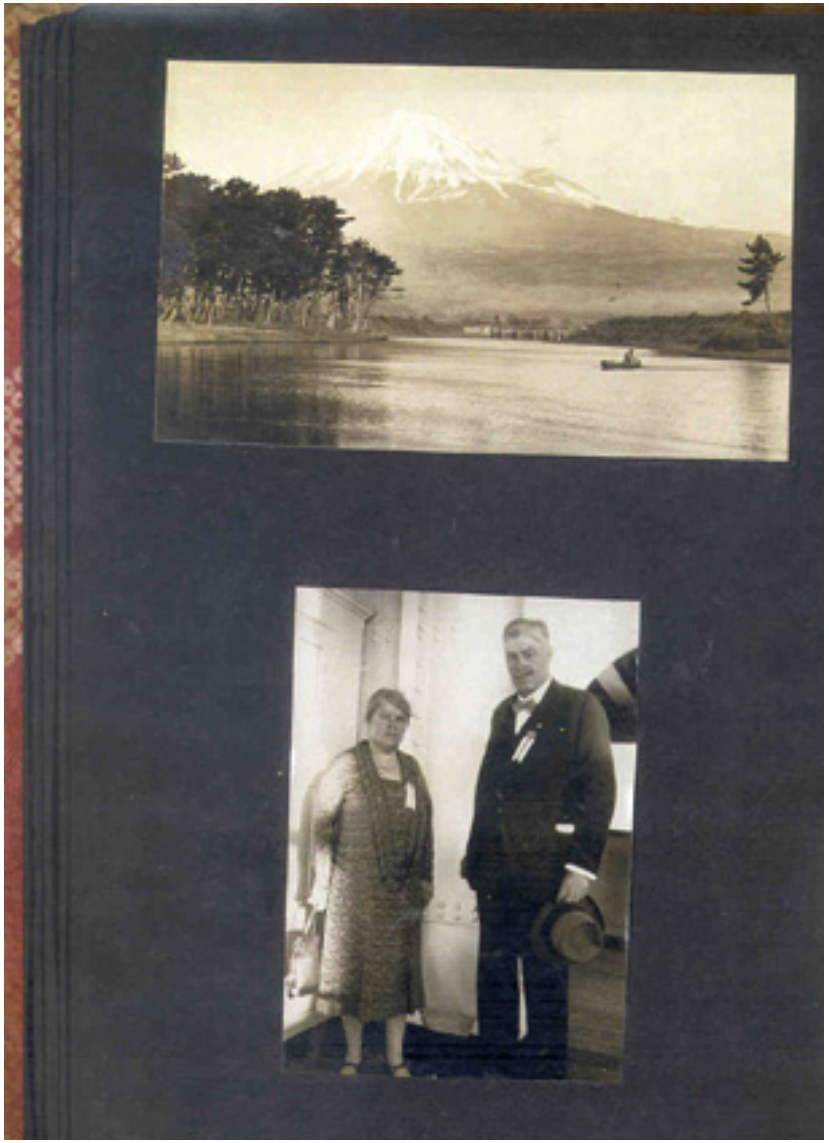
- **Statistical flood frequency analysis started in US with Fuller's (1914) paper on Flood Flows, ASCE Transactions Volume 77, Paper No. 1293:**
  - **used plotting positions to get at-site estimates**
  - **developed first equation relating discharge for a given return period to drainage area (regional analysis)**
  - **in discussion of Fuller's (1914) paper, Hazen presented for the first time the concept of probability paper and argued for the use of the lognormal distribution as a model for peak flows**

Flood Frequency - The Early Years

- In 1921, Hazen suggested the use of a three parameter distribution that included skew and developed an approach for adjusting the logarithms of peak flows for skew
- In 1924, Foster introduced the Pearson system of frequency distributions and recommended use of the Pearson Type III for flood flows
- In 1930, Hazen documented in Flood Flows
  - his plotting position (2m-1/2N) where m=1 for the largest event and N is the sample size and
  - his method for adjusting for skew

World Engineering Congress in Japan (1929)

- Allen Hazen attended the World Engineering Congress in Tokyo, Japan in the fall of 1929 as a representative of ASCE. See picture of Mr. and Mrs. Hazen on the steamer (Hazen's scrapbook of trip). He passed away in 1930.



Flood Frequency - The Early Years

- In 1943, Beard developed the median plotting position which is (m-0.30/N+0.4), where m=1 for the largest event and N is the sample size
- In the 1940s, the USGS adopted the Weibull plotting position (m/N+1) and plotted annual peak flows on Gumbel probability paper (Dalrymple, 1960; Benson, 1962)
- For the 1940s and 1950s, plotting positions were the prevalent approach for at-site frequency analysis

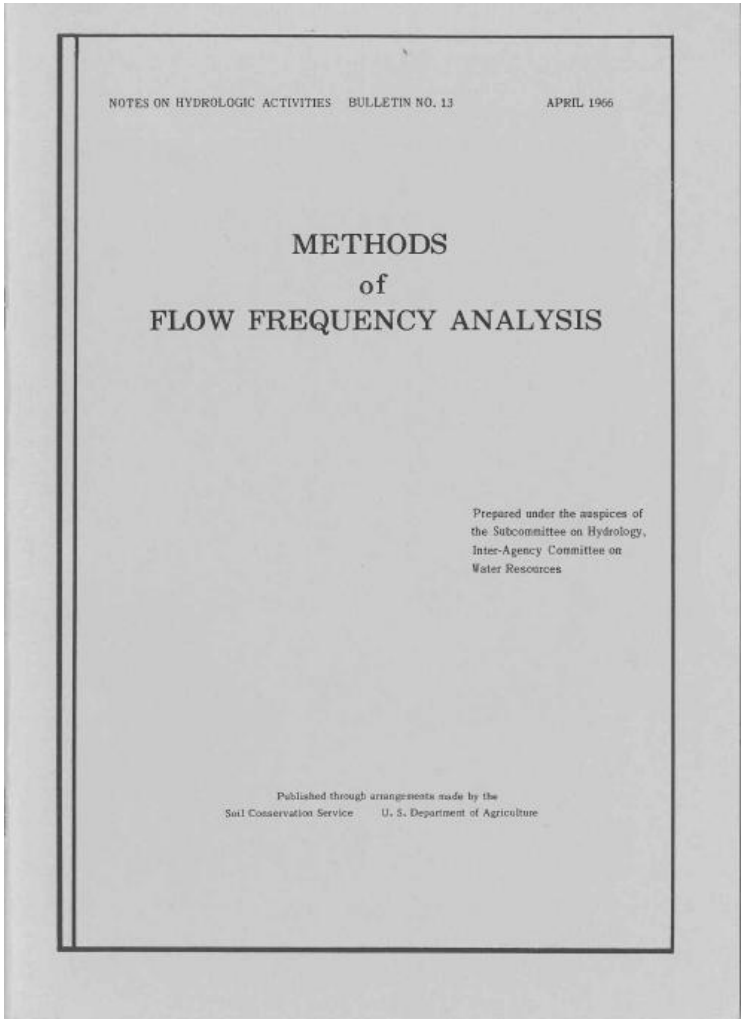
Flood Frequency - The Early Years

- Leo Beard contributed significantly to statistical hydrology in the early years and established procedures used by USACE as evidenced by:
  - Beard (1952) – Statistical Methods in Hydrology
  - Beard (1962 – Statistical Methods in Hydrology
- Beard (1962) described the application of the Pearson Type III distribution to the logarithms of annual peak flows, implying USACE was using the LPIII method by 1962

Bulletin 13

- **Bulletin 13:**

  April 1966 - First Federal interagency effort to describe procedures for flood frequency analysis by Subcommittee on Hydrology, Inter-Agency Committee on Water Resources – no testing or evaluation of procedures



NOTES ON HYDROLOGIC ACTIVITIES BULLETIN NO. 13 APRIL 1966

METHODS
of
FLOW FREQUENCY ANALYSIS

Prepared under the auspices of the Subcommittee on Hydrology, Inter-Agency Committee on Water Resources

Published through arrangements made by the Soil Conservation Service U. S. Department of Agriculture

House Document No. 465

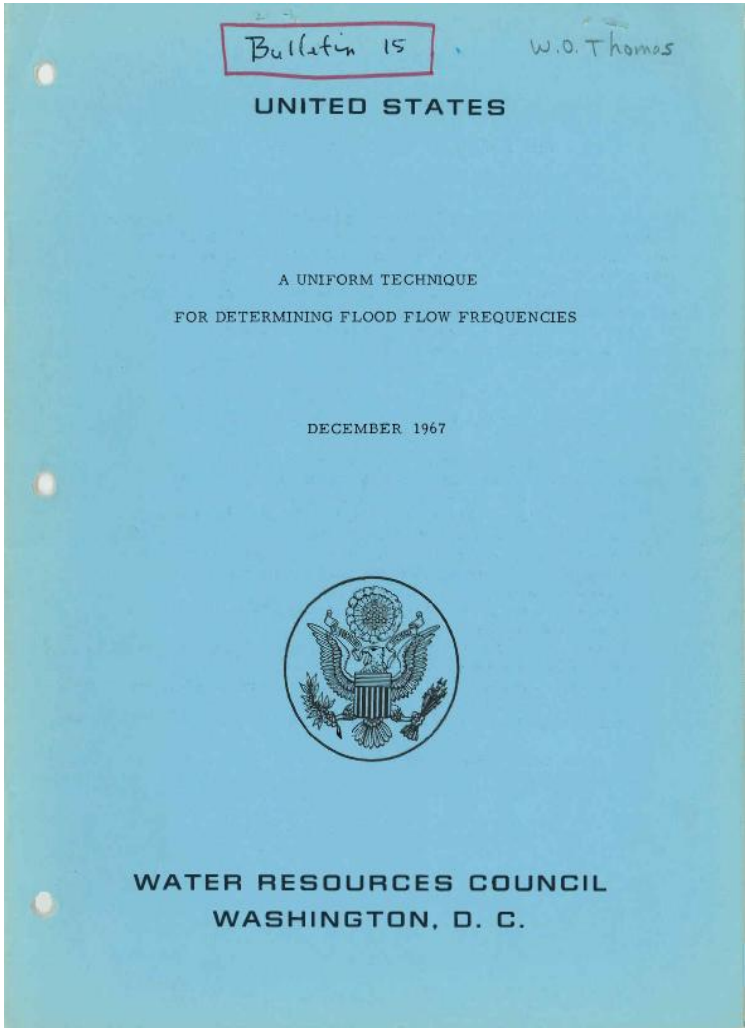
- House Document No. 465 (August 1966), passed by the 89th Congress, recommended the establishment of a panel of the Hydrology Committee of the U.S. Water Resources Council (WRC) to "present a set of techniques for frequency analysis that are based on the best of known hydrological and statistical procedures."

- House Document No. 465 "A Unified National Program for Managing Flood Losses" - motivation for uniform flood frequency procedures was to reduce flood losses (recommended national flood insurance program that was established in 1968).

Bulletin 15

- **Bulletin 15:**

  Published in December 1967 by the U.S. Water Resources Council (WRC), recommended fitting the Pearson Type III distribution to the logarithms of annual peak flows by the method of moments (LPIII). Testing of 6 different methods at 10 long-term gaging stations (details provided by Benson (1968)).

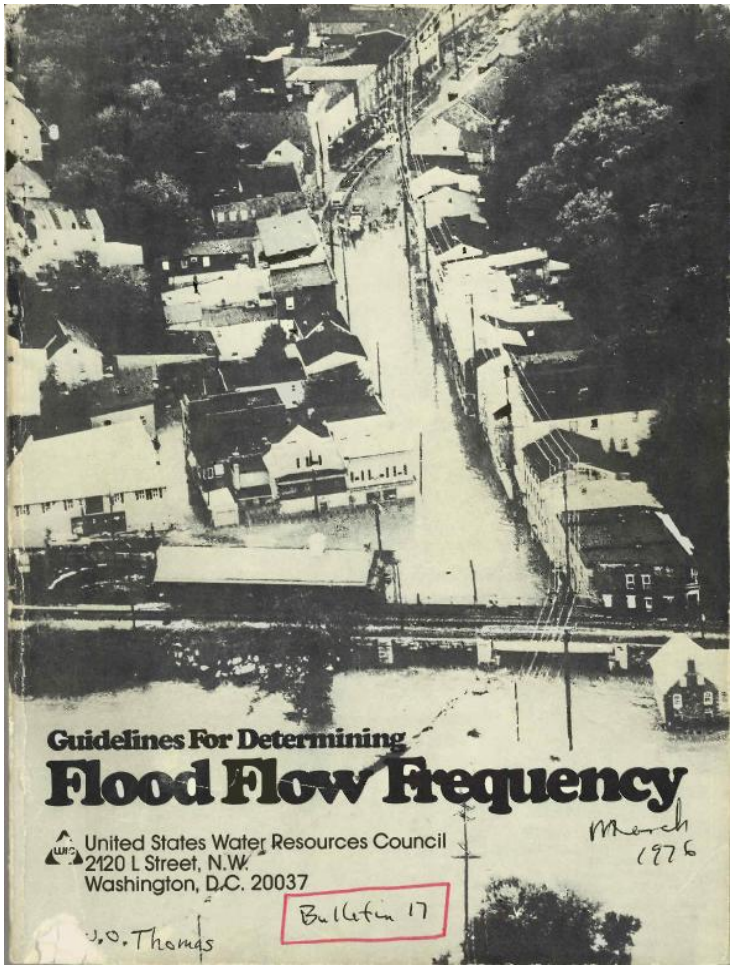


Bulletin 17

- **Bulletin 17:**

  Published in March 1976 by WRC, continued use of LPIII, included the use of low-outlier test, generalized skew, and adjustment for historic information.

  Testing by Beard (1974) of 8 different methods at 300 gaging stations indicated that LPIII with regional skew was best method.



Bulletin 17A

- **Bulletin 17A:**

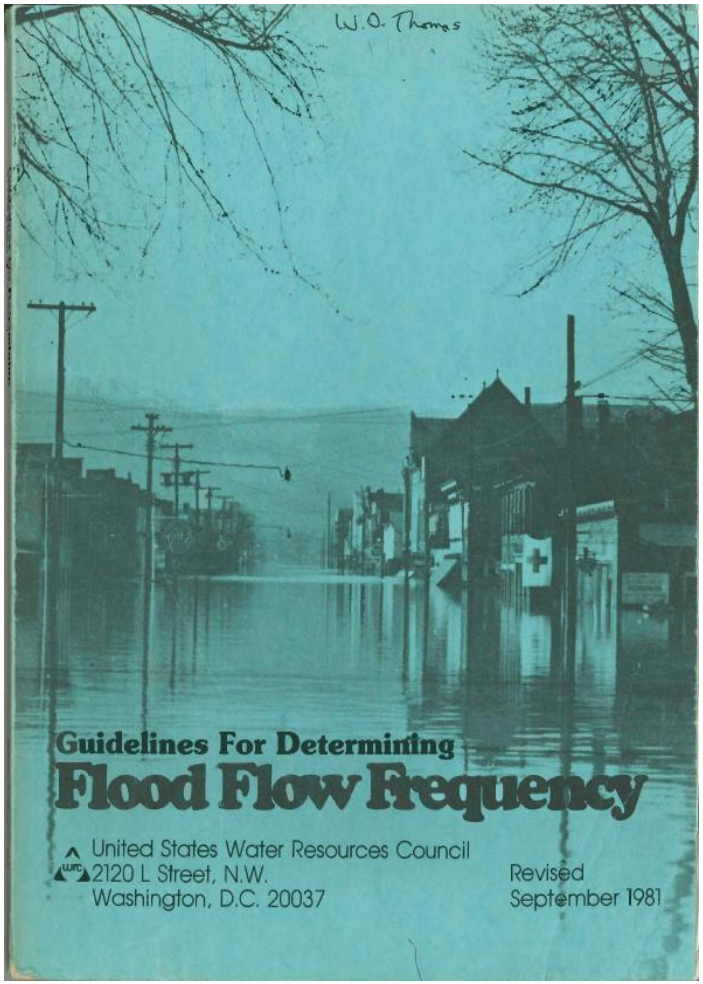
  Published in June 1977 by WRC, clarified that the adjustment for historic data was to occur before the weighting of station and generalized skew. A few editorial changes were also made.

Bulletin 17B

- **Bulletin 17B:**

  Published in September 1981 by WRC, included revised guidelines for (Thomas, 1985):

  - **Estimating generalized skew**
  - **Weighting of generalized and station skew**
  - **Detection of low- and high-outliers**
  - **Application of conditional probability adjustment**



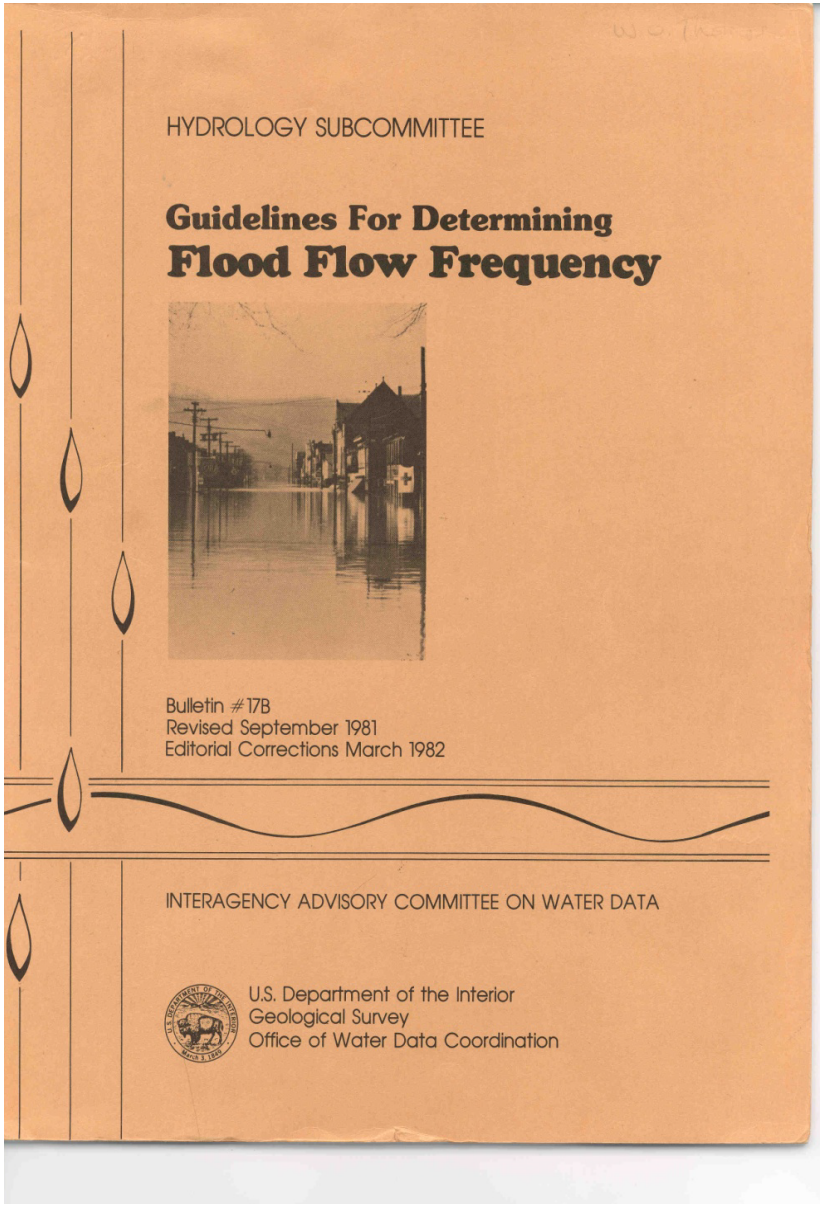
WRC Transition to IACWD

- In 1982 fiscal year - Hydrology Committee of WRC became Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (IACWD)
- IACWD was comprised of Federal agencies involved in water resources analyses
- WRC was terminated on October 31, 1982
- Bulletin 17B - Re-issued in March 1982 by IACWD, corrected typographical errors in 1981 version, no technical changes

Existing Guidelines - Bulletin 17B

Published in March 1982, includes guidelines for:

- Fitting the Pearson Type III distribution to logs of annual peak flows
- Estimating generalized skew
- Weighting generalized skew with station skew
- Low- and high-outlier detection tests
- Conditional probability adjustment for low outliers
- Adjustments for historical flood information



Transition of Procedures

- The early years of flood frequency analysis focused on plotting positions – Hazen, Median and Weibull
- The use of the Pearson Type III distribution and logarithms of annual peak flows was prevalent before Bulletin 15 in 1967
- The emphasis starting with Bulletin 15 was on a uniform and consistent approach for all Federal agencies to reduce flood losses
- The effort leading to the development of Bulletin 17B, existing guidelines, was by Federal agencies

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Hydrologic Frequency Analysis WG

- Established December 1999 under the Subcommittee on Hydrology of the Advisory Committee on Water Information
- Representatives from Federal agencies, private consultants, academia, water management agencies
- Minutes of meetings from January 2000 to September 2012 are on the following web site:
- http://acwi.gov/hydrology/Frequency/
- Bulletin 17B is located at:
- http://water.usgs.gov/osw/bulletin17b/bulletin_17B.html

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HFAWG Scope

- The overall goal of the HFAWG is to recommend procedures to increase the usefulness of the current guidelines (Bulletin 17B)
- HFAWG plans are confined to research that can be accomplished with limited resources
- Maintain the “spirit” of Bulletin 17B through fitting the Pearson Type III distribution to the logs of annual peak flows with the method of moments

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HFAWG Current Activities

- Evaluate the Expected Moments Algorithm (EMA) for analyzing data sets with historical information
- Evaluate EMA for analyzing data sets with low outliers and zero flows
- Describe improved procedures for estimating generalized skew
- Develop improved procedures for defining confidence limits

HFAWG Current Activities

- Considerable progress has been achieved in 2012 with testing EMA versus current Bulletin 17B procedures
- A March 2012 report on the HFAWG web site (http://acwi.gov/hydrology/Frequency) describes this testing process
- It is anticipated that a revised draft of Bulletin 17B will be developed in 2013

Papers on Evolution of Flood Frequency

- Thomas, W.O., Jr., 1985, *A Uniform Technique For Flood Frequency Analysis*: ASCE Journal of Water Resources Planning and Management, Vol. 111. No. 3, 321-337.

- Griffis, V.W., and Stedinger, J.R., 2007, *Evolution of Flood Frequency Analysis with Bulletin 17B*: ASCE Journal of Hydrologic Engineering, Vol. 12, No. 3, 283-297.

- Dawdy, D.R., Griffis, V.W., and Gupta, V.K., 2012, *Regional Flood-Frequency Analysis: How We Got Here and Where We Are Going*: ASCE Journal of Hydrologic Engineering, Vol. 17, 953-959.