



**Status of the Hydrologic Frequency Analysis Work Group
(HFAWG)
April 19, 2012**

Report to the Subcommittee on Hydrology

Will Thomas

Chair of the HFAWG

Baker

Hydrologic Frequency Analysis WG

- Established December 1999 under the Subcommittee on Hydrology of the Advisory Committee on Water Information
- First meeting in January 2000
- Representatives from Federal agencies, private consultants, academia, water management agencies
- <http://acwi.gov/hydrology/Frequency/>
- http://water.usgs.gov/osw/bulletin17b/bulletin_17B.html

Hydrologic Frequency Analysis WG

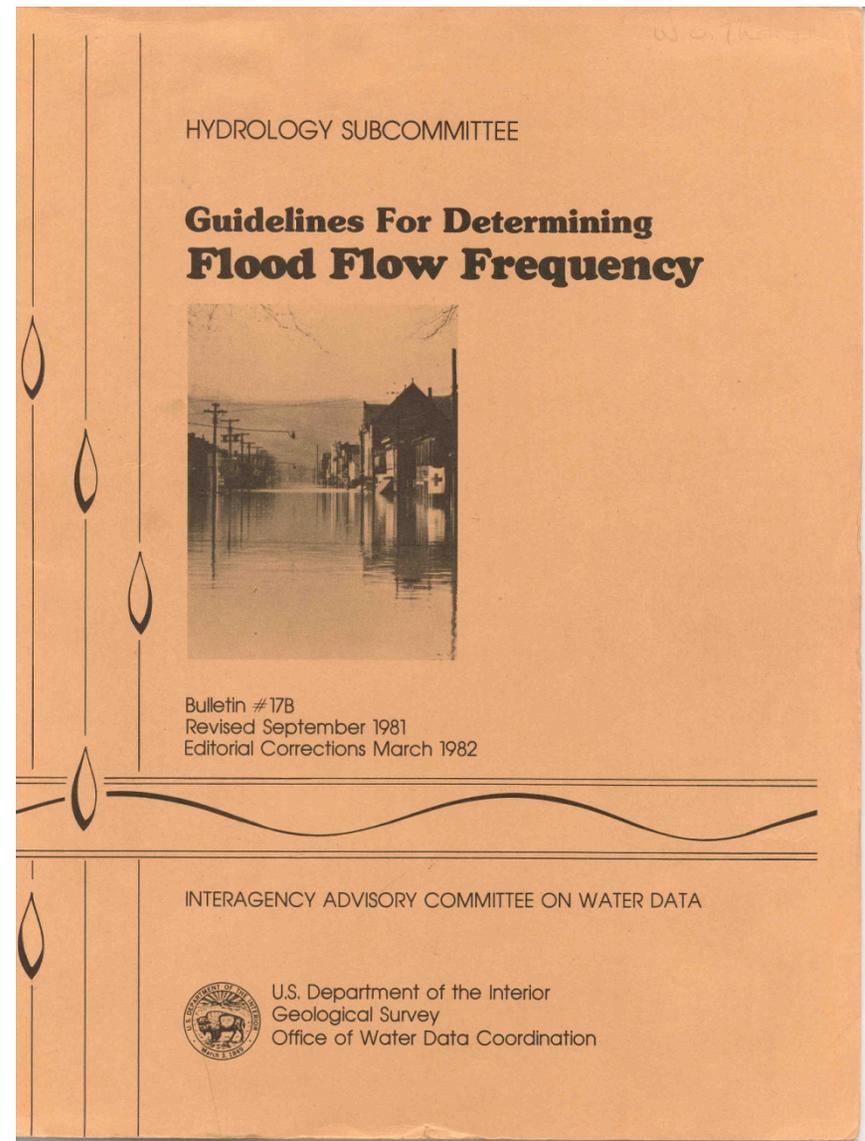
Purpose: “The overall goal of the Hydrologic Frequency Analysis Work Group is to recommend procedures to increase the usefulness of the current guidelines for Hydrologic Frequency Analysis computations (e.g. Bulletin 17B) and to evaluate other procedures for frequency analysis of hydrologic phenomena.”

http://acwi.gov/hydrology/FA_terms.html

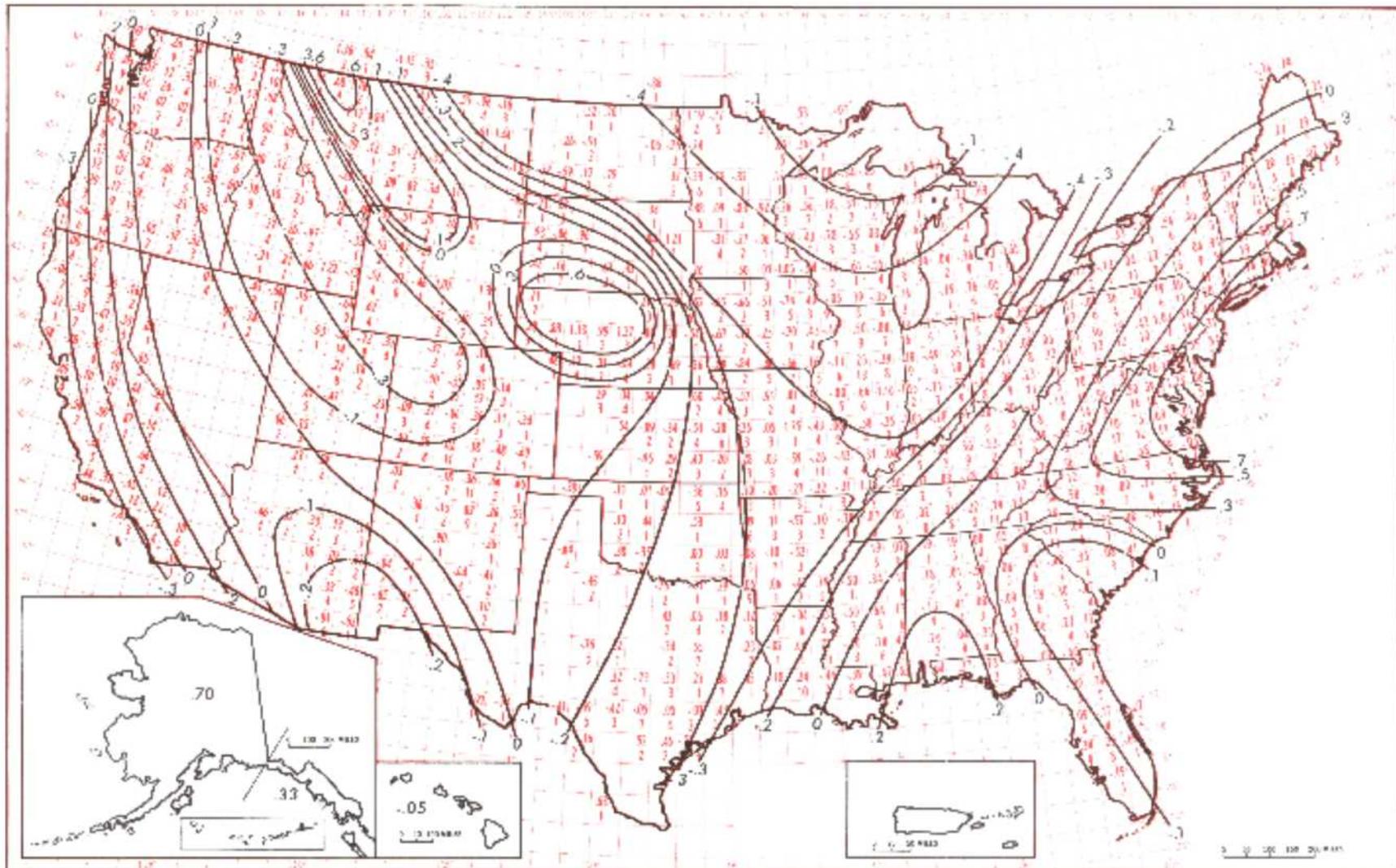
Existing Guidelines - Bulletin 17B

Published in **March 1982**,
includes guidelines for:

- Fitting 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



Regional Skew - B17B Skew Map

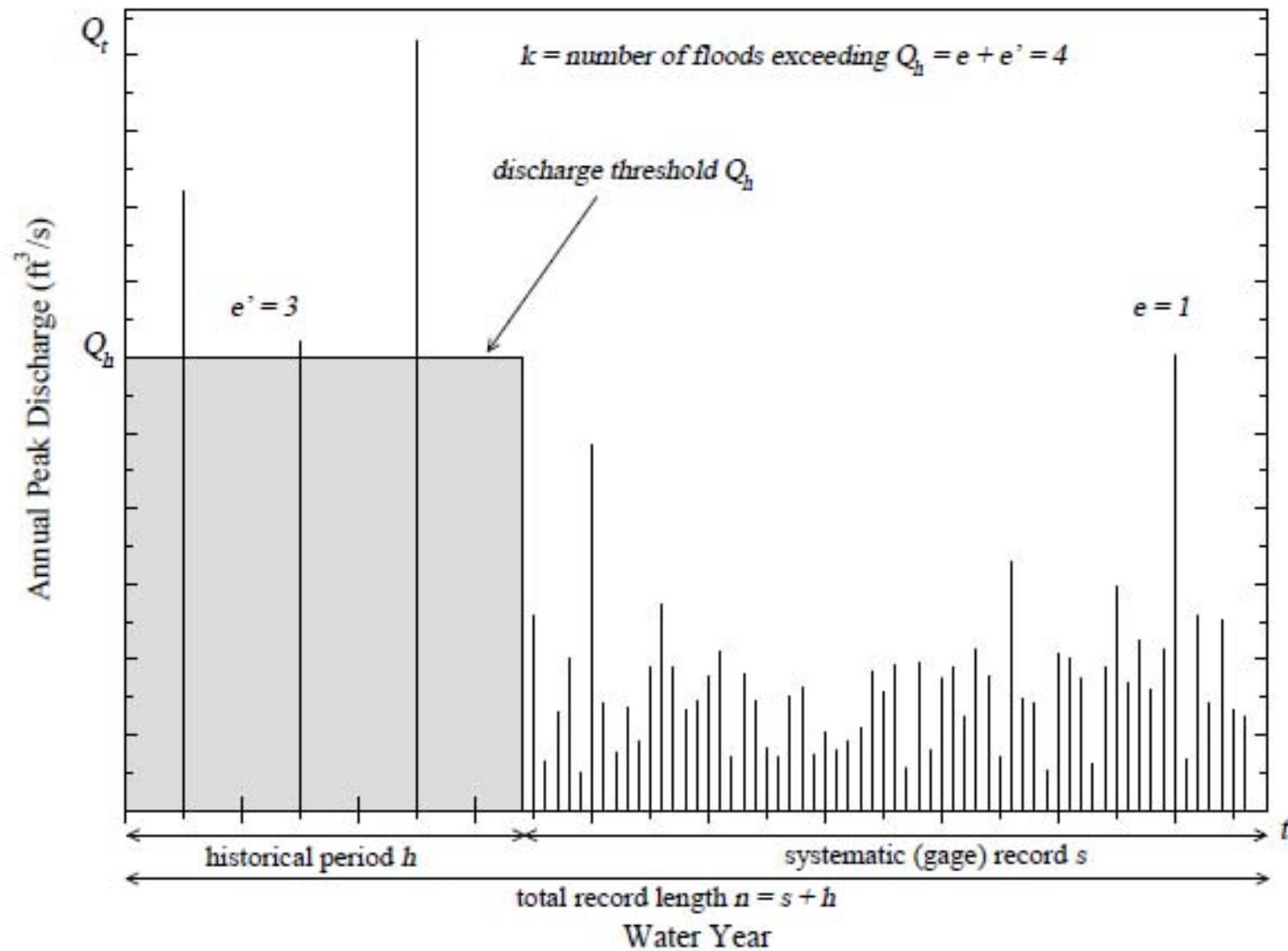


GENERALIZED SKEW COEFFICIENTS OF LOGARITHMS OF ANNUAL MAXIMUM STREAMFLOW

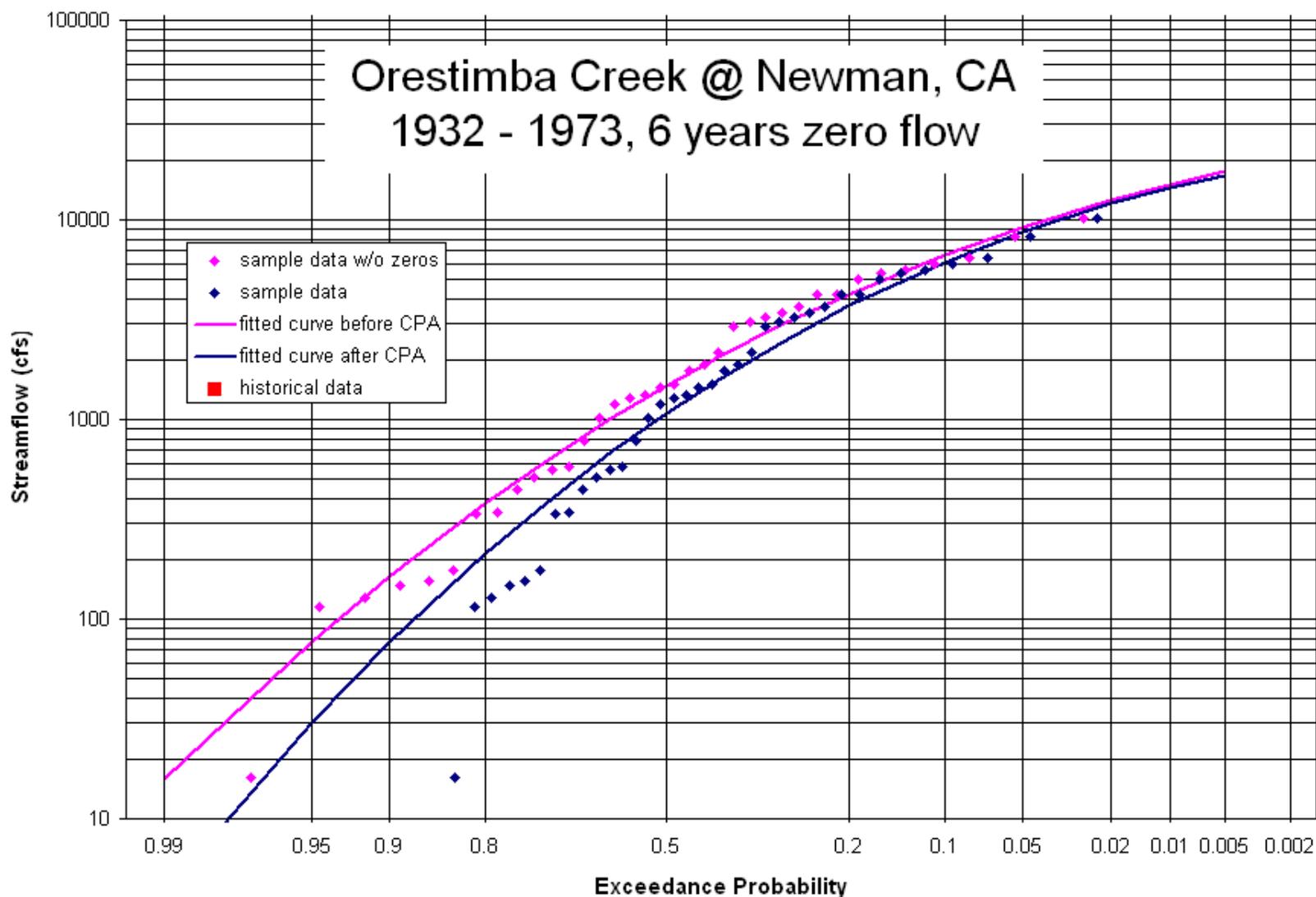
AVERAGE SKEW COEFFICIENT BY ONE DEGREE QUADRANGLES

Lower number in each quadrangle is number of stream gaging stations for which the average shown above it was computed

Historic Threshold Concept



Conditional Probability Adjustment



Original Tasks of HFAWG

- **Developed a paper on evaluating flood discharges for ungaged watersheds (October, 2001)**
- **Drafted a paper describing flood frequency procedures for regulated watersheds (latest draft dated October, 2002)**
- **Developed a list of Frequently Asked Questions (FAQs) for Bulletin 17B (September, 2005)**

HFAWG Meetings

- **HFAWG met on November 14-15, 2005 and developed a list of possible improvements to Bulletin 17B:**
 - **Compare Expected Moments Algorithm (EMA) to the weighted-moments approach for data sets with historic data**
 - **Compare EMA to the Conditional Probability Adjustment for data sets with low outliers and zero flows**
 - **Describe improved procedures for estimating generalized skew**
 - **Describe improved procedures for defining confidence limits**
- **Testing to be done with gaging station data**

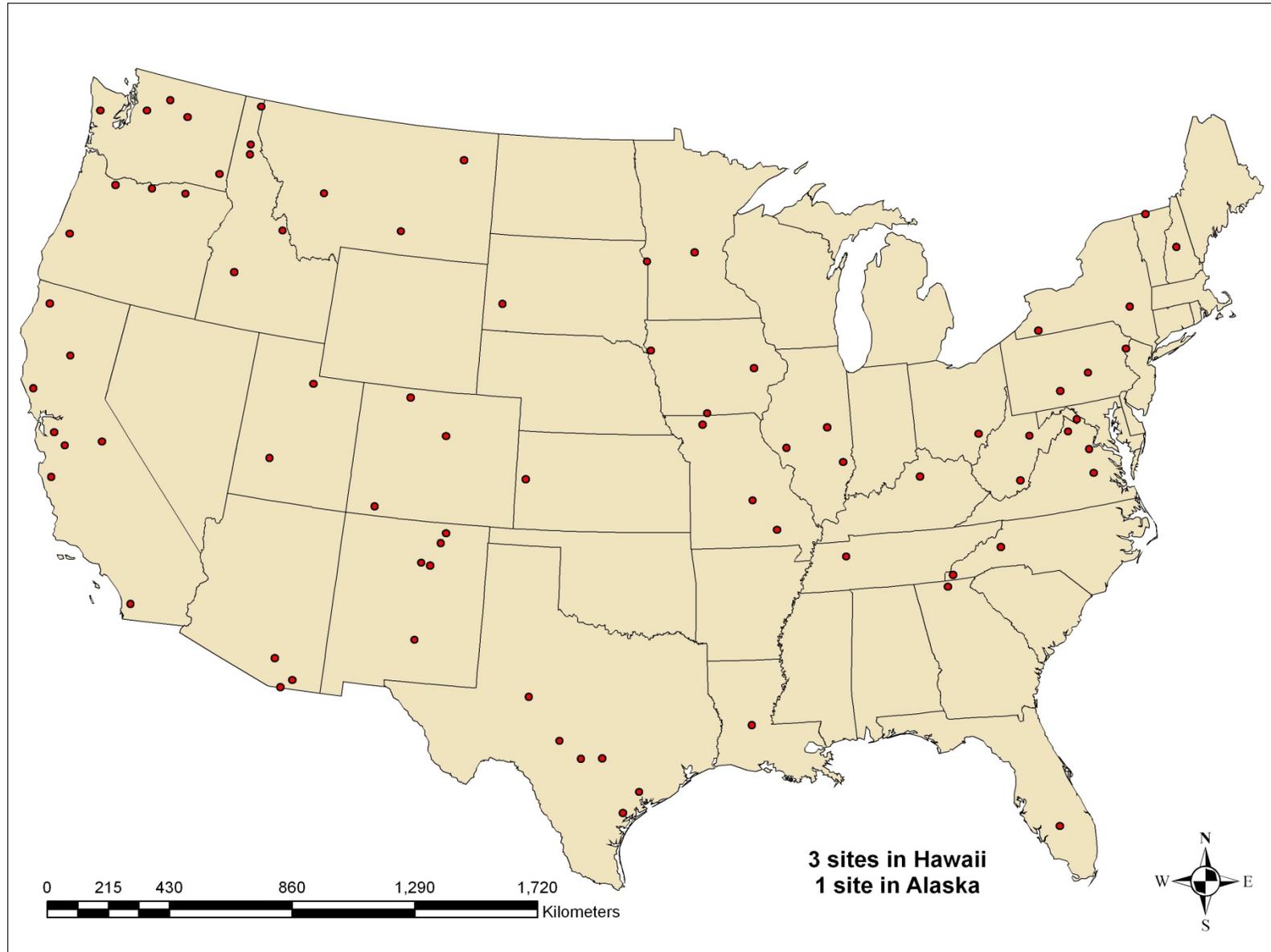
HFAWG Testing Approach

- **A Data Subgroup was formed in October 2006 to draft the testing procedures for comparing EMA to Bulletin 17B procedures**
- **The following persons formed the Data Subgroup:**
 - **Martin Becker**
 - **Don Woodward**
 - **Ken Bullard (now retired)**
 - **Jerry Coffey**
 - **Will Thomas**
 - **Beth Faber**
 - **Nancy Steinberger**

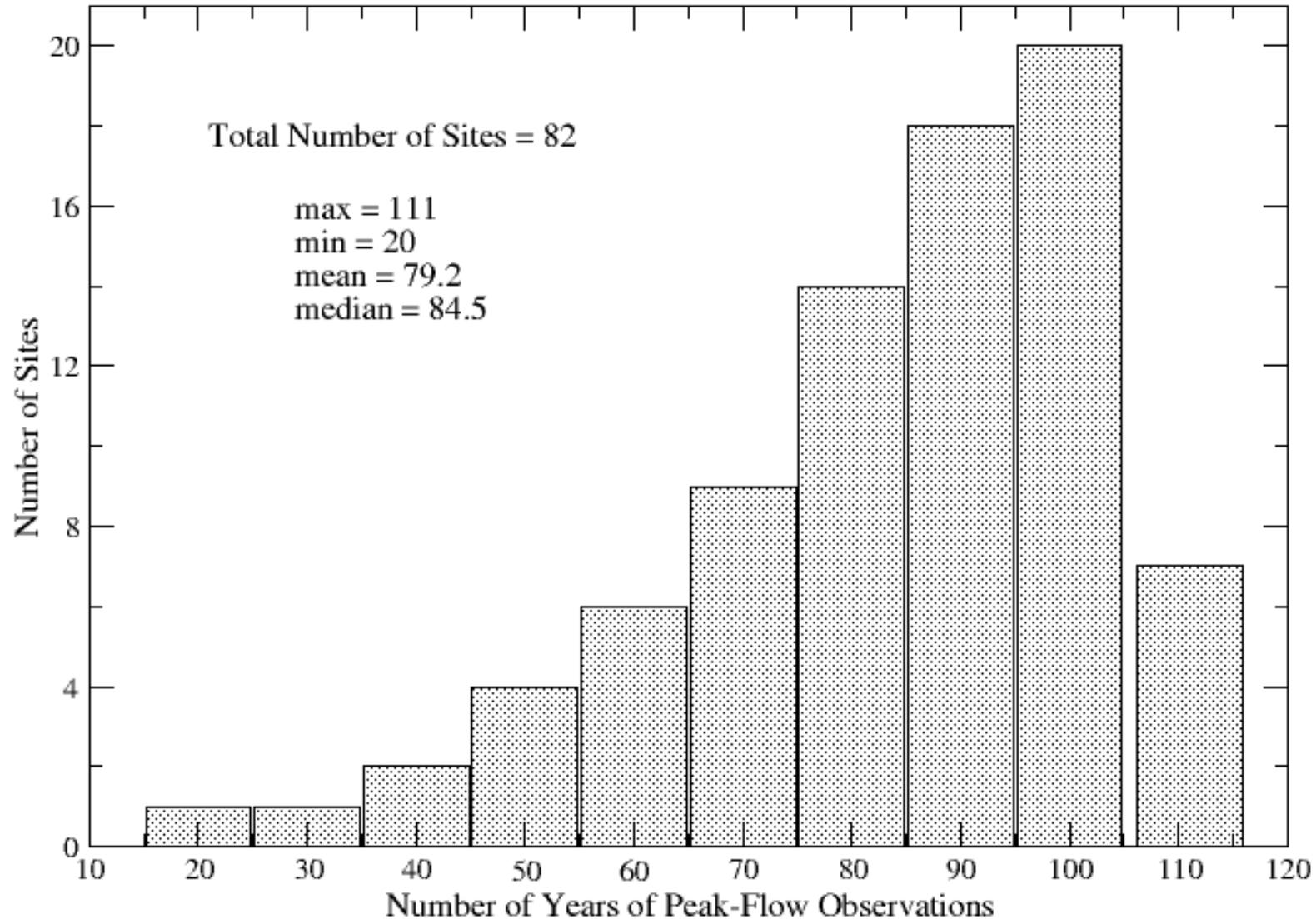
HFAWG Testing Approach

- **Testing of EMA for two approaches**
 - **Observed data – 82 gaging stations with historic peaks, high and low outliers**
 - **Monte Carlo simulation – simulate data from **six** assumed frequency distributions (LP III with negative and positive skews, mixed distributions, etc.)**
- **August 2007, testing plan and annual peak flows provided to John England (USBR), Tim Cohn (USGS)**

Location of Gaging Stations



Distribution of Record Lengths



HFAWG Meetings

- **HFAWG met November 19, 2009 to discuss test results for the 82 stations**
- **Test results completed by John England, Tim Cohn and Nancy Steinberger (FEMA)**
- **Action items from November 2009 meeting**
 - **Perform split-sampling analyses on observed data**
 - **Perform Monte Carlo simulations on two sets of mixed distributions**
 - **Summarize Monte Carlo simulations from published papers**
 - **Summarize frequency results for data sets with multiple thresholds, interval data, etc.**

HFAWG Progress

- **Discussions at the November 2009 meeting indicated that more research was needed on low outlier detection particularly with EMA**
- **Tim Cohn developed a Multiple Grubbs-Beck test for detecting low peaks (draft paper, Cohn et al., 2011)**
- **In the Fall of 2011, Testing Group (USGS, USBR, USACE) completed testing on simulated and observed data**

HFAWG Progress

- **The testing on observed data (for 82 stations) and simulated data was completed for three different estimators:**
 - **Bulletin 17B with Grubbs-Beck (GB) test**
 - **Bulletin 17B with Multiple Grubbs-Beck (MGB) test**
 - **EMA with Multiple Grubbs-Beck (MGB) test**
- **The test results were summarized in a report “Updating Bulletin 17B for the 21st Century”, Cohn et al., 2012**

Testing Software

- **USGS PeakFQ Version 5.2 was used for Bulletin 17B** (<http://water.usgs.gov/software/PeakFQ/>)

- **PeakqSA v 0.95 was used for EMA** (http://www.timcohn.com/TAC_Software/PeakfqSA/faq.html)

HFAWG Progress

- **March 4 – agenda and recommended changes in Bulletin 17B sent out for March 19, 2012 meeting**
- **March 5 – testing report (Cohn et al., 2012) posted on a ftp site for HFAWG review**
- **March 19 – HFAWG met to discuss:**
 - **Test results for 82 long-term stations**
 - **Monte Carlo simulations**
 - **Application of EMA with non-standard data**
 - **New approach for estimating confidence intervals**
 - **New approach for estimating generalized skew**
 - **Recommended revisions to Bulletin 17B**

Recommended Changes in Bulletin 17B

- **Replace Historical Weighted Moments and Conditional Probability Adjustment (CPA) with EMA**
- **Generalize the Grubbs-Beck (GB) test with the new Multiple Grubbs-Beck (MGB) test**
- **Replace confidence interval formulas with computations based on EMA**
- **Revise procedures for estimation of generalized (regional) skew**

Recommended Changes in Bulletin 17B

- **Replace the single threshold plotting position with multiple-threshold plotting position (Hirsch and Stedinger, 1987)**
- **Replace outdated statements on “Climate Trends” with a revised statement reflecting the current understanding of climate change**
- **Remove the discussion of “Expected Probability” since it is no longer used**

HFAWG Progress

- **Members of HFAWG are posted on web site (<http://acwi.gov/hydrology/Frequency/>)**
- **14 members attended March 19 either in person or by conference call/live meeting**
- **A poll of members was taken near the end of the March 19 meeting as to their opinion on adopting the recommendations**
- **More clarification was needed on comments on the testing report plus some people left the meeting early**

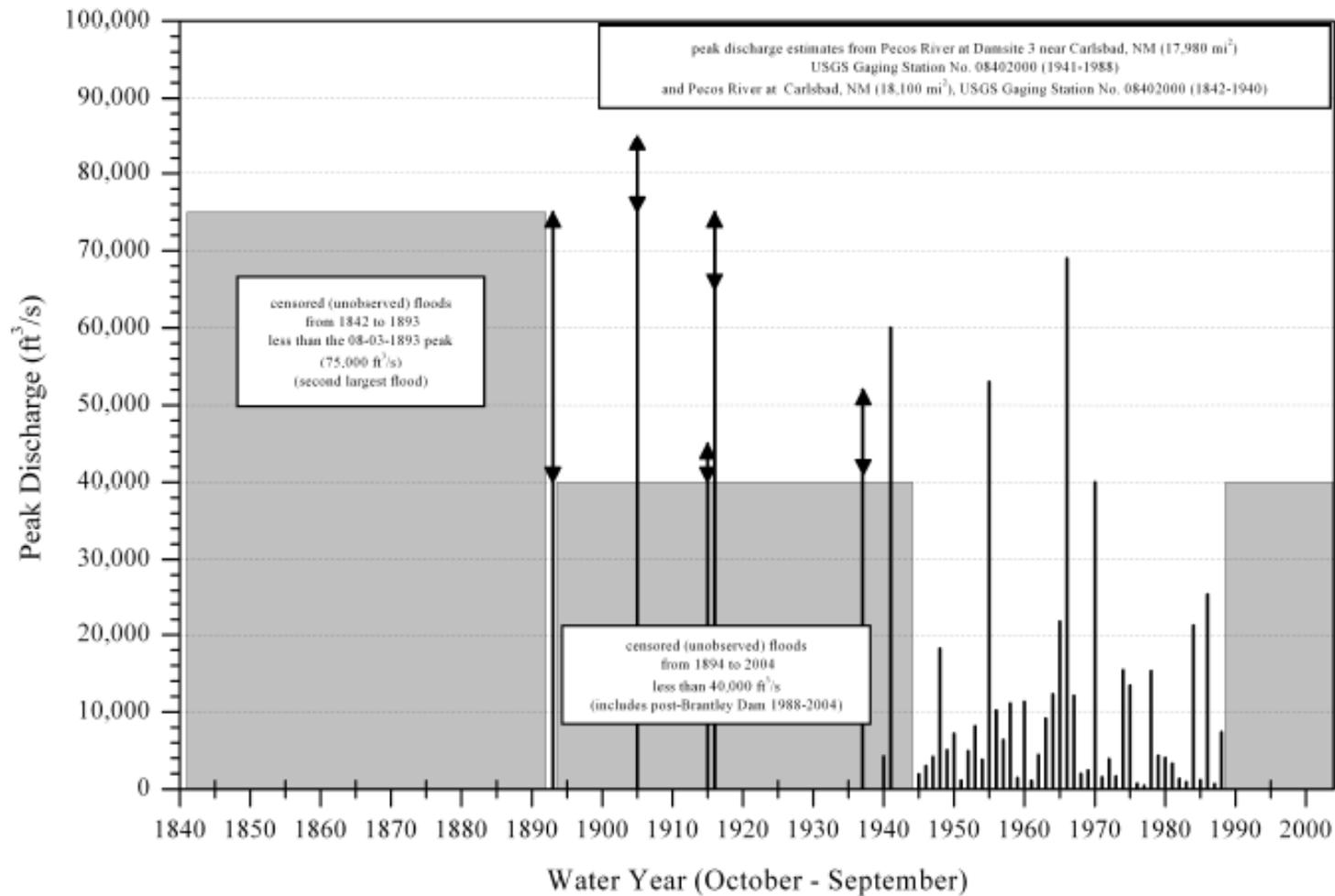
HFAWG Progress

- Responses to all written comments on the testing report sent out to HFAWG members on March 26
- Chair of HFAWG sent out minutes of March 19 meeting on April 2 and asked if members were in favor of adopting the recommendations
- 9 members responded Yes, 4 members responded No, and one member abstained

EMA Recommendation – Why adopt

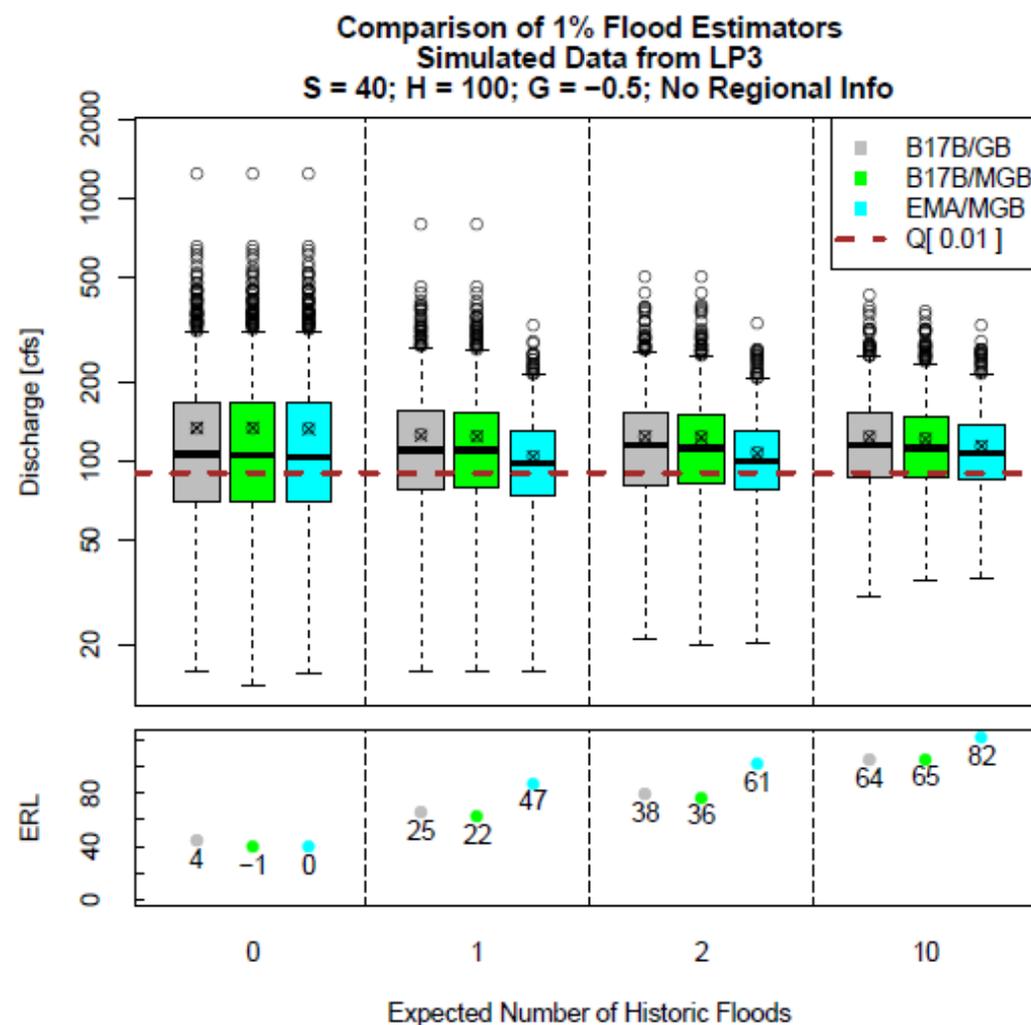
- **Replace Historical weighted moments and CPA with EMA – Generalize GB test with new MGB test**
 - **EMA deals with multiple thresholds and interval data**
 - **Testing on simulated data indicated EMA/MGB closer to true 1-percent chance flood, less variability of estimates, more effectively utilized historical information**
 - **Test results not conclusive for observed data, only 21 stations where 1-percent chance discharges differed by 9 percent or more**

Multiple thresholds and interval data



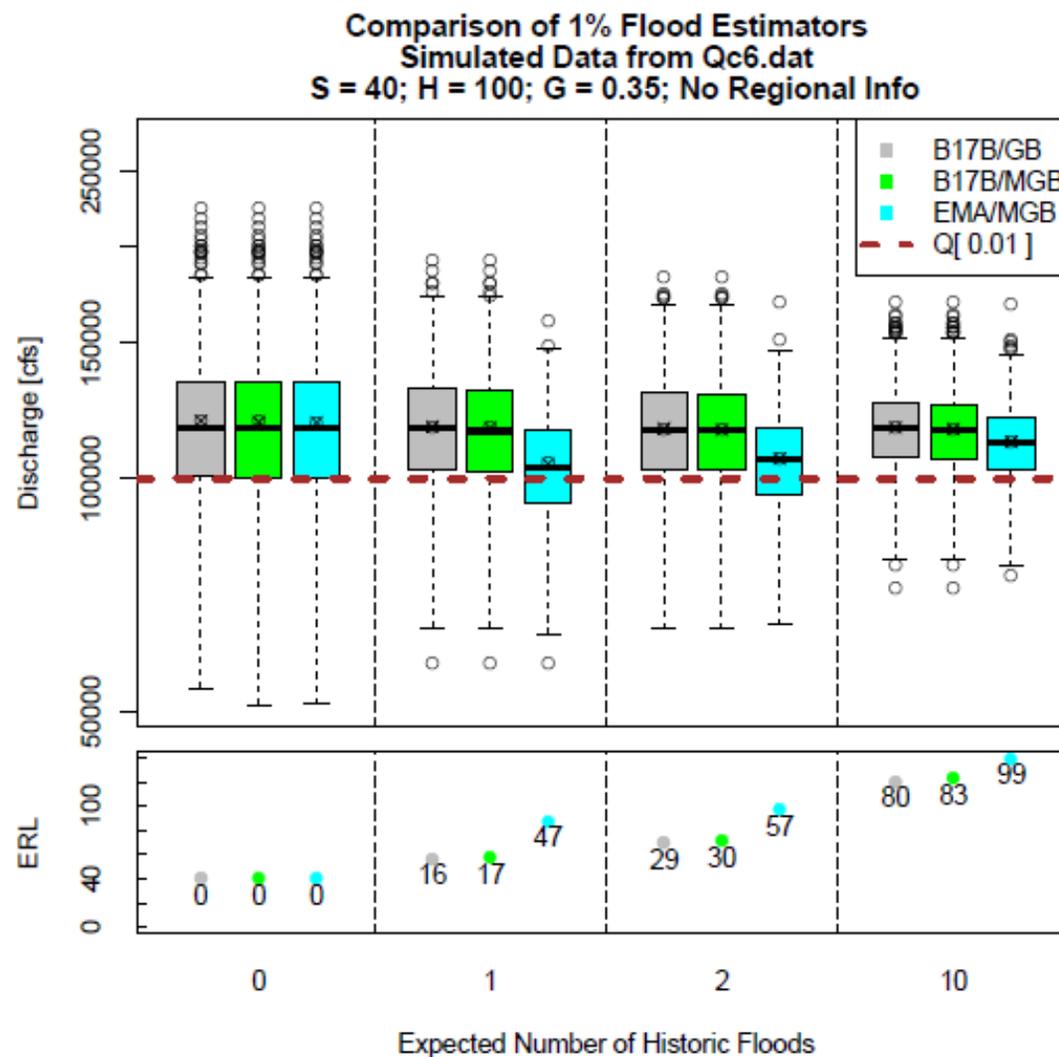
Simulated Data Test Results

Figure 15: Results are based on 1000 replicate samples drawn from a Log-Pearson Type 3 distribution with skew $\gamma = -0.5$.



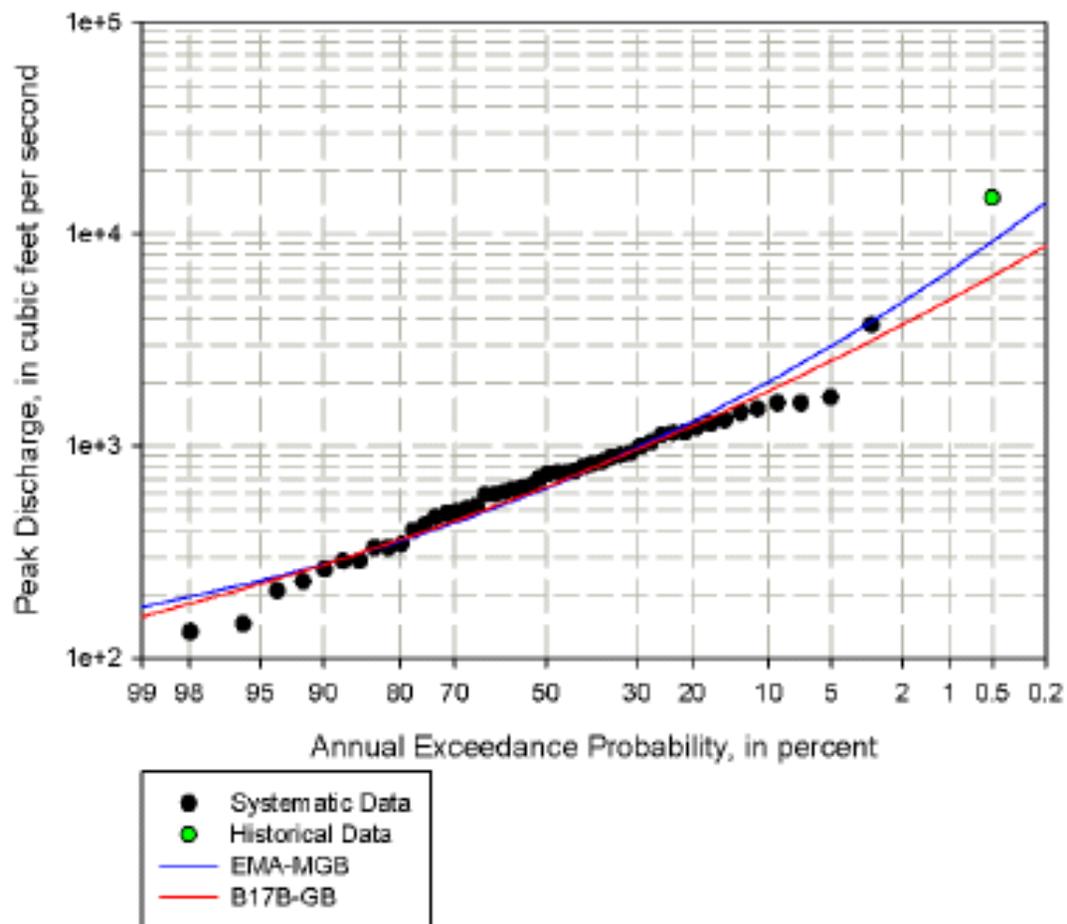
Simulated Data Test Results

Figure 20: Results are based on 1000 replicate samples drawn from robustness test curve 6



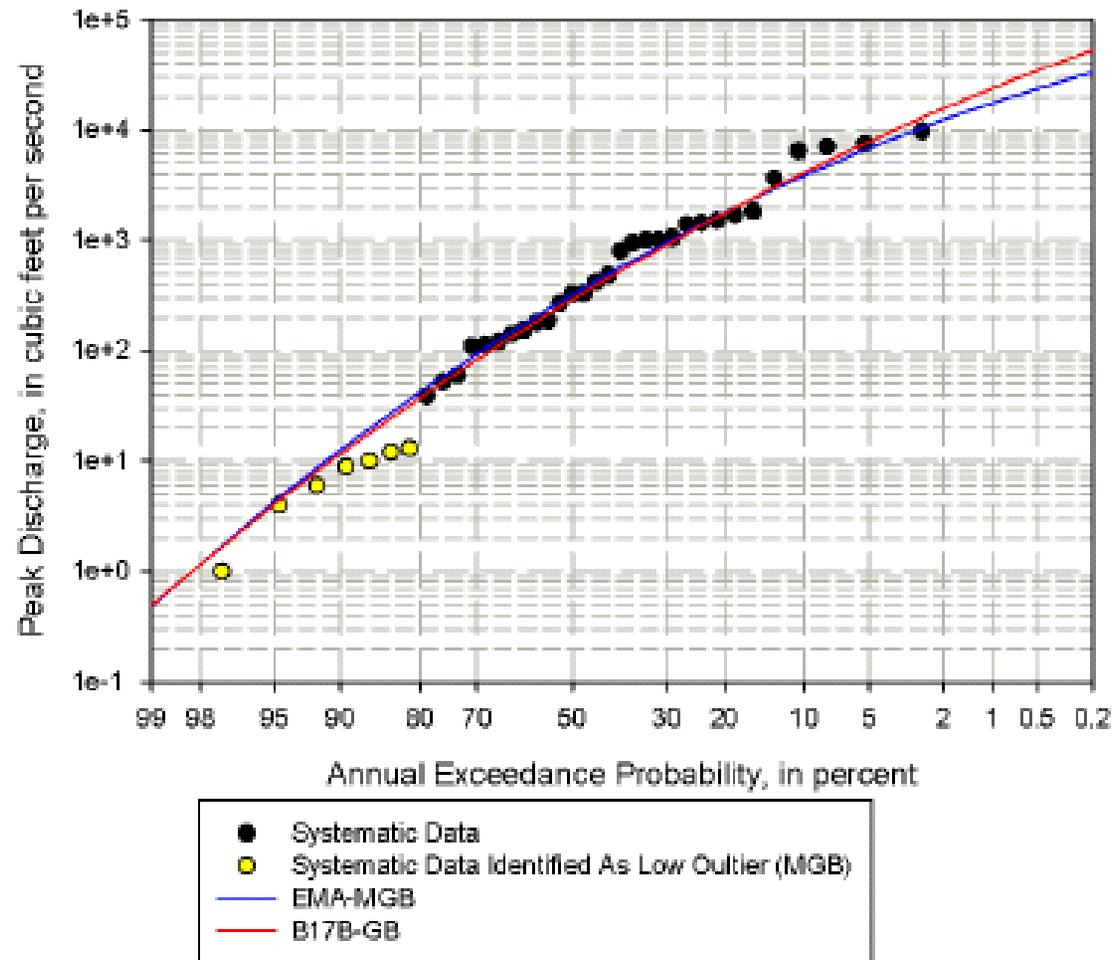
Comparison of EMA and Bulletin 17B

Pryor Creek near Billings, MT
(Station 06216500)



Comparison of EMA and B17B

Wolf Creek near Wolf Point, MT
(Station 06176500)

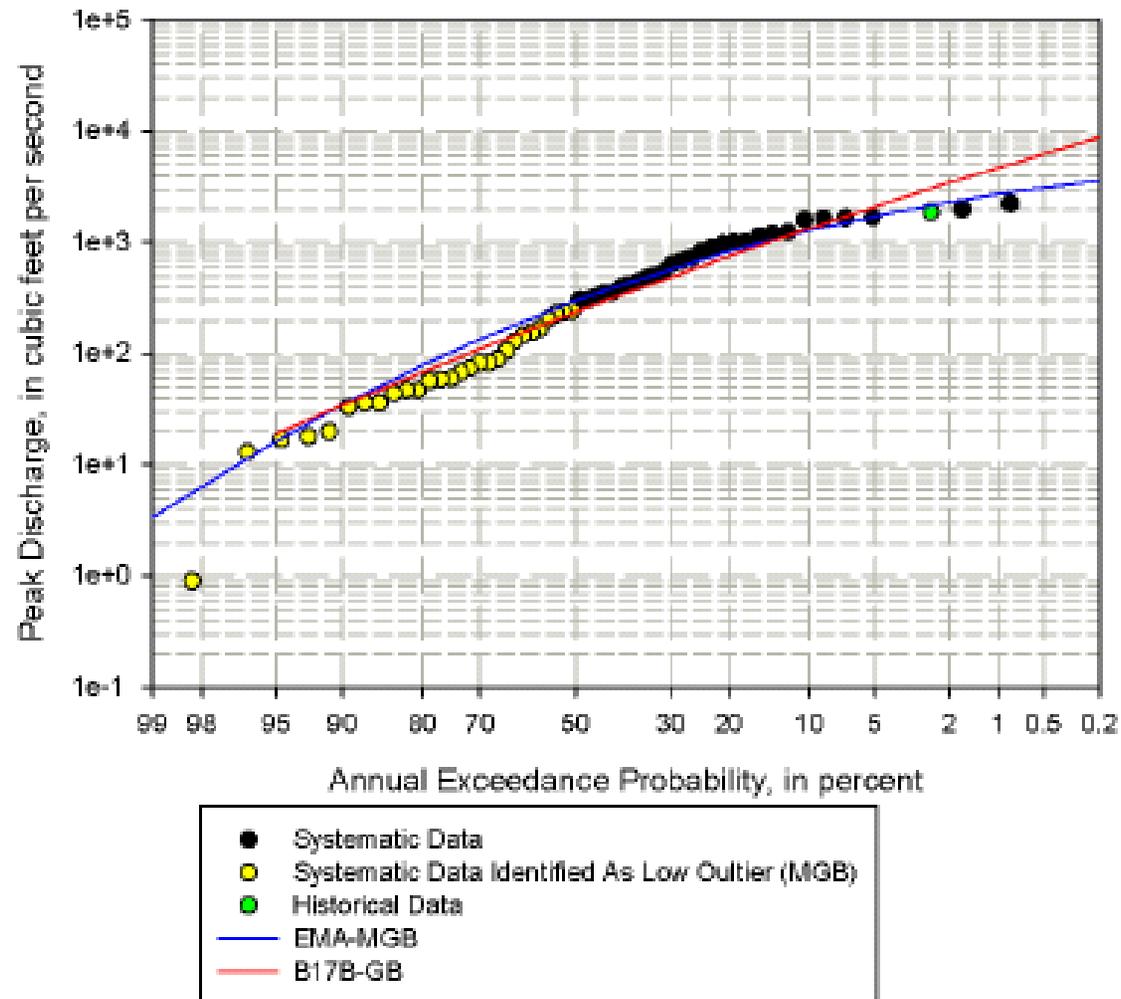


EMA Recommendation – Why not adopt

- **Replace Historical Weighted Moments and CPA with EMA – Generalize G-B test with new MGB test**
 - **No significant differences for observed data so why adopt**
 - **MGB test identifying too many low peaks that do not appear to be outliers**
 - **MGB paper (Cohn et al., 2011) not peer reviewed**
 - **Challenges in implementing EMA because it is more complicated and requires training**

Detection of Potentially Influential Low Peaks

Arroyo Mocho near Livermore, CA
(Station 11176000)

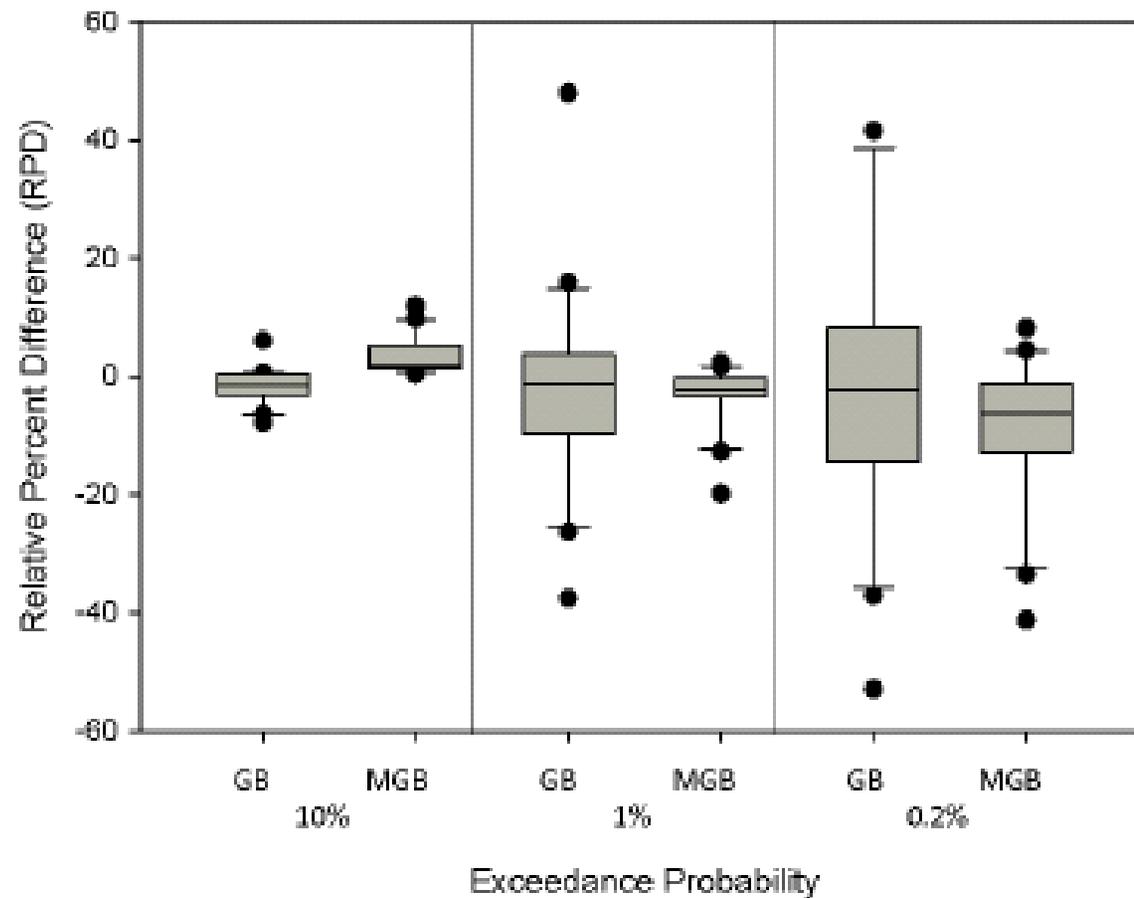


Proposed Additional Testing

- **Proposed test (Martin Becker) - Compare estimates from EMA/MGB and B17B/GB for the same number of censored low peaks**
- **Testing Group – This test not meaningful since it is not the recommended method for EMA/MGB**
- **Issue – EMA is more sensitive to the censoring of low peaks since it is fitting the entire distribution – should evaluate EMA with identified low peaks by MGB test**

Comparison of EMA and B17B with same number of low outliers

RPD: Low Outliers,
No Historical Information: 20 Sites
(EMA-MGB and B17B-GB and MGB)



Confidence Intervals

- **Confidence intervals provide estimates of uncertainty in flood discharges**
- **EMA confidence intervals are more accurate because they:**
 - **Consider uncertainty in skew coefficient**
 - **Account for the effects of historical data**
 - **Consider impact of censoring low peaks**

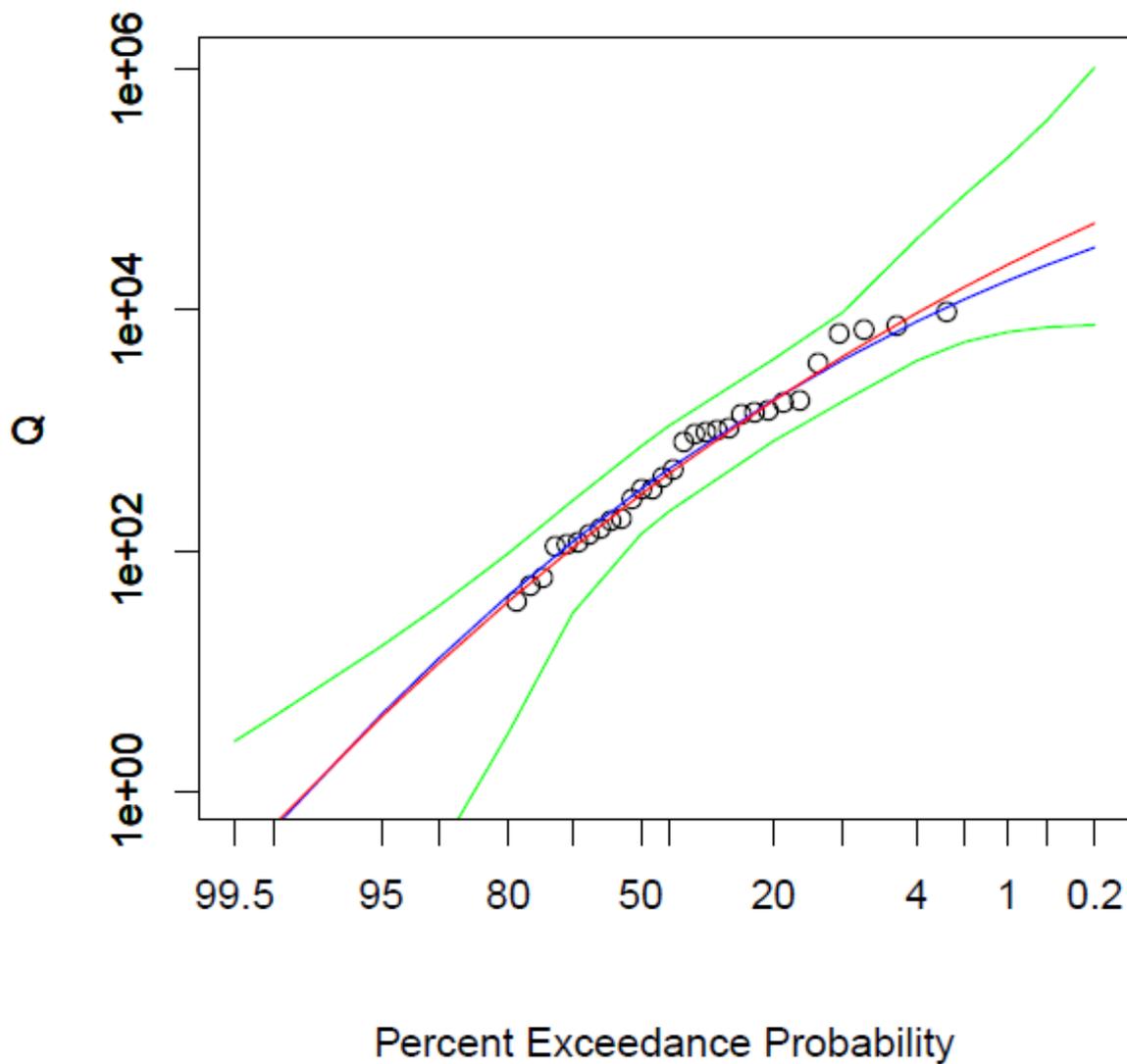
Confidence Intervals

- There is an inconsistency in the confidence intervals when potentially influential low peaks are identified by MGB test
- This results in some “kinkiness” in the confidence intervals as exhibited in the following graph for:
 - Wolf Creek near Wolf Point, MT (06176500)

Tim Cohn is fixing this inconsistency.

EMA Confidence Intervals

06176500



Software Discussion

- USGS is currently testing a beta version of PeakFQ that incorporates EMA/MGB
- A number of software bugs have been identified that will be fixed before software release
- PeakFQ 6.1 will have a GUI, graphics and an input screen that makes it easier to run EMA
- Two schools of thought on the software issue:
 - Get approval of the methodology then develop user-friendly accepted software
 - Develop accepted **tested** software first to evaluate the proposed methodology

Software Discussion

- **Some people feel that an accepted agency program, available to the public, is needed to evaluate the EMA methodology or run additional tests**
- **USGS is working on PeakFQ Version 6.1 to achieve these objectives**
- **The issues with PeakFQ 6.1 do not impact the test results completed with PeakfqSA v 0.95**
- **The same Fortran code for the EMA computations is in both programs**

HFAWG Plans Moving Forward

- **Develop Bulletin 17C based on recommendations discussed earlier**
 - **Develop an outline and draft of document**
 - **Define the review, comment and approval process**
- **Develop supporting material for Bulletin 17C**
 - **Web site for FAQs, references, software links**
 - **Prepare conference papers and journal articles**

HFAWG Plans Moving Forward

- **Develop software for Bulletin 17C**
 - Individual agency software is under development
 - Provide application examples with software
- **Conduct outreach and training on Bulletin 17C**
 - Present Bulletin 17C update plans at conferences
 - Develop training materials on Bulletin 17C

- **All documents and references cited in this presentation are included on a ftp site (<ftp://ftp.usbr.gov/jengland/HFAWG/>), e.g.,**
- **“Updating Bulletin 17B for the 21st Century”, Cohn et al., 2012**
- **“A Generalized Grubbs-Beck Test for Detecting Multiple Potentially Influential Low Outliers in a Flood Series”, Cohn et al. 2011**
- **Minutes of the March 19, 2012 HFAWG meeting**
- **March 16, 2012 responses to comments on the testing report**
- **All powerpoint presentations from March 19 meeting**