Interagency Flood Risk Management (InFRM)
Trinity River Watershed Hydrology Assessment

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Bret Higginbotham, P.E., CFM
Chief, H&H Studies Section
US Army Corps of Engineers
Fort Worth District

Trinity River Watershed

- 18k Square Mile Drainage Area
- 100 Active USGS Streamflow and Reservoir Gages
- Fort Worth and Dallas Levee Systems
- 8 USACE Reservoirs
- Results & Models are available upon request for other future studies (at no cost)
- Published Final Report and Appendices at www.InFRM.us

The Interagency Flood Risk Management (InFRM) Team

Collaboration of Federal Agencies
- Pilot Program began in 2014 within FEMA Region 6
- Purpose to develop actionable information for reducing flood risk in the Region
- Leverages expertise, information, programs and resources across the federal agencies
- Operates under the umbrella of Integrated Water Resources Science and Services (IWRSS)
Purposes of the InFRM Watershed Hydrology Assessments (WHAs)

- Produce the best possible estimate of the 1% annual chance (100-yr) and other frequency flows across the basin
- Employ a Thorough Approach to Hydrology:
  - Uses a range of hydrologic methods and compares their results to one another and to previous studies
  - Tells the story of how the 1% annual chance flow has changed over time
  - Formulates recommendations based on multiple lines of evidence
- Results suggest areas where the FEMA flood hazard mapping may need to be updated

Major Tasks in the InFRM Watershed Hydrology Assessments

- Statistical Analysis of the Gage Records with Bulletin 17C
- Period of Record Simulations in RiverWare
- Reservoir Analysis using RMC RFA Stochastic Analysis
- Rainfall Runoff Modeling in HEC-HMS
- Model Calibration
- Uniform Rainfall Frequency Storms
- Elliptical Frequency Storms
- Compare Results from Different Methods & Investigate the Differences
  - Investigation may include comparisons with Historic Storms, Storm Shifting, & 2D HEC-RAS Rain-on-Grid
- Draft Documentation with Draft Recommended Frequency Flow Results
- Peer Reviews of Draft Report and Results
- Publish Final Report at www.InFRM.us

Statistical Estimates from 17C Change Over Time

- "Major problems in flood frequency analysis at gaged locations are encountered when making flood estimates for probabilities more rare than those directly defined by the at-site flood period of record..." – B17C,p31
Statistical Change over Time Plots

- New Option in HEC-SSP Version 2.3

- Even with 100+ years of record, the 100-yr (1% ACE) flow estimate is still a moving target.

- Statistical estimates don’t stabilize until you have a length of record that is 3 to 4 times the return period being estimated.

- 300 to 400 years of record are needed for a stable 100-year estimate.

- Help communicate uncertainty and the effects of climate variability.

Variation in 17C Statistical Results at Long Record Gages (50-100 years) in Texas

RiverWare Analysis

- Period of Record (POR) Modeling in RiverWare (example 1940-Present)

- Simulates the basin as if all dams have been in operation since the beginning of the POR.

- Perform Bulletin 17C Analysis with the extended record.

- Example: RiverWare effectively extended the POR for the Dallas gage by accounting for all dams currently in operation.
**Reservoir Analysis with RMC-RFA**

- Analyze USACE reservoirs plus selected other major reservoirs
- Use RMC-RFA software from USACE's Dam Safety Program
- Runs 10,000+ Monte Carlo Simulations that randomly sample inflow volumes & starting pool elevations
- Estimate pool elevations for Rare Frequencies (100 yr to 1,000+ yrs)
- Results include frequency pool elevations and frequency outflows from each dam

**Initial HEC-HMS Model**

- Typically use an existing model (USACE CWMS HEC-HMS) as a starting point
- Add Detail to the HEC-HMS model as needed:
  - Increase level of detail and number of subbasins near populated areas
  - Update routing data with LiDAR terrain data
- Update Initial Model Parameters

**HEC-HMS Model Calibration for the InFRM WHAs**

- Start with an Initial Basin Model
- Select recent large storm events (1990s to Present) to Calibrate (Fine Tune) the model parameters
- Apply the NWS Radar Gridded Rainfall Data
- Adjust the model parameters to achieve a better match between the model results to observed USGS data at streamflow gages and reservoirs
- Goal: Produce a final model that accurately simulates the response of the watershed to a range of observed flood events, including events similar to a 1% ACE flood.
HEC-HMS Model Calibrations for the InFRM WHAs

- Calibration is typically performed on the 3 - 7 largest flood events available at each gage from late 1990s - Present
- Calibrate 30 - 100+ gage locations per river basin (Trinity, 46)
- A total of 100 to 400+ Calibrations are completed for each river basin (Trinity, 245)

Uniform Rainfall Frequency Storms in HEC-HMS

- Frequency Storm Method in HMS
- Apply NOAA Atlas 14 Point Rainfall Depths as variable by subbasin
- Rainfall depths are reduced uniformly across the entire watershed through a TP-40 Depth-Area Analysis
- Run 2, 5, 10, 25, 50, 100, 200, & 500-yr Frequency Storms
- Appropriate for Smaller Drainage Areas up to approximately 1,000 square miles

Elliptical Frequency Storms in HEC-HMS

- Elliptical Shaped Frequency Storms
- NOAA Atlas 14 Point Rainfall Depths
- No reduction at storm center, greater reduction toward outward ellipses
- Apply Depth Area Reduction curves from Regional Observed Storms
- Storm Center Location is Optimized for each location on the Rivers
- Appropriate for Larger Drainage Areas (> 400-1000 square miles)
Comparisons of Results from Multiple Methods

- Compare the Results of the Various Methods to One Another and to Previously Published Values
- Investigate the Reasons for any Significant Differences & Adjust Assumptions when Appropriate

Mary's Creek at Benbrook, TX (Upstream Gage)

2D HEC-RAS Analysis: Mary's Creek at Benbrook, TX

- HEC-HMS Transform Parameters calibrated to 2D HEC-RAS results
- Runoff was faster and lag times were shorter with more intense rain
- Used to inform the final HEC-HMS Transform Parameters

- 5 in/hr rainfall intensity
- 1 in/hr rainfall intensity

Mary's Creek Watershed Response

2D HEC-RAS Model

Storm Shifting Analysis: Clear Fork Trinity River at Fort Worth, TX

- Shifted the June 2000 storm by 15 miles
- Shifted storm had a 24-hr rainfall total of 10+ inches (similar to the 1% ARI)
- Peak Flow from the June 2000 Shifted Storm was very similar to the HEC-HMS 100-yr Results
- Added the Shifted Storm results to the 17C statistical analysis as a Sensitivity Test
- This increased the 1% ARI statistical estimate by 100% (from 25,000 to 50,000 cfs) and increased the upper 95% confidence limit by 80% (from 50,000 cfs to 90,000 cfs)
- Shows that 17C Statistical Results are very sensitive to Sample Bias
InFRM WHA Review Process and Final Report Publication

- Draft Report and Technical Appendices are sent out for Peer Review
- Peer Reviewers include Experts from Federal, and State Agencies, Regional Stakeholders, and the InFRM Academic Council
- Peer Review Comments & Responses are published in an Appendix
- Final Report Published on the InFRM website: www.InFRM.us
- Final Reports and Technical Appendices are available for public download
- Models and data are provided upon request at no charge
- Results Recommended by InFRM team as Best Available Flood Risk Information for use in Future Studies & Mapping Updates

Comparison of 100-yr Flows: InFRM WHA versus FEMA FIS Flows

- WHA Results showed significant differences from the effective FIS flows in some areas
- Many FEMA FIS flows had not been updated in 30 - 40+ years
- Large flow increases usually due to increased Rainfall Depths, Urbanization, and Gage Sample Bias in 17C

Storm Shifting Studies – Why Should I Care?

- Flooding doesn’t stop at lines on a map.
- Flood maps don’t account for all flood scenarios.
- Commonly asked questions:
  - “Does a 100 year storm mean I’ll get a 100-year flood?”
  - “How is my flood risk?”
  - “What if that storm hit where I live?”
  - “Is this area safe from flooding?”
- There’s a tool for that:
  - Storm shifting provides informative, relatable, and non-regulatory data to help communities better understand and mitigate their flood risk
  - Valuable non-regulatory planning and design guidance for more resilient communities
  - Can be used in EM Action/Hazard Mitigation Plans
WHY: INCREASING FREQUENCY AND MAGNITUDE OF PRECIPITATION EVENTS

- Regional observed storms
  - USACE extreme storm database
  - Gray TP40 band was design standard (100-year) until 2018
  - Gray NA14 (NOAA Atlas 14) design standard (100-year) since 2018
  - Blue X's are 2010-2019 storms that exceeded the 100-year
  - 20+ events exceeded the 100-year design standard

- Region is experiencing abnormally active storm period

Introducing Storm Shifting

- Planning and design-level guidance for various organizations and projects
- Planning, design and operational data for dams and levees
- Evaluation criteria for civil works projects, real estate actions, risk assessments, dam and levee safety studies
- Support for response, mitigation, and higher standards
- Helps address gaps in coverage and questions with existing/historic data
Upper Trinity Storm Shift Initial Results

- Tropical Storm Bill (13.6" in 48 hours):
  - Sample peak flows for Dry, Best Estimate, and Wet scenarios shown below
  - Includes comparisons between storm shift scenarios and Trinity Watershed Hydrology Assessment (WHA) 100, 200, & 500 year flows
  - Comparison between storm shift scenarios and FEMA 100 and 500 year floodplains shown in image to right

<table>
<thead>
<tr>
<th>Storm Shift</th>
<th>Peak Flow (cfs)</th>
</tr>
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<tbody>
<tr>
<td>Dry</td>
<td>30,404</td>
</tr>
<tr>
<td>Best Estimate</td>
<td>51,911</td>
</tr>
<tr>
<td>Wet</td>
<td>105,369</td>
</tr>
</tbody>
</table>

- Elm Fork Junction 070:
  - 45,100
  - 52,800
  - 62,400

Storm Shifting – Other Examples

- Waco, TX:
  - Issue: Uncertainty associated with determination of flood potential (dams)
  - Shifted several storms (30+ mi)
  - Examined different operational constraints, multiple scenarios
  - Outcome: showed flood potential is greater than 100 year

- Mary's Creek, DFW, TX area:
  - Issue: Uncertainty associated with determination of flood potential
  - Shifted 2000 100-year ± storm 15 miles
  - Outcome: Flood potential is greater than previously understood

Future

- Interagency Flood Risk Management (InFRM)
- Watershed Hydrology Assessment (WHA) integration
- Integrated Transportation and Stormwater Infrastructure (TSI) project
- San Marcos study
- DFW Airport project and other regional projects

Comparison of 100-yr Flows: InFRM WHA versus 1D Base Level Engineering (BLE) Data

- BLE use approximate methods, while the WHAs use more detailed & complete information
- WHA 1% Flows were similar to the BLE data in some areas, but very different in other areas
- Reservoir Impacts: BLE data plots the floodplain as if Reservoirs do not exist, in some cases

- Newberr Mills Lake
  - Est. BFE (100-yr): 449.3 ft
  - WHA Est. (100-yr): 444.6 ft
  - WHA Est. (2-yr): 431.0 ft
  - Record Pool, 443.3 ft (Oct. 2015)
Applications of the WHAs in Texas: Redefining Flood Risk

- FEMA is using the InFRM WHA results in their mapping updates (Middle Guadalupe River, East Fork Trinity River, etc.)
- Adding Detail for Local Floodplain Updates on smaller streams (City of San Marcos)
- Updates to the Existing 1D BLE Data (Hetcha River Basin)
- Adjusting New 2D BLE Data to WHA results (note)
- WHA Methods are being applied in the GLO’s River Basin Flood Studies
- Results & Models are available upon request for other future studies (at no cost)

Questions?

Bret Higginbotham, P.E., CFM
Chief, H&H Studies Section
US Army Corps of Engineers
Fort Worth District
Bret.W.Higginbotham@usace.army.mil
817-886-1542 (office)
817-897-1212 (cell)