Workshop on Nonstationarity, Hydrologic Frequency Analysis, and Water Management

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Red River of the North Flood Frequency Estimation

Pat Foley

Abstract

For the last few decades the Fargo, North Dakota, and Moorhead, Minnesota, area has had to flight Red River of the North floods with regularity, culminating in the flood of record in spring 2009. Only heroic efforts by flood fighters during weeks of adverse conditions prevented a catastrophe. The St. Paul District of Corps of Engineers is currently working with the local communities to develop reliable flood protection. One of the first tasks for the flood risk management study is to determine the probability of future floods. This evaluation is used for the economic analysis of the project and to determine its reliability. The Corps standard practice is to assume historic floods provide an accurate representation of future flood probabilities, i.e. stationarity and no impact from climate change is assumed. However, a plot of the period-of-record natural annual maximum mean daily flows at the Fargo gage showed the an obvious upward trend. The 50-yr moving average of natural annual maximum flows increases from about 3400 cfs in 1950 to currently over 8000 cfs.

The Fargo-Moorhead flood risk study is on a fast track with selection of the flood reduction measure due by January, 2010. The short time frame for the study did not allow a reliable, detailed study of reasons for increasing flood flows and an analytical evaluation of how flood flows will change in the future. The St. Paul District proposed doing an Expert Opinion Elicitation, EOE, to help the project delivery team decide how to properly address future flood risks. The local sponsors and Corps headquarters agreed with the use of an EOE. The EOE was held September 28-29, 2009, in Minneapolis, Minnesota. The official panel members were: Bob Hirsch, USGS; Dave Raff, Bureau of Reclamation; Scott Dummer, NWS; Skip Vecchia, USGS; Rolf Olsen, Corps of Engineers: and Mike Deering, Corps of Engineers, and the EOE was facilitated by Dr. David Ford of Ford Engineering. The experts addressed the following basic question:

What specific actions, in any, should the Corps take to account for future climate uncertainty in the quantification of flood risk for Fargo, ND-Moorhead, MN?

The experts fairly quickly agreed that there was too much uncertainty in climate change impacts on flood flows to provide a recommendation on how to accommodate climate change in the flood risk management study. However, the experts did reach agreement that the Red River of the North at Fargo flood peak record was non-stationary and that the river has recently experienced a wet period. Tree ring studies have shown that the Red River basin has alternated between wet and dry periods for several hundred years. A paper by Gabriele Villarini and others had shown that the Red River at Fargo met statistical tests for nonstationarity with a break in the record in 1941. The panel recommended that the Corps include the impact of non-stationarity in its flood risk study. The panel did not make specific recommendations on how to incorporate nonstationarity.

The St. Paul District contracted with the Corps Hydrologic Engineering Center, HEC, in Davis, CA, to develop specific guidance on how to incorporate nonstationarity. HEC was also asked to review and

evaluate how upstream reservoirs and floodplain storage impact flood peaks at Fargo. Dr. Beth Faber at HEC recommended the St. Paul District use the 1941-2009 records (wet period) to develop the current, year 0, discharge-frequency curve. For year 50, it's far enough out that HEC said there was no way of knowing which condition would be correct, so they recommended using long-term probabilities based on how much of the observed record was wet, and how much dry. This gave 65% chance wet, 35% chance dry. For year 25, HEC chose a reasonable transition between the current 100% chance wet, and the future 65% chance wet. For year 25 HEC recommended assuming an 80% chance wet and 20% chance dry. The dry period frequency curve was based on the 1902-1940 Fargo records. HEC also recommended using the skew coefficient from the Fargo records. The previous Fargo curve has used the longer record Grand Forks station for the regional skew.

As of 3 January 2010 the St. Paul District and HEC are still coordinating on how to accurately incorporate the impact of upstream reservoirs and floodplain storage on the Fargo discharge-frequency curve, so the exact impact of nonstationarity on the final Fargo flood values has not been completed. However, comparing the previous natural flood frequency curve using the full period of record with the new wet period curve based on 1941-2009, the mean of the logarithms of the annual peaks increased while the standard deviation of the logs of the peaks decreased. The results are a wet period natural frequency curve that is higher than the total period curve for intermediate floods but lower for very large floods like the 0.2%, 500-yr, flood. The wet period flood frequency curve provides a better fit to plots of the recent large floods.

The St. Paul District also compared results of a study of the impact of predicted future climate change on the discharge frequency curve for the James River at Jamestown, ND, done by Dave Raff and others, with Fargo. The James River study found that the Jamestown 100-yr discharge would likely increase significantly over the next 100 years. Jamestown is about 90 miles west of Fargo and the IPCC precipitation and temperature predictions are very similar. However, the James River flows south and the Jamestown drainage area is north of the city while the Red River flows north and its drainage area is south of the city. Direction of flow is important in snow melt flooding and the translation of the James River results to Fargo is uncertain. Also, the James River basin is more of a prairie pothole region than the upstream Red River basin. Climate change is currently not being considered in the Fargo-Moorhead risk reduction study.

Pat Foley
St. Paul District,
Corps of Engineers
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