Project Summary
Texas Department of Transportation

0-5521: Develop Statewide Regression Equations for Improved Flood Peak Estimation

Background

Texas Department of Transportation (TxDOT) is responsible for many miles of Texas highways. A component of the design, construction, and maintenance of this transportation system requires estimates of annual peak streamflow, for selected design risk or probability criteria, that are used to size drainage works (crossings and parallel systems). One of the estimation techniques used is based on statistical regionalization of frequency curves, fit to time series of annual peak streamflow, using regression equations.

The most well-known set of currently applicable regional regression equations is a suite of 96 regression equations described in the TxDOT Hydraulics Design Manual. End users of those equations have reported difficulty in implementation because of sheer number of equations and other concerns of applicability as thoroughly described in the final project report. The authors demonstrate the number of equations required to represent Texas hydrologic conditions could be reduced to nine equations and that systematic bias for drainage areas less than about 30 square miles could be reduced using traditional regression analysis augmented by minimization of the Prediction Error Sum of Squares (PRESS) statistic.

The purpose of the research project described here, which resulted from reflections on the 96 regression equations, was to revisit annual peak-streamflow frequency in Texas using a suite of probability distributions, the method of L-moments, and PRESS-minimized regression analysis to further refine, simplify, and update regional regression equations for estimating floodflow

What the Researchers Did

The U.S. Geological Survey records for 1,030 streamflow-gaging stations were reviewed. From this group of candidate stations, 638 stations were selected for the flood-frequency analysis. The reduction in station count was based on an assessment of watershed characteristic reliability and minimum record length. Generally, seven candidate distributions — generalized extreme value, generalized logistic, generalized normal, generalized Pareto, kappa, Pearson Type III, and log-Pearson Type III — were fit to the annual maximum gaging record.

Research Performed by:

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For each of the selected nine recurrence intervals, a symmetrically trimmed mean was computed using estimates from the suite of fitted probability distributions. The resulting mean is a robust estimate of the station-specific annual peak discharge for each recurrence interval.

Regression equations were developed on the basis of watershed characteristics of drainage area, dimensionless main-channel slope, and mean annual precipitation. Residuals were computed from the regression equations and plotted on a map of the study area so the spatial structure of the residuals could be examined. A fourth parameter, termed OmegaEM, was developed for each 1-degree quadrangle of Texas and the 10-year event (90th percentile). This parameter is interpreted as a terrain and climate index that expresses relative differences in annual peak-streamflow potential across the study area. The OmegaEM parameter was included as a predictor variable for a second round of regression analyses.

What They Found

- Use of the PRESS statistic for minimizing bias in the resulting regression equations is effective.
- Only one of the predictor variables (drainage area for this research project) is adjusted using PRESS statistic minimization to remove bias from the resulting regression equations.
- The OmegaEM parameter is an effective tool for summarizing the relative differences in annual peak-streamflow potential between areas of substantial difference in terrain and climate that occur in Texas. Incorporation of OmegaEM into a second ensemble of regression equations produced improved estimates of streamflow peak discharges.
- The residual standard error for the ensemble of regression equations ranges from 0.25 to 0.37, which is considered an excellent result.
- Adjusted R-squared values for the nine equations range from 0.81 to 0.89, which indicates that a large portion of the variance in the observations is explained by the regression equations.

What This Means

The 96 regional regression equations can be replaced by a simpler ensemble of nine regression equations that are believed to be technologically superior and expected to produce estimates of streamflow at ungaged sites with less potential bias and error.

For More Information:

0-5521-1 Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas Using an L-moment-Based, PRESS-Minimized, Residual-Adjusted Approach

0-5521-2 Alternative Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas using PRESS Minimization

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