



# Project Summary

Texas Department of Transportation

## 0-4405: Identify Appropriate Size Limitations for Hydrologic Methods

### Background

Under current design guidance, Texas Department of Transportation (TxDOT) designers use the *rational method* for watersheds less than 200 acres, *hydrograph procedures* for watersheds less than about 20 square miles, and *statistically based methods* for watersheds with drainage areas exceeding 20 square miles.

There is little corporate memory as to why these particular boundaries were selected. Also, there are discrepancies between design discharges computed using these methods, and attempts to reconcile the differences have been less than satisfactory.

Consequently, this project examined the relationship between watershed scale and hydrologic variables for a wide range of drainage areas and geographic locations. The primary objective was to examine the relationship between hydrologic processes, such as watershed response to rainfall, and watershed drainage area. Ancillary objectives were to determine, if possible, the relationship between watershed scale and watershed response processes, to determine how to apply analytic technology to model the relevant processes.

### What the Researchers Did

The work plan included a literature review, contacting other departments of transportation, examining regionalization of Texas, identification of appropriate modeling techniques, and documentation.

Contacts with other departments of transportation yielded little insight into the problem. TxDOT is a leader in hydrologic research.

After reviewing available data, researchers did not break Texas into regions. Available data did not indicate such subdivision would be appropriate.

During the course of the work, a number of technologies were explored and examined for a relationship between technology and watershed drainage area. In addition, a review of previous research on development of regional regression equations (as presented in the TxDOT hydraulic design guidelines) was done. A 20-watershed subset of an existing database of 91 watersheds was selected for further study. Criteria for selection included little or no urbanization and a period of record of at least ten years.

Site-specific flood frequency curves were computed by applying the L-moment method to determine distribution parameters. The four-parameter kappa and generalized logistic distributions were used. The runoff coefficient for the rational method was estimated from site-specific observations of rainfall and runoff. The rational method, the regional regression equations currently in use, the PRESS-minimized regression equations and log-transformed regression equations from past research were then applied to study watersheds. Discharge estimates from this variety of techniques were compared with the site-specific flood frequency relationship.

### Research Performed by:

Center for Multidisciplinary Research  
in Transportation, Texas Tech  
University

U.S. Geological Survey

Texas Transportation Institute

### Research Supervisor:

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### Project Completed:

8-31-05

## What They Found

Current practices used for estimating watershed time of concentration yield values that produce reasonable estimates of  $n$ -year discharge, at least for the rational method.

Estimates of  $n$ -year discharge using the rational method are based on best estimates for the runoff coefficient taken from a comparison of measured rainfall and runoff events. Selection of proper estimates of the runoff coefficient is critical for correct estimation of  $n$ -year discharges. Refinement of this process beyond simple selection of values from a table is appropriate.

For simple watersheds, the rational method may be applied when only an estimate of the peak discharge from the runoff hydrograph is required, provided that appropriate values for the runoff coefficient are estimated. Watershed drainage area does not seem to be an important consideration. However, watershed complexity was not examined as part of this research. Because the rational method is a simple procedure, application of it to a complex watershed would be inappropriate.

Results from application of current regional regression equations are mixed. For study watersheds, estimates of the 2-year discharge tended to be less than those from the site-specific frequency curve. In contrast, estimates for the 50- and 100-year discharges tended to be greater than those from the site-specific frequency curve. Furthermore, there appears to be a relationship between watershed drainage area and median values from the regression equations, especially for the smallest watersheds. Differences in  $n$ -year discharge estimates could be a reflection of the possible bias with respect to drainage area present in the equations.

Results from application of a recently developed set of experimental log-transformed regression equations are also mixed, possibly due to bias in the equations. Furthermore, median values of the ratio of log-based regression estimates to site-specific frequency estimates tended to increase with increasing return interval. The latter was less in evidence for the PRESS-minimized regression equations, but median values for the more frequent events tended to be less than those from the site-specific frequency distributions. No bias with respect to drainage area appears to be present in the PRESS-minimized regression equations.

## What This Means

In general, the methods used in this study did not compare well with the site-specific frequency distributions for 2-year events, in particular, and to a lesser extent, 5-year events. It is not clear why this occurs. It is possible that the observed runoff coefficient for the rational method was larger than it should be for the most frequent events. That would explain why the 2-year discharges from the rational method generally exceeded those from site-specific frequency curves. However, additional analysis is necessary to determine the exact cause of this observation. It is possible that the processes which produce more frequent flood events differ from those of rare occurrence.

While watershed drainage area is an important factor in executing hydrologic computations, this project does not suggest that drainage area is useful for selecting a method for estimating a design discharge. This observation is in contrast to current practice.

### *For More Information:*

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