1. Introduction

This report is a part of the work of the research project, “A System of GIS-Based Hydrologic and Hydraulic Applications for Highway Engineering”, which is being developed by the Center for Research in Water Resources (CRWR) of the University of Texas at Austin and sponsored by the Texas Department of Transportation (TxDOT). It is also an extension and improvement of the Hydrologic Data Development System (HDDS) developed by Smith (1995). This introduction presents the background and the significance of the work in this report.

1.1 Background and Significance

Hydrologic analysis is vital to the design of drainage facilities in highway engineering. The cost of drainage facilities, such as storm drains, highway culverts, bridges, and water quality and quantity control structures, accounts for twenty five to fifty percent of the total cost of highway projects. The importance of drainage structures covers the range from transportation facilities to security against natural disaster, life safety and economics. Hydrologic analysis has always been an important component in highway engineering design and directly affects the success of whole projects. Accurate hydrologic analysis is desired. But accurate analysis depends not only on advanced and reasonable hydrologic models, but also the availability and the processing of wide range of spatial data. Substantial efforts are required to manually establish and manipulate spatial data. The traditional approach usually balances accuracy with simplicity. In general,
simplicity limits the choice of hydrologic models and so limits the degree of accuracy. Due to the development of computer and hydrologic computation techniques, GIS-based hydrologic systems are improving the situation by both improving accuracy and reducing the effort of data establishment and manipulation.

The work in this report is a part of the work of the project of the System of GIS-Based Hydrologic and Hydraulic Applications for Highway Engineering which is being developed by the Center for Research in Water Resources (CRWR) of the University of Texas at Austin. The idea behind the system is combining a digital spatial description of the environment with GIS data processing and a graphic interface, and with hydrologic design procedures. The whole system includes a database for the entire state of Texas and a series of computer programs which employ relatively new hydrologic and hydraulic approaches based on the latest GIS technologies. The objective of work in this report is to make the system workable on PC machines with a CD-ROM storing all the required data.

1.2 Hydrologic Data Development System (HDDS)

The Hydrologic Data Development System (HDDS) is the achievement of the MS thesis of Smith(1995). The HDDS provides a package of spatial data and menu-driven programs that allow user-interactive determination of hydrologic parameters and estimation of flood frequency relationships for the design of highway drainage structures. The system was built within the environment of GIS Arc/Info through using the Arc Macro Language (AML).
The main purpose of HDDS was to establish and manipulate digital spatial data under a GIS environment to generate and provide fundamental hydrologic parameters as the input data for THYSYS, as well as creating drainage maps, tables and related documents. The HDDS focused on the design and programming by using Arc/Info Arc Marco Language and associate data. The hydrologic parameters generated by HDDS include drainage basin boundaries, areas and sub-areas, maximum flow path length, estimated travel time, average watershed slope, hydrologic soil group, design rainfall and weighted runoff coefficients. The system was applied on a study area of the North Sulphur River Basin in Northeast Texas above state highway 24. The results demonstrated that reasonable values of hydrologic parameters could be found by the automated system.

1.3 Work in This Report

The work in this report contains two main parts. The first part is focused on determining peak-flow discharge based on the relationship between the documented peak discharges and drainage area. The USGS potential extreme peak discharge equations for all the Texas hydrologic regions applied using a spatial database prepared for the state. The details of this part of work are discussed in Chapter 2.

The second part of the work is involved with developing the TxDOT Hydrology Extension, which is a further development and improvement of Hydrologic Data development System (HDDS). The TxDOT Extension is developed for hydrologic data processing and modeling analyzing, in the environment of ArcView on both PC machines and UNIX workstations. The
hydrologic parameters, which can be generated in HDDS using Arc/Info, can be generated in the TxDOT Extension through using ArcView. This change will make the work in HDDS available to more users, and with a less software cost, since ArcView is much cheaper than Arc/Info, and it is also easier for use, especially in a PC platform. The details of the TxDOT Hydrology Extension are discussed in the Chapter 3, 4, and 5.

As a part of the work of the research project of the System of GIS-Based Hydrologic and Hydraulic Applications for Highway Engineering, the hydrologic parameters generated in the TxDOT Hydrology Extension directly serve as input data for other parts of the system. One of the major functions of the TxDOT Hydrology Extension is to develop data processing and analysis programs which can be used to establish a linkage between the vast volume of spatial data and advanced hydrologic models in a GIS environment, through generating the hydrologic parameters mentioned above from the external spatial data. All the functions in the TxDOT Hydrology Extension are customized by using Avenue, an object-oriented language associated with ArcView. These functions for hydrologic modeling and analysis include delineating watershed and calculating its topographic parameters when the outlet is identified by a point clicked on the river basin map, determining peakflow at any selected location, calculating runoff curve number at any selected location, and calculating the average flow velocity and travel time. Grid modeling is used in the TxDOT Hydrology Extension.

A CD-ROM was prepared to install the spatial database of peakflow and the TxDOT Hydrology Extension which includes the extension file and essential testing data.