

A Partial Summary of USGS Activities Related to the FHWA and State Highway Agencies

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Introduction

Part of the mission of the U.S. Geological Survey (USGS) is to assess the quantity, quality, and trends of the Nation's water resources, to advance the understanding of natural processes related to these resources, and to provide information that will assist resource managers and policymakers in making sound decisions. The USGS has a long history of jointly funded investigations with the Federal Highway Administration (FHWA) and State highway agencies to provide data and information to address various issues related to water resources and the Nation's transportation infrastructure. These issues cover a wide spectrum and include items such as regional flow statistics, flood documentation, regional stream characteristics, bridge scour, and water-quality assessments.

The following table and text provides a partial summary of current or recently completed USGS activities related to highway issues. Table 1 organizes the current and recent activities into categories and subcategories and gives a quick overview of the USGS programs and the State and (or) Federal agencies that are helping sponsor the programs. The text following table 1 provides more detailed information on the various activities. The text initially describes activities that have been, or are being conducted on a national level and is followed by state activities listed alphabetically by State. If you should have questions regarding this information, please contact Stephen T. Benedict (benedict@usgs.gov) or Charles Berenbrock (ceberenb@usgs.gov).

Table 1. Partial summary of USGS activities related to the FHWA and State Highway Agencies

Project Type	Sponsoring Agencies/States
Regional Flow Frequency/Statistics Investigations	
- National Flood Frequency Program	USGS
- StreamStats Program/automated basin characteristics	AZ, CT, CO, DE, IL, ID, IN, KS, KY, MD, MN, MS, NJ, NM, NY, OH, OK, OR, PA, RI, SD, TN, UT, VT, WA, WI
- Investigation of rural flow-frequency	AL, AZ, DE, FL, HI, IL, IA, KS, MA, MS, NC, NM, NY, OK, OR, PA, SC, SD, TN, UT, VA, WI, WV
- Investigation of urban flow-frequency	KS
- Investigation of small watershed flow-frequency	IA, KS, ME, TX, VA
- Investigation of hydrograph timing, rainfall hyetographs, and rainfall-duration-frequency maps	TX
Bridge Scour and Sediment Transport	
- National Bridge Scour Project	
- Scour at Contracted Bridge Sites	NCHRP
- Near real time scour monitoring	AK, GA
- Data collection and analysis	AK, AL, ME, MS, MT, SC, FHWA
- Investigation of Scour in cohesive soils using the EFA	IL, SC
- Channel stability and scour assessment	AK, AZ, MO, MT, SD
- Investigation/modeling of sediment transport	TN, TX
- Investigation of bio-engineered bank protection and A-jacks scour countermeasures	OR, UT
Hydrologic and Hydraulic River Investigations	
- Investigation of bridge site hydrology and hydraulics	AL, GA, MN, MS, MO, NY, NC
- Investigation and modeling of multi-dimensional flows	NC, PA
- Flood documentation	DE, IA, MS, NV, NY, PA
Stream Characteristic Investigations	
- Regional channel characteristics/bankfull discharge	NY, OH, WV, PA, VA
- Investigation of Manning's roughness coefficients	AZ
Gages	
- Tidal gages	DE, NJ
- Crest stage gages to estimate annual peak flows	AK, GA, HI, IA, KS, LA, ME, MI, MN, MS, MO, MT, NV, NJ, NM, NY, ND, OH, SC, SD, TN, VT, VA, WV, WI
- Continuous-record discharge and stage gages	AK, FL, HI, IN, IA, LA, ME, MD, MI, MN, MS, MO, MT, NH, ND, PA, SC, TN, VT, WV
- Real time monitoring network on hurricane evacuation routes; monitors stage, rain, wind, and traffic count	LA
Water Quality/Environmental Investigations	
- Evaluation of Stormwater Runoff Models	FHWA, MA
- Monitor water quality/quantity at selected sites	HI, MA, MN, MT, NV, TN, VT, WI
- Investigation of wetland impact/remediation	DE, MT, PA
- Investigation of stream restoration	MD
- Investigation of the impact of deicing chemicals	VT
- Investigation of habit impact by bridge pier	PA
- Investigation of BMP	SC, WI

Partial Summary of USGS National Activities

Scour at Contracted Bridge Sites (NCHRP and University of Louisville)

The objective of NCHRP Project 24-14 was to collect field data from which processes affecting scour magnitude in contracted bridge openings could be identified, to support verification of physical and numerical model studies, and to improve guidelines for applying scour-prediction methods at contracted bridge sites. Detailed data were collected at 15 bridge sites and predicted scour based on one- and two-dimensional flow models were compared to measured scour. Results of this investigation are documented in report cited below and will be posted as an NCHRP web document in January 2006:

Wagner, C.R., Mueller, D.S., Parola, A. C., Hagerty, D. J., and S.T. Benedict, 2006, NCHRP Project 24-14 Scour at Contracted Bridges: Transportation Research Board, National Research Council, Washington D.C. [p. 288]. On-line at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w83.pdf

National Streamflow Information Program (NSIP)

NSIP—a USGS network effort to identify and fund only with Federal dollars those long-term streamgages that address Federal interests and to upgrade streamgaging technology—faired well in the President's 2007 proposed budget. An increase of nearly \$2M was slated for NSIP with the idea of expanding the network, speed implementation of StreamStats, and help pilot a hazards warning system for flood and debris flows. However, that increase is now in doubt (as of this writing) following the action of Congress to fund the government in 2007 with a continuing resolution. The NSIP program description and list of proposed NSIP streamgages is on-line at <http://water.usgs.gov/nsip/>.

The National Water-Quality Monitoring Network

Another network effort is now taking form in response to recommendations of the Presidents Commission on Ocean Policy and the President's Ocean Action Plan. This is a coordinated effort led by the National Ocean and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), and the USGS working through the National Water Quality Monitoring Council (NWQMC) to develop an integrated system of long-term streamgages, water-quality and ecological monitoring sites with standardized monitoring techniques, parameters, and data-dissemination portals. The network will link elements of Federal, State, and local monitoring networks to reduce duplication and strengthen coverage. The network design will focus on water and ecological issues affecting coastal waters and ocean environments. Pilot projects are anticipated in FY2008. The NWQMC report describing the network is available at <http://acwi.gov/monitoring/network/index.html>.

Flood-Frequency Analysis Using Bulletin 17B Guidelines

Flood-frequency analysis provides information about the magnitude and frequency of selected flood discharges. Bulletin 17B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (1982) defines procedures recommended to provide a consistent approach for determining flood-flow frequency from peak-flow records. The procedures include methods for improving skew estimates using regional skew information, tests for high and low outliers, adjustments for low outliers and zero flows, and methods for incorporating historic peak-flow information. The Peak flow FreQuency analysis program (PeakFQ) implements the Bulletin 17B recommended procedures for flood-frequency analysis of streamflow records. The program has been updated and now provides an interactive Windows interface to PeakFQ. Also the program can be run from a batch-style processing on DOS, UNIX and Linux operating systems. The PeakFQ program is available at <http://water.usgs.gov/software/peakfq.html> and documentation is available at <http://pubs.usgs.gov/tm/2006/tm4b4/>. PeakFQ is being currently modified to include the Expected Moments Algorithm (EMA). EMA is a highly efficient approach for capturing the information contained in historical flood data, particularly paleoflood data. EMA provides a way to incorporate historical information, paleoflood

information, truncated data sets, censored data, low and (or) high outliers, and zero flows into flood-frequency analysis.

National Streamflow Statistics

The National Streamflow Statistics (NSS) Program is a Windows-based computer program created by the USGS to provide an easily accessible graphical user interface to estimate high and low streamflow statistics for ungaged sites across the United States. NSS is a replacement for the National Flood Frequency (NFF) Program. The name change from NFF to NSS resulted from enhancements to the program which now provide estimates for many other types of streamflow statistics and not just flood-frequency estimates such as the 100-year flood. The NSS program has four components—a user interface, an equation calculation routine, a database, and a help feature. The user interface allows users to control the operation of the software and present results. The equation calculation routine computes streamflow statistics using basin and climatic characteristics entered by the user and provides tabling and graphing capabilities. The database contains all the information needed, such as the regression coefficients and standard errors, to solve more than 2,000 regression equations. The help facility contains the NSS Program User's manual, a link to the NSS program Web page, and version information. The NSS Program was written in Visual Basic programming language.

The NSS program and documentation can be downloaded from the Internet at <http://water.usgs.gov/software/nss.html>. A report describing the NSS program and user's manual is in review and will be published in 2007. Regression equations for estimating flood-frequency statistics are available for every state including the Commonwealth of Puerto Rico and the island of Tutuilla, American Samoa. Regression equations for estimating other streamflow statistics such as low-flow duration and (or) frequency are also currently available in NSS for less than half of the United States. All equations contained in NSS were compiled from USGS reports that were generally prepared in cooperation with departments of transportation in each state.

StreamStats Program

The USGS Office of Surface Water (OSW) has partnered with ESRI, Inc. to develop a prototype Web application named StreamStats that greatly reduces the time needed to estimate streamflow statistics for ungaged sites and to make published streamflow statistics for USGS data-collection stations easily accessible. A prototype version of StreamStats is now available for review on the Web at <http://streamstats.usgs.gov> for Colorado, Idaho, Oregon, Vermont, and Washington. Basin delineation and estimation of basin characteristics are only available for Pennsylvania. The StreamStats prototype incorporates (1) a map-based user interface for site selection, (2) a GIS program that determines boundaries of the drainage basins for ungaged sites, measures the physical characteristics of the drainage basins, and solves regression equations to estimate streamflow statistics for the sites, and (3) a GIS database needed to display maps and determine the physical characteristics of the drainage basins. In addition, a database that provides streamflow statistics and other information for data-collection stations will be available by the end of 2004. Work is underway to complete implementation for Pennsylvania. Also StreamStats is being implemented in Connecticut, Rhode Island, Maryland, Delaware, Kentucky, Tennessee, Mississippi, Utah, Indiana, Minnesota, New Jersey, New York, South Dakota, Oklahoma, Virginia and Washington. Several enhancements to the program are planned. The USGS encourages review of the prototype application, and requests comments be sent GS-W StreamStats@usgs.gov.

Evaluation and Update of the Federal Highway Administration (FHWA) Pollutant Loadings Model for Highway Stormwater Runoff

Valid, current, and technically defensible stormwater runoff models are needed to (1) interpret data collected by field studies, (2) support existing highway and urban runoff planning processes, (3) meet National Pollutant Discharge Elimination System (NPDES) requirements, and (4) provide methods for calculation of

Total Maximum Daily Loads (TMDLs) in a systematic and economic manner. The FHWA formulated a model to predict pollutant loadings and impacts from highway stormwater runoff in 1990. Unfortunately, the 1990 FHWA model has several limitations that affect the use of the model; defensibility and representativeness of model results, and documentation of model results. The 1990 FHWA model was written for the DOS operating system, and does not always work on more recent (Windows 2000/XP) operating systems. The model was based on data collected from the mid 1970's through the mid 1980's. Changes in materials used to build roads and vehicles, the advent of vehicular emission controls, and changes in the formulation of fuels and lubricants have substantially changed the composition of runoff in the last 20 years. Research also indicates that water-quality monitoring methods may substantially effect measurements of concentrations, flows, and the resultant calculation of runoff loads.

The 1990 FHWA model was framed as a dilution model with the assumption that background concentrations were zero. This approach was chosen to examine the effects of highway runoff on receiving waters and to highlight the potential effects of best management practices (BMPs) on receiving waters. Currently (2006), however, regulators and decision makers will not accept a model with a background concentration of zero, and regulators are focusing on concentrations at low-flows such as the 7Q10 or 4B3, which are included in state and federal water-quality standards. This study will evaluate the 1990 FHWA model and update the model using new information and data. More specifically, the study will implement a Monte Carlo model in a new software platform as a prototype for a new national model, update the existing model with more recent streamflow and water-quality information, and expand the model to address regulatory concerns. This model will provide a "best estimate" (mean or median) and confidence intervals for expected EMCs. The model also will utilize this EMC estimate and estimates of precipitation, and runoff coefficients to produce a population of estimates for loads based on the location and site characteristics of highway sites of interest.

Standard tools and techniques for obtaining and processing information and data about highway runoff quality and quantity and the quality and quantity of upstream flow in the receiving waters were needed to support this new national FHWA model. The USGS in cooperation with the FHWA has developed and tested a highway runoff database as well as computer applications that can be used to automatically download and process water-quality and streamflow data from the USGS National Water Information System (NWIS) Web. The following is a brief summary of each product and its current status:

- **Highway-Runoff Database (HRDB v. 1.0): A Data Warehouse and Preprocessor for the Stochastic Empirical Loading and Dilution Model.**

Status: In Second Stage of Technical Review

The highway-runoff database application was developed to serve as a data warehouse for highway-runoff data-sets that can be used to facilitate estimation of statistical properties of runoff coefficients, runoff-quality statistics, and relations between water-quality variables in highway runoff. This highway runoff database currently includes over 39,000 event mean concentration values from analysis of more than 100 different water-quality constituents. These EMC values were collected at 100 highway-runoff monitoring sites in the conterminous United States during more than 2,600 storm events as documented in 6 highway-runoff quality data sets. The user may select and export water-quality data in tab-delimited or comma-delimited format. The user may generate water-quality statistics for data with censored values by use of the robust Regression on Order Statistics (ROS) method. The user may export paired water-quality data in a format suitable for regression analysis. Finally, the user may export precipitation, runoff flow, and runoff coefficient data in tab-delimited format. In each case the user may select data from different sites and different data sets based on highway-runoff monitoring site characteristics.

- **Kendall-Theil Robust Line (KTRLine--version 1.0)--A Visual Basic Program for Calculating and Graphing Robust-Nonparametric Estimates of Linear-Regression Coefficients Between Two Continuous-Variables.**

Status: Report Published

The Kendall-Theil robust line program was developed because this nonparametric method is resistant to the effects of outliers and nonnormality in residuals that commonly characterize water-quality data sets. A single-segment model or a multi-segment model may be specified. The program was developed to provide regression equations with an error component for stochastic data generation because nonparametric multi-segment regression tools are not available with the software that is commonly used to develop regression models. The report is available from <http://pubs.usgs.gov/tm/2006/tm4a7/>. Also a Visual Basic Program for calculating and graphing robust nonparametric estimates of linear-regression coefficients between two continuous variables is available from the report's Web site.

- **Methods for Compilation and Interpretation of Data for Development of Transport Curves for Planning-Level Estimates of Water-Quality at Unmonitored Sites in the Conterminous United States.**

Status: In Second Stage of Technical Review

This report documents methods for data compilation and analysis of water-quality-transport curves that meet data-quality-objectives for planning-level estimates of stream water-quality at unmonitored sites in the 84 U.S. EPA ecoregions in the conterminous U.S. Transport curves are regression relations used to estimate constituent concentrations from measured or estimated water discharge values. This national synthesis effort was based on data available on the USGS National Water Information System (NWIS) Web. A total of 24,581 surface-water-quality monitoring stations with drainage areas ranging from 0.002 to 1,040 square miles were identified throughout the conterminous U.S. and cataloged for retrieval of water-quality data. A total of 252 regional transport curves were developed for suspended sediment, total phosphorus, and total hardness. Four computer applications were developed to download, process, and build a database of about 1.2 million paired streamflow and water quality measurements for 14 water-quality constituents commonly measured in runoff studies. The user may utilize the regional regression models, or develop their own regional, local, or site-specific estimates with these data and methods.

- **Methods for Compilation and Interpretation of Data for Development of Transport Curves for Planning-Level Estimates of Streamflow at Unmonitored Sites in the Conterminous United States.**

Status: In Preparation

This report documents methods for data compilation and analysis of streamflow statistics that meet data-quality-objectives for planning-level estimates of streamflow at unmonitored sites in the 84 U.S. EPA ecoregions in the conterminous United States. This national synthesis effort was based on data available on the USGS National Water Information System (NWIS) Web. Streamflow statistics are available in a database for 2,783 USGS streamflow-gaging stations within the conterminous United States that were selected because they have at least 24 years of daily discharge records during the period 1961-2004 and drainage areas ranging from 10-500 square miles. The streamflow statistics were calculated using standard methods. Four computer applications were developed to download, process, and build a database of summary statistics for USGS streamflow-gaging stations that may be used to estimate a population of streamflows by ecoregion or by using selected gaging stations. The user may choose regional statistics, or develop their own regional, local, or site-specific estimates with these data and methods.

- **Stochastic Empirical Loading and Dilution Model.**

Status: In Preparation

The stochastic empirical loading and dilution model is designed to use Monte Carlo methods to provide information on the probability distributions of: (1) precipitation characteristics, (2) highway-runoff volumes, (3) highway-runoff concentrations, (4) upstream flow, (5) upstream receiving-water concentrations, and (6) structural best management practice performance. This information will be used to: estimate the probability distributions of (7) concentrations and (8) loads in receiving waters downstream of the highway outfall. These estimates will provide the information necessary to estimate the probability of exceeding a water-quality standard. The stochastic empirical loading and dilution model is designed as a database application that will facilitate generation of local or regional planning-level estimates based on site-specific characteristics.

- **FHWA/USGS NDAMS web page (<http://ma.water.usgs.gov/fhwa/>)**

Status: On-line and active.

We have maintained the FHWA/USGS NDAMS web page (which receives about 130,000 visits per year) since 1996. In 2005 the Stochastic Empirical Loading and Dilution Model WEB page was developed. The Web page posts the 1990 FHWA model, documentation (which was scanned into PDF format), and data on-line.

Partial Summary of USGS Water Science Center Activities Supported by State Highway Agencies

Alabama

- Performed hydrologic, hydraulic, and scour analyses at selected bridge sites for the Alabama DOT.
- Currently updating the statewide flood-frequency equations for the Alabama DOT.
- Clear-water pier and contraction scour envelope curves—In January 2006, the USGS and the Alabama DOT began a cooperative program to investigate clear-water pier, contraction, and abutment scour in the Black Prairie Region of the Coastal Plain of Alabama. The purpose and objectives of this project will be to:
 - Gather field data to describe observed clear-water pier, contraction and abutment-scour depths at 25 bridges in the Black Prairie Region of the Coastal Plain Physiographic Province of Alabama.
 - Compare theoretical clear-water pier, contraction and abutment-scour depths with observed scour depths.
 - Describe various relations within geometric field data and hydraulic properties that may help explain scour.
 - Develop simple tools for assessing clear-water pier, contraction and abutment scour at bridges in the Black Prairie Region of the Coastal Plain of Alabama.

Alaska

- The Alaska Science Center, Water Resources Office, operates 50 partial record stations (crest-stage gages), and 15 flood hydrograph (seasonal or perennial continuous stream gages) in cooperation with the Alaska Department of Transportation and Public Facilities (ADOT&PF). These gages are primarily designed to collect peak streamflow from small basins to enhance the ability to predict magnitude and frequency of flooding in vast regions of the state that are sparsely monitored and where little hydrologic information exists for design of roads, bridges, and other streamside structures.
- Auxiliary flood-data during August flooding in the Matanuska-Susitna Borough (see <http://ak.water.usgs.gov/flow/2006August/>) was collected in cooperation with ADOT&PF. Two major highway bridges, dozens of local roads, and over 150 structures were damaged, resulting in over \$8 million in damages from floods having estimated recurrence intervals of 50 to over 100 years.
- An additional program with ADOT&PF that focuses on streambed scour monitoring and modeling had these accomplishments in 2006:
 - Monitored near real time pier scour at 17 sites around Alaska with pier-mounted sonars.
 - Surveyed channel crossings at 41 scour-critical bridges.
 - Published: Conaway, J.S., 2006, Temporal variations of scour and fill processes at selected bridge sites in Alaska, in Proceedings of the Eighth Federal Interagency Sedimentation Conference, April 2-6, 2006, Reno, Nevada, 8 p.
 - Alaska streambed scour website: http://ak.water.usgs.gov/usgs_scour/
- Finally, another study with ADOT&PF examines the geomorphology and river dynamics of the lower Copper River. Primary data activities included:
 - Three bridges that pass most of the flow of the Copper River (Bridges 339, 340, and 342) were instrumented to monitor scour on a continuous basis.
 - Channel bathymetry was collected using a multi-beam system integrated with GPS RTK (Real Time Kinematic) equipment. Bathymetry and LIDAR data (collected in 2005) were then integrated for input to flow models.
 - Began testing two flow models: Finite element surface water model system (FESWMS) and the Multi-Dimensional Surface Water Modeling System (MD_SWMS).
 - Obtained aerial photography after the 2007 October flood (estimated 50 to 100 year recurrence interval) to document channel changes.

Arizona

- Currently engaged in a small channel morphology/bridge scour program with Maricopa County.

- In planning stages of a multi-year project for upgrading a portion of the State's flood-frequency equations and implementing StreamStats.
- Development of new guidelines for estimating Manning's roughness coefficient, and vegetation maintenance plan guidelines for vegetated urban channels in Maricopa County. This project has been completed and a report published. Phillips, J.V. and Tadayon, Saeid, Selection of Manning's Roughness Coefficient for Natural and Constructed Vegetated and Non-Vegetated Channels, and Vegetation Maintenance Plan Guidelines for Vegetated Channels in Central Arizona: U.S. Geological Survey Scientific Investigations Report 2006-5108, 49 p. (November 2006) (<http://pubs.usgs.gov/sir/2006/5108/>)

Arkansas

- A 3-year study that began in 2006 is underway in cooperation with Arkansas State Highway and Transportation Department (AHTD). The study is located at Springs National Park in central Arkansas. AHTD and the National Park Service have concerns that the blasting of the hills to make a road in the park might cause cracks deep within the earth that will affect the flow system of the Hot Springs.

California

- No highway related projects at this time.

Colorado

- No highway related projects at this time.

Connecticut

- In process of implementing StreamStats; Mapping Division completed in 2004 the centerline hydrography data layer with stream and watershed attributes.

Delaware

- Monitoring a remediated wetland created by DeIDOT in a former borrow pit, along with an adjacent natural wetland. Monthly water level and rainfall data are reported to DeIDOT annually.
- DeIDOT partially funds two tide gages on Atlantic coastal bays.
- A 2-year study in cooperation with DeIDOT to update flood-flow frequency regression equations, and to implement StreamStats in Delaware was completed. The 100-year recurrence interval flood computed for streamgaging stations in Delaware was reduced by about 20 percent in the Coastal Plain region and by about 5 percent in the Piedmont region of Delaware, on average, compared to computations done for the previous study, published in 1996. A report that describes the study is available. Ries, K.G., III, and Dillow, J.A., 2006, Magnitude and frequency of floods on nontidal streams in Delaware: U.S. Geological Survey Scientific Investigations Report 2006-5146, 57 p. (<http://md.water.usgs.gov/publications/sir-2006-5146/index.html>)
- The StreamStats application for Delaware is on the Web at <http://water.usgs.gov/osw/streamstats/delaware.html>.
- An administrative letter was released to the Federal Emergency Management Agency to describe completed mapping of high-water marks throughout the Red Clay Creek basin in northern Delaware and indirect measurements of discharge at streamgaging stations in the basin to define water surface elevations and discharges for a new peak of record that occurred on Sept. 15, 2003, as a result of record rainfall generated by remnants of Hurricane Henri.

District of Columbia

- No highway related projects at this time.

Florida

- Completed working on a 10-year cooperative program with the Florida State Department of Transportation that began in 1996. The goal of this program was to determine annual peak stages and discharges for 30 small basin sites in northern Florida. The anticipated climax of this program will be an update of the flood frequencies for all Florida gages, probably in the 2007 program.

Georgia

- Ongoing statewide flood and bridge-site studies at sites selected by GADOT. Open-File Reports published as needed.
- Maintain a statewide network of 50 crest-stage gages as part of ongoing flood-frequency study.
- Continue bridge scour research project. The overall investigation combines the field monitoring data of bridge scour with physical modeling in the Georgia Tech laboratory, and 3 dimensional numerical modeling also at Georgia Tech. USGS is monitoring scour at three bridges in Georgia that have been instrumented with an array of recording fathometers and Acoustic Velocity Meters on two of the bridges. The three sites transmit the scour data via satellite telemetry, and the data can be viewed near real-time via the web. This work will end in 2006. A document was published for the 2003 Georgia Water Resources Conference and can be access at <http://gwri.ce.gatech.edu/GAConf/Proceedings/Papers/2003/Gotvald.pdf>. A final report on field monitoring is in review.

Hawaii

- Operates a network of 44 crest-stage gages and one real-time continuous-record streamgage to monitor peak stages and discharges at or near highway crossings on the islands of Kauai, Molokai, Maui, and Hawaii. The peak-flow data collected at these stations adds significantly to peak-flow data collected at continuous stations and improves regional coverage of peak-flow measurements in Hawaii.
- Monitors storm-water quality and quantity from a portion of the H-3 freeway near Aiea, and receiving water bodies. Water-quality samples are collected during storms quarterly at 5 stations, and streamflow is continuously monitored with telemetry at 3 of these stations. Two of the stream stations are now collecting suspended-sediment samples for daily sediment records, and turbidity monitoring equipment has been installed. Two telemetered raingages are also operated as part of this project.
- Monitors storm-water quality and quantity from a portion of the H-1 freeway near the University of Hawaii Manoa campus. A stormwater monitoring station and raingage are now in operation.
- Updating flood-frequency estimates for ungaged streams in Hawaii.
- Preparing a report analyzing water-quality data collected during the past 6 years at stations along the H-3 freeway. The report will compare water-quality data to state water-quality standards and to results of other studies of urban and highway runoff, compare constituent loads in highway runoff to those in receiving streams, and examine relations between constituent loads and related variables such as rainfall and traffic counts.
- **Recent publications**
Presley, T.K., Jamison, M.T.J., and Young-Smith, S.T.M., 2006, Rainfall, streamflow, and water-quality data during stormwater monitoring, Halawa Stream drainage basin, Oahu, Hawaii, July 1, 2005 to June 30, 2006: U.S. Geological Survey Open-File Report 2006-1223, 27 p.

Idaho

- No highway related projects at this time.

Illinois

- Illinois StreamStats--The USGS Illinois Water Science Center (IWSC), in cooperation with Illinois Department of Transportation (IDOT), received funding through the Illinois Transportation Center to start Illinois StreamStats project in FY2006. The Illinois Department of Natural Resources-Office of Water Resources is also a cooperating partner. The peak flood discharge results returned from StreamStats will be compared to the published values (Soong and others, 2004, Estimating Flood-Peak Discharge Magnitudes and Frequencies for Rural Streams in Illinois: U.S. Geological Survey Scientific Investigations Report 2004-5103, 147 p.), and corrections applied if necessary. Project duration is 2 and half years and will end in FY2008.
- Field Verification of SRICOS-EFA for Illinois Streams--The Scour Rate In Cohesive Soils-Erosion Function Apparatus (SRICOS-EFA) Methodology outlined in the National Cooperative Highway Research Program Report 24-15, provides a potentially useful methodology for assessing scour in

cohesive sediments, but field validation data for the method are limited. The overall objective of this study is to test the SRICOS-EFA method for estimating scour depth of cohesive soils in Illinois streams. The project has started and site selection on gaged streams in coordination with IDOT District offices is underway.

Indiana

- INDOT cooperatively funds 20 continuous-record gaging stations.
- The USGS Indiana Water Science Center, Geohydrologic Studies section had a cooperative project in FY 2005 with INDOT to evaluate the use of geophysical logs to evaluate trends in ground-water quality at a former deicer storage site. Preliminary comparisons of results from electromagnetic-induction logging of polyvinyl chloride cased observation wells in 2005 with data from previous years revealed decreased formation conductivity since the start of INDOT efforts to pump saline water from the aquifer. Future plans are to collect more data and document these findings.

Iowa

- Cooperatively funds 25 continuous-record gaging stations.
- Cooperatively funds 89 crest-stage gages.
Cooperatively funds ongoing flood-profiles project to document water-surface profiles of significant flood events. Eash, D.A., 2006, Flood of May 23, 2004, in the Turkey and Maquoketa River Basins, northeast Iowa: U.S. Geological Survey Open-File Report 2006-1067, 35 p. (see <http://pubs.usgs.gov/of/2006-1067/>)
- Iowa StreamStats—A 2005-2006 investigation to develop and evaluate flood-frequency discharge estimation methods for rural, ungaged streams in Iowa with drainage areas less than 50 square miles identified several needs that, if addressed, would provide an easier implementation of the regression equations for users. First, there is a need to develop the same hydrologic regions for both small- and large-basin regression equations. Secondly, there is a need to reduce the transition zone between small- and large-basin regression equations. And lastly, there is a need to provide a Web-based application that makes it easier for users to apply the various regression equations. The Project began in 2006.

Kansas

- The Kansas Water Science Center streamflow statistics project has provided improved estimates versus the ungaged regression equations for 5427 stream segments for flood frequency and various duration flows.
- The Kansas StreamStats is on the web at <http://ks.water.usgs.gov/Kansas/studies/strmstats/>.
- Cooperatively funds 32 crest-stage gages.
- The Kansas Water Science Center continues to verify theoretical stage-discharge ratings using direct measurement of flow at Flood Alert streamgages operated by Johnson County. Once the ratings for all stations are verified, peak-flow information can be used to develop flood-frequency equations for urban sites.
- Currently, there are few active streamgages with drainage areas less than 10 mi² used to compute flood frequency. National Weather Service precipitation estimates from significant events shortly after their occurrence will be used to determine areas where indirect measurements are needed. The relation between discharges per unit area (Q/DA) will be related to the probability of the precipitation event, the season of the year, and other basin characteristics. These relations will be tested to determine flood frequency at ungaged sites for streams less than 10 mi² and if successful will improve flood frequency estimates for ungaged sites in small watersheds. Initially data collection will focus on the Topeka NWS radar area.

Kentucky

- No highway related projects at this time.

Louisiana

- Cooperative program to operate 10 continuous real-time streamflow data collection stations, 14 real-time stage stations, 21 crest-stage gages, and 14 flood-profile gages.

- Cooperative program to operate a real-time monitoring network located on hurricane evacuation routes. Presently operating 12 real-time stations monitoring water level, precipitation, wind speed and direction, and traffic count. Network used to determine when flood inundation or wind speed will close highway evacuation routes in coastal Louisiana. Network is planned to be expanded to 22 sites.

Maine

- **Abutment Scour**—The USGS is collecting abutment-scour information during low flows at 50 older bridges in Maine with vertical concrete abutments and wingwalls. The information collected at the bridges, along with hydraulic modeling, will provide the necessary data to test the computation of abutment scour predicted by several common methods against actual abutment scour.
- **Small watershed peak flows**—For 17 basins that have drainage areas of between 1 and 10 square miles, peak flows for selected recurrence intervals are being computed with the Rational Method, TR-20, Probabilistic Rational Method and statewide regression equations. Computed flows are being compared to peak flows of selected recurrence intervals at USGS streamflow gages. Actual peak flows for 9 rainfall events at 4 sites with drainage areas of less than 1 square mile are being computed by the Rational Method and TR-20, using actual rainfall data. Computed peak flows are being compared with actual peak flows at USGS crest-stage gages.
- **Small watershed data collection**—Ongoing peak-flow data collection (crest-stage gages) on 15 streams, all basins less than one square mile. Nine sites have 6 complete years of data collection; four sites have 5 complete years of data collection.
- **Continuous streamflow data collection**—Ongoing data-collection at 10 USGS streamflow gages and one tide gage.

Maryland

- MDSHA provided about 50 percent funding for 21 streamgaging stations during fiscal year 2005.
- A study is underway in cooperation with USEPA of the effects of stream restoration activities on streamflow, water quality, and ground water in a small urban watershed with a major highway in its headwaters.

Massachusetts

- Evaluated and updated the Federal Highway Administration (FHWA) pollutant loadings model for highway stormwater runoff for the continuous US (cooperator— FHWA).
- Continued assessment of stormwater discharges for state highways in Massachusetts and the development of a statewide predictive loading model (cooperator— Massachusetts Highway Department). Data was collected and analyzed in 2006. A report is planned for publication in 2008.
- Updating equations for estimating the magnitude and frequency of floods for streams in Massachusetts (cooperator— Massachusetts Highway Department). Project pending final approval.

Michigan

- The Michigan Water Science Center operates 10 continuous record streamgages and 5 crest-stage gages for the Michigan Department of Transportation.

Minnesota

- Operating a network of 77 crest-stage gages and one continuous discharge gage for flood frequency analysis. Updated data are being analyzed for a new Flood Frequency Report on Small Streams for MN. This report is planned for publication in FY 07.
- Provide hydraulic investigation support as requested, including bridge scour.
- Continued year four of a multi-year cooperative project to investigate the effects of a proposed four-lane divided highway on the water quality and hydrology of relatively pristine streams and wetlands that drain to a large lake important for fisheries and tourism. The highway expansion has been delayed due to funding cuts, so an interpretive report summarizing the data collected is underway for FY07.
- The Basin Characteristics project/Minnesota Department of Natural Resources Lakeshed Project prepares (http://www.dnr.state.mn.us/watersheds/lakeshed_project.html) hydrologically enhanced

1:24,000 Digital Elevation Model (DEM) data for use with automated basin characteristic and flood frequency ArcHydro extension. The Basin Characteristics project is updating basin characteristics for over 10,000 level 4-7 HUs in Minnesota and surrounding States.

- Stream-Slope Research: Testing automated methods of generating stream-slopes with DEMs and lidar, against the manual, semi-manual, and traditional survey methods.
- All basin characteristics data is available on-line at the Minnesota Watershed Information Project <http://gisdmnspl.cr.usgs.gov/watershed/index.htm>. This web page allows users to get basin characteristics and watershed areas for over 10,000 level 4-7 watersheds in and around Minnesota.

Mississippi

- Continue to provide streamflow records, hydrologic analyses of basins, and hydraulic analyses of the flooding potential at selected stream crossings, known as bridge-site studies. Provide Mississippi Department of Transportation (MDOT) the capability to query and view the bridge-site-study data and provide all current reports with embedded figures in MS Word.
- Continue to operate and maintain 96 crest-stage gages.
- Scour monitoring instrumentation to be installed at coastal bridge. Streambed soundings will be obtained at this and other selected bridges to document scour.
- Continue to prepare an updated version of the 1991 flood-frequency reports to include the use of GIS determined basin characteristics for development of regional flood-frequency equations and the implementation of StreamStats.

Missouri

- Operated a network of 38 crest-stage gages to be used with future flood frequency study.
- Operation and maintenance of 6 stream-gaging stations as part of the state-wide stream-gaging network.
- Hydraulic analysis at selected bridge sites.

Montana

- Bridge-scour data collection and analysis program ongoing since 1991. As part of this program, near real-time scour monitoring is being conducted at four sites.
- Small-stream peak-discharge data collection program ongoing since 1955. Currently operating over 100 crest-stage gages and 2 flood-hydrograph continuous-record streamflow gages.
- Ongoing cooperative project to investigate the hydrology of selected wetland areas affected by proposed highway projects.

Nebraska

- No highway related projects at this time.

Nevada

- Maintain a Statewide network of 24 crest-stage gages.
- USGS and Nevada Department of Transportation entered into an agreement in FY06 to compute sediment loads in the Clear Creek Drainage. This study will assess the impact of runoff from a U.S. Highway. The study is event driven where the sample collection intensifies during snowmelt and summer thunderstorms. The study is over a three period (ending in FY08) and also includes limited water-quality data collection at three sites.
- A web based flood chronology of the Carson River Basin in cooperation with the State of Nevada and FEMA is available at <http://nevada.usgs.gov/crflid/index.htm>. The web site shows frequency plots, lists of flood discharge with Return Periods or Recurrence Intervals, and digital photographs of floods in the Carson River Basin.

New Hampshire

- New Hampshire Department of Transportation (NHDOT) funds approximately one-third of New Hampshire's stream-gaging network.

- Designing and planning to implement a cooperative study with NHDOT to calculate flood frequency equations for the state and a point and click system to calculate flow statistics for streams in the state.

New Jersey

- Operate and maintain the New Jersey Tide Telemetry System, which includes 25 real-time tide gages, 31 tidal crest-stage gages, and 5 computer base stations. These gages are located on various back bays and tidal estuaries of coastal rivers. The purpose of the System is to provide real-time data for road closures and evacuations, and also to develop a long-term tide database for design purposes.
- Operate and maintain 44 crest-stage gages on small drainage basins of less than 2 square mile, and 15 older crest-stage gages under 9 square miles in drainage area. After 10-years of record have been recorded, a study to compare the gaged results with the various flood magnitude and frequency estimation methods will be initiated.

New Mexico

- The New Mexico crest-stage gage network of 100 gages will be expanded to 120 gages the next 2 years. Currently, 48 crest-stage gages with automated transducers are in operation in ephemeral streams around New Mexico. A USGS Fact Sheet FS 2005-3136, titled "Automated crest-stage gage application in ephemeral streams in New Mexico," by Scott Waltemeyer has been published.
- An updated flood-flow frequency report is planned for New Mexico in FY2007, which will include new and updated basin/climatic characteristics using the USGS National Elevation Dataset (NED) and other raster data layers. New variable average basin slope and average basin elevation are statistically significant in several regional regression equations as is revised drainage area.
- StreamStats: A U.S. Geological Survey (USGS) Web application for stream information for New Mexico has been funded by the USGS in cooperation with the New Mexico Department of Transportation for FY 2006-09. Information about the StreamStats can be found at <http://water.usgs.gov/osw/streamstats/>.

New York

- Flood investigations including bridge-site studies and localized flood-frequency analyses. Computed a contracted-opening indirect to determine the flow of Carrs Creek near the site of the Interstate Route 88 road collapse in June 2006.
- Documentation of notable floods through collection of flood information such as peak stages and discharges at discontinued gages, flood profiles along flooded streams, and indirect flood discharge measurements at miscellaneous flooded sites.
- Heavy rain during April 2005 resulted in record flooding in the Esopus Creek and Neversink River basins (Suro and Firda, 2006). Several indirect measurements were made.
- Heavy rain during June 2006 resulted in record flooding in the Delaware, Susquehanna and Mohawk River basins. This event resulted in 100- to greater than 500-year recurrence intervals in the Delaware, Susquehanna and Mohawk River basins. Several indirect measurements were made and a flood report to document this flooding is in progress.
- Characteristics for more than 500 gaged basins throughout New York have been derived using GIS techniques and coverages. These characteristics include several land use categories, meteorological parameters, and numerous morphometric variables (based on the physical shape, drainage structure, and relief of each basin and main channel) have been used in an update of flood-frequency relations for New York (Lumia, 2006). GIS datasets and software are included on a DVD in the report to allow automated calculation of flood frequency discharges.
- Maintain a statewide network of 48 crest-stage gages.
- Continue to investigate the use of GIS techniques and coverages to automate the computation of flood discharges at any unregulated site on streams in New York (STREAMSTATS).
- An effort to update a report showing the maximum known stages and discharges at nearly 1500 gaging stations in New York is in progress. Recurrence intervals will be assigned to each peak discharge, where feasible. A report should be published in 2007.

- A multi-year effort to develop regional models (curves) of bankfull discharge and hydraulic geometry for streams of New York State. Relations have been developed by hydro-physiographic region and by Rosgen stream type to help define stable reach characteristics for reference reaches used to plan natural-channel-design restoration projects. The study is collaboration between the USGS, New York City Department of Environmental Protection, Cornell, and New York State Departments of Transportation, State, and Environmental Conservation. Selected streams in about 80 percent of the State have been surveyed at this time.

- Recent Publications:

Suro, T.P. and Firda, G.D., 2006, Flood of April 2-3, 2005 in the Neversink River Basin, New York: U.S. Geological Survey Open-File Report 2006-1319, 90 p.

Suro, T.P. and Firda, G.D., 2006, Flood of April 2-3, 2005 in the Esopus River Basin, New York: U.S. Geological Survey Open-File Report 2006-xxxx, 90 p.

Mulvihill, C.I., Ernst, A.G., and Baldigo, B.P., 2005, Regionalized Equations for Bankfull Discharge and Channel Characteristics of Streams in New York State: Hydrologic Region 6 in the Southern Tier of New York: U.S. Geological Survey Scientific Investigations Report 2005-5100, 14 p., online only. (<http://ny.water.usgs.gov/pubs/wri/sir055100/sir2005-5100.pdf>)

Mulvihill, C.I., Ernst, A.G., and Baldigo, B.P., 2006, Regionalized Equations for Bankfull-Discharge and Channel Characteristics of Streams in New York State: Hydrologic Region 7 in Western New York: U.S. Geological Survey Scientific Investigations Report 2006-5075, 14 p., online only. (<http://ny.water.usgs.gov/pubs/wri/sir065075/sir2006-5075.pdf>)

Westergard, B.E., Mulvihill, C.I., Ernst, A.G., and Baldigo, B.P., 2005, Regionalized Equations for Bankfull-Discharge and Channel Characteristics of Streams in New York State – Hydrologic Region 5 in Central New York: U.S. Geological Survey Scientific Investigations Report 2004-5247, 16 p., online only. (<http://ny.water.usgs.gov/pubs/wri/sir045247/sir2004-5247.pdf>)

North Carolina

- **Updated Rural Flood Frequency Equations for North Carolina:** The USGS North Carolina Water Science Center is currently working on an updated flood-frequency study in cooperation with the North Carolina Department of Transportation (Hydraulics Unit) and North Carolina Division of Emergency Management (Floodplain Mapping Program). The previous flood-frequency study was based on peak discharges through September 1996. With 9 additional years available, peak discharges now include those that occurred during September 1999 and 2004 in two major flood events in the Coastal Plain and Blue Ridge provinces, respectively. A pilot-study aspect of this project is the collaborative effort with the USGS Water Science Centers in South Carolina and Georgia to jointly develop regional relations for estimating flood-frequency characteristics that are applicable across State boundaries. Analyses of regional relations will help to identify one or more basin and/or climatic characteristics that can be used for estimating peak discharges. Another pilot-study aspect of this project is the assistance from the USGS Office of Surface Water to explore use of a Bayesian Generalized Least Squares regression procedure to compute regional skew estimates that have greatly reduced uncertainty. Completion of analyses in this study is anticipated by end of the calendar year 2007 with publication of the report by end of September 2008. Contact Curtis Weaver (jcweaver@usgs.gov) for concerning this project.
- **Two-Dimensional and One-Dimensional Numerical Models for Bridges in North Carolina:** The main objective of the project is to develop a one-dimensional step-backwater model and two-dimensional hydrodynamic model for the Highway 13 bridge over the Tar River near Greenville, NC and compare results to field data to evaluate the ability of each model to represent field conditions. This information will help to provide an initial basis for ongoing development of modeling guidelines that will ensure cost-effective hydraulic analysis. Two high-flow hydrographic surveys (including the collection of discharge, three-dimensional velocity profiles and water-surface profile) were collected

in the study reach for model calibration and to provide a basis for model comparisons. An online Scientific Investigations Report that summarizes this phase of the project will be published in 2007. Contact Chad Wagner (cwagner@usgs.gov) concerning this project.

- **Internet Accessible Basin Characteristics Database:** In cooperation with the North Carolina Department of Transportation (NCDOT), the North Carolina Water Science Center has been developing a web-based flood frequency database. The database includes information for approximately 16,000 stream sites in North Carolina. The USGS has determined the latitude and longitude, drainage area, and other characteristics for each of these sites. The information determined by the USGS can be used by NCDOT engineers to derive flood frequency estimates which can be used by highway engineers to help design new or replacement bridges and culverts. When completed in 2006, this flood frequency database will be served on the USGS North Carolina web page. Contact Doug Smith (dgsmith@usgs.gov) concerning this project.
- **Publications:** Wagner, C.R. and others, 2006, Scour at Contracted Bridges, National Cooperative Highway Research Program (Project 24-14), Transportation Research Board, 299 pp. available at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w83.pdf
- In cooperation with the North Carolina Department of Transportation (NCDOT), the North Carolina Water Science Center has been developing a web-based flood frequency database. The database includes information for approximately 16,000 stream sites in North Carolina. The USGS has determined the latitude and longitude, drainage area, and other characteristics for each of these sites. The information determined by the USGS can be used by NCDOT engineers to derive flood frequency estimates which can be used by highway engineers to help design new or replacement bridges and culverts. When completed, this flood frequency database will be served on the USGS North Carolina web page.
- Maintain flood-frequency estimates and information on the Web and is available at <http://nc.water.usgs.gov/floodstats/gaged/index.html>. The project focused on developing a GIS and Microsoft ACCESS database for 15,000 bridge crossings that will include latitude and longitude, station number, drainage area, and a digital image of selected USGS data available at those sites.

North Dakota

- Operated 33 gages in a crest-stage gage program. At one gage site (a double barrel culvert), a low profile acoustic Doppler was installed in each culvert to better define stage-discharge relations. Also a stage recorder and a rain gage were installed to better understand the characteristics of the basin. A thunderstorm in August 2006 produced enough runoff to develop an excellent rating for the site for discharges ranging from 0 ft³/s to about 50ft³/s.
- Operated a stage-discharge station to define flows into a closed lake basin.

Ohio

- A network of 18 crest-stage gages was operated in cooperation with the Ohio DOT and the Ohio Department of Natural Resources. The crest-stage gage data will be used to augment existing flood-frequency information available for Ohio.
- A final report was published for a study to develop curves and equations for estimating bankfull depths and widths of natural streams in Ohio. The reference for the report is: Sherwood, J.M. and Huitger, C.A., 2005, Bankfull Characteristics of Ohio Streams and their Relation to Peak Streamflows: U.S. Geological Survey Scientific Investigations Report 2005-5153, 52 p. (<http://pubs.usgs.gov/sir/2005/5153/>)
- A StreamStats application is being developed for Ohio. It is anticipated that Ohio's StreamStats application will be available in January 2007. A report will be published describing the development of the Ohio application and providing revised regional regression equations for peak flows.

Oklahoma

- StreamStats is being developing for Oklahoma to:
 - Automatically measure basin and climatic characteristics for ungaged sites using GIS;

- Provide published streamflow statistics, basin and climatic characteristics, and other information for data-collection stations contained in published streamflow statistics reports.
- Provide estimates of flood-frequency statistics, basin and climatic characteristics, and other information for user-selected points on ungaged streams; and
- Link to USGS NWIS on line data.
- This work began in July 2005 and will be completed June 2009.

Oregon

- Initiated a project for estimation of streamflow characteristics using regression equations, including flow duration and low-flow, at ungaged sites for the entire state of Oregon. These coverages and equations will be implemented into Oregon StreamStats.
- Currently investigating existing bio-engineered sites at four gaging stations in Oregon to document how bio-engineered bank protection performs over a range of hydraulic conditions. The stage, discharge, and velocity information, combined with the covering, design and construction of the bio-engineered bank protection installations will assist in evaluating and improving current design procedures.

Pennsylvania

- StreamStats: The current application of StreamStats for Pennsylvania (<http://water.usgs.gov/osw/streamstats/pennsylvania.html>) only calculates basin characteristics. The ability to calculate low flow at ungaged sites will be added to StreamStats in 2007.
- Low-flow frequency streamflow statistics were updated, and regression equations were developed for ungaged areas. A report describing this work is available. Stuckey, M. H., 2006, Low-flow, base-flow, and mean-flow regression equations for Pennsylvania streams: U.S. Geological Survey Scientific Investigations Report 2006-5130, 84 p. (<http://pubs.usgs.gov/sir/2006/5130/>)
- Update of flood-flow frequency streamflow statistics and development of statewide regression equations for ungaged areas. A report will be made available and equations will be implemented in StreamStats in 2008.
- Continuous radar is being used to collect water velocities at the surface at the Susquehanna River at Bloomsburg (01538700) gaging station. This instrument is ideal especially during unsteady flow events such as those created by debris and ice jams and will help to provide real-time streamflow estimates throughout the year without the need for a series of flow measurements.
- Investigation and modeling of velocity and streambed configuration in relation to mussel habitat and bridge-pier design in the Allegheny River at Foxburg, Pa.
- Flood documentation/floodplain mapping for Larrys Creek and Rattling Camp Run.
- Hydraulic analyses and floodplain delineations for the 10, 2, 1, and 0.2 percent probability flood elevations for Cocalico Creek and Conestoga River.
- A karst terrain underlying a major transportation corridor in northeastern Pennsylvania has been investigated and report is available. Risser, D. W., 2006, Simulated water budgets and ground-water/surface-water interactions in Bushkill and parts of Monocacy Creek watersheds, Northampton County, Pennsylvania--A preliminary study with identification of data needs: U.S. Geological Survey Open-File Report 2006-1143, 31 p. (<http://pubs.usgs.gov/of/2006/1143/>)
- Completion of regression equations for bankfull discharge based on channel characteristics has been developed and report is available. Chaplin, J. J., 2005, Development of regional curves relating bankfull-channel geometry and discharge to drainage area for streams in Pennsylvania and selected areas of Maryland: U.S. Geological Survey Scientific Investigations Report 2005-5147, 34 p. (<http://pubs.usgs.gov/sir/2005/5147/>)
- Biological investigations—Distribution, density, and viability of native freshwater mussel populations in the free-flowing Allegheny River (BRD project).
- Investigation of wetland and riparian mitigation projects:
 - Saucon Creek Highway Encroachment—Completed and report is available. Chaplin, J. J., White, K. E., and Loper, C. A., 2006, Physical and vegetative characteristics of a relocated stream reach, constructed wetland, and riparian buffer, Upper Saucon Township, Lehigh County, Pennsylvania, 2000–04: U.S. Geological Survey Scientific Investigations Report 2006-5042, 65 p. (<http://pubs.usgs.gov/sir/2006/5042/>)

- Valley Creek Highway Encroachment—Monitoring a wetland compensation site, stream bank stabilization features in a reach through Valley Forge National Historical Park, and a riparian buffer adjacent to the stream.
- Investigation of in-stream habitat near bridge piers:
 - Effect of relocation and disturbance from bridge construction on survival and recolonization of freshwater mussels in the Allegheny River at West Hickory, Pa. (BRD project).
 - Relocation of native freshwater bivalves: evaluation of survival, movement, and recruitment in the Allegheny River at Kennerdell, Pa. (BRD project).

Puerto Rico

- No highway related projects at this time.

Rhode Island

- No highway related projects at this time.

South Carolina

- Operates 6 continuous-record gaging stations and 52 partial-record crest-stage stations. (Number of gaging stations fluctuates slightly from year to year.)
- **Live-bed pier and contraction scour envelope curves**

In October 2005, the USGS and SCDOT began a cooperative program to investigate live-bed pier and contraction scour in the Piedmont and Coastal Plain of South Carolina. A primary objective of this investigation is to develop field-derived envelope curves for live-bed pier and contraction scour in the Piedmont and Coastal Plain. The live-bed scour envelope curves combined with the previously developed clear-water scour envelope curves will allow an evaluation of all scour components at bridges in these regions without sole reliance on theoretical equations derived from laboratory investigations.

The purpose and objectives of this project include (1) the documentation of historic occurrences of live-bed pier scour and contraction scour at approximately 80 bridges in the Piedmont and Coastal Plain of South Carolina using ground penetrating radar; focus will be given to old bridges and bridges that have had large floods; (2) a comparison of observed scour with predicted scour in order to assess the scour prediction methods of HEC-18; (3) the investigation of various physical relations that may help explain live-bed scour processes in South Carolina, and (4) if possible, the development of envelope curves for evaluating the potential for live-bed pier and contraction scour in South Carolina. Data have been collected at 66 bridges, and hydraulic models and scour analysis are being made at these sites. Data collection and analysis for the remaining sites will take place in FY07.

- **Calibration of clear-water abutment scour equations using field data**

Research conducted by the U.S. Geological Survey (USGS) in cooperation with the Federal Highway Administration and the Maryland State Highway Administration has identified the critical velocity variable as a primary source of error for selected clear-water abutment scour equations. Preliminary results indicate that performance of these equations could significantly improve if a better method for estimating this variable was used. A literature review indicated that current practice for estimating critical velocity is poorly defined, has limited field verification, and is unlikely to see improvement in the near future. Therefore, a direct way to develop a method for estimating critical velocity that will lead to improved scour prediction equations is not readily available. However, it is possible to indirectly evaluate critical velocity and in turn improve the scour prediction equations by calibrating the equations with field data. To accomplish the calibration, the clear-water abutment scour equations are used to back-calculate the critical velocity required to force the equation to match measured scour. These back-calculated critical velocities can then be used to develop an improved method for estimating critical velocity. Field data from South Carolina and the USGS National Bridge Scour Database, including 224 measurements of abutment scour, will be used in the calibration and validation analysis. Preliminary results indicate that the calibration will significantly improve the

performance of the clear-water abutment-scour equations. Additionally, the results suggest that better performance for other bridge-scour equations can be achieved by using a similar procedure.

- **Rural flood frequency investigation**

The USGS in cooperation with the SCDOT began a rural flood frequency investigation in 2006. The objectives of this investigation are to update the magnitude and frequencies of peak streamflows of unregulated and regulated streams in South Carolina, when adequate data are available. The South Carolina Water Science Center will coordinate with the Georgia and North Carolina Water Science Centers to establish consistent physiographic regions at the state boundaries and will also seek to establish consistent explanatory variables and (or) regional equations at the state boundaries. The project will result in updated regional rural-flood-frequency equations for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals.

- **Performance of four best management practices for highway runoff**

In June 2004, the U.S. Geological Survey and the SCDOT began a cooperative investigation to collect water-quality data to be used to assess the performance of four Best Management Practices (BMP) for highway runoff in Beaufort and Colleton Counties. This investigation has four objectives: (1) determine event-mean concentrations, (2) calculate loads entering and leaving the BMPs, (3) estimate the removal efficiency of the commercially available BMPs for selected constituents such as suspended sediment, metals, oil and grease, and fecal indicator bacteria in roadway runoff, and (4) evaluate the relation between water-quality constituent concentrations and loads to average daily traffic data by correlation analysis. To reduce uncertainty in the removal efficiency estimation and average daily traffic correlation evaluation, a data set of 12 to 15 sampling events will be used.

- **Published Reports**

Benedict, S.T., and Caldwell, A.W., 2006, Development and evaluation of clear-water pier and contraction scour envelope curves in the Coastal Plain and Piedmont Provinces of South Carolina: U.S. Geological Survey Scientific Investigations Report 2005-5289. (<http://pubs.usgs.gov/sir/2005/5289/>)

Benedict, S.T., Deshpande, N., Aziz, N.M., and Conrads, P.A., 2006, Trends of abutment-scour prediction equations applied to 144 field sites in South Carolina: U.S. Geological Survey, Open-File Report 03-295. (<http://pubs.usgs.gov/of/2003/ofr03-295/>)

South Dakota

- Operate a network of 48 crest-stage gages for the purpose of peak flow analysis
- Work is continuing on updating peak-flow frequency estimates for gaged streams in the state. Analyses for most stations have been completed and results are under review by DOT staff. A joint-probability approach is being utilized to resolve complexities in the Black Hills area associated with high outliers for many sites that resulted from a particularly large storm in 1972.
- Work is continuing on a multi-year study initiated in 2003 to evaluate scour potential at bridges on primary highways using a combination of Level 1.5 and Level 2 analyses. Level 1.5 analyses have been completed for most of the primary bridges in the state. Efforts during 2006 shifted primarily to performing Level 2 analyses at selected sites, with a focus on sites where Level 1.5 results indicate potentially scour-critical conditions may occur. A report summarizing the study results is planned for 2007.
- Implementation of StreamStats in South Dakota was initiated in 2005 and will continue through 2008. An important initial activity has been formation of a statewide steering committee that will help guide decisions regarding utilization of existing geospatial information, and possible procurement of additional, relevant geospatial information.
- A reconnaissance study has been initiated to evaluate the potential of using paleoflood hydrology techniques to improve flood-frequency estimates for the Black Hills area through extension and extrapolation of existing peak-flow records. The initial phase is focusing on evaluating the utility of paleoflood surveys for estimating magnitudes and ages of historical peak-flow events. Implementation of subsequent phases would include more detailed application of field surveys and performing appropriate analytical procedures for developing flood-frequency relations.

Tennessee

- Providing hydraulic interpretative support and miscellaneous flood-measurement support to Tennessee Department of Transportation (TDOT) as needed.
- Operating an ongoing network of 40+ crest-stage gages at or near highway crossings and operating another 15 stage-discharge gages across the state for the purpose of flood-frequency analysis and general resource evaluation.
- Routinely updating basin characteristics files and statewide flood-frequency equations for ungaged streams in Tennessee. Our most recent update was based on the region-of-influence statistical model and was completed in FY 2003.
- Continuously monitoring turbidity and relating turbidity to sediment concentrations on a stream in West Tennessee. This was initiated in FY2004.
- Large-scale study of the effects of highway construction on stream ecology throughout Tennessee—looking specifically at sediment export from disturbed areas, the efficiency of sediment control structures (EPSCs) at construction sites, sediment transport processes, the effects of sediment on downstream habitat and biotic communities, and improved methods for monitoring sediment-related effects. This work began in FY2004 and should continue through FY2012.
- Building GIS coverages and developing necessary analytical protocols to adapt Streamstats for application in Tennessee. This work began in January of FY2004 and will be completed in 2006.

Texas

- **Bed mobility in Edwards Plateau, Central Texas (FY06-07): ON-GOING**
The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project funded by the Texas Department of Transportation to investigate gravel transport phenomena within the Plateau. Gravel transport within high gradient streams is contributing to recurring infrastructure damage in the study area. The Department hopes that the research will contribute to enhanced design guidance on bridges and low-water crossings. The primary USGS focus will be on spatial documentation of gravel transport through imagery and field investigations. Contact Frank T. Heitmuller (ftheitmu@usgs.gov) for further information.
- **Storm statistics for Texas (FY05-06): ON-GOING**
The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project extended from the completed hyetograph project to document the distribution of storm depth, storm duration, and storm arrival rates throughout eastern New Mexico, Oklahoma, and Texas for selected values of minimum inter-event time ranging from 6 to 72 hours. A total of 774 National Weather Service hourly rainfall stations having 155 million values of data were processed. Contact William H. Asquith (wasquith@usgs.gov) for further information.

Asquith, W.H., Roussel, M.C., Cleveland, T.G., Xing, Fang, and Thompson, D.B., 2006, Statistical Characteristics of Storm Interevent Time, Depth, and Duration for Eastern New Mexico, Oklahoma, and Texas: U.S. Geological Survey Professional Paper 1725, 299 p.
[\[http://pubs.usgs.gov/pp/pp1725/pdf/pp1725.pdf\]](http://pubs.usgs.gov/pp/pp1725/pdf/pp1725.pdf)
- **Unit hydrographs for Texas (FY00-07): ON-GOING**
The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University, Lamar University, and University of Houston in a project funded by the Texas Department of Transportation to investigate the timing characteristics for unit hydrographs on small to moderately sized rural and urban watersheds in Texas. Unit hydrographs for 93 watersheds in Texas have been estimated through a myriad of techniques including linear programming, instantaneous unit hydrograph, and gamma distribution fitting to peak and time to peak values. The project has been on going for many years and several publications are completed or in progress; the reports lists here are those not previously reported in this summary. The project has rainfall and runoff data for a total of 3,018 storms from 229 watersheds in Texas. This data resides in ASCII files and under version control.

Asquith, W.H., Cleveland, T.G., Xing, Fang, Thompson, D.B., 2006, Unit hydrograph estimation for applicable Texas watersheds: Texas Department of Transportation Research Report 0-4193-4, Center for Multidisciplinary Research in Transportation, Texas Tech University, 71 p. [<http://www.techmrt.ttu.edu/Research/Reports/Complete%20Reports/0-4193-4.pdf>]

Cleveland, T.G., He, Xin, Asquith, W.H., Fang, Xing, and Thompson, D.B., 2006, Instantaneous unit hydrograph selection for rainfall-runoff modeling of small watersheds in North and South Central Texas: ASCE Journal of Irrigation and Drainage, vol. 132, no. 5, pp. 479-485.

- **Small Watershed Gaging Program: (FY06-10, and three more 5-year increments)**

The Texas Department of Transportation and the USGS are in the early stages of a program consisting of about 50 crest-stage gages for flood-peak recording on small watersheds in western Texas. Ten of these gages will have autonomous stage and rainfall recording for production of rainfall and runoff data sets. Three of the gages will also be operated as continuous real-time gages. Long-term data collected at these gages will be used for flood frequency analysis.

- **Small Watershed: (FY07-08) BRAND NEW**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University and University of Houston in a project funded by the Texas Department of Transportation to investigate the influence of watershed subdivision in hydrology and hydraulic modeling exercises. This project has just started. Contact William H. Asquith (wasquith@usgs.gov) for further information.

- **Statewide Flood Frequency Analysis: (FY07-09) BRAND NEW**

The SW research group with Texas Water Science Center is engaged in a peer-to-peer research consortium with Texas Tech University in a project funded by the Texas Department of Transportation to generate alternative regional regression equations for estimation of annual peak streamflow in Texas using several "alternative" statistical tools from more traditional approaches. The team will be using L-moment statistics for primary definition of flood frequency for approximately 1,000 streamflow-gaging stations. The stations encompass both "rural" and "urban". The flood frequency will be derived from multiple distributional fits to the data. The team will be developing a large scale visualization system for the annual peak streamflow data base. The team will be redefining watershed characteristics for the study. Finally, the team will use some sort of PRESS minimization for alternative transformation (in other words, non log10) of drainage area in the regression modeling. This project has just started. A salient paper from a previous project that instigated the Flood Frequency Analysis project is listed below. Contact William H. Asquith (wasquith@usgs.gov) for further information.

Asquith, W.H., 2006, L- and TL-moments of the Generalized Lambda Distribution: Computational Statistics and Data Analysis, online since August 2006, in press queue.

Utah

- Continuation of a multi-year cooperative project with UDOT to update the National Flood Frequency equations for the state of Utah. In conjunction with this update, the USGS StreamStats program will be implemented for the state of Utah. StreamStats is a web-based GIS model user interface that allows for immediate point and click catchment delineation and regression model calculation.

- Recent Publication:

Kenney, T.A., and McKinney, T.S., 2006, Hydraulic and geomorphic monitoring of experimental bridge scour mitigation at selected bridges in Utah, 2003-05: U.S. Geological Survey Scientific Investigations Report 2006-5033, 16p. See <http://pubs.usgs.gov/sir/2006/5033/>.

Vermont

- Vermont Agency of Transportation (VTrans) is currently funding a crest-stage gage network.
- VTrans is funding two streamgaging stations (Potash Brook in South Burlington, VT and Allen Brook in Williston, VT) for continuing research of storm water management on small urban streams.

- A cooperative investigation between VTrans and the USGS began in 2005 to investigate the effects of road salting on stream quality. In FY07 a second year of monitoring chloride, sodium and calcium in 3 streams at locations upstream and downstream of state highways is being conducted.

Virginia

- Continuation of Annual Flood Peaks of Streams in Virginia--The objectives of the study are to update annual flood-peak data for these gages in preparation for a flood frequency analysis study, and to collect annual peak flow data at the 6 remaining small basin sites for future flood frequency analysis.
- Maintain and operate a network of 45 crest-stage gages to determine annual peak flows, document extreme flow events, and improve flood frequency estimates.
- Collection of stream geomorphic data in the Piedmont physiographic province at USGS streamflow-gaging stations to be used in the development of regional channel geometry curves.
- Recent Publications:
 - Hayes, D.C., and Young, R.L., 2006, Comparison of peak discharge and runoff characteristic estimates from the Rational Method to field observations for small basins in central Virginia: U.S. Geological Survey Scientific Investigations Report 2005-5254, p. 38. (http://pubs.usgs.gov/sir/2005/5254/sir05_5254.pdf)
 - Krstolic, J.L., 2006, Drainage basins for Virginia and surrounding areas: U.S. Geological Survey Digital Spatial Data Set (<http://water.usgs.gov/lookup/getspatial?OFR2006-1308>) which are digital boundaries of basins with peak flows and other basins (in press).
 - Hayes, D.C. and Wiegand, Ute, 2006, Drainage areas of selected streams in Virginia, U.S. Geological Survey Open-File Report 2006-1308, in press, which list the areas of selected peak flow basins in Virginia, methods of delineation and quality assurance (in press).

Washington

No highway related projects at his time.

West Virginia

- Operates and maintains 20 crest stage gages.
- Provides some funding for operation and maintenance of streamflow-gaging stations.
- Collection of stream geomorphic data in the Appalachian Plateaus physiographic province at USGS streamflow-gaging stations and some ungaged locations.
- Analysis of flood-frequency skew coefficients following WRC guidelines.

Wisconsin

- A network of about 90 crest-stage gages will continue to be operated in cooperation with WisDOT to provide on-going peak-flow data for flood-frequency information and analysis.
- Working on GIS determination of basin outlines for stations that cross state boundaries. Plans are to determine basin characteristics using GIS techniques.
- Currently investigating alternatives for frequency analysis and regionalization. Plans are to update thee regression equations using GIS-based basin characteristics. Revised report will be printed in FY2007.
- Currently investigating use of the StreamStats application, which allows for automated determination of basin characteristics and flood frequency analysis for ungaged sites.
- **Evaluation of Storm Water Treatment Technologies for Highway Runoff:** Comparing Structural BMPs at Milwaukee's Historic Third Ward River Walk and I-794 Freeway Test Site -The Wisconsin Department of Transportation (WisDOT) is required to improve the quality of runoff from roadways under their control as part of the National Pollution Discharge Elimination System (NPDES) and an agreement with the Wisconsin Department of Natural Resources (WDNR). In addition, future state and federal regulations will prescribe new performance standards for non-point runoff management and calculation requirements for total maximum daily loads (TMDLs) of contaminants discharging in watershed basins.

One way to improve the quality of roadway runoff, particularly in urban areas, is to use structural Best Management Practices (BMPs). There are several commercially available BMPs that could be used, but these new technologies lack field performance testing and validation, especially in Wisconsin type climates. So it is essential to field test these devices to determine their contaminant removal efficiency and practical application for WisDOT.

This study is funded by the National Cooperative Highway Research Program and is being conducted by the WisDOT in cooperation with the U.S. Geological Survey. The objective of this study will evaluate two structural BMPs to determine their removal efficiency.

Data collection and analysis is complete and a final report will be available in 2007.

- **Pollutant Loadings to Storm Water Run-Off from Highways:** The Impact of a Highway Sweeping Program-Phase II - This study is in cooperation with the National Cooperative Highway Research Program and is being conducted by the WisDOT in cooperation with the U.S. Geological Survey. The study site is located on USH 151 near IH 90/94/39, in Madison WI. The objective of this study is a continuation of a previous highway sweeping study that will evaluate the effectiveness of a highway-sweeping program as a best management practice (BMP) for reducing pollutant levels. Phase II would address the data collection and analysis issues that occurred during the Phase I study by using new technology for monitoring and calibrating flow, eliminating freeway median area, improved sample processing and change in laboratory procedures for particle size distribution.

Phase I Report

Waschbusch, R.J. 2003, Data and Method of a 1999-2000 Street Sweeping Study on an Urban Freeway in Milwaukee County, Wisconsin, U. S. Geological Survey Open file Report 03-03, 41P.

Data collection is complete and a final report on Phase II should be available in 2008.

- **Evaluation of Storm Water Treatment Technologies for Parking-lot Runoff:** The Wisconsin Department of Transportation (WisDOT) has a Cooperative Agreement with the Wisconsin Department of Natural Resources (WDNR) (November 2002), Trans401 (December 2002), and NR 216 (September 2002), that require the Department to establish a Storm water Management program to reduce Total Suspended Solid (TSS) loading from highway surfaces. The regulations require the Department evaluate and assess best management practices (BMPs). This study is made possible by a partnership with the Madison Gas and Electric Company (MG&E), United States Geological Survey (USGS), Stormwater Management Inc., and the Wisconsin Department of Natural Resources (WDNR). The site is a parking lot located in downtown Madison, WI at the MG&E facilities plant and the BMP to be evaluated is gravity filtration.

This study would complement research just completed on a filtration BMP called the StormFilter (Evaluation of Storm Water Treatment Technologies for Highway Runoff, under the direction of Wendy Braun, WDOT). The StormFilter was evaluated using runoff from Highway 794 in Milwaukee. A 45 percent reduction in TSS loads was observed for the 30 storms used for the evaluation. Before these results are applied to other highways or DOT facilities, such as park and rides, maintenance yards and rest areas, it must be determined if the findings are unique to the characteristics of the runoff from elevated freeways.

Data collection is continuing and a final report is scheduled to be available in 2008.

Wyoming

- No highway related projects at this time.