A Partial Summary of 2015 USGS Activities of Interest to the FHWA and State Highway Agencies

Todd Koenig (tkoenig@usgs.gov)

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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 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. For example, on a national scale the USGS is supporting efforts to enhance and maintain the National Streamflow Statistics Program, the StreamStats flow statistics application and delivery tool, and WaterAlert, a tool for automatic notification of threshold exceedance for stream stage, streamflow, and other water-related data collected by USGS.

On a regional scale, the USGS is conducting investigations to update Bulletin 17B skew maps, to define channel characteristics at bankfull discharge, and to document storm tide as a result of major coastal storms. Current locally focused investigations include the examination of rural, urban, and small watershed flow frequency; the documentation of extreme inland floods along with flood-frequency updates; and the development of flood inundation maps to assist with the protection of public infrastructure, such as roads and bridges, and to improve public safety.

The following table and text provide 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 Todd Koenig (tkoenig@usgs.gov).

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

Project Type	Sponsoring Agencies/States
Regional Flow Frequency/Statistics Investigations	
National Streamflow Statistics (NSS) Program	USGS
StreamStats Program/automated basin characteristics	Implemented: AK, AL, AR, CA, CO, CT, DE, GA, HI, IA, ID, IL, IN, KY, MA, MD, ME, MN, NC, NH, NJ, NM (partial area), NY, OH, OK, OR, PA, RI, SD, TN, UT, VA, VT, WA Basin Characteristics only: AK (Cook Inlet Basin only), AZ, MT, SC In progress: KS, MI, MO, MS, ND, WI, WV
Investigation of rural flow-frequency	AL, AR, CO, GU, HI, ID, KS, LA, MA, ME, MI, MN, MT, MS, NE, NM, NY, OH, OK, OR, PA, SD, TN, TX, VA, WA, WI, WV, FEMA
Investigation of urban flow-frequency	IL, SC, VA
Investigation of small watershed flow-frequency	IA, KS, LA, ME, MT, TN, TX
Non-stationarity of peak flows	ME
Updating Bulletin 17B Regional Skew Map	AK, AZ, CO, ID, IL, LA, MI, NY, OH, OR, PA, WA
Flow-duration curve estimates	MN
Bridge Scour and Sediment Transport	
FHWA scour countermeasures field investigation	AL, ID, KY, MO, NC, SC
Evaluation of abutment-scour equations	SC, NCHRP
Near real time scour monitoring	AK, CO, MS, MT, NJ
Data collection and analysis	AK, AZ, ID, KS, LA, ME, MN, MO, MS, MT, NJ, NV, SC, WA, FHWA
Channel stability and scour assessment	AK, ID, IN, MO, MS, MT, ND, NJ, SD, TN, WA
Investigation/modeling of sediment transport	ID, KS, LA, MN, ND, TN, WA
Investigation of bio-engineered bank protection and A-jacks scour countermeasures	TN
Hydrologic and Hydraulic River Investigations	
Investigation of bridge site hydrology and hydraulics	AL, IN, MN, MT, MS,
Investigation and modeling of multi-dimensional flows	AK, ID, ND, OR, PA
Flood documentation	AZ, CO, CT, IA, IN, LA, MA, MN, MT, NE, NH, NM, NY, NV, OR, PA, RI, SC, TN,
Operational flood inundation mapping	GA, ID, IL, IN, LA, MA, ME, MI, MN, MO, MS, NC, NH, NJ, NY, OR, PA, RI, VT
Manning's n verification	AZ
Flood warning system	CO
Stream Characteristic Investigations	
Regional channel characteristics/bankfull discharge	ID, NY, OR, TX, WV
Tidal Gages and Streamgages	
Tidal gages	CT, DE, FL, LA, MA, ME, NC, NJ, OR
Crest stage gages to estimate annual peak flows	AK, AL, AR, AZ, CO, FL, GA, GU, HI, IA, ID, IN, KS, LA, ME, MI, MN, MS,

	MO, MT, NV, NJ, NM, NY, OH, OR, PA, SC, SD, TN, TX, VT, VA, WI, WV

Continuous-record discharge and stage gages	AK, AZ, CO, CT, DE, GU, HI, IA, ID, IN, LA, MA, ME, MD, MI, MN, MS, MO, MT, NC, NH, NJ, OR, PA, SC, TN, TX, VT, WV
Water Quality and Environmental Investigations	
Evaluation of stormwater runoff models	MA, OR, TX, FHWA
Monitor water quality/quantity at selected sites	CT, FL, HI, ID, KS, LA, MA, ME, MI, MN, MO, MT, NC, NE, NH, NV, PA, SC, TN, UT, VT, WA, WI
Investigation of wetland impact/remediation	LA, MT
Investigation of stream restoration	ID, MT, NE, NY, TN
Investigation of the effect of deicing chemicals	NC, OR, FHWA
Investigation of BMP	MI, OH, OR, TN, WA, WI, FHWA
Investigation of potential impacts of highway culvert construction to the natural conditions of streams	AL, TN
Investigation of the potential effects of runoff from roads and bridges to receiving waters	MA, NC, SC

Partial Summary of USGS National Activities

USGS WaterAlert and WaterNow

The USGS continues to provide a very popular water-threshold exceedance notification program. The system sends email or text messages when water levels, water-quality conditions, or rainfall meet user-specified criteria at real-time USGS hydrologic data collection sites. Criteria can include greater-than, less-than, within, and out-of-range thresholds. Reporting frequencies can include once-per-day or once-per-hour alerting while the condition lasts. In 2012, the process was started to link subscribers with the USGS Flood Inundation Mapping Program Map Viewer (http://wim.usgs.gov/FIMI/) to help users select thresholds of interest. These maps, where available, along with National Weather Service E-19 flood stage information, provide locations and descriptions of local features such as roads or structures in the vicinity of streamgages and river stages that affect those features. The USGS WaterAlert system can be accessed at http://water.usgs.gov/wateralert/.

A complimentary interactive USGS query and alert feature called WaterNow has also been developed. This system allows users to query any real-time USGS hydrologic data collection site and request reports of the most recent values for any data collected at the site of interest. The query and response can be sent and received using any device with email or text message capabilities. Information about the USGS WaterNow system is available at: http://water.usgs.gov/waternow/.

National Streamflow Information Program (NSIP) and Groundwater and Streamflow Information Program (GWSIP)

In 2015, the USGS Streamflow Information Network provided streamflow information at more than 8,100 streamgages across the Nation. The USGS provides a continuous source of streamflow information that is used in countless ways by governmental organizations, private industries, and the general public.

Historically, the collection and dissemination of hydrologic information have been managed through multiple USGS programs, including in large part, the Cooperative Water Program (CWP) and the National Streamflow Information Program (NSIP). Beginning in 2016, the information is managed and funded in the Groundwater and Streamflow Information Program (GWSIP) to enhance its comprehensiveness and interdisciplinary value and more effectively represent key components of the hydrologic cycle (including surface water, groundwater, evapotranspiration, and precipitation).

One of the highest goals of the USGS is to maintain long-term stability of a "federal needs backbone network of streamgages" (a total of 4,774 streamgages as defined in the NSIP design) for long-term tracking and forecasting/modeling of streamflow conditions in the future in response to changes in land use, water use, and climate. Specifically, consistent and systematically-collected information is paramount to meet the full gamut of Federal water priorities and responsibilities over the long term (previously defined by the NSIP) related to:

- Forecasting extreme hydrologic events (floods and droughts);

- Monitoring water flows across international, interstate, and tribal borders needed to address inter-jurisdictional and court adjudicated water rights and other legal responsibilities;
- Tracking streamflow, water quality, and habitat in major river basins, such as those discharging into key estuaries or draining heavily populated areas; and,
- Tracking long-term streamflow trends and causes, such as relating to population growth and changes in land use, water use, and climate.

In 2015, approximately 3,100 streamgages of the 8,100 streamgage network met these strategic long-term Federal priorities and responsibilities. These Federal high-priority streamgages were funded by the NSIP, the CWP, and USGS partners. In 2015, a total of 1,138 of these streamgages were fully funded by the USGS (through NSIP), which increased the number of USGS fully funded streamgages by 162 relative to 2014. In general, the 162 streamgages had been: (1) supported by other funding sources which may be less stable over the long term or (2) discontinued because of funding reductions in recent years. An increase of $1.2 million to NSIP in 2015 helped build upon this investment and continued the expansion and improved stabilization of federal priority streamgages. Support for a full "federal needs backbone network of streamgages" requires about $126.4M, requiring an additional $92 million dollars annually.

Beginning in 2016, the USGS is aligning its budget structure to the Water Science Strategy by consolidating its existing seven programs into four major program areas. The first, Groundwater and Streamflow Information Program, focuses on *observing* and *delivering*. The other three programs, National Water Quality Program; Water Availability and Use Science Program; and Water Resources Research Act all focus on *understanding*, *predicting* and *delivering*. The USGS Water Science Strategy (URL: http://pubs.usgs.gov/of/2012/1066/of2012-1066.pdf) identifies water science goals and objectives that serve the Nation and address the water challenges for the future. The Strategy outlines areas where hydrologic science can make substantial contributions to the Nation and identifies opportunities for the USGS to better use its hydrologic science capabilities to advance healthy watersheds and sustainable, secure water supplies and to minimize impacts of water-related hazards.

GWSIP will encompass the USGS objectives to provide long-term, national networks for observation of the vital components of the hydrologic cycle and include activities previously associated with the National Streamflow Information Program (NSIP) such as the USGS streamgaging network, flood monitoring and flood inundation science, as well as those previously comprising the National Groundwater Monitoring Network.

National Monitoring Network for U.S. Coastal Waters and Tributaries

The goal of the National Monitoring Network (NMN) effort is to provide information about inland influences on coastal waters for improved management of coastal ecosystem health. Formed in response to recommendations of the President's Commission on Ocean Policy and the President's Ocean Action Plan, the NMN 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), the NMN seeks to develop a "network of networks" that link elements of Federal, State, and local monitoring networks to reduce duplication and strengthen coverage to provide an integrated system of long-term streamgages, water-quality and

ecological monitoring sites with standardized monitoring techniques, parameters, and data-dissemination portals.

In 2012, two studies to demonstrate network concepts began in Albemarle Sound and Puget Sound. Data collection is complete and final reports on these studies will be published in 2016. Three pilot studies were completed in 2011 in San Francisco Bay, Lake Michigan, and Delaware Estuary. Current NMN efforts include supporting four long-term USGS monitoring sites and continued development of the Water Quality Portal (http://www.waterqualitydata.us/index.jsp). For more information on the network, visit the NMN homepage at http://acwi.gov/monitoring/network/index.html.

The 10th National Monitoring Conference entitled, "Working Together for Clean Water" will be held May 2-6, 2016 in Tampa, Florida. For more information, see the National Monitoring Conference website at http://acwi.gov/monitoring/conference/2016/.

Updated Flood-Frequency Analysis Guidelines

Flood-frequency analysis provides information about the magnitude and frequency of flood discharges. Bulletin 17B, which was written by the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (1982), defines procedures that provide a uniform and consistent approach for determining flood-flow frequency from peak-flow records. The procedures include methods for improving statistical 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. In the near future, the Advisory Committee on Water Information, Subcommittee on Hydrology, Hydrologic Frequency Analysis Workgroup will consider a number of changes to the Bulletin 17B including the Expected Moments Algorithm (EMA) and a new multiple low outlier test based on a generalization of the Grubbs-Beck test. EMA is a highly efficient approach for capturing the information contained in historical flood data and other censored datasets.

The Peak flow FreQuency analysis program (PeakFQ) implements the Bulletin 17B recommended procedures for flood-frequency analysis of streamflow records. The program was updated in 2014 to include EMA and the new multiple low outlier test. A Windows version is available at http://water.usgs.gov/software/PeakFQ/.

Contact Tim Cohn (tacohn@USGS.gov) for more information about the USGS contributions to the effort.

Updated Flood-Frequency Regional Skew Map

The USGS is working with FEMA and various state and local agencies to update the National flood-frequency skew map now used in Bulletin 17B. Since the first map was published in 1976, over 35 years of additional streamflow information has accumulated, and better spatial estimation procedures have been developed (Stedinger and Griffis, 2008). A new statistical technique, Bayesian Generalized Least Squares (B-GLS) regression, is being used to estimate new regional skewness values. Thus far, this technique has been used in studies in: the Southeastern U.S. (South Carolina, North Carolina, and Georgia), California, Iowa, Missouri and Arizona. Projects are underway in New England (Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont), Alaska, the Pacific Northwest (Oregon, Washington, and Idaho), Arkansas-Louisiana (joint study); and planning has begun for projects

encompassing multiple states in the Missouri River Basin and the Upper Mississippi River Basin. Instead of updating the map on a state-by-state basis, we intend to update the map on a multi-state, hydrologic basis with the eventual goal of updating the map for the entire Nation.

Contact Andrea Veilleux (aveilleux@usgs.gov) if you have questions related to efforts related to updating the National flood-frequency skew map.

Contact Robert Mason (rrmason@usgs.gov) for general information about the flood-frequency program.

National Streamflow Statistics

The National Streamflow Statistics (NSS) Program is a Microsoft Windows-based computer program created by the USGS to present high and low streamflow estimation equations for ungaged sites across the United States. Equations and their solutions in NSS provide low-flow duration and frequency estimates in addition to flood-frequency estimates such as the 100-year flood.

The NSS program has an equation database, a graphical user interface (GUI), and an equation calculation routine. The equation calculation routine computes streamflow statistics using basin and climatic characteristics entered by the user. The GUI allows users to control the operation of the software and presents results. It also provides tabling and graphing capabilities that graph frequency and hydrographs. The database contains all the information needed, including the regression equations and standard errors, to solve more than 6,500 regression equations.

Regression equations for estimating flood-frequency statistics of peak flows for rural and naturally flowing rivers are available for all 50 United States as well as the Commonwealth of Puerto Rico and the island of Tutuila, American Samoa. State-specific regression equations for estimating flood-frequency statistics of peak flows for urban streams are available in NSS for 17 U.S. States. In addition, nationwide urban regression equations are available. Regression equations for estimating low-flow duration and (or) frequency are also currently available in NSS for 35 States. All equations contained in NSS were reviewed by USGS and were typically prepared in cooperation with state and local transportation, environmental, and/or water resource management agencies in each state.

The NSS program and documentation can be downloaded from the Internet at: http://water.usgs.gov/software/NSS/.

If you should have questions regarding this information, please contact Todd Koenig (tkoenig@usgs.gov).

StreamStats Program

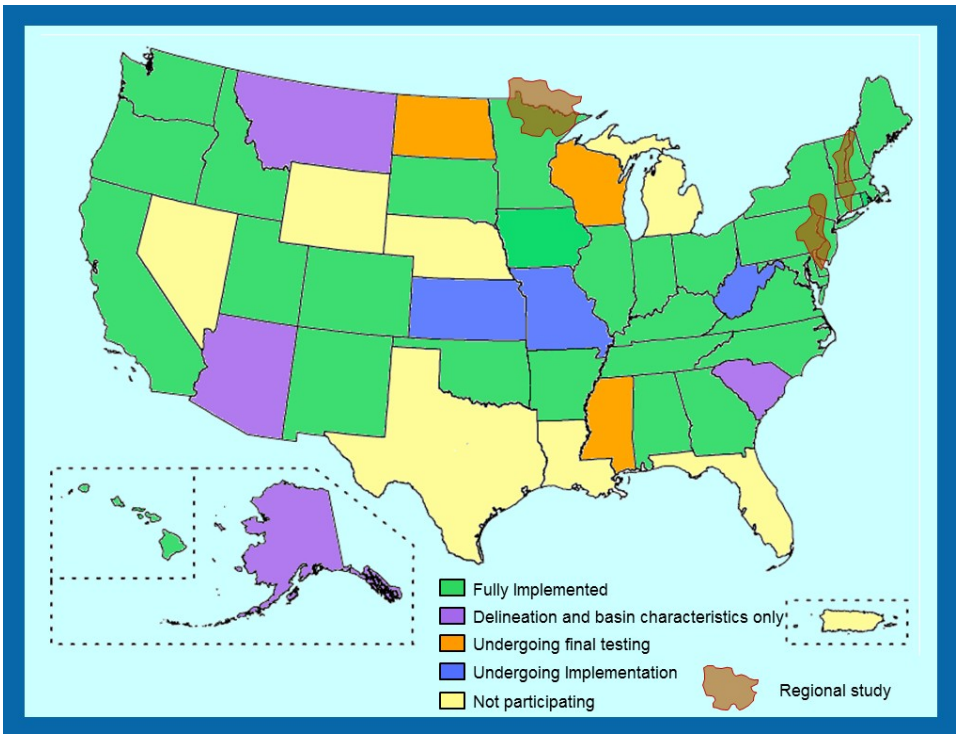
StreamStats (http://streamstats.usgs.gov) is a Geographic Information Systems-based Web application, developed by the U.S. Geological Survey (USGS) Office of Surface Water (OSW), which greatly reduces the time needed for users to obtain streamflow statistics, basin characteristics, and other information for USGS data-collection stations and for ungaged sites. This information is used by engineers, land and water-resource managers, biologists, and many others to help guide decisions in their everyday work. Users can select data-collection station locations shown on a map interface in a Web browser window to

obtain previously published information for the stations. Users also can select any location along a stream to obtain the drainage-basin boundary, basin and climatic characteristics, and estimated streamflow statistics for that location. The estimates for ungaged sites are determined from USGS regional-regression equations and usually can be obtained in only a few minutes.

StreamStats version 2 was implemented at the beginning of fiscal year 2015. In addition to the ability to delineate drainage basins and obtain estimates of streamflow statistics for user-selected ungaged sites, version 2 had the ability to (1) navigate the stream network to locate upstream or downstream streamgaging stations, dams, point discharges and other water-related features and get information about those features, (2) estimate flows at ungaged sites based on the flows at nearby streamgaging stations, (3) change the basin characteristics for an ungaged site and obtain new estimates of flow statistics that reflect the changed basin characteristics, (4) obtain graphs of land-surface and stream-channel elevation profiles, (5) trace the path of a drop of water or a hazardous- waste spill from a point on the land surface to where it reaches a stream, and then downstream through the stream network, and (6) access StreamStats functionality from other Web or desktop GIS applications remotely by use of Web services. In addition, StreamStats for Maryland allowed users to obtain summaries of water use activities within the drainage basins for user-selected sites.

The Dept. of Interior required shutting down StreamStats version 2 by July 15, 2015 because it was operated on servers with an old operating system that was considered a security threat. Consequently, StreamStats beta version 3 was released for all states by that date, but only with the ability to delineate drainage areas and estimate flows for ungaged sites, as well as to provide information for USGS streamgages. Version beta 3 provides a new user interface which is easier to use than version 2. Version 3 is considered an interim product to which no additional functionality will be added.

As of December 2015, StreamStats is available to the public for 33 states with full beta version 3 functionality. Applications also are available for four states and two river basins that allow only basin delineations and computation of basin characteristics. The two river basins are the Connecticut River Basin, which encompasses area in Connecticut, Massachusetts, New Hampshire, and Vermont, and the Rainy River Basin, which encompasses area in northern Minnesota and the Canadian provinces of Manitoba and Ontario. Applications are in testing for 3 states and the Delaware River Basin, which encompasses area in Delaware, Pennsylvania, New Jersey, and New York. See the map and table below to determine the status for individual state and river basin applications.



Status of StreamStats implementation on December 8, 2015

The StreamStats development team is working to develop version 4, which will have a much different user interface that will coach users through the steps needed to obtain information. The team expects to release beta version 4 in mid-January 2016, which will duplicate the functionality that is in version 3, but also add the ability to edit delineated basins, modify computed basin characteristics, and print maps. Stream-network navigation tools will be added during spring of 2016. Updated documentation will be released coincident with the release of the new version. In addition, new equations will be added for many states, as indicated in table below, and streamflow statistics served by StreamStats for many USGS streamgages will be updated.

State	Implemented	Planned for FY16 completion	To be implemented after FY16	New equations in FY16	Comments
Alabama	X				
Alaska	X			X	Cook Inlet Basin only with delineations and basin characteristics, new peak-flow equations in FY16
Arizona	X				Delineations and basin characteristics only
Arkansas	X			X	New monthly mean and harmonic mean equations
California	X				
Colorado	X			X	New peak-flow equations for eastern CO
Connecticut	X				
Delaware	X				
Florida					No effort underway
Georgia	X			X	Adding new urban peak-flow equations
Hawaii	X			X	Adding low-flow equations for Maui
Idaho	X				
Illinois	X			X	Adding new flow-duration equations
Indiana	X			X	Adding new flow-duration equations
Iowa	X			X	Adding low-flow equations

State	Implemented	Planned for FY16 completion	To be implemented after FY16	New equations in FY16	Comments
Kansas		X			
Kentucky	X				
Louisiana					No effort underway
Maine		X			
Maryland	X				
Massachusetts	X			X	Adding new peak-flow equations
Michigan					
Minnesota	X			X	Adding new peak-flow equations
Missouri			X		Separate St. Louis and state applications
Mississippi		X			
Montana	X			X	Delineations and BC only now – adding peak-flow equations during FY16
Nebraska					No effort underway
Nevada					No effort underway
New Hampshire	X				
New Jersey	X				
New Mexico	X				Plan to expand to State-wide during FY16
New York	X				
North Carolina				X	New flow-duration equations in FY16
North Dakota		X			
Ohio	X				
Oklahoma	X			X	New peak-flow equations
Oregon	X			X	New peak-flow equations for eastern OR
Pennsylvania	X				
Puerto Rico					No effort underway
Rhode Island	X				
South Carolina	X				Delineations and BC only now
South Dakota	X				
Tennessee	X				
Texas					No effort underway
Utah	X				
Vermont	X			X	Adding new peak-flow equations
Virginia	X				
Washington	X			X	Adding low-flow equations
West Virginia		X			
Wisconsin		X			
Wyoming					underway
River Basin					
Connecticut	X				
Delaware		X			
Rainy	X			X	Delineations and basin characteristics only

Performance and Effectiveness of Scour Countermeasures

Scour countermeasures have become a major part of Federal Highway Administration's (FHWA's) national bridge scour program and are considered vital in reducing the vulnerability of bridges to scour. However, due to the lack of field verification of the performance and effectiveness of these countermeasures, there remains uncertainty in the reliability of scour countermeasures for protecting foundations, especially for use at new bridges. FHWA, therefore, has teamed with the U.S. Geological Survey (USGS) to conduct a comprehensive, national investigation of scour countermeasures. Through this investigation FHWA hopes to evaluate and improve its published guidance and technical procedures for the selection, design, construction and maintenance of scour countermeasures and possibly reevaluate its policy of not using scour countermeasures at new bridge piers.

For this project, the USGS will perform various levels of site evaluations at approximately 100 bridges with scour countermeasures across the Nation. Some of the techniques to be used include stream-side investigations and underwater reconnaissance using state-of-the-art survey techniques such as terrestrial LiDAR, multi-beam bathymetry and side-scan sonar. FHWA will identify the bridge locations and provide technical assistance; USGS will conduct the evaluations, document each evaluation in templates, make all data available to FHWA via the web, and summarize data and findings in a series of official USGS reports (2 open-file reports and a final scientific-investigations report). As a complement to the USGS site evaluations, the J. Sterling Jones Hydraulics Research Laboratory (HRL) will run hydraulic physical models and computational fluid dynamics (CFD) on several bridge sites. The goal of these lab tests is to test and model at high flows the stability and performance of the as-built countermeasures observed in the field. These results will also be used to evaluate FHWA guidance on scour countermeasure design.

To date, USGS and FHWA teams have assessed bridges in Florida, Missouri, Idaho, Missouri/Illinois (border bridge), Indiana/Illinois (border bridge), and Missouri/Tennessee (border bridge). Potential sites for assessment in 2016 are located in Pennsylvania, Nebraska, Montana, Mississippi, Minnesota, South Carolina, New Jersey, and Connecticut; USGS team leads are working with various state transportation departments to obtain information for these sites and, subsequently, will seek FHWA approval for each site's inclusion in the project. The bridge-site identification process is on-going and USGS / FHWA are actively seeking additional bridge sites to survey. Approved USGS metadata standards have been adopted for digital data and all information is available to FHWA and USGS via a structured, internal web page; information from this web page will be published in 2016 as more data becomes available.

Training and technical support for the FHWA-USGS Stochastic Empirical Loading and Dilution Model (SELDM)

The purpose of the project is to help State DOTs and decision makers adopt and use SELDM by providing training and technical support for the model. The USGS in cooperation with the FHWA has developed and delivered a 3-day classroom training course, an abbreviated half-day training class, and a series of webinars. In 2015 the 3-day training course was delivered in Lakewood Colorado. To date, 72 people from across the Nation who work for State DOTs, USEPA, USGS, and other agencies have attended the 3-day classes in person and 32 attended the three-day class remotely by webinar. The webinars were delivered to 418 people from across the Nation who work for State DOTs, USEPA, USGS, and other agencies. This project also supported a Transportation-Research Board webinar with 144 participants and a USEPA webinar with 735 participants.

A graphical post-processor for SELDM output also will be developed as part of this project. The post-processor will extract model results from the SELDM output and generate graphs that can be used to communicate the results of modeling efforts. We will be looking for software beta testers and reviewers for the documentation in the second half of 2016.

Publications:

Granato, G.E., and Jones, S.C., 2015, A case study demonstrating analysis of stormflows, concentrations, and loads of nutrients in highway runoff and swale discharge with the Stochastic Empirical Loading and Dilution Model (SELDM) in Proceedings of StormCon, August 2-6, 2015, Austin, Texas: Santa Barbara, CA, Forester Media Inc., 10 p.

Granato, G.E., and Jones, S.C., 2015, Estimating the risks for adverse effects of total phosphorus in receiving streams with the Stochastic Empirical Loading and Dilution Model (SELDM) in Proceedings of the 2015 International Conference on Ecology and Transportation (ICOET 2015), September 20-24, 2015, Raleigh, North Carolina: Raleigh, North Carolina, Center for Transportation and the Environment, 19 p.

Web page (with links to the published reports):

http://webdmamrl.er.usgs.gov/g1/FHWA/SELDM.htm

National Synthesis on Potential Sources, Fate and Transport, and Potential Effects of Chloride in Surface- and Ground-Water Resources of the Conterminous United States

The Chloride (Cl) ion is receiving increasing attention as population growth makes increasing demands on available water resources and anthropogenic activities increase solute loads in natural waters. Cl is a growing concern because anthropogenic inputs may increase Cl concentrations to the USEPA's 250 mg/L taste criterion for potable waters, the 230 mg/L chronic criterion for aquatic life, or the 860 mg/L acute criterion for aquatic life. The Cl ion is ubiquitous in natural waters, has a wide variety of sources, readily moves through surface and ground waters, and is difficult to remove from runoff and water supplies. This national synthesis is a cooperative effort between the USGS and Federal Highway Administration designed to provide the information necessary for watershed managers to assess all potential sources of Cl in a given watershed as part of a total water and solute budget.

Chloride exists as a major ion in most natural waters, but many anthropogenic sources are increasing concentrations of chloride in many receiving waters. Although natural concentrations in continental waters can be as high as 200,000 milligrams per liter, chloride concentrations that are suitable for freshwater ecology, human consumption, and agricultural and industrial water uses commonly are on the order of 10 to 1,000 milligrams per liter. "Road salt" frequently is identified as the sole source of anthropogenic chloride, but only about 30 percent of the salt consumed and released to the environment is used for deicing. Furthermore, several studies in Southern States where the use of deicing salt is minimal also show anthropogenic chloride in rising concentrations and in strong correlation to imperviousness and road density. This is because imperviousness and road density also are strongly correlated to population density. The term "road salt" is a misnomer because deicers applied to parking lots, sidewalks, and driveways can be a substantial source of chloride in some catchments because these land covers are comparable to roadways as a percentage of the total impervious area and commonly receive higher salt application rates than some roadways. Other sources of anthropogenic chloride include wastewater, dust control on unpaved roads, fertilizer, animal waste, irrigation, aquaculture, energy production wastes, and landfill leachates. The assumption that

rising chloride concentrations in surface water or groundwater is indicative of contamination by deicing chemicals rather than one or more other potential sources may preclude the identification of toxic, carcinogenic, mutagenic, or endocrine-disrupting contaminants that are associated with many sources of elevated chloride concentrations. Once the sources of anthropogenic chloride in an area of interest have been identified and measured, water and solute budgets can be estimated to guide decision makers to identify and apply potential mitigation measures that can reduce the problem.

Scientists, engineers, regulators, and decision makers need information about potential sources of chloride, water and solute budgets, and methods for collecting water-quality data to help identify potential sources. This information is needed to evaluate potential sources of chloride in areas where chloride may have adverse ecological effects or may degrade water supplies used for drinking water, agriculture, or industry. Knowledge of potential sources will help decision makers identify the best mitigation measures to reduce the total background chloride load, thereby reducing the potential for water-quality exceedances that occur because of superposition on rising background concentrations. Also, knowledge of potential sources may help decision makers identify the potential for the presence of contaminants that have toxic, carcinogenic, mutagenic, or endocrine-disrupting effects at concentrations that are lower by orders of magnitude than the chloride concentrations in the source water.

Publication:

Granato, G.E., DeSimone, L.A., Barbaro, J.R., and Jeznach, L.C., 2015, Methods for evaluating potential sources of chloride in surface waters and groundwaters of the conterminous United States: U.S. Geological Survey Open-File Report 2015–1080, 89 p.

Web pages:

The project web page: http://webdmamrl.er.usgs.gov/g1/FHWA/Cl.htm.

Partial Summary of USGS Water Science Center Activities of Interest to State Highway Agencies

To obtain more detailed information about state-based activities from a USGS Water Science Center, visit http://water.usgs.gov/ and select a state from the "Water Science Centers" drop-down link.

Alabama

Note: Beginning in FY 2015, human resources of the USGS now employed in the study of water resources across the five states of Alabama, Arkansas, Louisiana, Mississippi, and Tennessee began a transformation to the **USGS Lower Mississippi-Gulf Water Science Center** (LMGWSC).

Hydrologic and Hydraulic investigations: at various bridge replacement/construction sites in Alabama, including a crest-stage gage (CSG) data collection effort for urban streams.

Culvert Impacts Study: A study to look at the impacts that culvert construction has on geomorphology, sediment concentrations and turbidity in streams during storm events, and benthic macro-invertebrate populations. The study is set up to look at three phases - before, during, and 2-year post construction.

Magnitude and Frequency of Floods in Alabama: an update of station flood-frequencies and regional regression equations for rural streams in Alabama using the latest methods and tools.

Recent Publications

Hedgecock, T.S., and Lee, K.G., 2010, Magnitude and frequency of floods for urban streams in Alabama, 2007: U.S. Geological Survey Scientific Investigations Report 2010–5012, 17 p. Available online at: http://pubs.usgs.gov/sir/2010/5012/.

Lee, K.G., and Hedgecock, T.S., 2010, Flood-depth frequency relations for rural streams in Alabama, 2003: U.S. Geological Survey Scientific Investigations Report 2010–5066, 25 p. Available online at: http://pubs.usgs.gov/sir/2010/5066/.

Alaska

Gaging stations: The Alaska Science Center, in cooperation with the Alaska Department of Transportation and Public Facilities, operates 18 real-time continuous record streamflow stations and 31 partial record crest-stage stations. (Number of gaging stations fluctuates slightly from year to year.)

2015 Summary of Alaska Bridge Scour Project:

- Continued continuous monitoring and evaluation of streambed change and water surface elevations at 17 scour-critical bridges around Alaska.
- Established a new continuous monitoring site on the Quartz Creek.
- Collected time-lapse imagery at 10 scour critical bridges during open-water season; collected time-lapse imagery of breakup at 5 locations, and processed freeze-up imagery from 3 locations.

- Collected flood soundings at 3 sites that experienced flood and scour events.
- For bridges with unknown foundations or incomplete scour analyses, completed report for 18 scour critical bridges visited in 2012, compiled model geometry for 32 bridges surveyed in 2013 and 2014, and surveyed an additional 21 bridges.

Recent Publications

Beebee, R.A., and Schauer, P.V., 2015, Streambed scour evaluations and conditions at selected bridge sites in Alaska, 2012: U.S. Geological Survey Scientific Investigations Report 2015–5154, 45 p., http://dx.doi.org/10.3133/sir20155154.

Arizona

The Arizona Water Science Center (AzWSC) is conducting an n-verification study in Maricopa County aimed at quantifying the roughness effects of in-channel vegetation. The study will employ Continuous Slope-Area gages and direct discharge measurements to determine Manning's roughness over a range of flows at several sites. Recording pressure transducers will be installed in the Gila River and in two smaller tributaries for use with the Flood Control District of Maricopa County's (FCDMC) flow model to calibrate roughness. The project is in cooperation with the FCDMC, the Salt River Project (water supplier to Maricopa County), and the Arizona Department of Transportation (ADOT).

A continuing cooperative program has also been established directly by ADOT during FY 2015. The AzWSC is currently providing high resolution land-surface models to help ADOT with Jurisdictional Delineations and other surface-water concerns around current construction projects. Data for these efforts are being collected by newly acquired Unmanned Aircraft Systems and ground based LiDAR equipment. This equipment will also be used in FY16 to do repeat scans of bridges and channels to be used for change detection, runoff modeling and scour studies.

Arkansas

Note: Beginning in FY 2015, human resources of the USGS now employed in the study of water resources across the five states of Alabama, Arkansas, Louisiana, Mississippi, and Tennessee began a transformation to the **USGS Lower Mississippi-Gulf Water Science Center** (LMGWSC).

USGS began a Crest Stage Gage (CSG) data collection project with the Arkansas Highway and Transportation Department (AHTD), installing 52 new gages in FY 2013 and 2014. Operation began in FY 2015. This is a reestablishment of a CSG project that was discontinued in 2004.

During FY 2014, USGS partnered with the US Army Corps of Engineers Little Rock District and AHTD to update the flood frequency statistics for Arkansas. That project began in the spring of 2014 and will conclude in December, 2015. The project will add two decades of additional peak flow data for regional flood regression estimating equations which were last updated in 1994.

California

Flood and Landslide Warning: The USGS California Water Science Center has come alongside stakeholders in the California Governor's Office of Emergency Services (OES) to assist with technical monitoring of stream flow and precipitation at various sites in the Butte and Valley Fire burn areas. To date there have been a total of 5 stream gages and 6 precipitation gages installed by the CAWSC in these two burn areas. Sites were strategically located in conjunction with the National Weather Service/NOAA to insure that the best locations were chosen that would give emergency managers the data needed for the issuance of flood warnings. Debris flows are expected in the steep areas of these burns, and sites with high probability of landslides were also considered in the siting of these gages with the help of the USGS Landslides Hazards group. Data from these gages will also assist emergency managers with the potential identification of expected road closures as a result of mud and debris flows.

Land Subsidence: In 2015 the CAWSC began a study to quantify and develop a greater understanding of the subsidence along proposed high-speed rail alignments, which traverse hundreds of miles through California from the Los Angeles Basin to San Francisco. Along this route are some known areas of historical subsidence. The extent and magnitudes of land-surface-elevation changes along the route during 1992–2018 will be quantified. This subsidence information will be used to constrain models of groundwater flow and subsidence that will be used to develop and analyze scenarios of the potential extent and magnitude of future subsidence. This information will allow the California High-Speed Rail Authority and their contractors to better design, construct, operate, and maintain the track system and the subsidence monitoring system. The study will provide new tools to better understand the availability and sustainability of water resources and the interaction of surface-water availability, groundwater levels, and land use with land subsidence.

Recent Publications

Faunt, C.C. and Sneed, M., 2015, Water Availability and Subsidence in California's Central Valley, San Francisco Estuary and Watershed Science, 13(3), 8 p.
http://ca.water.usgs.gov/pubs/2015/FauntSneed2015.pdf

Colorado

In 2015, the Colorado Water Science Center (CWSC), in cooperation with the Colorado Department of Transportation (CDOT) designed, installed, and operated three streamgages in Waldo Canyon, which experienced a wildfire in 2012. The streamgages provide real-time stage and velocity data that is transmitted either hourly or every 1 to 15 minutes depending on the alarm thresholds and are delivered to CDOT staff and other agencies such as the National Weather Service (NWS). This data is used to inform CDOT and NWS staff of the hydraulic conditions in the basin in response to precipitation events. The project operates as an early warning proof-of-concept and augments existing USGS streamgages, precipitation gages, and real-time cameras which were installed in 2014 and currently operate in various basins in the burn scar. The data is used by CDOT staff to take appropriate action along U.S. Highway 24 in response to extreme weather conditions.

In 2015, the CWSC, in cooperation with CDOT updated and maintained the online Colorado Flood Database. The database was completed in 2013 and uses an ESRI map interface to facilitate easy access to flood data, including indirect streamflow measurements published in USGS Water-Supply Papers and USGS Data Reports, indirect streamflow measurements stored in USGS offices, paleoflood measurements published in scientific journals, and the peak flood of record information at all USGS gages in Colorado available from the USGS NWISweb and is updated annually. The Colorado Flood Database is available at http://cwscpublic2.cr.usgs.gov/projects/coflood/COFloodMap.html.

In 2015, the CWSC in cooperation with CDOT completed a project that used paleoflood and streamflow data to update the flood-frequency equations in eastern Colorado. Previously collected and new paleoflood data will be analyzed along with existing flood data through 2013 to provide peak discharge estimates needed to update the regional-flood equations for eastern Colorado. A USGS Scientific Investigations Report is in press and will be published in late 2015 to document the methods and results of the paleoflood study. For more information, visit the project website at http://co.water.usgs.gov/projects/CDOT_Flood_Frequency/index.html.

Starting in 2015, the CWSC in cooperation with CDOT began a 10 site crest-stage gage network in eastern Colorado. The study implemented pressure transducers equipped in traditional cork crest-stage gages which were installed on the upstream and downstream side of culverts to streamline indirect discharge measurements at the culvert. In the future, discharge can be computed using continuous culvert indirect discharge methods. All data will be stored in NWISweb and additional information on this study can be found at http://co.water.usgs.gov/projects/EastCOCrestStageGage/index.html.

Starting in 2015, the CWSC in cooperation with CDOT installed a real-time bridge scour monitoring study at two streamgages in western Colorado. The installation of streambed scour monitoring instrumentation can provide site specific assessment of scour conditions at bridges in real-time as well as supplement CDOT's current bridge Plan of Action. Real-time bridge scour monitoring data through the USGS NWISweb and WaterAlert services will be produced. The project will also produce a peer-reviewed interpretive publication to document the bed elevations, stage, and continuous streamflow data.

Starting in 2015, the CWSC in cooperation with CDOT began implementing modifications to the standard USGS StreamStats program to accommodate known flows. The Colorado StreamStats interface will be customized for use by CDOT and will include a new "partial basin" tool to provide estimates of flow for drainage basins downstream of a known control such as a reservoir. The CWSC will develop methodology to allow CDOT personnel to estimate flows for "partial basins" and will work with the StreamStats development team, through the USGS Wisconsin Internet Mapping group, to implement the methodology for incorporating known flows and provide CDOT with a new StreamStats map interface.

References

Kohn, M.S., Jarrett, R.D., Krammes, G.S. and Mommandi, Amanullah, 2013, Web-based flood database for Colorado, water years 1867 through 2011: U.S. Geological Survey Open-File Report 2012-1225.

Kohn, M.S., Stevens, M.R., Harden, T.M., Godaire, J.E., Klinger, R.E., and Mommandi, A., (in press), Paleoflood investigations to improve peak-streamflow regional-regression equations for natural streamflow in eastern Colorado, 2015: U.S. Geological Survey Scientific Investigations Report 2015–XXXX, xx p.

Connecticut

Chloride (Cl) concentrations and loads and general water chemistry were assessed to evaluate potential effects of road-deicer applications on stream-water quality in four small (less 5.98 mi^2) watersheds intersected by Interstate 95 in southeastern Connecticut from 2008-11. Water-quality samples were collected and specific conductance was measured continuously at paired water-quality monitoring sites to observed conditions upstream and downstream of I-95. Streamflow and water-quality data were compared with weather data and with the timing, amount, and composition of deicers applied to state highways.

Cl concentrations at the eight water-quality monitoring sites during winter storms peaked as high as 270 mg/L in the predominantly forested and undeveloped watersheds, and were well below the U.S. EPA recommended chloride toxicity criteria. Cl concentration peaks (1) varied with the type of winter storm event and were highest during or after winter storms of frozen precipitation and rain, in which the rain or melt water effectively washes off the deicers; and (2) correlated positively with the duration of deicer application but generally not with streamflow. A multiple linear regression model was developed to describe the variability of the natural log of peak Cl concentrations. Five significant variables best explained the variability in the natural log of the peak chloride concentration after deicing events: (1) snow on ground before deicing event; (2) precipitation type; (3) specific conductance in baseflow; (4) highway lane miles divided by watershed area; and (5) amount of Cl amount from deicers applied to State roads per lane mile.

Preliminary report:

Brown, C.J., Mullaney, J.R., Morrison, J., Mondazzi, R., 2011, Preliminary assessment of chloride concentrations, loads, and yields in selected watersheds along the Interstate 95 corridor, southeastern, Connecticut, 2008-09: U.S. Geological Survey Open-File Report 2011-1018, 41 p. Available online at: http://pubs.usgs.gov/of/2011/1018.

Final report:

Brown, C.J., Mullaney, J.R., Morrison, Jonathan, Martin, J.R., and Trombley, T.J., 2015, Chloride concentrations, loads, and yields in four watersheds along Interstate 95, southeastern Connecticut, 2008–11—Factors that affect peak chloride concentrations during winter storms: U.S. Geological Survey Scientific Investigations Report 2015–5057, 68 p., http://dx.doi.org/10.3133/sir20155057.

Delaware

The USGS, in cooperation with Delaware Department of Transportation (DelDOT), has implemented a data-delivery system that will allow DelDOT to independently poll USGS stage data, enhancing DelDOT's

capabilities to create and maintain a hydrometeorological-response system to enhance traffic safety. The scope of work includes establishment and operation of five new stage gages and one new streamflow gage, as well as proof-of-concept integration of a selected DelDOT data-logger with USGS real-time hydrologic data-collection equipment at four pre-existing tide gages in Delaware.

District of Columbia

No highway related projects at this time.

Florida

FHWA / USGS Scour Countermeasure Study (Project Chief: Peter Cinotto, IN-KY WSC): Performance and Effectiveness of Scour Countermeasures Evaluated by USGS: Scour countermeasures have become a major part of Federal Highway Administration's (FHWA's) national bridge scour program and are considered vital in reducing the vulnerability of bridges to scour. However, due to the lack of field verification of the performance and effectiveness of these countermeasures, there remains uncertainty in the reliability of scour countermeasures for protecting foundations, especially for use at new bridges. FHWA, therefore, has teamed with the U.S. Geological Survey (USGS) to conduct a comprehensive investigation of scour countermeasures in north Florida and other states (MO, IL, IN, ID, MT). Through this investigation FHWA hopes to evaluate and improve its published guidance and technical procedures for the selection, design, construction and maintenance of scour countermeasures and possibly reevaluate its policy of not using scour countermeasures at new bridge piers.

The USGS will perform various levels of site evaluations at approximately 100 bridges with scour countermeasures. Some of the techniques to be used include stream side investigations and underwater reconnaissance using state-of-the-art survey techniques such as terrestrial LIDAR, multi-beam bathymetry, and side-scan sonar. The USGS will document each evaluation in templates and then summarize its findings in an official USGS Scientific Investigations Report. As a complement to the USGS site evaluations, the J. Sterling Jones Hydraulics Research Laboratory (HRL) will run hydraulic physical models and computational fluid dynamics (CFD) on several bridge sites. The goal of these lab tests is to test and model at high flows the stability and performance of the as-built countermeasures observed in the field. These results will also be used to evaluate FHWA guidance on scour countermeasure design.

Planned report: due end of 2016

Georgia

The USGS, in cooperation with the Georgia Department of Transportation and Georgia Environmental Protection Division, has implemented StreamStats for Georgia. A factsheet has been published at http://pubs.er.usgs.gov/publication/fs20143027/.

Georgia Water Science Center maintains a statewide network of 60 crest-stage gages as part of an ongoing flood-frequency study with GADOT.

Guam

The Pacific Islands Water Science Center operates a network of 2 crest-stage gages in Guam to monitor peak stages and discharges at or near highway crossings. The peak flow data collected at these gages adds significantly to peak-flow data collected at continuous-recording streamflow monitoring stations and improves regional coverage of peak-flow measurements.

The Pacific Islands Water Science Center operates 6 streamflow monitoring stations in Guam. Data from these gages are used for post-flood analysis.

The Pacific Islands Water Science Center operates 8 rain gages (3 with real-time telemetry) and one reservoir monitoring station in Guam. Data from these gages are used to aid flood warning and flood forecasting.

Hawai'i

The Pacific Islands Water Science Center operates a network of 65 crest-stage gages to monitor peak stages and discharges at or near highway crossings on the islands of Kaua`i, Oahu, Moloka`i, Maui, and Hawai`i. The peak-flow data collected at these gages adds significantly to peak-flow data collected at continuous-recording streamflow monitoring stations and improves regional coverage of peak-flow measurements in Hawai`i.

The WSC also monitors rainfall, streamflow, and daily suspended-sediment concentration and load in North Halawa Stream to study impacts in the H-3 freeway corridor and receiving water bodies.

The WSC operates 21 real-time rain gages, 57 real-time streamflow monitoring stations, and 7 reservoir monitoring stations on the islands of Kaua`i, Oahu, Moloka`i, Maui, and Hawai`i. Data from these gages are used to aid in flood warning, flood forecasting, and post-flood analysis.

Idaho

The Idaho Transportation Department uses the Idaho StreamStats web site extensively in the design of their Idaho Bridge Watch program (an early-warning bridge scour monitoring program based on the Q25 and Q50) as well as for other transportation-related design projects. The Idaho StreamStats website is at http://water.usgs.gov/osw/streamstats/idaho.html

The Idaho Water Science Center (IDWSC) is updating peak flow frequency statistics and regional regression equations for relatively unregulated streams in Idaho. The project is funded by the Idaho Transportation Department and will provide more accurate, updated information to Federal, State, regional and local cooperators on peak flow frequency in Idaho rivers, which is often needed for designing infrastructure, determining flood elevations and flood zones, and managing aquatic habitat. The updated statistics and equations will be published and integrated with Idaho StreamStats in FY16/17. In a related effort, the IDWSC is working with Washington Water Science Center and Office of Surface Water staff to develop a revised regional skew map for the Pacific Northwest. Information from the skew map will be used to update the state-specific peak flow frequency statistics.

The IDWSC is actively involved in the Idaho Chapter of the Silver Jackets, a coalition of federal and state agencies that work together to develop comprehensive and sustainable solutions to Idaho's flood hazard issues. The IDWSC is chairing a Silver Jackets subcommittee to develop a plan to develop, prioritize, and deploy a cache of rapid deployment gages, which are temporary water level sensors or precipitation gages which can be deployed swiftly to provide hydrologic information to emergency and transportation managers prior to and during floods. The Idaho Transportation Department is a member of the subcommittee. The IDWSC is also discussing a proposal with the Idaho Silver Jackets to develop a StreamStats-based contaminant time-of-travel tool. The tool is a web- and GIS-based application that could be used to simulate a contaminant spill in a river and determine how long it would take the spill to migrate downstream to a point of interest. Several Idaho Silver Jackets agencies have expressed interest in developing a tool to assist with disaster response and transportation planning.

The BLM and USGS continue to operate a project to define minimum streamflows or streamflow statistics needed to maintain outstanding remarkable values within stream segments designated "Wild & Scenic" in southwest Idaho. The water right proposal was intended to protect the rivers in the study area from future development and excessive water demands. Unfortunately, the study area currently lacked sufficient streamflow data, and streamflow statistics obtained from the U.S. Geological Survey StreamStats program are imprecise for this purpose. The USGS Idaho Water Science Center collected short-term streamflow data at selected locations and indexed those stations to streamflow data collected at long-term streamgages to produce exceedance probability distributions and synthetic streamflow records, as shown in the Wood and Fosness (2013) and Wood (2014) reports below. The USGS continues to collect streamflow data and plans to update the equations and statistics published in Wood and Fosness (2013) at a later date.

The Idaho Water Science Center is collecting streamflow, sediment, bathymetry, and videography data from the Kootenai River in Northern Idaho in support of the Kootenai River Habitat Restoration Program being conducted by the Kootenai Tribe of Idaho to restore listed Kootenai White Sturgeon. The information that the USGS is providing will be used to guide project remediation design and to evaluate changes resulting from remedial efforts. A multidimensional hydraulic flow model was developed for the spawning reach of the Kootenai River and will continue to be calibrated and used as a tool to predict changes to the channel morphology following remedial modifications. A recently approved and soon-to-be published report entitled, "Sediment Transport and Evaluation of Sediment Surrogate Ratings in the Kootenai River near Bonners Ferry, Idaho, Water Years 2011-14", by Wood, Fosness, and Etheridge (SIR 2015-5169) describes findings for sediment transport in the Kootenai River in the project area.

The IDWSC is participating in a national bridge scour study, previously described in the section titled "Performance and Effectiveness of Scour Countermeasures". The IDWSC will visit selected bridges in the western United States and report on the countermeasure, bridge, and channel characteristics. The project website is at http://water.usgs.gov/osw/techniques/bs/scour_fhwa/.

Recent Publications

Wood, M.S., 2014, Streamflow statistics for development of water rights claims for the Jarbidge Wild and Scenic River, Owyhee Canyonlands Wilderness, Idaho, 2013-14: a supplement to Scientific Investigations Report 2013-5212, 14 p.

Wood, M.S., and Fosness, R.L., 2013, Streamflow monitoring and statistics for development of water rights claims for Wild and Scenic Rivers, Owyhee Canyonlands Wilderness, Idaho, 2012: U.S. Geological Survey Scientific Investigations Report 2013–5212, 66 p.

Skinner, K.D., 2013, Post-fire debris-flow hazard assessment of the area burned by the 2013 Beaver Creek fire, near Hailey, central Idaho: U.S. Geological Survey Open-File Report 2013-1273, 11 p., 9 pls., http://dx.doi.org/10.3133/ofr20131273.

Illinois

Urban Flood Frequency: The rural regional flood-frequency (F-F) equations for Illinois (IL) that were developed by the USGS and implemented in the online tool, StreamStats (SS) are widely used throughout the State to compute peak discharges for design of bridges, culverts, and other purposes. With increased urbanization, especially in northeastern IL, regional F-F equations that include the effects of urbanization are needed. The most recent urban regional F-F equations for IL were published in 1979 and are not implemented in SS because the data and methods have been superseded. The USACE recently funded the adjustment of the annual peak discharge time series records at gages in northeastern IL to 2010 land-use conditions. These time series utilize new streamflow, land-use, and precipitation data to represent current conditions. These time series have been analyzed to develop an accurate and easy-to-use method of determining peak discharges on urbanized watersheds for design and reference. The analysis will enable the transfer of urbanization effects to other regions in IL, and the implementation of the methods in the IL SS. This project is in cooperation with the Illinois Center for Transportation and is to be completed by April 2016.

Sediment and Streamflow: Data collected by the Illinois Water Science Center in cooperation with State, Federal, and local partners are used to assess the effects of dam removals and stream restoration. HEC-RAS modeling is calibrated to simulate transport of streamflow and sediment through bridges, culverts, piers, and dams. Validation of the model through measured streamflow and sediment data are critical to successful bridge and culvert designs and, when needed, the restoration of damaged stream systems.

Recently completed projects for which recent publications are also listed below are:

Regional Flow Duration Equations: Extends statewide streamgaging information by regionalizing flow duration statistics for rural watersheds, similar to the flood-frequency regional regression equations. This report makes it possible to estimate the flow duration statistics for ungaged rural streams in Illinois and Indiana. These results can also serve as the basis for daily streamflow estimation by utilizing a method of index station selection, and are more accurate than drainage-area ratio methods. The results in this study can be implemented in the Illinois and Indiana StreamStats http://pubs.usgs.gov/sir/2014/5177/.

Pier and Contraction Scour in Cohesive Soils: In Straub and Over (2010), the results of testing the Scour Rate In Cohesive Soils-Erosion Function Apparatus (SRICOS-EFA) method for estimating scour depth of cohesive soils at 15 bridges in Illinois are presented. The report also presents techniques developed to estimate streamflow at ungaged sites. In Straub and others (2013), the results of using the SRICOS-EFA

method to predict ultimate scour on an additional 15 bridge sites in Illinois are presented. Also, results of the comparison of historic IDOT laboratory and field values of unconfined compressive strength of soils (Qu) are presented.

Flood inundation map libraries for four USGS streamgage sites (three with collocated NWS flood forecast points) that can assist with highway, road, and bridge operations during floods have been published and can be accessed from http://il.water.usgs.gov/ifhp/. These map libraries were completed in cooperation with various local agencies.

Recent Publications

Over, T.M., Riley, J.D., Sharpe, J.B., and Arvin, Donald, 2014, Estimation of regional flow-duration curves for Indiana and Illinois: U.S. Geological Survey Scientific Investigations Report 2014–5177, 24 p. and additional downloads, Tables 2–5, 8–13, and 18, http://dx.doi.org/10.3133/sir20145177.

Over, T.M., Soong, D.T., and Su, T.Y., 2014, Identifying and adjusting for effects of urbanization on peak streamflows, oral presentation, FHWA National Hydraulic Engineering Conference, Iowa City, Iowa, August 19-22, 2014.

Straub, T.D., Over, T.M., and Domanski, M.M., 2013, Ultimate Pier and Contraction Scour Prediction in Cohesive Soils at Selected Bridges in Illinois, Illinois Center for Transportation Report FHWA-ICT-13-025, 40p. http://ict.illinois.edu/Publications/report%20files/FHWA-ICT-13-025.pdf

Straub, T.D., and Over, T.M., 2010, Pier and Contraction Scour Prediction in Cohesive Soils at Selected Bridges in Illinois: Illinois Center for Transportation Report FHWA-ICT-10-074, 119 p. http://ict.illinois.edu/Publications/report%20files/FHWA-ICT-10-074.pdf

Murphy, E.A. and Sharpe, J.B., 2013, Flood-inundation maps for the DuPage River from Plainfield to Shorewood, Illinois, 2013: U.S. Geological Survey Scientific Investigations Map 3275, 9 sheets, 8-p. pamphlet, http://dx.doi.org/10.3133/sim/3275.

Soong, D.T., Murphy, E.A., and Sharpe, J.B., 2012, Flood-inundation maps for a 1.6-mile reach of Salt Creek, Wood Dale, Illinois: U.S. Geological Survey Scientific Investigations Map 3185, 8 p. pamphlet, 14 sheets, scale 1:6,500.

Murphy, E.A., Soong, D.T., and Sharpe, J.B., 2012, Flood-inundation maps for a nine-mile reach of the Des Plaines River from Riverwoods to Mettawa, Illinois: U.S. Geological Survey Scientific Investigations Report 2012–5227, 17 p., available only at http://pubs.usgs.gov/sir/2012/5227.

Murphy, E.A., Sharpe, J.B., and Soong, D.T., 2012, Ohio River backwater flood-inundation maps for the Saline and Wabash Rivers in southern Illinois (ver. 1.1, September 2014): U.S. Geological Survey Scientific Investigations Report 2012–5212, 20 p., available only at http://pubs.usgs.gov/sir/2012/5212.

Indiana

In 2015 the USGS operated 30 streamgages in cooperation with the Indiana DOT.

Flood inundation map libraries have been developed for 7 USGS streamgage sites and collocated NWS flood forecast points to assist with highway, road, and bridge operations during floods. An additional 7 libraries will be developed and are scheduled to be complete by mid-2017.

Recent Publications

Coon, W.F., 2013, Flood-inundation maps for the Flatrock River at Columbus, Indiana, 2012: U.S. Geological Survey Scientific Investigations Map 3241, 12 p., 12 sheets, available only at http://pubs.usgs.gov/sim/3241.

Fowler, K.K., and Bunch, A.R., 2013, Flood-inundation maps for the Iroquois River at Rensselaer, Indiana: U.S. Geological Survey Scientific Investigations Map 3246, 9 map sheets, 8-p pamphlet, available at http://pubs.usgs.gov/sim/3246.

Fowler, K.K., 2014, Flood-inundation maps for the East Fork White River near Bedford, Indiana: U.S. Geological Survey Scientific Investigations Map 3274, 20 sheets, 8-p. pamphlet, http://dx.doi.org/10.3133/sim3274.

Lombard, P.J., 2013, Flood-inundation maps for the Wabash River at Terre Haute, Indiana: U.S. Geological Survey Scientific Investigations Map 3232, 22 sheets, 7-p. pamphlet, http://pubs.usgs.gov/sim/3232/.

Lombard, P.J., 2013, Flood-inundation maps for the East Fork White River at Columbus, Indiana: U.S. Geological Survey Scientific Investigations Map 3255, 15 sheets, 8-p. pamphlet, http://pubs.usgs.gov/sim/3255/.

Menke, C.D., Bunch, A.R., and Kim, M.H., 2013, Flood-inundation maps for the Tippecanoe River near Delphi, Indiana: U.S. Geological Survey Scientific Investigations Map 3243, 13 sheets, 9-p. pamphlet, available at http://pubs.usgs.gov/sim/3243.

Robinson, B.A., 2013, Recent (circa 1998 to 2011) channel-migration rates of selected streams in Indiana: U.S. Geological Survey, Scientific Investigations Report 2013–5168, 14 p. plus 1 app., http://pubs.usgs.gov/sir/2013/5168/.

Robinson, B.A., 2013, Regional bankfull-channel dimensions of non-urban wadeable streams in Indiana: U.S. Geological Survey, Scientific Investigations Report 2013–5078, 33 p., available only at http://pubs.usgs.gov/sir/2013/5078.

Iowa

The Iowa Water Science Center cooperatively funds 26 continuous-record real-time streamgaging stations and 80 crest-stage gages with the Iowa Department of Transportation Highway Research Board. There are 24 real-time crest-stage gages and the remaining are non-real-time.

Flood Profiles: Iowa WSC cooperatively funds an ongoing flood-profiles project to document water-surface-elevation profiles of significant flood events. Streams in Iowa that have been selected for the preparation of flood-profile reports typically have drainage areas of 100 mi^2 or greater and have annual exceedance probabilities of less than 2-4 percent (recurrence intervals greater than 25-50 years).

Statistical Summary of Selected Iowa Streamflow Data: The Iowa WSC will soon publish two sets of statistics: (1) long-term for the entire period of record and (2) recent-term for the 1984-2013 period of record. The statistics will be computed for streamflow data collected at 184 continuous-record streamgages in Iowa with at least 10 years of record. The statistics will be computed on the daily mean and annual instantaneous peak values of streamflow data collected through water year 2013. The following daily-flow statistics will be computed: monthly and annual flow durations; probability of the highest annual 1-, 3-, 7-, 15-, and 30-consecutive day high discharges; probability of the lowest annual 1-, 3-, 7-, 14-, 30-, 60-, 90-, 120-, and 183-consecutive day low discharges; probability of the lowest annual 1-, 7-, 14-, and 30-consecutive day seasonal low discharges; and Kendall's Tau trend analyses of annual flow durations and consecutive day low and high discharges. Long-term and recent-term graphs of annual discharges, mean daily mean discharges, and flow-duration curves will be included with the streamflow statistics for each streamgage. Instantaneous peak-flow probabilities will be computed for unregulated streamgages using the weighted independent estimates (WIE) program in which annual exceedance-probability estimates computed using the expected moments algorithm (EMA) program with the multiple Grubbs-Beck test for detecting low outliers will be weighted with annual exceedance-probability estimates computed using regional-regression equations. A trend analysis will be provided for the annual instantaneous peak discharges.

Flood-Estimation Comparisons for Small Drainage Basins in Iowa: The Iowa WSC performed two sets of flood-estimation comparisons. First, flood estimates calculated from five different flood-estimation methods for streamgages in Iowa with drainage areas less than 2 square miles were compared to flood estimates calculated at the streamgages using expected moments algorithm/multiple Grubbs-Beck test (EMA/MGB), annual-exceedance-probability (AEP) streamgage analyses. The five flood-estimation methods included (1) StreamStats multi-variable estimates, (2) single-variable estimates from the Iowa 2013 peak-flow report, (3) Iowa Runoff Chart estimates, (4) estimates from the report WRIR 87-4132, and (5) TR-55 rainfall-runoff model estimates. Second, flood estimates calculated from four different flood-estimation methods for streamgages in Iowa with drainage areas between about 2 and 20 square miles were compared to flood estimates calculated at the streamgages using EMA/MGB, AEP streamgage analyses. The four flood-estimation methods included the previously mentioned methods with the exception of the Iowa Runoff Chart method. Only streamgages included in the Iowa 2013 peak-flow study that meet all U.S. Geological Survey requirements for AEP streamgage analyses were included in the study. Eighty streamgages were selected for inclusion in this study. Twenty-five of these streamgages have drainage areas less than 2 square miles and 55 of them have drainage areas between about 2 and 20 square miles.

Investigation of LiDAR data: Dr. Brian Gelder (Iowa State University) will test at least four different quantitative methods to define stream initiation using 3-meter LiDAR data for 17 streamgages with drainage areas less than 50 square miles that are located within the Des Moines Lobe landform region in north-central Iowa. Watersheds for the 17 streamgages will be enforced using the method developed by Dr. Gelder for the Iowa Highway Research Board and at least four stream initiation methods will be used to define channel initiation points and the downstream flow paths. The Iowa WSC will use the stream initiation methods to define channelized flow paths on the hydrologically enforced LiDAR DEMs, creating multiple sets of selected basin-characteristic values that will be measured for each streamgage.

The 4-6 different quantitative methods to define stream initiation will be tested side-by-side for three watershed delineations (1) the total drainage-area delineation, (2) an effective drainage-area delineation based on a 2-percent AEP 24-hour rainfall, and (3) an effective drainage-area delineation based on a 20-percent AEP 24-hour rainfall producing 12-18 different data sets of basin-characteristic values for each streamgage watershed. Basin-characteristic values for stream density, relative stream density, total stream length, constant of channel maintenance, the number of first-order streams, and drainage frequency will be measured for each streamgage watershed from at least four stream initiation methods and LiDAR DEMs. The 4-6 sets of LiDAR-measured basin-characteristic values for total drainage area will be evaluated and compared to 1:24,000-scale StreamStats-measured basin-characteristic values for total drainage area for determining optimum stream-channel delineations from LiDAR data. Additional selected basin characteristics will be measured for each streamgage to also test optimum stream-channel delineations from LiDAR data using flood-estimation regression analyses. Expected moments algorithm/multiple Grubbs-Beck test, AEP streamgage analyses will be updated through the 2015 water year for the 17 streamgages and regression analyses will be performed to identify which of the 12-18 sets of LiDAR-measured basin-characteristic values from the 4-6 stream initiation methods and the three watershed delineation methods are the most significant for flood estimation for drainage areas less than 50 square miles located within the Des Moines Lobe landform region.

Entry of Iowa historic high-water marks into the USGS Flood Event Viewer mapping application: The Iowa WSC will implement the data entry of approximately 8,400 historic high-water marks (HWMs) for approximately 3,400 stream site locations in Iowa. All HWMs published in 47 USGS flood-profile reports and currently known historic HWMs collected by other agencies will be entered into the Flood Event Viewer (FEV) mapping application. For HWMs collected by the USGS, the flood elevation of the HWM, a description of the type of HWM found, the quality of the HWM, and the latitude and longitude of the HWM will be entered into the FEV application for each historic HWM. For HWMs collected in Iowa by other agencies, the flood elevation and latitude and longitude of the HWM, along with any available HWM description and quality information, also will be entered into the FEV application. Peak discharges will be entered for stream sites with HWM information if peak discharges have been published for the sites. If the FEV application is revised to include annual exceedance-probability (AEP) estimates for stream sites with peak discharges, then published AEP estimates will also be entered for HWM sites.

Recent Publications:

Eash, D.A., 2015, Comparisons of estimates of annual exceedance-probability discharges for small drainage basins in Iowa, based on data through water year 2013: U.S. Geological Survey Scientific Investigations Report 2015–5055,37 p. Report is available at http://dx.doi.org/10.3133/sir20155055.

Kansas

Streamflow Statistics: The Kansas Water Science Center is working on a project to add Kansas to the USGS National StreamStats Program which provides users with access to an assortment of analytical tools that are useful for water-resources planning and management, and for engineering design applications, such as the design of bridges.

Flood Frequency: In cooperation with the Kansas Department of Transportation, the Kansas WSC initiated a study that will improve estimates of annual exceedance probability flood magnitudes at streamgages and ungaged sites in Kansas by using current available data with new analysis techniques.

The Kansas Water Science Center operated 5 crest-stage gages in small drainage basins, some urban and some rural, for use in future flood frequency determinations. Annual peaks for 2014 were compiled and published in the USGS Peak Flow File.

Kentucky

No highway related projects at this time.

Louisiana

Note: Beginning in FY 2015, human resources of the USGS now employed in the study of water resources across the five states of Alabama, Arkansas, Louisiana, Mississippi, and Tennessee began a transformation to the **USGS Lower Mississippi-Gulf Water Science Center** (LMGWSC).

Monitoring: USGS maintains cooperative programs with the Louisiana Department of Transportation and Development (LADOTD) and many other local, State, or Federal agencies to operate 107 stage sites, 70 discharge sites, 46 water-quality sites in the coastal zone, 20 crest-stage gages (CSGs), and 77 flood-profile gages in Louisiana. Many of the sites provide continuous records that are available on the internet in near real time. In addition, the USGS office in Ruston, Louisiana, actively monitored historic flooding on the Red River during the summer of 2015, providing State and local officials with stage and discharge data at several points along the river.

Analysis of Flood Magnitude and Frequency in Louisiana: Streamflow statistics are used by government agencies, engineers, scientists, and environmental groups for the purpose of water management, permitting, and design. The primary source of streamflow data are streamgages operated by the USGS. The magnitude and frequency for floods are a primary consideration in bridge design. The USGS, in cooperation with the LADOTD, currently is updating flood-frequency statistics at gaging stations and developing updated regression equations to estimate flood frequency at ungaged sites. A new regional skew value is being developed concurrently with the project.

Maine

Methods for computing a wide range of flows, from very low to very high flows; suitable for estimating flow-duration curves at ungaged locations in Maine: Variable flow statistics at USGS streamflow gages are being derived on annual and monthly bases; spanning a wide range of exceedance probabilities (e.g. 0.01, 0.05, 0.10, 0.25, 0.50, 0.75, 0.90, 0.95, 0.99). Derived regression equations were published in a USGS Scientific Investigations Report. Not only will these regression equations provide managers and engineers with more complete flow information at ungaged locations, they provide the means for estimating flow duration curves at ungaged locations. With this ability, it paves the way for the development of more sophisticated methods for flow estimation at ungaged locations.

Dudley, R.W., 2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015–5151, 35 p., http://dx.doi.org/10.3133/sir20155151.

Evaluating the use of field indicators for computing design streamflows for small ungaged streams in Maine: The USGS, in cooperation with Maine DOT, developed regression equations to estimate peak streamflows with annual exceedance probabilities from 99 to 0.2 percent for small streams in Maine with drainage areas from 0.3 to 12 square miles. Field indicators such as culvert rust lines and bankfull widths were tested for use in the regression equations but were either not commonly found in the field (rust lines) or did not explain enough of the variability in the streamflow statistics to warrant inclusion in the final equations (bankfull width). The best explanatory variables were drainage area and percent basin wetlands. Generalized least-squares regression was used with these two variables to determine the equation coefficients and estimates of accuracy for the final equations.

Lombard, P.J., and Hodgkins, G.A., 2015, Peak flow regression equations for small, ungaged streams in Maine—Comparing map-based to field-based variables: U.S. Geological Survey Scientific Investigations Report 2015–5049, 12 p., http://dx.doi.org/10.3133/sir20155049.

Web-Based Streamflow Statistics Tool for Maine: StreamStats: The USGS, in cooperation with Maine DOT, implemented the USGS web-based interactive tool StreamStats for Maine. This tool provides descriptive information and previously published streamflow statistics and basin characteristics for USGS streamgages and allows the user to delineate drainage basins, determine basin characteristics and provides reproducible streamflow statistics for any stream location within Maine for which applicable streamflow regression equations have been published.

Lombard, P.J., 2015, Maine StreamStats—A water-resources Web application: U.S. Geological Survey Fact Sheet 2015–3014, 2 p., http://dx.doi.org/10.3133/fs20153014.

Estimating Time of Concentration for Runoff Events for Small Rural Basins in Maine: The study's objectives are: (1) to evaluate existing lag time and time of concentration equations for small basins in Maine using existing rainfall and streamflow data, and (2) to develop and test new regression equations for lag time and time of concentration using existing rainfall and streamflow data from small rural basins in Maine. The streamgages used in the study will have drainage areas less than 50 mi^2, and 20 to 30 paired streamgage/precipitation gage sites will be selected. Multiple storms will be identified where there is straightforward hydrographs, and a clear relation between rainfall data and the runoff peak. The average lag times and time of concentrations will be determine from these. Regression equations will them be developed by relating the lag times and time of concentrations to basin characteristics. The study begins in FY 2016, and ends in less than 2 years. The cooperator for this study is Maine DOT

Small-watershed data collection: Peak-flow data collection (crest-stage gages) continues on 13 streams, all with basins less than one square mile. Eight sites have 14 complete years of data collection, three sites have 13 complete years of data collection, and two have less than 10 years of data. In addition, 10 seasonal rain gages have been installed to prepare for a future small watershed time-of-concentration study. Five basins were selected for rain gages and two rain gages have been installed in each basin: one rain gage near the flow monitoring point and the other in the headwaters of the basin.

Continuous streamflow data collection: Continuous data collection continues at 18 USGS streamflow gages.

Maryland

Fourteen streamgages were operated cooperatively with the Maryland State Highway Administration (MDSHA).

Massachusetts

Massachusetts Flood Frequency Analysis: A study to update the magnitude of 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability (AEP) floods is being conducted in cooperation with the Massachusetts Department of Transportation. The last comprehensive regional AEP flood flows for Massachusetts were computed from data up to 1976. The new analysis reports AEP flows using data up through 2013 at 222 streamgages in Massachusetts and surrounding states. New streamgage AEP flows were determined from a weighted at-site skew with a recently competed regional skew for New England, updated techniques that use Expected Moments Algorithm (EMA), and censoring for multiple low outliers. Of the 222 streamgages reported, 199 streamgages were used in a regional analysis to develop equations for computing AEP flows at ungagged sites. The analysis was made using generalized least squares regression methods. The significant explanatory variables were drainage area, mean elevation, and percent of the basin area in open water and wetlands. A report documenting the work is in progress and is expected to be published later this year. After publication, the updated database of at-site AEP flows, along with the regional equations for computing flows at ungagged sites, will be made available in the point-and-click environment of the web-based USGS StreamStats application. The report is currently in review.

Zarriello, P.Z., 201X, Magnitude of flood flows for selected annual exceedance probabilities in Massachusetts through 2013: U.S. Geological Survey Scientific Investigations Report 201X–XXXX, XX p. (IN REVIEW).

Characterization of Total Nutrients and Suspended Sediment Concentrations in Stormwater Runoff from Bridge Decks in Eastern Massachusetts: While extensive information exists on stormwater runoff from Massachusetts highways as a whole, available information focused on bridge deck runoff is lacking. Therefore, the primary objective of this investigation is to characterize concentrations and loads of total phosphorus, total nitrogen, and suspended sediment from three bridges in Eastern Massachusetts over a two year period. This study also will evaluate the potential transferability of these data to other highway sites by performing a statistical comparison with previous highway runoff data (U.S. Geological Survey Scientific Investigations Report 2009-5269) in relation to traffic volume and total imperviousness surrounding the bridge locations. These new data will be entered into an updated version of the Federal Highway Runoff Database (FHWA-HEP-09-004), which will be used to support model estimates of loads and concentrations for phosphorus, nitrogen, and suspended sediment from bridge-deck runoff for the proposed monitoring sites. Three bridge-deck monitoring stations were installed late in water year 2014

and several flow-proportional composite samples were subsequently collected. Data collection will continue through water year 2016.

Flood inundation map libraries for four USGS streamgage sites (one with collocated NWS flood forecast point) that can assist with highway, road, and bridge operations during floods have been published. Another USGS streamgage sites' report is in review. These map libraries were completed in cooperation with FEMA.

Bent, G.C., Lombard, P.J., and Dudley, R.W., 2015, Flood-inundation maps for the North River in Colrain, Charlemont, and Shelburne, Massachusetts, from the confluence of the East and West Branch North Rivers to the Deerfield River: U.S. Geological Survey Scientific Investigations Report 2015–5108, 16 p., appendixes, http://dx.doi.org/10.3133/sir20155108.

Flynn, R.H., Bent, G.C. and Lombard, P.J., 201X, Flood-inundation maps for the Green River, in Colrain, Leyden, and Greenfield, Massachusetts, from the USGS Streamgage 01170100 near Colrain to the Deerfield River: U.S. Geological Survey Scientific Investigations Report 201X-XXXX, xx p. (IN REVIEW).

Lombard, P.J., and Bent, G.C., 2015, Flood-inundation maps for the Hoosic River, North Adams and Williamstown, Massachusetts, from the confluence with the North Branch Hoosic River to the Vermont state line: U.S. Geological Survey Scientific Investigations Report 2014–5236, 16 p., appendixes, http://dx.doi.org/10.3133/sir20145236.

Lombard, P.J., and Bent, G.C., 2015, Flood-inundation maps for the Deerfield River, Franklin County, Massachusetts, from the confluence with the Cold River tributary to the Connecticut River: U.S. Geological Survey Scientific Investigations Report 2015–5104, 22 p., appendixes, http://dx.doi.org/10.3133/sir20155104.

Michigan

In fiscal year 2015, the USGS Michigan Ohio Water Science Center (MI-OH WSC) operated about 170 streamgages and 10 crest-stage gages in Michigan. Most of the gages are operated cooperatively, including Michigan Department of Transportation support for 8 streamgages and 4 crest-stage gages. At five crest-stage gages, water levels are recorded continuously to document the timing of peak-flow events. Most crest-stage gages are located near highway crossings and provide peak stage and flow to support local and state transportation and emergency response agencies. During late 2014, increased NSIP funding supported the installation of a new streamgage in the central Upper Peninsula, in an area that previously has had limited continuous-streamflow information.

In coordination with adjoining states, Michigan is preparing for a new regional flood skew study that would update estimates from a 1983 study. Station skew estimates have been updated using peak flow data through 2013 from a set of streamgages and crest-stage gages that have been augmented since the 1983 study. New computational algorithms have been applied to these data for computing the skew of the Pearson type-3 flood-frequency distribution. The algorithms are based on a multiple Grubbs-Beck low-outlier test and an Expected Moments Algorithm (T. Cohn, USGS, written communication, 2013).

These algorithms are likely to supersede those published in a 1982 as Bulletin 17B report. The updated report is expected to be entitled Bulletin 17C.

A preliminary comparison of station skews computed by use of Bulletin 17B and Bulletin 17C methods with data from the 1983 study, shows that station skew estimates are consistent when there are no historic peaks or low outliers, and are generally higher when historic peaks or outliers are present. Data files needed to regionalize flood skew using a Bayesian generalized least squares (GLS) regression analysis have been compiled according to standards prescribed by the USGS Office of Surface Water. Completion of the regional flood skew update would provide a basis for an initial StreamStats implementation in Michigan.

Minnesota

The U.S. Geological Survey (USGS) Minnesota Water Science Center (MNWSC) operates a network of 79 crest-stage gages that record peak-flow at or near highway crossings. Two of those crest-stage gages provide real-time stage for hydropower and flood warnings. The peak-flow data collected at these stations augments data collected at the 155 continuous recording stations operated in Minnesota and enhances coverage of peak-flow measurements in the region. The project was cooperatively funded by the USGS and the Minnesota Department of Transportation (MNDOT).

MNWSC provided hydraulic investigation support, and bridge scour monitoring as requested. This work is funded by MNDOT.

The MNWSC will publish a report in 2017 titled, “Techniques for Estimating Peak Flow on Small Streams in Minnesota and the portion of the Rainy River Basin Upstream of Kenora, Ontario, Canada”. This report requires large amounts of data generation and collection for the process of identifying the critical characteristics needed for estimating flood frequencies in Minnesota. This project will publish flood frequency statistics for all gaging stations with 10 or more years of high flow data. The report will be developed in cooperation with the MNDOT and the International Joint Commission.

The MNWSC produced digital flood-inundation maps for a 6.3-mile reach of the Mississippi River in Saint Paul, Minnesota. These were developed through a multi-agency effort by the USGS in cooperation with the U.S. Army Corps of Engineers and in collaboration with the National Weather Service. The inundation maps, which can be accessed through the USGS Flood Inundation Mapping Science Web site at http://water.usgs.gov/osw/flood_inundation/ and the National Weather Service Advanced Hydrologic Prediction Service site at http://water.weather.gov/ahps/inundation.php, depict estimates of the areal extent and depth of flooding corresponding to selected water levels (stages) at the USGS streamgage at the Mississippi River at Saint Paul (05331000). The National Weather Service forecasted peak-stage information at the streamgage that can be used in conjunction with the maps developed in this study to show predicted areas of flood inundation.

USGS is collecting sediment and streamflow data that are used by the Minnesota Department of Natural Resources (MNDNR) to validate statewide stream restoration directives. The MNDNR Division of Ecological and Water Resources uses HEC-RAS models to improve culvert designs at stream/road

crossings in order to improve ecological function and water quality and ensure channel and floodplain connectivity. Proper culvert design and placement is needed to ensure transport of water and sediment in such a manner that the stream is able to maintain its dimension, pattern, and profile over an extended time without either aggrading or degrading. HEC-RAS modeling is used to simulate transport of streamflow and sediment through bridges, culverts, piers, and dams. Validation of the model through measured streamflow and sediment data are critical to successful bridge and culvert designs and, when needed, the restoration of damaged stream systems.

The USGS, in cooperation with the MNDNR is conducting a study to develop region regression equations for flow-duration curves in the state. The results of the study will enable hydrologists to simulate flow conditions at ungaged locations and will assist in efforts such as ecological flows and TMDLs. This work is cooperatively funded by the USGS and the Minnesota Pollution Control Agency.

The USGS worked with MNDOT to find two suitable bridge sites, as requested for the national study with FHWA to assess scour-related countermeasures. Bridges found were in category 9 (very simple), which was a shortage category nationally.

Recent Publications

Kessler, E.W., Lorenz, D.L., and Sanocki, C.A., 2013, Methods and results of peak-flow frequency analyses for streamgages in and bordering Minnesota, through water year 2011: U.S. Geological Survey Scientific Investigations Report 2013–5110, 43 p., http://pubs.usgs.gov/sir/2013/5110/.

Ellison, C.A., Savage, B.E., and Johnson, G.D., 2014, Suspended-sediment concentrations, loads, total suspended solids, turbidity, and particle-size fractions for selected rivers in Minnesota, 2007 through 2011: U.S. Geological Survey Scientific Investigations Report 2013–5205, 43 p., http://dx.doi.org/10.3133/sir20135205.

Czuba, C.R., Fallon, J.D., Lewis, C.R., and Cooper, D.F., 2014, Development of flood-inundation maps for the Mississippi River in Saint Paul, Minnesota: U.S. Geological Survey Scientific Investigations Report 2014–5079, 24 p., http://dx.doi.org/10.3133/sir20145079.

Mississippi

Note: Beginning in FY 2015, human resources of the USGS now employed in the study of water resources across the five states of Alabama, Arkansas, Louisiana, Mississippi, and Tennessee began a transformation to the **USGS Lower Mississippi-Gulf Water Science Center** (LMGWSC).

The Mississippi office had the following projects during 2015:

- Providing streamflow records, hydrologic analyses of basins, and hydraulic analyses of the flooding potential at selected stream crossings, known as bridge-site studies. Scour analyses are also conducted at selected sites, and LiDAR is providing additional cross section data at sites as it becomes available across the State.

- Operating and maintaining 98 CSGs and 2 flood hydrograph gages. Thirteen flood-discharge measurements were made at eight CSGs in FY 2015.
- Operating a near-real-time scour monitoring gage at a coastal bridge. Streambed soundings and bathymetric surveys are obtained at this and other selected bridges to document scour.
- Preparing 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. Expected Moments Algorithm (EMA) is also being included in the analyses to be completed in FY 2016.

Missouri

Ongoing activities of the Missouri Water Science Center in 2015 included:

- Continued operation of a network of 38 crest-stage gages.
- Continued operation and maintenance of the statewide network of streamgages, 7 of which are operated in cooperation with Missouri Department of Transportation.
- Ongoing bathymetric surveys with comparisons to past surveys at Missouri and Mississippi River bridge sites. 2015 marked the third set of surveys at the bridges over the Missouri River in the Kansas City area (2010, 2011, and 2015).

FHWA Bridge Scour Countermeasures: The MOWSC is participating as a team member in the national bridge scour countermeasures study, previously described in the section titled "Performance and Effectiveness of Scour Countermeasures," as one of the technical leads. In 2015, the MOWSC participated in visits to 8 bridge sites in Florida, Missouri, and Indiana, and will report on the countermeasures, bridge, and channel characteristics. The MOWSC plans to participate in visits to additional selected sites in the central United States in 2016. The project website is at http://water.usgs.gov/osw/techniques/bs/scour_fhwa/.

Recent Publications

Huizinga, R.J., 2015, Bathymetric and velocimetric surveys at highway bridges crossing the Missouri and Mississippi Rivers on the periphery of Missouri, June, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5048, 81 p., http://dx.doi.org/10.3133/sir20155048.

Montana

Bridge Scour Data Collection: The Wyoming-Montana Water Science Center (WY-MT WSC, formerly the MT WSC) has been cooperating with Montana Department of Transportation (MDT) on a bridge-scour data collection and analysis program since 1991. As part of this program, real-time scour monitoring is being conducted at two sites on the Yellowstone River, and seasonal scour monitoring is being conducted at one site on the Sun River.

Crest-Stage Gages: The WY-MT WSC has been cooperating with MDT on a small-stream peak-discharge data collection program since 1955 to assist with infrastructure design; currently we are operating 88 crest-stage gages in Montana. An interactive web map was created to display the data and provide links to the data: http://wy-mt.water.usgs.gov/projects/CSG/index.html

Wetland Hydrology: A cooperative project with MDT continues to investigate the hydrology of selected wetland areas affected by proposed and recently constructed highway projects.

I-90 Bridge Monitoring: In cooperation with MDT, WY-MT WSC continues to monitor scour and related hydraulic conditions at the I-90 bridge near the mouth of the Blackfoot River following the 2008 removal of Milltown Dam, which was located just downstream on the Clark Fork River.

Streamflow Statistics: WY-MT WSC will soon publish a Montana StreamStats report in several chapters; including peak-flow frequency analyses and statistical summaries for more than 660 USGS gaging stations in Montana; trends and stationarity analyses; and regression equations for estimating peak flow frequencies and other streamflow statistics at ungaged sites. The Montana StreamStats application should be online by early 2016.

Nebraska

Several studies investigating the cumulative effects of human activities such as transportation infrastructure on the lower Platte River corridor ecosystem are being conducted in cooperation with local, state, and federal agencies. Techniques such as time-lapse photography, sediment sampling over time, and sediment transport modeling are being used to study impacts on geomorphology and habitat on river reaches at or near bridges.

A study is underway to update peak-flow frequency analyses using the Expected Moments Algorithm (EMA) and a new multiple low-outlier test based on a generalization of the Grubbs-Beck test. This project would be the first step in a phased approach to implement StreamStats in Nebraska.

Flood inundation map libraries have been developed for a reach of the Big Papillion Creek in Omaha and are currently be developed for the North Platte River at Scottsbluff. The National Weather Service provides river forecasts for both sites. This study provides cooperators with a flood planning tool for road and bridge construction and operation.

Nevada

Nevada Water Science Center maintains a Statewide network of crest-stage gages: 25 with the Nevada Department of Transportation and 4 with the US Army Corps of Engineers. Peak stages recorded at the crest-stage gages are computed to discharge peaks by direct or indirect measurements, or by application of stage-discharge ratings.

USGS and the Nevada Department of Transportation entered into an agreement in FY06 to compute sediment loads in the Clear Creek drainage. This study assessed the impact of runoff from a U.S.

highway. The study collected samples throughout the year, but was also event driven, meaning sample collection intensified during snowmelt and summer thunderstorms. A USGS Scientific Information Report (sir 2009-5005) was published in FY09 by Seiler and Wood documenting baseline discharge and sediment conditions during FY2004-07. A three-year agreement with the Nevada Department of Transportation was signed in October 2009 to continue monitoring discharge, sediment, and selected water quality constituents in the Clear Creek drainage from FY2010-12. This report was published in September 2015 by Huntington and Savard (sir 2015-5124). A new agreement to extend the study through the end of FY16 was signed in August 2013. Two more reports, one documenting FY2013-14 will be published in FY16 and another documenting FY2015-2016 will be published in FY17.

New Hampshire

NHDOT – USGS Sources of Nitrate to Wells: A project to help determine sources of nitrate to wells in the vicinity of active roadway blasting is in its second of two years. Sampling was completed between April 2013 and October 2014 for the USGS and New Hampshire Department of Transportation (NHDOT) study. Concentrations and isotopic compositions of nitrate and other nitrogen compounds in groundwater are being used to identify sources of nitrate such that nitrate derived from septic system (human waste) sources can be differentiated from nitrate that is sourced from blasting agents (ammonium nitrate and fuel oil). This study will help the NHDOT determine when it is responsible for nitrogen (nitrate) contamination of groundwater as a result of their roadway construction efforts that involve blasting for rock removal. Additional water chemistry data will used to corroborate findings and to develop relations between isotopic data and more commonly collected constituents in groundwater. The journal article is in review for acceptance.

New Jersey

A bridge scour data collection project was started in April 2008 and ran through FY 2014. The general objectives of this program were to monitor and validate the effects of scour at New Jersey Department of Transportation bridge structures designated as scour critical and to obtain updated flow and velocity data. The New Jersey Water Science Center plans to reactivate this project in the upcoming fiscal year.

New Mexico

Flood Analysis: The USGS New Mexico Water Science Center (NMWSC) operates and maintains a crest-stage gage network of 85 gages in ephemeral streams around the State. Fifty-two of the crest-stage gages in the network are currently equipped with automated pressure transducers. Notable floods are documented through collection of flood information such as high-water marks, peak stages and discharges by indirect measurements at miscellaneous flooded sites.

StreamStats: New Mexico StreamStats development has been partially funded by the USGS in cooperation with the USDA (Forest Service, Southwestern Region) and the New Mexico Department of Transportation (NMDOT). Information about the StreamStats program can be found at: http://water.usgs.gov/osw/streamstats/new_mexico.html.

A New Mexico StreamStats pilot area (the portion of the San Juan Basin within New Mexico) is complete, tested, and available online (see web page link above). Coverage should be expanded to include the entire State of New Mexico by the end of FY 2015 using recently released NHD-Plus Version 2 data. Basic basin characteristics will be available at release and more advanced features could be added in the future.

Flood Frequency: In cooperation with the New Mexico Department of Transportation, the NMWSC initiated a study to update the flood frequency statistics for New Mexico. That project will begin in 2016 and will conclude September, 2018. The project will add a decade of additional peak flow data for regional flood regression estimating equations which were last updated in 2008.

New York

Transportation-related activities in the New York Water Science Center during 2015 included:

- Documenting notable floods through collection of peak flood stage and discharge data, flood profiles, and indirect measurements of peak flood discharges.
- Maintaining a statewide network of 40 crest-stage gages to determine annual peak flows.
- Working with the PA, OH, and MI Water Science Centers, as well as the USGS Office of Surface Water, to determine regional skew for the 4-state area. Results of the regional skew effort will replace the current generalized skew map for NY. (http://ny.water.usgs.gov/pubs/wri/wri004022/WRIR00-4022.pdf)
- The web-based tool "Application of Flood Regressions and Climate Change Scenarios to Explore Estimates of Future Peak Flows (ver. 1.0)" and an accompanying report are near final approval for public release. The application is a climate-scenario tool which piggy-backs on StreamStats capabilities and available downscaled-climate models. Future precipitation estimates are used with existing regional regression equations for NY to assess the future change in flood-frequency discharges from current conditions.
- A flood inundation mapping project, in cooperation with the New York State Department of Environmental Conservation, is nearing completion for the Schoharie Creek in Prattsville, NY, a community heavily damaged by Hurricane Irene. A project fact sheet is available here: http://ny.cf.er.usgs.gov/nyprojectsearch/projects/LK00-A6APV.html
- Working with the NYS Emergency Management Office, NYS DOT, NYS Geological Survey, and others to develop a statewide landslide susceptibility map. Schenectady County was completed in 2008, but continuation of the project is currently on-hold due to lack of funding.
- Monitoring stream restoration reaches in the New York City reservoir watershed to track changes in suspended-sediment loading and turbidity.

Recent Publications

Wall, G.R., Murray, P.M., Lumia, Richard, and Suro, T.P., 2014, Maximum known stages and discharges of New York streams and their annual exceedance probabilities through September 2011: U.S. Geological Survey Scientific Investigations Report 2014–5084, 16 p., http://dx.doi.org/10.3133/sir20145084.

Lumia, Richard, Firda, G.D., and Smith, T.L., 2014, Floods of 2011 in New York: U.S. Geological Survey Scientific Investigations Report 2014–5058, 236 p., http://dx.doi.org/10.3133/sir20145058.

Coon, W.F., and Breaker, B.K., 2012, Flood-inundation maps for the West Branch Delaware River, Delhi, New York, 2012: U.S. Geological Survey Scientific Investigations Map 3216, 9 p. pamphlet, 10 sheets, scale 1:20,000. Available online at http://pubs.usgs.gov/sim/3216.

Mulvihill, C. I. and B. P. Baldigo, 2012, Optimizing bankfull discharge and hydraulic geometry relations for streams in New York State, Journal of the American Water Resources Association. v.48, pg 449-463.

North Carolina

The USGS South Atlantic Water Science Center (SAWSC) Raleigh, North Carolina office continues to maintain and provide the statewide USGS StreamStats application for North Carolina, which was completed in June 2012 in cooperation with the North Carolina Department of Transportation (NCDOT). The application has been updated to provide users with flood-frequency statistics and techniques from a recently published report on flood frequency in urban and small rural basins in Georgia, South Carolina, and North Carolina (USGS SIR 2014-5030; Feaster and others, 2014). Updated streamflow statistics were added to the application in 2015 following the publication of a USGS report providing updated low-flow and flow-duration statistics at selected continuous-record streamgages across North Carolina (Weaver, 2015; see below). During 2015, data describing land-cover characteristics from the 2011 National Land Cover Database was also added to the application (impending release of updated application by end of calendar year 2015). Use of the NC StreamStats application outside of the USGS continues to result in positive feedback being received from external users.

In September 2015, the USGS SAWSC Raleigh, North Carolina office began a cooperative investigation with the NCDOT Hydraulics Unit to “customize” the Stochastic Empirical Loading and Dilution Model (SELDM) for use in North Carolina. Developed by Gregory Granato, hydrologist with the New England Water Science Center (Massachusetts office), the SELDM uses Monte-Carlo methods to quantify the effects of precipitation characteristics, streamflow, estimated runoff quantity and quality, and best management practices on the probability distribution of receiving-water concentrations. Use of the model allows for planning-level assessments of potential effects on water quality in runoff from highway projects. This project will result in the addition of more recent streamflow and water-quality data for sites in North Carolina and is due to be completed in March 2018.

The SAWSC Raleigh, North Carolina office concluded data collection to establish baseline bed-sediment chemistry and water-quality conditions and the associated circulation dynamics of Currituck Sound in northeastern North Carolina in the vicinity of the planned alignment of the proposed Mid-Currituck Bridge. These data were summarized in a USGS Open File Report (recently approved but not yet published) that will be used to evaluate the environmental effects associated with the bridge construction and bridge deck stormwater runoff on Currituck Sound in the second phase of the study. In association with the study on the Currituck Sound, the SAWSC Raleigh, North Carolina office also continues to collect stage-only and wind speed/direction data for the Currituck Sound on the east bank at Corolla, NC (USGS Sta. 02043433 and 362228075500401, respectively).

During FY 2015, the SAWSC Raleigh, North Carolina office operated continuous streamflow gaging stations on Goose Creek at Fairview, NC (USGS Sta. 02124692) and Waxhaw Creek near Jackson, NC (USGS Sta. 02147126) just outside of Charlotte in cooperation with the NCDOT. These sites were discontinued effective October 1, 2015 (beginning of FY 2016).

Recent Publications

Weaver, J.C., 2015, Low-flow characteristics and flow-duration statistics for selected USGS continuous-record streamgaging stations in North Carolina through 2012: U.S. Geological Survey Scientific Investigations Report 2015–5001, 89 p., http://dx.doi.org/10.3133/sir20155001.

North Dakota

Souris River Flood Risk Assessment: In response to the recent extreme flooding in the Souris Basin, the North Dakota Water Science Center, in cooperation with the North Dakota State Water Commission, completed a project in 2015 to evaluate future flood risk for the Souris River in response to potential climate change or natural climate non-stationarity. A stochastic climate and streamflow simulation model was developed to simulate future streamflow and evaluate flood risk. It was determined that long-term (multi-decadal to century scale) climate in the region is characterized by shifts between wet and dry climatic conditions, with the most recent wet period starting in the 1970's and continuing to the present (2015). The historical record flood of 2011 in Minot, ND, was determined to be about 6 times more likely during a wet climatic period compared to a dry period. A report in in press (expected publication January 2016; contact: avecchia@usgs.gov)

Soil Water Balance Effects on Flood Reduction in the Red River of the North: The North Dakota Water Science Center began a cooperative project with USDA/NRCS in 2015 to investigate the loss of soil moisture that occurs during agricultural production as a potential store for rainfall and snowmelt runoff water to reduce flooding in the Red River of the North Basin as part of the NRCS Red River Basin Initiative. These efforts would benefit communities downstream, especially in times of heavy rain and flooding, by reducing potential damage that could occur to highways, bridges, and other and infrastructures. USDA/NRCS will assess results of this project to possibly introduce programs to assist agricultural producers store water in soils for extended period of time. (contact: kcvining@usgs.gov)

StreamStats: The current application of StreamStats for North Dakota is located at http://ssdev.cr.usgs.gov/ss_dev/. Streamflow statistics in StreamStats for North Dakota are currently in development.

Ohio

Crest-stage gages: 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.

StreamStats: Ohio has had an operational StreamStats application (available at http://water.usgs.gov/osw/streamstats/ohio.html) for computing flood-frequency estimates since 2006. In recent years, the Ohio StreamStats application has been expanded to compute an array of other streamflow statistics as a result of cooperative projects with other Federal, State, and local agencies.

Oklahoma

StreamStats is fully operational, and public availability occurred in 2011.

The Oklahoma Water Science Center, in cooperation with the Oklahoma Department of Transportation, completed a Web-based flood database for Oklahoma. The objectives of this project were to develop (1) a digital database of USGS and ODOT historical flood information, and (2) a web-based mapping interface (using the ESRI JavaScript API) that facilitates access to this information and results in improved flood-frequency statistic estimation for structural design in Oklahoma. Data sources of historical flood information include: the peak flood of record at all USGS gages, published USGS indirect measurements, unpublished USGS and ODOT indirect measurements, and selected ancillary data and documents related to historical flooding. Maintenance of the database is on-going as peak flows are added each year.

The web-based product produced from this study is available here:
http://ok.water.usgs.gov/projects/dbflood/

The USGS Oklahoma Water Science Center, in cooperation with the Oklahoma Department of Transportation, completed a study to update and develop new regional regressions for estimating rural flood-frequency statistics in the Oklahoma Panhandle. The objectives of the study were to: (1) delineate and define the extent of the Oklahoma Panhandle/Northwest region where StreamStats is suspected (by State engineers) to compute unreasonable estimates of flood-frequency statistics ; (2) review previous flood-frequency regression studies in Oklahoma and Kansas, (3) develop new flood-frequency regression equations for the Panhandle/Northwest region of Oklahoma, (4) publish a peer-reviewed USGS report describing methods and results of equation review and development, and (5) incorporate new regional flood-frequency regression equations into StreamStats (which has not been completed yet). In terms of scope, the project will consider about 30 streamflow-gaging stations located in the Oklahoma Panhandle and surrounding counties of Oklahoma, Kansas, and Texas. The time period covered by the study will be the irrigation-affected period covering water years 1978 to 2013.

Recent Publications

Smith, S.J., Lewis, J.M., and Graves, G.M., 2015, Methods for estimating the magnitude and frequency of peak streamflows at ungaged sites in and near the Oklahoma Panhandle: U.S. Geological Survey Scientific Investigations Report 2015–5134, 35 p., http://dx.doi.org/10.3133/sir20155134.

Oregon

SELDM: In FY 2014, the USGS Oregon Water Science Center (ORWSC) completed a two-year coop study with the Oregon Department of Transportation (ODOT) to implement the Stochastic Empirical Loading and Dilution Model (SELDM) in Oregon (Risley, J.C., and Granato, G.E., 2014). Specific objectives of the study were to: 1) Develop and refine local precipitation and hydrologic geospatial data layers needed for SELDM, 2) Install precipitation and hydrologic geospatial data layers into the Oregon StreamStats site, 3) Develop and compile upstream basin and highway water-quality transport curves and data sets for Oregon applications, and 4) Evaluate the impacts of storm water runoff on downstream water quality at five Oregon highway sites using SELDM and Best Management Practices (BMP).

In FY 2015 ODOT provided funding to the Oregon Water Science Center (ORWSC) to develop new basin characteristic datasets for the Oregon StreamStats viewer. These new datasets include 1) land-cover categories such as imperviousness, water, wetlands, cultivated, herbaceous, shrub land, forest, and barren land; 2) developed land-use categories such as open space, low intensity, medium intensity, and high intensity; and 3) Oregon state roads. The new basin characteristic datasets will provide a percentage breakdown of land-use categories in a basin, which is quantitative information needed in SELDM modeling applications.

ODOT is currently seeking internal funding for a follow up study to the earlier ODOT-ORWSC study which will assess the planning capability of using of SELDM at multiple highway sites within a single basin.

StreamStats: Currently the Oregon StreamStats site includes equations for estimating 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood frequencies in western Oregon (Cooper, 2005). For the entire state, StreamStats can also compute basin characteristics needed to estimate low-flow frequency (7Q2, 7Q10) and flow duration (5^{th}, 10^{th}, 25^{th}, 50^{th}, and 95^{th}) statistics from equations currently installed in the NSS program (Risley and others, 2008). StreamStats will soon have the capability of computing those low-frequency and flow duration statistics automatically.

In FY 2015 ODOT provided funding to ORWSC for the review of 2-, 5-, 10-, 25-, 50-, 100-, and 500-year eastern Oregon flood frequency regression equations that were created and published by the State of Oregon Department of Water Resources (Cooper, 2006). It is anticipated that ODOT will provide ORWSC additional funding in FY 2016 to install the equations in the Oregon StreamStats viewer.

Stream Gages: ODOT relies heavily on numerous USGS continuous streamflow gages for their bridge scour inspection analyses. In FY 2016 ORWSC hopes to start a bridge scour program with ODOT that will utilize newer data collection technologies.

Multi-Dimensional Hydraulic Modeling: ORWSC is starting two new multi-dimensional hydraulic modeling studies in the Willamette River and the lower Columbia River tidal estuary. Although the studies are not funded by ODOT, the studies will include modeling multi-dimensional flow conditions at numerous State owned highway bridge sites.

Publications:

Cooper, R.M., 2005, Estimation of peak discharges for rural, unregulated streams in western Oregon: U.S. Geological Survey Scientific Investigations Report 2005-5116, 134 p. Available online at: http://pubs.er.usgs.gov/publication/sir20055116.

Cooper, R.M., 2006, Estimation of peak discharges for rural, unregulated streams in eastern Oregon: State of Oregon Water Resources Department Open File Report SW 06-001, 158 p. Available online at: http://www.oregon.gov/owrd/pages/sw/peak_flow.aspx

Granato, G.E., 2013, Stochastic Empirical, Loading and Dilution Model (SELDM) Version 1.0.0: Techniques and Methods of the U.S. Geological Survey, book 4, chap. C3, 112 p. with CD-ROM (The FHWA reference number is FHWA-HEP-09-006)

Risley, J.C., and Granato, G.E., 2014, Assessing potential effects of highway runoff on receiving-water quality at selected sites in Oregon with the Stochastic Empirical Loading and Dilution Model (SELDM): U.S. Geological Survey Scientific Investigations Report 2014–5099, 74 p., http://dx.doi.org/10.3133/sir20145099.

Risley, J., Stonewall, A., and Haluska, T., 2008, Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126, 22 p.

Pennsylvania

StreamStats: The current application of StreamStats for Pennsylvania is located at http://water.usgs.gov/osw/streamstats/pennsylvania.html. StreamStats for Pennsylvania can be used to estimate the following flow statistics:

- Low-flows: 7-day, 10-year; 7-day, 2-year; 30-day, 10-year; 30-day, 2-year; 90-day, 10-year
- Base-flows: 10-year, 25-year, and 50-year recurrence intervals
- Mean flows: including the harmonic mean and mean annual flow
- Flood-flows: 2- year, 5- year, 10- year, 50- year, 100- year, and 500-year recurrence intervals.

Flood inundation mapping: Inundation maps for selected water-surface elevations at National Weather Service (NWS) flood forecast points are available for the West Branch Susquehanna River at Lewisburg and Milton on the USGS National Flood Inundation Mapping (FIM) Program and for the Susquehanna River at Harrisburg on NWS Advanced Hydrologic Prediction Service web site (AHPS), FIM, and the Susquehanna River Basin Commission Inundation Mapping Viewer (SimV).

Flood flow statistics: Peak annual exceedances were computed for 40 streamgages in Pennsylvania with a recorded 2011 peak greater than the 4-percent annual exceedance probability (AEP). These statistics will be included in a regional USGS report documenting 2011 flooding in the Northeast, to be completed in 2015. A new study with the Federal Emergency Agency has started that will update flood frequencies at streamgages across the Pennsylvania. Multi-frequency variations over time at the streamgages will be analyzed to identify possible trends. This work is expected to be completed in 2018. A proposal has been submitted to the Pennsylvania Department of Transportation that would update flood-flow regression equations, including 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent AEPs, and investigate the possible effects of climate change on peak streamflows in Pennsylvania.

Stream Geomorphology: Development of a refined set of regional curves for estimating bankfull channel geometry for the dynamic streams common to the glaciated portion of northern Pennsylvania is expected to begin in early 2016. These revised regional curves would be incorporated into StreamStats.

Bathymetry: A bathymetric map of Chambers Lake in Chester County for the computation of reservoir storage capacity was developed with a table showing the storage capacity of the reservoir at 2-foot increments from minimum usable elevation up to full capacity at the crest of the auxiliary spillway.

Streamgages: A cooperative network of peak-flow and continuous-record streamgages is operated statewide to provide real-time and historical stage and streamflow data to support real-time flood-warning and forecasting efforts. Streamflow data collected from streamgages in the network will also be used in the development of streamflow statistics to describe and predict low-flow and peak-flow conditions. These streamflow statistics are critical to the design of structures in, over, and near waterways. Stations located within the Pennsylvania network and the data collected at each streamgage can be viewed at the National Water Information System Web Interface (http://waterdata.usgs.gov/pa/nwis/rt).

Recent Publications

Gyves, M.C., 2015, Bathymetry and capacity of Chambers Lake, Chester County, Pennsylvania: U.S. Geological Survey Scientific Investigations Map 3346, http://dx.doi.org/10.3133/sim3346. http://pubs.er.usgs.gov/publication/sim3346.

Langland, M.J., 2015, Sediment transport and capacity change in three reservoirs, Lower Susquehanna River Basin, Pennsylvania and Maryland, 1900–2012: U.S. Geological Survey Open-File Report 2014–1235, 18 p., http://dx.doi.org/10.3133/ofr20141235.

Puerto Rico

The Puerto Rico Authority of Highways and Transportation provides funding for monitoring water quality/quantity at selected sites (SW quality network) and Flood documentation (Dam Failure analyses project).

Flood inundation mapping: Development is underway for flood inundation maps produced by the analysis of simulated failures of a dam located within the Rio Grande de Manati watershed. The analysis

included water-surface elevations at six bridges along the lower reach of the Rio Grande de Manati. The reference for the report presenting the results of the dam failure analysis is listed below.

Torres-Sierra, Heriberto and Gómez-Fragoso, Julieta, 2015, Dam failure analysis for the Lago de Matrullas Dam, Orocovis, Puerto Rico: U.S. Geological Survey Scientific Investigations Report 2015–5065, 54 p., http://dx.doi.org/10.3133/sir20155065.

Rhode Island

Flood inundation map libraries for one USGS streamgage site (with collocated NWS flood forecast point) that can assist with highway, road, and bridge operations during floods was started late in 2015. The flood-inundation study is being done for the main stem of the Pawtuxet River in Cranston, Warwick, and West Warwick, Rhode Island. This section of river was extremely hard hit by the spring 2010 flood. The peak flow at the Pawtuxet River at Cranston of streamgage during the spring 2010 flood was about 2.7 times higher than the previous peak flow of record in the 70 plus years of operation. The map library is being done as a Silver Jackets project for Rhode Island in cooperation with the USACE, FEMA, and RIEMA. The project is scheduled to be completed in late 2016.

South Carolina

Gaging stations: The South Carolina Data Program of the U.S. Geological Survey (USGS) South Atlantic Water Science Center (SAWSC), in cooperation with the South Carolina Department of Transportation (SCDOT), operates 7 real-time continuous record streamflow stations, 1 continuous record water-quality station, and 47 partial record crest-stage stations. (Number of gaging stations fluctuates slightly from year to year.)

Evaluation of recently developed NCHRP abutment-scour equations: The USGS SAWSC, in cooperation with the National Cooperative Highway Research Program (NCHRP), began an investigation (2012) to evaluate the performance of recently developed abutment-scour equations (NCHRP Projects 24-15(2) and 24-20) using 329 field measurements of abutment scour collected in South Carolina (Benedict, 2003), Maine (Lombard and Hodgkins, 2008), Alabama (Lee and Hedgecock, 2008), and the USGS National Bridge Scour Database (NBSD; http://water.usgs.gov/osw/techniques/bs/BSDMS/index.html, accessed December 11, 2012; Wagner and others, 2006). Results from the analysis will identify performance characteristics for each scour-prediction method and will help formulate application guidance. The project started in October 2012 and the final draft report was transferred to the NCHRP in June, 2015.

References:

Benedict, S.T., 2003, Clear-water abutment and contraction scour in the Coastal Plain and Piedmont Provinces of South Carolina, 1996–99: U.S. Geological Survey Water-Resources Investigations Report 03–4064, 137 p.

Lee, K.G., and Hedgecock, T.S., 2008, Clear-water contraction scour at selected bridge sites in the Black Prairie Belt of the Coastal Plain in Alabama, 2006: U.S. Geological Survey Scientific Investigations Report 2007–5260; 56 p.

Lombard, P.J., and Hodgkins, G.A., 2008, Comparison of observed and predicted abutment scour at selected bridges in Maine: U.S. Geological Survey Scientific Investigations Report 2008–5099, 23 p.

Wagner, C.R., Mueller, D.S., Parola, A.C., Hagerty, D.J., and Benedict, S.T., 2006, Scour at contracted bridges: Transportation Research Board, National Cooperative Highway Research Program Document 83 (Project 24-14), 299 p., accessed December 19, 2008, at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w83.pdf

Development of a manual to integrate findings of previous field investigations of bridge scour: The USGS SAWSC, in cooperation with the SCDOT, conducted a series of three field investigations of bridge scour (Benedict, 2003; Benedict and Caldwell, 2006; Benedict and Caldwell, 2009) with the goal of collecting historic scour measurements to better understand regional trends of scour within South Carolina. Data collected in these investigations were used to develop envelope curves defining the upper bound of pier, abutment, and contraction scour. The new investigation will conduct additional research on the field data and use previous and new findings to develop an integrated procedure for applying the South Carolina bridge-scour envelope curves to help assess scour potential at riverine bridges in South Carolina. The project started in December 2012 and will be completed July 2016.

As part of this investigation, field measurements of pier, abutment, and contraction scour, previously collected from various parts of the United States, are being compiled into a digital database, and these data will be used to verify the trends of the South Carolina bridge-scour envelope curves. This effort has produced a large database that includes 1,805 pier-scour field measurements. The compiled field data (in spreadsheet format) offer an extensive database and valuable resource to engineers and researchers seeking to understand the trends of pier scour in the field. Preliminary comparison of the compiled field data with the South Carolina pier-scour envelope curves verifies that the envelope curves are reasonable.

References:

Benedict, S.T., 2003, Clear-water abutment and contraction scour in the Coastal Plain and Piedmont Provinces of South Carolina, 1996–99: U.S. Geological Survey Water-Resources Investigations Report 03–4064, 137 p.

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, 98 p.

Benedict, S.T., and Caldwell, A.W., 2009, Development and evaluation of live-bed pier and contraction scour envelope curves in the Coastal Plain and Piedmont Provinces of South Carolina: U.S. Geological Survey Scientific Investigations Report 2009–5099, 108 p.

Benedict, S.T., and Caldwell, A.W., 2014, A pier-scour database—2,427 field and laboratory measurements of pier scour: U.S. Geological Survey Data Series 845, 22 p., http://dx.doi.org/10.3133/ds845.

Bridge Deck Stormwater Runoff: In South Carolina, stormwater runoff from highways may be treated by structural or non-structural systems. Some stormwater may enter receiving waters without treatment such as from bridge deck scuppers. The impact of this discharge, if any, may be driven by the daily traffic volume or atmospheric deposition from surrounding industry. Even though numerous studies have been conducted to analyze the impacts of stormwater from highways and, to a lesser extent, bridges to receiving waters, prior to this investigation, no specific studies had been conducted in South Carolina. In June 2013, the USGS South Atlantic Water Science Center, in cooperation with the SCDOT, began a 4.75-year investigation in South Carolina on stormwater quality. This investigation is anticipated to end in March 2018 (FY2018). The purpose of this study is to quantify the downstream changes in receiving water-quality conditions during periods of observable stormwater runoff from 6 selected bridge deck locations in South Carolina. The information collected might help to estimate or predict changes in water quality at bridge crossings with similar characteristics. Additionally, comparison of sediment-quality conditions and benthic macroinvertebrate community structure at upstream and downstream locations from selected bridge decks will assess cumulative impact of bridge deck runoff effects on receiving water. Data collection began in January 2014. Data were collected from two bridges during calendar year 2014 and will be collected from two new bridges during calendar years 2015 and 2016. Data analysis will be ongoing throughout the data-collection phase and during part of calendar year 2017. A USGS Scientific Investigations Report documenting the investigation will be published. The tentative publication date is spring 2018.

FHWA Bridge Scour Countermeasures: The USGS SAWSC has been selected to participate as a team member in the USGS cooperative effort with the FHWA to conduct a comprehensive, national, investigation of scour countermeasures. Details regarding this project are described in the report section, “Partial Summary of USGS National Activities, Performance and Effectiveness of Scour Countermeasures.”

South Carolina StreamStats Program: The USGS SAWSC, in cooperation with the SCDOT, began the StreamStats project on October 1, 2014. This project will incorporate LiDAR derived data for the elevation data as well as updating the NHD and WBD (internal to the application) with that data. This project has an end date of April 2018. Details regarding this project are described in the report section, “Partial Summary of USGS National Activities, StreamStats Program”. An early “barebones” version of the application, with delineating capability only, was released in the first week of November 2015. This is in response to the October 2015 flooding and is intended to assist the SCDOT with infrastructure repair and rebuilding.

Collection of high-water mark data at selected roadway crossings to document October 2015 flooding: Heavy rainfall occurred across South Carolina during October 1–5, 2015, as a result of an upper atmospheric low-pressure system that funneled tropical moisture from Hurricane Joaquin into the State. The storm caused major flooding from the central to the coastal areas of South Carolina. Almost 27

inches of rain fell near Mount Pleasant in Charleston County during this period. U.S. Geological Survey streamgages recorded peaks of record at 17 locations, and 15 other locations had peaks that ranked in the top 5 for the period of record. The impacts of this event were widespread across South Carolina. Approximately 410 roads or bridges were closed during the event including 74 miles of I-95 between I-26 and I-20 (Feaster and others, 2015).

In response to the flooding, the U.S. Geological Survey (USGS) made about 140 streamflow measurements at 86 locations throughout the affected area (Feaster and others, 2015). The USGS, in cooperation with the Federal Emergency Management Agency, also flagged and surveyed almost 600 high-water marks (HWMs) to document the extent of the flooding in selected urban and suburban areas. The S.C. Department of Transportation needs additional flood documentation at selected bridge and culvert crossings throughout the State. Therefore, the USGS is working in cooperation with the SCDOT to collect HWM data at approximately 50 selected bridge or culvert crossings.

Publication:

Feaster, T.D., Shelton, J.M., and Robbins, J.C., 2015, Preliminary peak stage and streamflow data at selected USGS streamgaging stations for the South Carolina flood of October 2015: U.S. Geological Survey Open-File Report 2015–1201, 19 p., http://dx.doi.org/10.3133/ofr20151201.

South Dakota

Crest stage gage network: In cooperation with the South Dakota Department of Transportation (SDDOT), the South Dakota Water Science Center operates a network of about 50 crest-stage gages for the purpose of peak-flow analysis.

StreamStats: Developmental efforts for StreamStats in South Dakota were initiated in 2005. This project was ongoing for a number of years, primarily to address circumstances such as allowing incorporation of increased availability of higher-resolution topographic data and addressing difficulties in the application for determination of basin characteristics. Full-scale implementation of the StreamStats application was achieved in 2013, and maintenance-level activities have continued since then, providing benefits to many agencies including SDDOT.

Statewide flood-frequency analysis: USGS recently initiated a new project in cooperation with SDDOT to perform a statewide update for South Dakota. The project will involve (1) updating at-site flood-frequency analyses for all appropriate sites (using data through water year 2013) and (2) developing statewide regional regression equations for estimating peak-flow magnitude and frequency relations for ungaged streams. As part of this effort, South Dakota has been working with a number of other states in the Great Plains and Upper Midwest to pursue a regional-scale effort for development of new skew coefficients. A coordinated effort is underway among a large block of contiguous states, with a goal of having updated skew coefficients that can be incorporated in the at-site frequency analyses. To date, most of the necessary data sets have been provided by participating states, and analytical efforts are poised to begin.

Rainfall-runoff modeling for peak-flow analysis and characterization: USGS recently initiated a new project in cooperation with SDDOT to perform rainfall-runoff modeling in support of peak-flow analysis and characterization for the Black Hills area of western South Dakota. Peak-flow analyses for this area are especially complicated because of complex hydrogeology and the occurrence of exceptionally large outliers within peak-flow data sets for many area streamgages. Previous efforts to address this vexing issue have included innovative methods for peak-flow analyses and application of paleoflood hydrologic techniques to extract geologic records of past exceptional floods. Distinctive differences in peak-flow potential for different hydrogeologic and topographic settings have been qualitatively identified through previous studies and this project will attempt to improve quantitative capabilities.

Peak-flow characterization in support of flood-risk quantification: The South Dakota "Silver Jackets Team" was recently successful in an application for a demonstration project for identification of flood risk for a rapidly developing housing area. This housing area is located along a stream channel which currently lacks floodplain mapping, but for which geomorphic and historical evidence indicates large potential for catastrophically large peak flows. Through a partnership with SDDOT, USGS will assist by providing peak-flow information for use in hydraulic modeling and mapping of flood-prone areas to be conducted by other project partners.

Tennessee

Note: Beginning in FY 2015, human resources of the USGS now employed in the study of water resources across the five states of Alabama, Arkansas, Louisiana, Mississippi, and Tennessee began a transformation to the **USGS Lower Mississippi-Gulf Water Science Center** (LMGWSC).

Tennessee had the following projects during 2015:

- Providing hydraulic interpretative support and miscellaneous flood-measurement support to Tennessee Department of Transportation (TDOT) as needed.
- Operating an ongoing network of 33 crest-stage gages (CSGs) at or near highway crossings and operating another 12 stage-discharge gages across the state for the purpose of flood-frequency analysis and general resource evaluation.
- Statewide update of flood-frequency prediction methods for ungaged streams in Tennessee. Recent peak streamflow data, improved flood-frequency computations, and GIS-calculated basin characteristics will be incorporated into the original flood-frequency region-of-influence statistical model completed in FY2003. This work began in FY2014 and will continue through FY2016.
- Refining GIS coverages and enhancing tools and analytical protocols for the Tennessee StreamStats page (http://water.usgs.gov/osw/streamstats/tennessee.html). This page was completed and released in 2007.

- Developing and applying GIS techniques to identify karst features on a regional scale and producing a GIS karst dataset for Tennessee. The dataset of karst features will span the eastern 2/3 of Tennessee classified as karst and will include closed depressions and their watersheds. The GIS techniques will be applied to the highest-resolution and most accurate digital elevation datasets available for Tennessee. This work began in FY2009 and is in late stages of report preparation.

- Continuing a review of State-funded stream relocation and restoration projects that will identify design objectives that have and have not been achieved and types of structures and channel configurations that have been stable, have needed repair, or have been destroyed. This work will lead to a report on successful approaches to stream channel management in Tennessee physiographic regions, and will be completed in FY2016.

- Continuing a study of seepage from acid-rock outcrops exposed by road construction. The study will examine flow rates and composition of seepage, surface and subsurface flow paths to streams, and possible mitigation measures. The study will continue through FY2016.

Texas

Small Watershed Gaging Program: (FY06–15 and on-going): The Texas Department of Transportation (TxDOT) and the USGS cooperate in 5-year increments on a small watershed data collection program. The program is currently extended through FY15. A new agreement for FY16–20 (third project phase) is expected to be in place by March 2016. The program is comprised of a network of about 51 crest-stage gages for flood-peak recording on small watersheds in western Texas. About ten of these gages record autonomous stage and rainfall for creation of rainfall and runoff data sets to drive the TxDOT research program in future decades. Forward capital investments are being made to increase telemetry presence at the now autonomous sites. About three of the gages will also be operated as continuous real-time (conventional gages). Over 725 measurements of peak discharge have been made through about February 2015 with water year 2015 computations pending.

Harwell, G.R., Asquith, W.H., 2011, Annual peak streamflow and ancillary data for small watersheds in central and western Texas: U.S. Geological Survey Fact Sheet 2011–3082, 4 p., [http://pubs.usgs.gov/fs/2011/3082/].

Asquith, W.H., 2014, Parameter estimation for the 4-parameter asymmetric exponential power distribution by the method of L-moments using R: Special Section—Statistical Algorithms and Software in R, Guest eds.: P. Filzmoser, C. Gatu, and A. Zeileis, Computational Statistics and Data Analysis, v. 71, pp. 955–970, [http://dx.doi.org/10.1016/j.csda.2012.12.013].

Updated Rainfall Intensity-Duration Frequency Coefficients by County in Texas: (FY14–15): The surface water research group with the Texas Water Science Center in peer-to-peer research with Texas Tech University (Theodore G. Cleveland) has implemented various previously-published USGS reports (circa 2004) in Texas that include dimensionless rainfall hyetographs and depth-duration frequency of rainfall annual maxima. This particular study is to integrate the results of the prior studies, with

refinement as necessary through additional quality-control and quality-assurance steps, into special spreadsheet macros to replace and extend a quite venerable spreadsheet (circa late 1980s) for intensity-duration frequency of rainfall estimation for durations from 10 minutes to 24 hours. The principle products of this project are lookup tables by county (254 counties in Texas) of three coefficients in a nonlinear equation unique for each of six return periods (2, 5, 10, 25, 50, and 100 years) for each county in Texas.

Cleveland, T.G., Hermann, G.R., Tay, C.C., Neale, C.M., Schwarz, M.R., [August 2015], New rainfall coefficients including tools for estimation of intensity and hyetographs in Texas: Texas Department of Transportation, Research Report 0-6824-1, [in review].

Neale, C.M., Tay, C.C., Herrmann, G.R., and Cleveland, T.G., 2015, TXHYETO.XLS: a tool to facilitate use of Texas-specific hyetographs for design storm modeling: in Proceedings of ASCE World Environmental and Water Resources Congress, ASCE-EWRI, Austin, Texas, May 17-21, 2015. pp. 241--254, [pre-release example of TXHYETO-2015.XLSX].

Tay, C.C., Neale, C.M., Herrmann, G.R., and Cleveland, T.G., 2015, Updated rainfall coefficients for Texas---The EBDLKUP-NEW.XLS Tool: in Proceedings of ASCE World Environmental and Water Resources Congress, ASCE-EWRI, Austin, Texas, May 17-21, 2015, pp. 442--452, [pre-release example of EBDLKUP-2015.XLSX].

Utah

No highway-related projects at this time.

Vermont

Vermont Agency of Transportation (VTrans) is currently funding approximately two-thirds of a network of 28 crest-stage gages located in small headwater watersheds throughout the state. VTrans funds one-third of the cooperative agreement for the state share of the Vermont's stream-gaging network.

Flood inundation map libraries for one USGS streamgage site (with collocated NWS flood forecast point) that can assist with highway, road, and bridge operations during floods have been published. The map library was completed in cooperation with FEMA.

Olson, S.A., 2015, Flood maps for the Winooski River in Waterbury, Vermont, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5077, 25 p., http://dx.doi.org/10.3133/sir20155077.

Flood recovery maps of water-surface elevations for selected reaches of the White River and Tweed River in central Vermont were determined using the USACE hydraulic model HEC-RAS. The water-surface elevations were determined for the flood having a 10-, 4-, 2-, 1-, and 0.2-percent annual exceedance probability and for the floodway. This work was done in cooperation with FEMA in response to the Presidential Disaster Declaration following tropical storm Irene on August 28-29, 2011.

Olson, S.A., 2015, Flood recovery maps for the White River in Bethel, Stockbridge, and Rochester, Vermont, and the Tweed River in Stockbridge and Pittsfield, Vermont, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5056, 32 p., http://dx.doi.org/10.3133/sir20155056

Virginia

A network of 17 crest-stage gages continues to operate in coordination with the Virginia Department of Transportation (VDOT) to determine annual peak flows, document extreme flow events, and improve flood frequency estimates.

A cooperative effort to implement StreamStats in Virginia is now completed and the site is up and running. This link: http://water.usgs.gov/osw/streamstats/virginia.html takes you to a site describing Virginia StreamStats. A second link (http://streamstatsags.cr.usgs.gov/v3_beta/viewer.htm?stabbr=VA) launches the fully interactive Virginia StreamStats map.

Our work assisting VDOT with bridge redesign across the Commonwealth continues. The current USGS-VDOT Bridge Scour Pilot Study develops guidance for hydrologic methods necessary to apply new techniques for estimating bridge scour that take advantage of attributes unique to cohesive soil and weathered rock. The study estimates duration of specific flows and potential cumulative stream power over the design lifespan of a bridge, providing compilation, calculation, and summation of hydrologic properties needed to determine potential rates of streambed scour. Hydrologic statistics and modeling methods, such as those demonstrated here: http://forio.com/simulate/saustin/shields-sediment-motion-2, assist in estimating future cumulative streambed scour at bridge pier locations over the projected design lifespan of a bridge. VDOT provides geotechnical data, while USGS provides hydrologic data for the designs.

Recent Publications

Austin, S.H., 2014, Methods for estimating drought streamflow probabilities for Virginia streams: U.S. Geological Survey Scientific Investigations Report 2014–5145, 20 p., http://dx.doi.org/10.3133/sir20145145. http://pubs.usgs.gov/sir/2014/5145/

Austin, S.H., 2014, Methods and equations for estimating peak streamflow per square mile in Virginia's urban basins: U.S. Geological Survey Scientific Investigations Report 2014–5090, 25 p., http://dx.doi.org/10.3133/sir20145090.

Austin, S.H., Krstolic, J.L., Wiegand, Ute, Peak-Flow Characteristics of Virginia Streams, U.S Geological Survey Scientific Investigations Report, 2011-5144, 106 p. Available online at: http://pubs.er.usgs.gov/publication/sir20115144.

Washington

Stormwater Workgroup: The USGS Washington Water Science Center (WAWSC) participates in a multiagency Stormwater Workgroup (SWG), which includes the Washington State Department of

Transportation (WSDOT). This workgroup is chartered under the Puget Sound Ecosystem Monitoring Program, and has implemented a coordinated stormwater-monitoring program in the Puget Sound area called the Regional Stormwater Monitoring Program (RSMP). Federal, State, and local agencies, Native American Tribes, business, and environmental groups are represented on the workgroup. For the RSMP Status and Trends in Small Streams program, USGS assisted with Quality Assurance Project Plan (QAPP) writing and site selection in 2014, is conducting water-quality and stream-ecology monitoring through December 2015, and will be on the data analysis team in 2016. For the RSMP Nearshore program, the USGS is preparing the QAPP and will be assisting with marine sediment chemistry sampling during 2016.

USGS staff continued their participation in the "Roads and Highways Subgroup" of the SWG that generated recommendations for the RSMP related to roads and highways that include priority best management practice (BMP) effectiveness studies and source identification and diagnostic studies. Those recommendations were incorporated into WSDOT's reissued municipal stormwater NPDES permit that includes a requirement to participate in the RSMP. WSDOT chose to contribute to the RSMP pooled funds account for status and trends monitoring in receiving waters, to monitor additional parameters related to commonly used roadside pesticides, and to monitor additional sites.

Flood Frequency: In cooperation with the Washington State Departments of Transportation and Ecology, WAWSC is continuing a study to develop a tool to estimate flood frequencies and magnitudes in ungaged watersheds in Washington State, and to determine if there are trends in flood frequencies and magnitudes in the state.

Timing and depth of scour and fill: In cooperation with the Seattle Public Utilities and Seattle City Light, WAWSC continued Phase II of a study in the Cedar River that includes determining the depth of streambed scour potentially affecting salmon egg pockets using the accelerometer scour monitors (ASMs) developed by Gendaszek and others (2013) to measure the timing of scour to discrete levels of the streambed. A second scour study funded by the same partners was initiated in the nearby Tolt River basin during 2015.

West Virginia

A network of crest-stage gages will continue to be operated in cooperation with WVDOT to provide on-going peak-flow data for flood-frequency information and analysis.

WVDOT provides funding in support of operating and maintaining streamflow-gaging stations.

Development of StreamStats in West Virginia was initiated in 2014. It is expected to take two years for development to be completed.

Wisconsin

A network of crest-stage gages will continue to be operated in cooperation with WIDOT to provide peak-flow data for flood-frequency information and analysis.

Effectiveness of Grass Swales at Reducing Stormwater Runoff from Urban Highways in Wisconsin: 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 Stormwater Management program to reduce Total Suspended Solid (TSS) loading from highway surfaces. The purpose of this study is to evaluate the performance of grass swales as a stormwater management practice. The primary objective of this study will be focused on measuring the effectiveness of grass swales at reducing stormwater runoff flowing from urban highways. It will evaluate the infiltrative capacity of grass swales and their potential to reduce pollutants such as TSS. This will be done by monitoring a section of grass swale separated into two contributing components: 1) vegetated side slopes and, 2) grassed channel. An additional section will be instrumented to monitor the grass swale as a whole.

This project will also help WisDOT determine their pollutant reductions for federal and State goals. The State of Wisconsin allows the use of computer models to determine both volume and TSS reduction. By isolating individual parts of grass swales, parameters in models can be modified to simulate site conditions. Wisconsin WSC will cooperate with WinSLAMM modelers to incorporate grass swales and filter strips data into modeling routines. After the calibration is complete, WisDOT highways can use WinSLAMM to determine performance reductions on all state highways with grass swales and filter strips. Project will continue through 2017.

Evaluation of Bioretention Swale at Reducing Highway Runoff Pollutant Concentrations and Loads Waukesha, Wi: 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 Stormwater Management program to reduce Total Suspended Solid (TSS) loading from highway surfaces. The purpose of this study is to evaluate the performance of bioretention swales as a stormwater management practice. The primary objective of this study will be focused on measuring the effectiveness of bioretention swales at reducing stormwater runoff flowing from urban highways. It will evaluate the infiltrative capacity of bioretention swales and their potential to reduce pollutants such as TSS. This study will evaluate two sections with different engineered soil mixtures: first mixture is using the Bioretention Technical Standard (1004) mix of 75 percent sand and 25 percent compost and the second mixture is 18-in. of sand at the bottom and 6-in. of the 75/25 compost mixture.

Another goal is to transfer the results from this study to determine if Wisconsin DOT is meeting federal and state standards. The state of Wisconsin allows the use of computer models to determine both volume and TSS reduction. By isolating individual parts of bioretention swales, parameters in models can be modified to simulate the site conditions. Modifications made to the Bioretention Technical Standard 1004 occurred in 2012.owing to a study in Neenah WI. The State of Wisconsin modified the amount of engineering compost from 50 to 25 percent, and is in the process of reducing the requirement of 3 feet of engineered soil to 2 feet. This study will validate those changes made to the technical standards. Wisconsin WSC will cooperate with WinSLAMM modelers to incorporate update bioretention routines in WinSLAMM.

Evaluating the Water Quantity and Quality Benefits of Permeable Pavement: The USGS, in cooperation with the Wisconsin Department of Transportation, the Wisconsin Department of Natural Resources, and permeable pavement industry representatives, has initiated a multi-year research project that will evaluate the water quality benefits of three variations of permeable pavement: pavers, concrete, and asphalt. The following are the specific objectives:

- Determine if the infiltration rate in each pavement surface changes over time.
- Measure the clogging rate of each permeable surface.
- Quantify the reduction in pollutant load for each surface.
- Understand how each surface responds to accumulating ice and snow with less salt use.
- Calibrate the permeable pavement routines in the Windows Source Load and Management Model (WinSLAMM) with the results from the study
- Use the results of the study to help develop a technical standard for the use of permeable pavement in the state of Wisconsin.

Construction of the study site was finished in September, 2014. Measurement of discharge, temperature, and water-quality will continue through 2018 to characterize the water-quantity and water-quality responses of each surface over a range of precipitation and snowmelt events.

Wyoming

Indirect Discharge Estimates: In cooperation with Wyoming Department of Transportation (WYDOT), the USGS Wyoming-Montana Water Science Center (WY-MT WSC, previously WY WSC) estimated discharges at 2 sites after flooding near Lusk, Wyoming.