A Partial Summary of 2016 USGS Activities of Interest to the FHWA and State Highway Agencies

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Introduction

Part of the mission of the U.S. Geological Survey (USGS) is to assess the quantity, quality, and trends of the Nation's water resources, to advance the understanding of natural processes related to these resources, and to provide information that will assist resource managers and policymakers in making sound decisions.

The USGS has a long history of 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 update the Federal Guidelines for Flood Frequency Determinations (Bulletin 17B), maintain the USGS PeakFQ Program, 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 Robert Mason (rrmason@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, AZ, CA, CO, CT, DE, GA, HI, IA, ID, IL, IN, KY, MA, MD, ME, MN, MT, NC, ND, NH, NJ, NM, NY, OH, OK, OR, PA, RI, SD, TN, UT, VA, VT, WA Basin Characteristics only: AK (Cook Inlet Basin only), MS, SC, WI In progress: KS, MO, OH (update), WV
Investigation of rural flow-frequency	AL, AR, CO, CT, GU, HI, IA, ID, KS, LA, MA, ME, MI, MN, MT, MS, NE, NM, NY, OH, OK, OR, PA, SD, TN, TX, VA, VT, WA, WI, WV, FEMA
Investigation of urban flow-frequency	IL, VA
Investigation of small watershed flow-frequency	IA, KS, LA, ME, MN, MT, TN, TX
Non-stationarity of peak flows	FHWA, ME, MT, NY, OR
Updating Bulletin 17B Regional Skew Map	AK, AZ, CO, ID, IA, IL, LA, MI, OH, OR, PA, WA
Flow-duration curve estimates	MN, OH
Bridge Scour and Sediment Transport	
FHWA scour countermeasures field investigation	AL, CT, IA, ID, IL, IN, KY, MO, MT, NC, NJ, PA, SC, WY
Evaluation of abutment-scour equations	SC, VA, NCHRP
Near real time scour monitoring	AK, CO, MS, MT, NJ, SC
Data collection and analysis	AK, AZ, ID, IN, KS, LA, ME, MN, MO, MS, MT, NJ, NV, SC, WA, FHWA
Channel stability and scour assessment	AK, AL, ID, IN, MO, MS, MT, ND, NJ, SD, TN, VA, WA
Investigation/modeling of sediment transport	ID, KS, LA, MN, MT, ND, NY, TN, VA, 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, MO, ND, OR
Flood documentation	AZ, CO, CT, IA, IN, LA, MA, MN, MT, NE, NH, NJ, NM, NV, OR, RI, SC, TN, VT, WI
Operational flood inundation mapping	GA, ID, IL, IN, LA, MA, ME, MI, MN, MO, MS, NH, NJ, NY, OH, OR, PA, RI, VT
Manning's n verification	AZ
Flood warning system	CO, DE, NY, OH, SC
Investigation of stream piracy and effects of large woody debris in streams	MO
Stream Characteristic Investigations	
Regional channel characteristics/bankfull discharge	ID, MA, ME, NY, PA, TX, WV
Tidal Gages and Streamgages	
Tidal gages	CT, DE, FL, LA, MA, ME, NC, NJ, NY, OR, RI
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, NY, OH, OR, PA, RI, SC, TN, TX, VT, WV
Water Quality and Environmental Investigations	
Evaluation of stormwater runoff models	CA, MA, OR, RI, 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, NY, PA, PR, SC, TN, UT, VT, WA, WI, WY
Investigation of wetland impact/remediation	LA, MT, NY
Investigation of stream restoration	ID, MT, NE, NY, TN
Investigation of the effect of deicing chemicals	OR, WY, FHWA
Investigation of BMP	MD, MI, NY, OH, TN, WA, WI, FHWA
Investigation of potential impacts of highway culvert construction to the natural conditions of streams	AL, TN, SC
Investigation of the potential effects of runoff from roads and bridges to receiving waters	MA, NC, OR, SC, WA

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/

Groundwater and Streamflow Information Program (GWSIP)

The U.S. Geological Survey (USGS) operates more than 8,100 near real-time streamgages in the National Streamflow Network (NSN) in cooperation with Federal, State, local, regional, tribal, non-governmental and industrial partners. 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, which were combined in 2016 into GWSIP, including in large part, the Cooperative Matching Funds (CMF, formerly the Cooperative Water Program) and the Federal Priority Streamgages (FPS, formerly the National Streamflow Information Program). The goal of GWSIP is to enhance its comprehensiveness and interdisciplinary value and more effectively represent key components of the hydrologic cycle including surface water, groundwater, evapotranspiration, precipitation, and some water quality and sediment (Super Gages).

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 4,760 streamgages as defined in the original NSIP design, now managed as FPS) 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 2016, approximately 3,400 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 GWSIP (approximately 1/3 of the funding) and USGS partners (the remaining 2/3 of the funding). In 2015, a total of 1,160 of these streamgages were fully funded by the USGS (through FPS). Support for a full "federal needs backbone network of streamgages" requires about $150M, requiring an additional $96 million dollars annually.

Beginning in 2016, the USGS has aligned its budget structure to the Water Science Strategy by consolidating the previous seven programs into four major program areas. The first, which has been discussed previously, 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 such as the USGS streamgaging network, flood monitoring and flood inundation science, as well as the groundwater networks including the National Groundwater Monitoring Network and USGS Climate Response Network. The USGS is working through the Advisory Committee for water Information (ACWI) Subcommittee on Hydrology (SOH) to create a new “streamgaging collaborative” to discuss the USGS streamgage network and to solicit suggestions for improvement in the network, its operations and funding. Interested state and local agencies can participate as a member of the consortium. Please contact Doug Yeskis (djyeskis@usgs.gov) for more information.

Flood Response Activities

The USGS, as the nation’s premier earth science agency, is expected by cooperators, emergency management agencies, news media, and the public to provide hydrologic information prior to, during, and after flooding, with a particular expectation that USGS will disseminate near real-time flood data and flood summaries on the World Wide Web. The role of the USGS related to flood response activities has greatly expanded over the years as commitments at all levels of government have increased. In addition, USGS has a responsibility to advance scientific understanding of floods and public risk awareness both internally in its own scientific studies as well as collaboratively with outside agencies, academics, and non-profits. Accordingly, USGS must prepare for and respond decisively and consistently to flood events, including post-flood scientific study when appropriate.

During major floods, the USGS deploys field crews to measure flood flows at streamgages and other locations of interest (such as breached levees, chemical spills, etc.). Data are available at http://waterdata.usgs.gov and alerts and situational awareness are available through http://water.usgs.gov/wateralert/and http://waterwatch.usgs.gov. In addition, a national website on major flooding is maintained at http://water.usgs.gov/floods.

While the USGS streamgage network is large, during an emergency, a streamgage may not exist where it is most needed. The needs include flood control reservoir operation, flood forecasting, flood fight operations, road closure, and emergency management, including evacuations. To meet this need, USGS develops, builds, and maintains a cache of rapid deployment streamgages (RDG) that can be installed to collect and transmit near real-time data within hours to days of a recognized need. They can be installed quickly and with minimal impacts to bridges and structures, and data will begin appearing on the web within minutes of installation.

If additional data is needed for calibration of models or documenting flood peaks, USGS technicians can install small water-level sensors in opportunistic networks. These have been used to document storm-tide flooding where the local coastal conditions prohibit a network of larger sensors. Over 800 USGS storm tide sensors and RDG's were installed in the 2016 water year to monitor and measure the effects of Hurricane Joaquin, Hurricane Matthew, and a number of other significant events.

High water marks (HWMs) are also instrumental in post-flood analyses. After an event, USGS technicians survey HWMs according to the standards in the recently published USGS Techniques and Methods manual: Identifying and Preserving High-Water Mark Data (https://pubs.er.usgs.gov/publication/tm3A24). In the 2016 water year, the USGS collected and documented over 3600 high-water marks, which are now stored with marks from many past events and accessible at the USGS Flood Event Viewer at http://stn.wim.usgs.gov/FEV/.

Many federal, state, and local partners use the data that USGS collects for modelling, peak verification, flood inundation mapping, flood frequency computation (discussed further below), emergency management, and public education. USGS scientists and technicians are also involved in documenting extreme floods (see http://water.usgs.gov/floods/reports/) and flood inundation studies (see https://wim.usgs.gov/FIMI).

Contact Bob Holmes (bholmes@USGS.gov), the USGS National Flood Hazard Coordinator, for more information.

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. A draft of the proposed new guidelines is posted at https://acwi.gov/hydrology/Frequency/b17c/.

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 Julie Kiang (jkiang@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: Alaska, Arizona, Arkansas, California, Iowa, Louisiana, Missouri, the Pacific Northwest (Idaho, Oregon, and Washington), the Southeastern U.S. (South Carolina, North Carolina, and Georgia), and Vermont. A project in New England (Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, and Vermont) is near complete and the initial phase is underway for projects encompassing multiple states in the Missouri River Basin and the Upper Mississippi River Basin as well as New York/Pennsylvania (joint study). 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.

Non-Stationarity in Flood Frequency Analyses

Flood frequency estimates are a major consideration in hydrologic design of culverts, bridges, and other infrastructure. In using historically observed peak flows to determine the peak design flow, the standard methods assume that the peak design flow will occur in the future with the same probability and magnitude as determined from the historical analysis. With changes to climate, land cover, snowpack, and agricultural and land drainage practices occurring across the United States and potential future changes, the assumption of stationarity in the observed peak flow record may not be valid.

Potential changes to floods may be the result of a number of factors, some of which operate at the watershed scale (such as changes to land-drainage or urbanization), some of which operate at the regional scale (such as changes to snowpack) and some of which operate at the global scale (such as changes to climate and large-scale weather patterns). USGS is using its extensive database of streamflow information and its site-specific knowledge about individual gages in cooperation with FHWA to advance the state of knowledge in three gap areas:

- **Characterize changes in peak flows:** In this study, we will extend on previous analyses by using data from long-record stream gages, to study observed trends - whatever the cause. We will also extend previous work which has shown that the observed changes depend on the magnitude of the flood event being studied.

- **Diagnose and attribute changes in flood frequency:** This study will attempt to relate the observed flood trends to changes in both climate-based metrics as well as land-cover characteristics such as artificial land drainage and urbanization and other land cover change.

- **Adjusting flood-frequency analysis for observed and projected change:** The study will include an assessment of different methods for incorporating trends into flood frequency analysis.

Contact Julie Kiang (jkiang@usgs.gov) for more information.

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 7,000 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 37 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.

Efforts are currently underway to convert the stand-alone program into a web-based service that can be accessed without downloading or installing any files. Contact Todd Koenig at the email address below for more information or if you would like to volunteer to test the new system.

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).

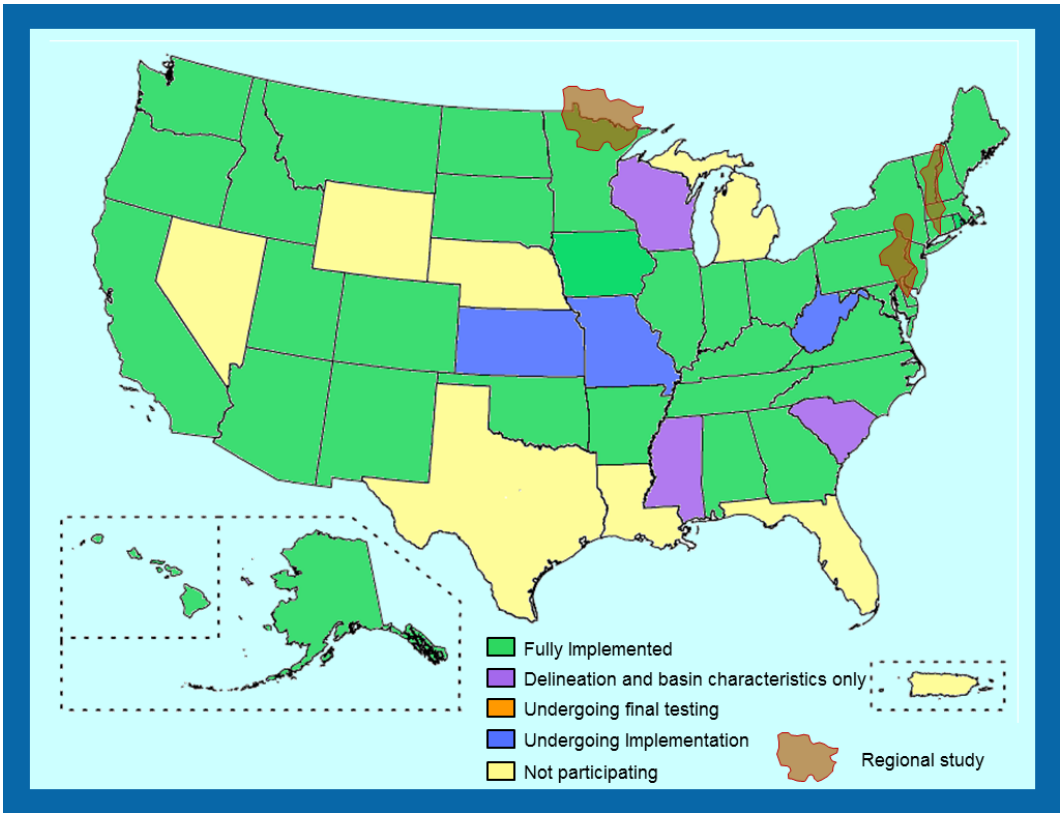
StreamStats Program

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 the location. The estimates for ungaged sites are determined from USGS regional-regression equations and usually can be obtained in only a few minutes.

Beta version 4 was released to the public on March 24, 2016. This new version has a completely new user interface that guides users through the process of delineating basin boundaries and computing basin characteristics and estimated streamflow statistics for user-selected sites. In addition, beta version 4 restores some of the tools that were lost when version 2 was forced into retirement in July 2015, but

several tools that use stream-network navigation are still in development. Outputs for user-selected sites now include a map of the delineated basin, improved formatting of information, and additional options for printing the output and saving it in a variety of formats. Beta version 4 also is compatible for use on mobile devices. StreamStats version 3 still is available and is considered the authoritative version of StreamStats while beta version 4 remains in development mode. Version 3 will be retired when version 4 is formally released later in 2017.

As of December 2016, StreamStats is available to the public for 37 states with full functionality. Applications also are available for three states and three river basins that allow only basin delineations and computation of basin characteristics. The three river basins are the Connecticut River Basin, which encompasses area in Connecticut, Massachusetts, New Hampshire, and Vermont; the Delaware River Basin, which encompasses area in Delaware, Maryland, New Jersey, New York, and Pennsylvania; and the Rainy River Basin, which encompasses area in northern Minnesota and the Canadian provinces of Manitoba and Ontario. Applications are in development for 3 states. In addition, new equations will be added for many states, and streamflow statistics served by StreamStats for many USGS streamgages will be updated. See the map and table below to determine the status for individual state and river basin applications.



Status of StreamStats implementation on December 15, 2016

Status of StreamStats Implementation by State and River Basin					
State	Implemented	Planned for FY17 completion	To be implemented after FY17	New equations in FY17	Comments
Alabama	X				
Alaska	X			X	Cook Inlet Basin only – New peak-flow equations
Arizona	X			X	New peak-flow and flow-duration equations
Arkansas	X			X	New monthly mean and harmonic mean equations
California	X				
Colorado	X			X	New peak-flow equations for eastern CO
Connecticut	X				Adding water-use reports
Delaware	X				
Florida					No effort underway
Georgia	X			X	New low-flow equations
Hawaii	X			X	New low-flow equations for Maui
Idaho	X			X	New peak-flow equations
Illinois	X			X	Added urban flood frequency equations
Indiana	X			X	Adding new flow-duration equations
Iowa	X			X	New low-flow equations
Kansas	X	X			
Kentucky	X				
Louisiana					No effort underway
Maine	X				
Maryland	X				
Massachusetts	X			X	New peak-flow equations and water-use reports
Michigan	X				No effort underway
Minnesota	X				
Missouri	X		X		Separate St. Louis and state applications
Mississippi	X			X	New peak-flow equations
Montana	X			X	New peak-flow equations
Nebraska					No effort underway
Nevada					No effort underway
New Hampshire	X				
New Jersey	X				Planned update will use Lidar-based data
New Mexico	X				Expanded to State-wide during 2016
New York	X			X	New peak-flow equations
North Carolina	X				
North Dakota	X			X	New flow-duration and low-flow equations
Ohio	X			X	New peak-flow equations
Oklahoma	X			X	New peak-flow equations for Panhandle
Oregon	X			X	New peak-flow equations for eastern OR
Pennsylvania	X				
Puerto Rico					Proposal sent to cooperator
Rhode Island	X				
South Carolina	X				Delineations and basin characteristics only
South Dakota	X				
Tennessee	X			X	New peak-flow equations
Texas					No effort underway
Utah	X				
Vermont	X			X	New peak-flow equations
Virginia	X				
Washington	X			X	New peak-flow and low-flow equations
West Virginia		X			
Wisconsin	X			X	New peak-flow equations
Wyoming					No effort underway
River Basin					
Connecticut	X				Delineations and basin characteristics only
Delaware	X				Delineations and basin characteristics only
Rainy	X				Delineations and basin characteristics only

If you would like to learn more about StreamStats, please contact Kernell Ries (kries@usgs.gov).

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 continue to perform various levels of site evaluations at approximately 100 bridges with scour countermeasures across the Nation; the project is scheduled for completion in December, 2017. 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, Iowa, Missouri/Illinois (border bridge), Indiana/Illinois (border bridge), Missouri/Tennessee (border bridge), South Carolina, Iowa, Montana, New Jersey, Pennsylvania, and Connecticut. Potential sites for assessment in 2017 are located in Pennsylvania, Mississippi, Minnesota, Missouri, New Jersey, and Colorado; 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 and again in 2017 as more data becomes available.

Please contact Peter Cinotto (pcinotto@usgs.gov) to learn more.

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 2016 the 3-day training course was delivered in Austin Texas, and a 1-day course was delivered at StormCon in Indianapolis, IN. To date, 89 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 492 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.

Work in 2017 will include an update to the highway-runoff database, another SELDM class for State and Federal DOT people, presentation of case studies at conferences, outreach to Universities to share SELDM training materials, and coordination/cooperation with research projects being done by the NCHRP and International BMP database teams.

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 FY 2017.

Publications:

Granato, G.E., and Jones, S.C., 2016, Modeling stormflow, total hardness, suspended sediment, and total copper to assess risks for water-quality exceedances with the Stochastic Empirical Loading and Dilution Model (SELDM): Proceedings of StormCon, August 22-25, 2016, Indianapolis, IN: Santa Barbara, CA, Forester Media Inc., 14 p.

Web page (with links to the published reports):

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

USGS Surface Velocity Workgroup

Objectives: The purpose of the Surface Velocity Work Group ("Surf Board") is to assist the USGS Water Mission Area (WMA) in its overall mission to identify and develop new, advanced streamflow and velocity measurement and monitoring methods, provide guidance and training to most effectively deploy and use them, and to evaluate the trade-offs in the quality of the resulting data. The Surf Board membership includes USGS scientists from each region as well as representation from international partners including Environment and Climate Change Canada; the Centro de Estudios y Tecnología del Agua (CETA) in Córdoba, Argentina; and Électricité de France (EDF).

The objectives of this work group include evaluating and testing the Large Scale Particle Image Velocimetry (LSPIV) and Surface Velocity Radar (SVR) techniques as well as developing training materials and guidance for their proper application. The work should result in less-costly techniques suitable for flood measurement and, potentially, an expanded flood-monitoring network for both operation decision making and long-term flood characterization.

Interested persons should contact Frank Engle (fengle@usgs.gov) to learn more.

Selected References

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Welber, M., Le Coz, J., Laronne, J., Zolezzi, G., Zamler, D., Dramais, G., Salvaro, M. (2016). Field assessment of noncontact stream gauging using portable surface velocity radars (SVR). Water Resources Research, 52, 1108–1126. http://doi.org/10.1002/2015WR017906

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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.

Investigation of Slope Stability: A study to examine the progression and potential causes of channel slope instability at several locations on the Coosa River downstream from hydroelectric dams using motion-compensated and tripod terrestrial LiDAR.

Recent Publications

Kimbrow, D.R., and Lee, K.G., 2013, Erosion monitoring along the Coosa River below Logan Martin Dam near Vincent, Alabama, using terrestrial light detection and ranging (T-LiDAR) technology: U.S. Geological Survey Scientific Investigations Report 2013–5128, 7 p., Available online at: http://pubs.usgs.gov/sir/2013/5128/.

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.)

2016 Summary of Alaska Bridge Scour Project:

- Ongoing continuous monitoring and evaluation of streambed change and water surface elevations at 17 scour-critical bridges with manual soundings at an additional 3 scour critical bridges around Alaska.
- Initiated periodic monitoring of streambed elevations at Crescent Creek.
- Collected time-lapse imagery at 8 scour critical bridges during open-water season; collected time-lapse imagery of breakup at 3 locations.
- Collected flood soundings at 4 sites that experienced flood and scour events.
- Collected flow data at 9 channels of the Copper River crossing the Copper River Highway to determine changing flow distribution.

- For bridges with unknown foundations or incomplete scour analyses, completed draft calculations and report for 52 scour critical bridges visited in 2013-2015, completed field surveys, flood frequency analysis, stream stability analysis, and compiled model geometry for an additional 15 sites.

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 reach-based water-surface profiling 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 reaches of 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 5-year cooperative program has been established directly with ADOT in 2016. 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 and structures at risk. Data for these efforts are being collected by unmanned aircraft systems and ground based LiDAR equipment. This equipment will also be used to do repeat scans of bridges and channels to be used for change detection, runoff modeling, and scour studies. A rapid deployment stream gage was also installed on a bridge scheduled for a future construction effort. Gaged data will be used by bridge engineers to refine design.

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).

Magnitude and Frequency of Floods in Arkansas: 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 concluded 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. The report, listed below, was released in the winter of 2016:

Wagner, D.M., Krieger, J.D., and Veilleux, A.G., 2016, Methods for estimating annual exceedance probability discharges for streams in Arkansas, based on data through water year 2013: U.S. Geological Survey Scientific Investigations Report 2016–5081, 136 p., http://dx.doi.org/10.3133/sir20165081.

A network of 55 crest-stage gages is operated in Arkansas in an effort to collect annual peak-flow data at smaller inflow-tributaries. The data collected at these stations will be used when the next flood frequency regression report is compiled for Arkansas.

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. Following is a link to the CAWSC Post-Fire Debris Flow website: http://ca.water.usgs.gov/flooding/wildfires-debris-flow.html.

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.

Training for the USGS-FHWA Stochastic Empirical Loading and Dilution Model (SELDM): The USGS New England Water Science Center is working with CalTrans in coordination with the USGS California Water Science Center to offer CalTrans personnel their own version of the 3-day SELDM training class. One class will be given at the CalTrans office in Santa Ana, CA and the other class will be given at the USGS California Water Science Center office in Sacramento, CA.

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 2016, the Colorado Water Science Center (CO WSC), in cooperation with the Colorado Department of Transportation (CDOT), 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 a real-time camera which was installed in 2014 and currently operates in the basin. The data is used by CDOT staff to take appropriate action along U.S. Highway 24 in response to extreme weather conditions.

The CO WSC, in cooperation with CDOT, began a study in 2016 to identify hydrodynamic thresholds such as water depth, velocity, shear stress, and shear velocity that can be computed from simulated hydrographs derived from the Precipitation Runoff Modeling System (PRMS). These metrics could then be used by CDOT personnel to assess whether hydraulic conditions will adversely affect CDOT structures and pose a risk to life and property. In stream reaches where existing hydraulic models exist, such as those developed by CDOT or their contractors, the streamflow generated by PRMS could be used as boundary conditions to drive these models and provide additional hydraulic metrics.

In 2016, the CO WSC, 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 NWIS Website and is updated annually. The Colorado Flood Database and project page is available at http://co.water.usgs.gov/projects/COFloodDB/index.html.

In 2016, the CO WSC, 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 was 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 was published in 2016 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.

The CO WSC, in cooperation with CDOT, documented the peak discharge, peak stage, and the annual-exceedance probability of two floods that occurred at CDOT hydraulic structures in Colorado in 2016. The two study areas were chosen collaboratively with CDOT staff because of the magnitude of the flood, availability of flood evidence, and the location of these sites to a recent wildfire or urban area. One one-dimensional hydraulic model and peak-streamflow regional-regression equations were used to determine the peak discharge and annual exceedance probability of the peak discharge and the limitations and accuracy which will be published in a USGS report in 2017. A project website will be available in 2017.

The CO WSC, in cooperation with CDOT, operated a 10 site crest-stage gage network in eastern Colorado in 2016. 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 NWIS Website and additional information on this study can be found at http://co.water.usgs.gov/projects/EastCOCrestStageGage/index.html.

The CO WSC, in cooperation with CDOT, operated a real-time bridge scour monitoring study at two streamgages in western Colorado in 2016. The installation of streambed scour monitoring instrumentation can provide site specific assessments 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 NWIS Website 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.

In 2016, the CO WSC, in cooperation with CDOT, implemented 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 CO WSC 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.

In 2016, the CO WSC, in cooperation with CDOT, implemented modifications to the standard USGS StreamStats program to accommodate additional climate and basin characteristics in Colorado. Some of the climate and basin characteristics include: SCS hydrologic soil classification, SCS basin lag time, land use classification, curve numbers, basin centroid location, basin outlet location, minimum and maximum elevation, elevation at outlet, perimeter of the basin, basin 10-85 slope, longest flow path in basin, potential watershed storage, rational method runoff coefficient, and rainfall intensity.

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, 26 p.

Kohn, M.S., Stevens, M.R., Harden, T.M., Godaire, J.E., Klinger, R.E., and Mommandi, A., 2016, Paleoflood investigations to improve peak-streamflow regional-regression equations for natural streamflow in eastern Colorado, 2015: U.S. Geological Survey Scientific Investigations Report 2015–5099, 58 p., http://dx.doi.org/10.3133/sir20165099.

Kohn, M.S., Stevens, M.R., Mommandi, A., and Khan, A.R., 2017, Floods at Big Cottonwood Creek at US Highway 50 near Coaldale, Colorado and Fountain Creek below US Highway 24 in Colorado Springs, Colorado, (IN PRESS): U.S. Geological Survey Scientific Investigations Report 2017–XXXX, XX p., http://dx.doi.org/10.3133/sir2017XXXXX.

Connecticut

Connecticut Flood Frequency Equations: A study to update equations for estimating 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 Connecticut Department of Transportation. The last comprehensive regional AEP flood flows for Connecticut were computed using data through water year 2001. The new analysis will report AEP flows using data up through water year 2016 at streamgages in Connecticut and surrounding states. New streamgage AEP flows will be 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. The updated equations will be added to USGS StreamStats upon publication of the report. The study is scheduled to be completed in fiscal year 2019.

Delaware

The USGS, in cooperation with Delaware Department of Transportation (DelDOT), has implemented a data-delivery system that has allowed DelDOT to independently poll USGS stage data, thus enhancing DelDOT's capabilities to create and maintain a hydrometeorological-response system to enhance traffic safety. Currently, 10 USGS gages are successfully integrated into this system (stage and stage-discharge). The next phase of the project is to expand the network to cover more areas of concern. This expansion

would consist of either: (1) adding DelDOT communications to existing USGS gages; (2) adding stage sensors to existing USGS water-quality gages; (3) upgrading existing DelDOT or other State monitoring sites; or, (4) construct new monitoring sites, to bring hydrologic data into the response system.

District of Columbia

No highway related projects at this time.

Florida

No highway-related projects at this time.

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 7 rain gages (2 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 72 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 Center 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, 63 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 a co-PI on a study to 1) develop a tool to identify streamflow permanence in headwater streams that can be used to improve NHD mapping and road design in remote areas and 2) design and evaluate simple low cost (<$20) methods to measure streamflow in small remote streams.

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 (Over and others, 2014b, 2016a). These time series have been analyzed using updated (Bulletin 17C with Bayesian regional skew and GLS regression) flood frequency methods to develop an accurate and easy-to-use method of determining peak discharges on urbanized watersheds for design and reference (Over and others, 2016b). The analysis enables the transfer of urbanization effects to other regions in IL and the implementation of the methods in the IL SS. This project was in cooperation with the Illinois Center for Transportation and was completed, including implementation in IL SS, in July 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 (Over and others, 2014a). 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.

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 (Soong and others, 2012; Murphy and others, 2012a,b; Murphy and Sharpe, 2013) and two additional studies are under development. The completed FIM studies can be accessed from http://wimcloud.usgs.gov/apps/FIM/FloodInundationMapper.html. These map libraries are being 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.

Over, T.M., Saito, R.J., and Soong, D.T., 2016a, Adjusting annual maximum peak discharges at selected stations in northeastern Illinois for changes in land-use conditions: U.S. Geological Survey Scientific Investigations Report 2016–5049, 33 p., http://dx.doi.org/10.3133/sir20165049.

Over, T.M., Saito, R.J., Veilleux, A.G., Sharpe, J.B., Soong, D.T., and Ishii, A.L., 2016b, Estimation of peak discharge quantiles for selected annual exceedance probabilities in northeastern Illinois: U.S. Geological Survey Scientific Investigations Report 2016–5050, 50 p. with appendix, http://dx.doi.org/10.3133/sir20165050; also published as: Illinois Center for Transportation Report FHWA-ICT-16-013, 318 p. with appendix.

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., 2012a, 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., 2012b, 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 2016 the USGS operated 36 streamgages in cooperation with the Indiana DOT.

Flood inundation map libraries have been developed for 8 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.

Velocity Measurements: A non-contact surface velocity meter was installed in 2016 at a bridge where high velocity conditions are a threat to current infrastructure. Data collected from this instrument will be used to support decisions on design criteria for a replacement structure scheduled for installation in the next 5 years.

Wabash River Channel Migration Impact on the I-64 Bridge: Channel migration near the Interstate 64 bridge over the Wabash River has become a concern for the Indiana and Illinois DOT's due to scour on the cut bank adjacent to one of the bridge abutments. The USGS is creating a 2-D model of the approach to the bridge to help run scenarios for different bank-armor and counter-scour measures. This includes velocity mapping of the channel, boat mounted LIDAR imagery collection, and channel migration modeling. Data collection was completed in August of 2016 and a final model and report are expected in early 2017.

Recent Publications

Boldt, J.A., 2016, Flood-inundation maps for the East Fork White River at Shoals, Indiana: U.S. Geological Survey Scientific Investigations Report 2016–5036, 22 p., http://dx.doi.org/10.3133/sir20165036.

Fowler, K.K., Kim, M.H., and Menke, C.D., 2012, Flood-inundation maps for the White River at Newberry, Indiana: U.S. Geological Survey Scientific Investigations Map 3231, 8 p., 22 sheets, scale 1:20,000, available only at http://www.pubs.usgs.gov/sim/3231

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.

Fowler, K.K., 2014, Flood-inundation maps for the Wabash and Eel Rivers at Logansport, Indiana: U.S. Geological Survey Scientific Investigations Map 3293, 9 sheets, 12-p. pamphlet, http://dx.doi.org/10.3133/sim3293.

Fowler, K.K., 2014, Flood-inundation maps for the White River near Edwardsport, Indiana: U.S. Geological Survey Scientific Investigations Report 2014–5219, 11 p., http://dx.doi.org/10.3133/sir20145219.

Fowler, K.K., 2015, Flood-inundation maps for the White River at Petersburg, Indiana: U.S. Geological Survey Scientific Investigations Report 2015–5107, 11 p., http://dx.doi.org/10.3133/sir20155107.

Fowler, K.K., 2016, Flood-inundation maps for the Wabash River at New Harmony, Indiana: U.S. Geological Survey Scientific Investigations Report 2016–5119, 14 p., http://dx.doi.org/10.3133/sir20165119.

Kim, M.H., and Johnson, E.M., 2014, Flood-inundation maps for the North Branch Elkhart River at Cosperville, Indiana: U.S. Geological Survey Scientific Investigations Report 2014–5128, 9 p., http://dx.doi.org/10.3133/sir20145128.

Martin, G.R., Fowler, K.K., and Arihood, L.D., 2016, Estimating selected low-flow frequency statistics and harmonic-mean flows for ungaged, unregulated streams in Indiana: U.S. Geological Survey Scientific Investigations Report 2016–5102, 45 p., https://pubs.er.usgs.gov/publication/sir20165102.

Martin, Z.W., 2016, Flood-inundation maps for Sugar Creek at Crawfordsville, Indiana: U.S. Geological Survey Scientific Investigations Report 2016–5043, 11 p., http://dx.doi.org/10.3133/sir20165043.

Menke, C.D., and Bunch, A.R., 2015, Flood-inundation maps for the Tippecanoe River at Winamac, Indiana: U.S. Geological Survey Scientific Investigations Report 2015–5103, 9 p., http://dx.doi.org/10.3133/sir20155103.

Nystrom, E.A., 2015, Flood-inundation maps for the White River at Indianapolis, Indiana, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5051, 12 p., http://dx.doi.org/10.3133/sir20155051.

Strauch, K.R., 2015, Flood-inundation maps for the St. Marys River at Decatur, Indiana: U.S. Geological Survey Scientific Investigations Report 2015–5099, 8 p., http://dx.doi.org/10.3133/sir20155099.

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 27 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). A flood-profile report is currently being prepared to document the August 24, 2016 flooding along a 15-mile reach of the Upper Iowa River, which will include 7 high-water mark sites, and along a 58-mile reach of the Turkey River, which will include 11 high-water mark sites.

Statistical Summary of Selected Iowa Streamflow Data: The Iowa WSC published 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 were computed for streamflow data collected at 184 continuous-record streamgages in Iowa with at least 10 years of record. The statistics were computed on the daily mean and annual instantaneous peak values of streamflow data collected through water year 2013. The following daily-flow statistics were 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 were included with the streamflow statistics for each streamgage. Instantaneous peak-flow probabilities were 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 were weighted with annual exceedance-probability estimates computed using regional-regression equations. A trend analysis was provided for the annual instantaneous peak discharges.

Investigation of LiDAR data: Dr. Brian Gelder (Iowa State University) tested five 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 were enforced using the method developed by Dr. Gelder for the Iowa Highway Research Board, and five stream initiation methods were used to define channel initiation points and the downstream flow paths. The Iowa WSC is using the stream initiation methods to define channelized flow paths on the hydrologically enforced LiDAR DEMs, creating multiple sets of selected basin-characteristic values that are being measured for each streamgage. The 5 different quantitative methods to define stream initiation are being 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 15 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 are being measured for each streamgage watershed from the five stream initiation methods and LiDAR DEMs. The 5 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 are being 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 were updated through the 2015 water year for the 17 streamgages, and regression analyses will be performed to identify which of the 15 sets of LiDAR-measured basin-characteristic values from the 5 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.

FHWA scour countermeasures field investigation: Three bridge sites in Iowa were selected for inclusion in the FHWA/USGS bridge scour study as part of the national assessment of scour and scour-related countermeasures. Field investigations for the three Iowa bridge sites were completed in October 2016.

Recent Publications:

Eash, D.A., O'Shea, P.S., Weber, J.R., Nguyen, K.T., Montgomery, N.L., and Simonson, A.J., 2015, Statistical summaries of selected Iowa streamflow data through September 2013: U.S. Geological Survey Open-File Report 2015–1214, 18 p., http://dx.doi.org/10.3133/ofr20151214.

Eash, D.A., Barnes, K.K., and O'Shea, P.S., 2016, Methods for estimating selected spring and fall low-flow frequency statistics for ungaged stream sites in Iowa, based on data through June 2014 (ver. 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016–5111, 32 p., http://dx.doi.org/10.3133/sir20165111.

Farmer, W.H., Knight, R.R., Eash, D.A., Hutchinson, K.J., Linhart, S.M., Christiansen, D.E., Archfield, S.A., Over, T.M., and Kiang, J.E., 2015, Evaluation of statistical and rainfall-runoff models for predicting historical daily streamflow time series in the Des Moines and Iowa River watersheds: U.S. Geological Survey Scientific Investigations Report 2015–5089, 34 p., http://dx.doi.org/10.3133/sir20155089.

Haj, A.E., Christiansen, D.E., and Hutchinson, K.J., 2015, Simulation of daily streamflow for nine river basins in eastern Iowa using the Precipitation-Runoff Modeling System: U.S. Geological Survey Scientific Investigations Report 2015–5129, 29 p., http://dx.doi.org/10.3133/sir20155129.

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 2015 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, 33 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. This report should be released in 2017.

A report titled, "Yield Estimates of Selected Streams, Lakes and Reservoirs in Louisiana" is currently in the review process. This report is also expected to be released in 2017.

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: USGS is working in cooperation with Maine Department of Transportation to evaluate existing lag time and time of concentration equations for small basins in Maine using existing rainfall and streamflow data and 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.

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 15 complete years of data collection, three sites have 14 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).

In FY2016, the USGS Maryland-Delaware-District-of-Columbia Water Science Center (MD-DE-DC WSC) initiated a project with the Maryland State Highway Administration (SHA) using a state-of-the-art nutrient and sediment data-collection and analysis approach designed to target suitable areas for impervious area treatment, while considering Total Maximum Daily Loads (TMDLs) and Best Management Practice (BMP) placements. This will be a multi-year study with several activities implemented in series throughout the study period.

Site selection will involve compiling available information that will contribute towards evaluating and determining watersheds that will be selected for reconnaissance. Site visits will determine potential site-specific locations suitable for stream monitoring (chemistry, streamflow) and sediment fingerprinting location(s) where impervious treatment will likely have an impact on water quality. This will be a joint activity between SHA and USGS. Results from previously calibrated nutrient and suspended-sediment SPARROW models representing the 2002 time period will be applied in a scale-able approach that can identify high nutrient and sediment loadings likely to be generated from urban land uses. Data

collection, water-quality-model derivation, and sediment analysis will be carried out to determine baseline conditions and evaluate changes over time in relation to designated treatment activities.

Sediment-Fingerprint Analysis designed to identify the sources of suspended sediment in selected watersheds will be performed, along with development of sediment budgets that quantify net sediment loads from selected watersheds. Further discrimination of sediment sources using sediment fingerprinting and geomorphic channel-measurement computations will be recommended based on preceding results.

Massachusetts

Massachusetts Flood Frequency Equations: A study to update equations for estimating 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 completed and approved. It is currently in press and should be published in early 2017. After the publication is online, 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.

Zarriello, P.Z., 201X, Magnitude of flood flows for selected annual exceedance probabilities in Massachusetts through 2013: U.S. Geological Survey Scientific Investigations Report 2015-5156, XX p. (IN PRESS).

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 in water year 2014 and operated through water year 2016. Over 50 flow-proportional composite samples were collected at each station and analyzed for concentrations of suspended sediment, total nitrogen, and total phosphorus.

Highway Runoff TMDLs: The FHWA sponsored an analysis of runoff-quality yields and the potential effectiveness of mitigation measures for meeting TMDLs in Rhode Island and eastern Massachusetts. This effort resulted in the paper:

> Granato, G.E., and Jones, S.C., 2017, Estimating long-term annual highway-runoff loads for total maximum daily load analyses with the Stochastic Empirical Loading And Dilution Model (SELDM): Proceedings of the 96th Annual Meeting of the Transportation Research Board, 16 p.

and a presentation of the same title in the AFB60 session 708, Solutions for Improved Water Quality on Tuesday January 10th from 3:45 to 5:30 PM.

Flood inundation map libraries for five USGS streamgage sites (one with collocated NWS flood forecast point) that can assist with highway, road, and bridge operations during floods have been published. Flood-inundation maps for two USGS streamgages are in one report for the Deerfield River. 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.
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> Flynn, R.H., Bent, G.C. and Lombard, P.J., 2016, 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 2016-5107, 18 p.
>
> 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.

Flood summary report for northwestern Massachusetts: The USGS in cooperation with FEMA produced a summary report of flooding due to Tropical Storm Irene, August 2011. The report documents peak flows at USGS streamgages and the annual exceedance probabilities (AEPs) of the flood flows from Tropical Storm Irene. Additionally, for selected stream reaches, the flood flow AEPs and the 1-percent AEP water-surface elevations, computed with hydraulic models produced for the study, were compared to those in the effective FEMA Flood Insurance Studies.

> Bent, G.C., Olson, S.A., and Massey, A.J., 2016, Tropical storm Irene flood of August 2011 in northwestern Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5027, 28 p., http://dx.doi.org/10.3133/sir20165027.

Michigan

In fiscal year 2016, 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. Increased NSIP/GWSIP funding during the past several years has supported the installation of several new streamgages, primarily in areas that previously have had limited continuous-streamflow information.

In coordination with adjoining states, Michigan and Ohio are preparing for a new flood skew study that would update previous regional skew estimates. Station skew estimates have been updated using peak flow data through 2013 from a set of streamgages and crest-stage gages. 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). The new algorithms will produce skew estimates that supersede those published in a 1982 as Bulletin 17B report. A draft report entitled "Guidelines for Determining Flood Flow Frequency—Bulletin 17C", by England, Cohn, Faber, Stedinger, Thomas, Veilleux, Kiang, and Mason (2015) was released for public comment on December 29, 2015; publication is expected in 2017.

Data files needed to regionalize flood frequency distribution skew coefficients using Bulletin 17C methods have been compiled according to standards prescribed by the USGS Office of Surface Water (OSW). The OSW plans to develop a generalized skew equation or map by use of a Bayesian generalized least-square (GLS) regression approach for selected Midwestern states that include Michigan and Ohio. There has been an unexpected delay, however, in initiating this regionalization study, so the completion date is unknown. A Bulletin 17C consistent estimation of regional flood skew would provide a basis for estimating peak flow-frequency characteristics at streamgages, updating peak-flow regression equations, and implementing StreamStats 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.

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 MPCA, completed a study to develop regional regression equations that estimate low-flow frequency statistics and flow-duration curve exceedance probabilities in Minnesota. Developed equations enable hydrologists to simulate mean daily flows at ungaged locations and will assist in efforts such as ecological flow analyses and development of TMDLs.

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

Ziegeweid, J.R., Lorenz, D.L., Sanocki, C.A., and Czuba, C.R., 2015, Methods for estimating flow-duration curve and low-flow frequency statistics for ungaged locations on small streams in Minnesota: U.S. Geological Survey Scientific Investigations Report 2015–5170, 23 p., http://dx.doi.org/10.3133/sir20155170.

Lorenz, D.L., and Ziegeweid, J.R., 2016, Methods to estimate historical daily streamflow for ungaged stream locations in Minnesota: U.S. Geological Survey Scientific Investigations Report 2015–5181, 18 p., http://dx.doi.org/10.3133/sir20155181.

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 2017.

Missouri

Streamgages: the Missouri Water Science Center MOWSC) streamgage activity in 2016 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.

Bathymetry and Scour at Major River Bridge sites: Ongoing bathymetric surveys with comparisons to past surveys at Missouri and Mississippi River bridge sites using multibeam sonar. 2016 marked the third set of surveys at the bridges over the Missouri River (2010, 2011, 2016) and the second set of surveys at bridges over the Mississippi River (2009 or 2010, 2016) in the St. Louis area.

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 South Carolina, Pennsylvania, Connecticut, and New Jersey, 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 2017. The project website is at http://water.usgs.gov/osw/techniques/bs/scour_fhwa/.

Investigation of Slope Stability: MOWSC personnel are working with the Alabama WSC in a study to examine the progression and potential causes of channel slope instability at several locations on the Coosa River downstream from hydroelectric dams using motion-compensated and tripod terrestrial LiDAR.

Investigation of Effects of Large Woody Debris and Stream Piracy: The MOWSC is examining the effects of large woody debris (LWD) in lower Locust Creek in north-central Missouri, as well as the resultant streamflow piracy from Locust Creek into Higgins Ditch. The study seeks to address questions regarding LWD dynamics and channel stability by: 1) determining differences in channel cross-sections in sub-reaches where debris removal/redistribution is permitted and adjacent reaches outside of the permitted areas; 2) document the stability of selected historical LWD redistribution projects; and 3) document LWD physical characteristics in selected hydrologically distinct stream segments. The project seeks to examine the effectiveness of management techniques historically employed by the Missouri Depts. of Natural Resources and Conservation. The LWD and resulting stream instability pose a threat to the stability of several highway bridges in the area.

StreamStats: The MOWSC is in the process of developing and implementing StreamStats for Missouri to estimate:

- Basin characteristics for ungaged basins

- Low-flow frequency and statistics
- Urban and rural flood frequency and statistics
- Parameters needed for Urban Unit Hydrographs (with the exception of rainfall information)

A high-resolution Urban StreamStats also is being developed for the St. Louis area, utilizing higher-resolution aerial LiDAR datasets available for that area, as well as the urban flood frequency and unit hydrograph parameters and equations.

Flood inundation mapping: Inundation maps for selected water-surface elevations at National Weather Service (NWS) flood forecast and non-forecast reference points are available for the Blue River and selected tributaries in Kansas City, Missouri and vicinity on the USGS National Flood Inundation Mapping (FIM) Program.

Modeling of Multidimensional Flow: A portion of the lower Meramec River is being modeled using the Nays2DH module of the multidimensional iRiC modeling package. The model will examine the effects of the Valley Park levee system and the Pointe Fenton Development area on an extreme flow event in December 2015.

Recent Publications

Heimann, D.C., Weilert, T.E., Kelly, B.P., and Studley, S.E., 2014, Flood-inundation maps and Wetland Restoration Suitability Index for the Blue River and selected tributaries, Kansas City, Missouri, and vicinity, 2012 (ver. 1.1, April 2015): U.S. Geological Survey Scientific Investigations Report 2014–5180, 23 p., http://dx.doi.org/10.313/sir20145180.

Heimann, D.C., Weilert, T.E., Kelly, B.P., and Studley, S.E., 2015, Flood-inundation mapping for the Blue River and selected tributaries in Kansas City, Missouri, and vicinity, 2012: U.S. Geological Survey Fact Sheet 2015–3008, 4 p., http://dx.doi.org/10.3133/fs20153008.

Huizinga, R.J., 2016, Bathymetric and velocimetric surveys at highway bridges crossing the Missouri River near Kansas City, Missouri, June 2–4, 2015: U.S. Geological Survey Scientific Investigations Report 2016–5061, 93 p., http://dx.doi.org/10.3133/sir20165061.

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, in cooperation with Montana Department of Transportation, Montana Department of Environmental Quality, and Montana Department of Natural Resources and Conservation, published Montana StreamStats Scientific Investigations Report 2015-5019 (https://pubs.er.usgs.gov/publication/sir20155019) in 7 chapters:

McCarthy, P.M., Dutton, D.M., Sando, S.K., and Sando, Roy, 2016, Montana StreamStats—A method for retrieving basin and streamflow characteristics in Montana: U.S. Geological Survey Scientific Investigations Report 2015–5019–A, 16 p., http://dx.doi.org/10.3133/sir20155019A.

Sando, S.K., McCarthy, P.M., Sando, Roy, and Dutton, D.M., 2016, Temporal trends and stationarity in annual peak flow and peak-flow timing for selected long-term streamflow-gaging stations in or near Montana through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015–5019–B, 48 p., http://dx.doi.org/10.3133/sir20155019B.

Sando, S.K., McCarthy, P.M., and Dutton, D.M., 2016, Peak-flow frequency analyses and results based on data through water year 2011 for selected streamflow-gaging stations in or near Montana: U.S. Geological Survey Scientific Investigations Report 2015–5019–C, 27 p., http://dx.doi.org/10.3133/sir20155019C.

Sando, S.K., Sando, Roy, McCarthy, P.M., and Dutton, D.M., 2016, Adjusted peak-flow frequency estimates for selected streamflow-gaging stations in or near Montana based on data through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015–5019–D, 12 p., http://dx.doi.org/10.3133/sir20155019D.

McCarthy, P.M., 2016, Streamflow characteristics based on data through water year 2009 for selected streamflow-gaging stations in or near Montana: U.S. Geological Survey Scientific Investigations Report 2015–5019–E, 10 p., http://dx.doi.org/10.3133/sir20155019E.

Sando, Roy, Sando, S.K., McCarthy, P.M., and Dutton, D.M., 2016, Methods for estimating peak-flow frequencies at ungaged sites in Montana based on data through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015–5019–F, 30 p., http://dx.doi.org/10.3133/sir20155019F.

McCarthy, P.M., Sando, Roy, Sando, S.K., and Dutton, D.M., 2016, Methods for estimating streamflow characteristics at ungaged sites in western Montana based on data through water year 2009: U.S. Geological Survey Scientific Investigations Report 2015–5019–G, 19 p., http://dx.doi.org/10.3133/sir20155019G.

The Montana StreamStats application is online.

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 is 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 being developed for the North Platte River at Scottsbluff. A report was published for the Big Papillion Creek flood inundation map library. The National Weather Service provides river forecasts for both sites. These studies provide cooperators with flood planning tools for road and bridge construction and operation.

Recent Publications

Strauch, K.R., Dietsch, B.J., and Anderson, K.J., 2016, Flood-inundation maps for a 12.5-mile reach of Big Papillion Creek at Omaha, Nebraska: U.S. Geological Survey Scientific Investigations Report 2015–5152, 11 p., http://dx.doi.org/10.3133/sir20155152.

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 FY2006 to compute sediment loads in the Clear Creek drainage near Carson City, NV. 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 FY2009 by Seiler and Wood documenting baseline discharge and sediment conditions during FY2004-2007:

Seiler, R.L., and Wood, J.L., 2009, Sediment loads and yield, and selected water-quality parameters in Clear Creek, Carson City and Douglas County, Nevada, water years 2004–07: U.S. Geological Survey Scientific Investigations Report 2009–5005, 44 p. https://pubs.usgs.gov/sir/2009/5005/

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 FY2010-2012. This report was published in September 2015 by Huntington and Savard (sir 2015-5124):

Huntington, J.M., and Savard, C.S., 2015, Discharge, suspended sediment, bedload, and water quality in Clear Creek, western Nevada, water years 2010–12: U.S. Geological Survey Scientific Investigations Report 2015-5124, 39 p., http://dx.doi.org/10.3133/sir20155124.

A new agreement to extend the study through the end of FY16 was signed in December 2012. Two more reports, one documenting FY2013-2014 and another documenting FY2015-2016 will be published in FY2017. Another agreement is expected to be signed very soon to extend the study through FY 2020. In addition to continued monitoring for sediment and select water quality constituents, sediment control mitigation efforts by Nevada Department of Transportation will be evaluated.

New Hampshire

NHDOT – USGS Sources of Nitrate to Wells: A project designed to help determine sources of nitrate to wells in the vicinity of active roadway blasting has been completed for the USGS and New Hampshire Department of Transportation (NHDOT). Concentrations and isotopic compositions of nitrate and other nitrogen compounds in groundwater were 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 has helped the NHDOT determine when it is responsible for nitrogen (nitrate) contamination of groundwater as a result of roadway construction efforts that involve blasting for rock removal. A journal article has been published to document the study.

Project Publications

James R. Degnan, John Karl Bohlke, Krystle Pelham, David M. Langlais, and Gregory J. Walsh, 2015, Identification of groundwater nitrate contamination from explosives used in road construction: Isotopic, chemical, and hydrologic evidence: Environmental Science and Technology, doi:10.1021/acs.est.5b03671. [https://pubs.er.usgs.gov/publication/70161737]

Degnan, J.R., Bohlke, J.K., Pelham, Krystle, Langlais, D.M. and Walsh, G.J., 2015, Isotopic Fingerprinting of Nitrate Sources in Groundwater Near Highway Blasting Sites: Northeastern Section, Geological Society of America, March 23-25, 2015, Bretton Woods, NH [https://pubs.er.usgs.gov/publication/70161737].

New NHDOT – USGS Project: Predicting iron precipitation from rock fill drainage: The USGS is working with the NHDOT on a new project to characterize sites where iron fouling has occurred near roadways constructed with blasted rock fill. The NHDOT has determined that rock fill material placed in contact with wet areas adjacent to roadways can mobilize high concentrations of iron and cause iron fouling in surface water. Accumulations of hydrated iron (ferric) oxide compounds with red-orange microbial deposits (collectively referred to as iron fouling) in drainage ways are a continuous maintenance challenge for NHDOT. Predictions of where iron fouling may occur will help NHDOT in planning new construction projects and modifying existing drainages with iron fouling issues. Insight gained from this project combined with existing information in the form of geologic maps, water level, and water quality data will enable NHDOT to better predict where iron fouling could be a problem and develop remedial measures.

New Jersey

NJDOT Bridge Scour Data Collection: The USGS New Jersey Water Science Center (NJWSC) developed a bridge scour data collection project with New Jersey Department of Transportation (NJDOT) that started in April 2008 and ran through FY 2014. The general objectives of this project 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 is trying to design a new project to further investigate scour in New Jersey but currently does not have an active project with NJDOT.

FHWA Bridge Scour Countermeasures: The NJWSC is currently participating as a team lead member in the national bridge scour countermeasures study that is investigating the performance and effectiveness of scour countermeasures. In 2016 the NJWSC began participating in the project with site visits and bridge surveys. In 2016 and 2017 the NJWSC is planning to participate in additional bridge visits and

surveys in New Jersey, Pennsylvania, and parts of New England. The project website can be found at http://water.usgs.gov/osw/techniques/bs/scour_fhwa/.

Flood inundation map libraries: The NJWSC recently completed the last in a series of flood inundation maps that will assist with highway, road, and bridge closures, evacuations and mitigation planning. These map libraries were completed in cooperation with NJ Department of Environmental Protection (NJDEP).

Niemoczynski, M.J., and Watson, K.M., 2016, Flood-inundation maps for the Peckman River in the Townships of Verona, Cedar Grove, and Little Falls, and the Borough of Woodland Park, New Jersey, 2014: U.S. Geological Survey Scientific Investigations Report 2016-5105, 13 p., http://dx.doi.org/10.3133/sir20165105

Watson, K.M., and Niemoczynski, M.J., 2015, Flood-Inundation maps for the Hohokus Brook in Waldwick Borough, Ho-Ho-Kus Borough, and the Village of Ridgewood, New Jersey, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5064, 12 p., http://dx.doi.org/10.3133/sir20155064

Watson, K.M., and Niemoczynski, M.J., 2014, Flood-inundation maps for the Saddle River in Ho-Ho-Kus Borough, the Village of Ridgewood, and Paramus Borough, New Jersey, 2013: U.S. Geological Survey Scientific Investigations Map 3299, 10 p., 10 sheets, http://dx.doi.org/10.3133/sim3299

Watson, K. M., and Hoppe, H. L., 2013, Flood-inundation maps for the Saddle River from Upper Saddle River Borough to Saddle River Borough, New Jersey, 2013: U.S. Geological Survey Scientific Investigations Map 3262, 8 p., 8 sheets, http://pubs.usgs.gov/sim/3262/

Hoppe, H.L. and Watson, K.M., 2012, Flood-inundation maps for the Saddle River from Rochelle Park to Lodi, New Jersey, 2012: U.S. Geological Survey Scientific Investigations Map 3221, 7 p., 11 sheets, scale 1:12,000. Available online at http://pubs.usgs.gov/sim/3221.

Flood Documentation: The NJWSC recently published a report in cooperation with FEMA and NJDEP that documented the flooding impact of Hurricane Sandy along the coast of New Jersey. The storm damaged thousands of homes and buildings, roads, bridges, railroads, power stations and left millions without power. The report also documented peak water levels and compared them to the new preliminary FEMA National Flood Insurance Study Program flood elevations and evaluated the effectiveness of forecasted inundation vs. actual documented depth and extent of flooding.

Suro, T.P., Deetz, Anna, and Hearn, Paul, 2016, Documentation and hydrologic analysis of Hurricane Sandy in New Jersey, October 29–30, 2012: U.S. Geological Survey Scientific Investigations Report 2016–5085, 73 p., http://dx.doi.org/10.3133/sir20165085.

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. The New Mexico Department of Transportation (NMDOT) and USGS began their cooperation on this gage network in 1942.

StreamStats: New Mexico StreamStats development has been partially funded by the USGS in cooperation with the USDA (Forest Service, Southwestern Region), NMDOT, and the New Mexico

Environment Department. Information about the StreamStats program can be found at: http://water.usgs.gov/osw/streamstats/new_mexico.html.

As of September 1, 2016, StreamStats was implemented for all of New Mexico in version 3 and is currently available online (see web page link above). Previously, it was implemented only for a pilot area in the San Juan Basin in the northwestern part of New Mexico. This application implements regression equations for estimating instantaneous peak flows with probabilities of occurring in any given year of 50, 20, 10, 4, 2, 1, 0.5, and 0.2 percent. These statistics also are referred to as the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods. Basic basin characteristics are available, and more advanced features could be added in the future.

Flood Frequency: In cooperation with the NMDOT, the NMWSC initiated a study to update the flood frequency statistics for New Mexico. That project began 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.

Post-fire Floods and Debris Flows: The NMWSC is cooperating with NMDOT and others to better understand debris-flow generation processes and flash-flood potential, and to improve predictions and assessments of hazard vulnerability and risk. Data are being collected and analyzed from unprecedented flooding and debris-flow activity after a record-breaking rainstorm in September 2013 that fell on a burn scar and surrounding areas. Results will assist in updating USGS debris-flow prediction equations.

New York

Peak Flows: Maximum known stages and discharges continue to be documented at locations across New York State. A web-based map (http://ny.water.usgs.gov/flood/floodinv.html) is available detailing 1,400 locations with documented peaks and associated Annual Exceedance Probability flood magnitudes.

Flood Documentation: The New York Water Science Center (NYWSC) documents notable floods through collection of peak flood stage and discharge data, flood profiles, and indirect measurements of peak flood discharges. Flood reports are produced at the request of New York State Department of Transportation (NYS DOT), FEMA, and other partners.

Crest-stage Gage Network: The NYWSC maintains a network of 40 crest-stage gages to improve flood frequency statistics at ungagged locations across the state. An online map of the network with links to available data can be found here: http://ny.water.usgs.gov/flood/floodinv.html.

Regional Skew: NYWSC is working with the PA, MI-OH Water Science Centers, as well as the USGS Office of Surface Water, to develop a regional skew model 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)

Climate Change: A web based climate-scenario tool, which piggy-backs on StreamStats capabilities and available downscaled-climate models, is now available online (http://ny.water.usgs.gov/maps/floodfreq-climate/). Future precipitation estimates are used with existing regional regression equations to estimate the magnitude of future floods for any stream or river in New York State (exclusive of Long Island) and the Lake Champlain Basin in Vermont.

Investigation of rural flow-frequency: In cooperation with NYS DOT, the NYWSC is updating annual exceedance probability flood magnitudes for 251 gages draining rural unregulated watersheds in NY. Results will be used to reevaluate existing regional regression equations and hydrologic regions for the state.

Flood-inundation Mapping: Flood inundation maps have been produced for the towns of Delhi, along the West Branch Delaware River, and Prattsville, along the Schoharie Creek. Maps are available through the USGS flood inundation mapper (http://water.usgs.gov/osw/flood_inundation/)

Landslide susceptibility: The NYWSC is 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.

Sediment Monitoring: The New York Water Science Center is monitoring suspended-sediment discharge in support of several studies across New York:

- Tributaries to Lake Ontario as part of the Great Lakes Restoration Initiative;
- Several sites in the Esopus Creek watershed in support of stream restoration work by the New York City Department of Environmental Protection;
- At three locations in the Mohawk River watershed to better define sources of sediment in the watershed (New York State Department of Environmental Conservation);
- In the Hudson Estuary to quantify the sediment flux from the freshwater tidal river (New York State Department of Environmental Conservation);
- At Rockaway Inlet on Long Island to determine the net flux of sediment into Jamaica Bay (New York State Department of Environmental Conservation).

Wetland Loss: In cooperation with the New York State Department of Environmental Conservation, the NYWSC is monitoring four tidal-wetland embayments along the north shore of Long Island to better understand the factors associated with the disappearance of these wetland areas.

Tide Gages: The USGS operates the most extensive satellite network of tide-gaging stations in the region, many of which form the backbone of flood-warning systems. The USGS provides real-time water-level/flow, water-quality, and meteorological data for these and other coastal sites in southeastern New York: http://ny.water.usgs.gov/projects/tidal/live_coast.html.

Water Quality: The NYWSC operates several continuous water-quality monitors across upstate New York and Long Island. These monitors are in place to support regulatory concerns, surrogate development, and studies focused on ecosystem health and general aqueous chemistry.

New York Streamflow Estimation Tool (NYSET): The NYWSC has created a tool to estimate daily mean streamflows for water years 1961-2010 for user-selected sites on ungaged streams. (Scientific Investigations Report at http://pubs.usgs.gov/sir/2014/5220/.) This tool has been incorporated into New York StreamStats (http://water.usgs.gov/osw/streamstats/new_york.html), which is used to delineate drainage areas and to provide the basin characteristics that are needed as input for the NYSET program.

BMP Evaluations: Agricultural BMPs to reduce sediment and nutrient loading are being evaluated at several locations in the Genesee Watershed as part of the Great-Lakes Restoration Initiative.

Recent Publications

Nystrom, E.A., 2016, Flood-inundation maps for the Schoharie Creek at Prattsville, New York, 2014: U.S. Geological Survey Scientific Investigations Report 2015–5190, 12 p., 17 sheets, http://dx.doi.org/10.3133/sir20155190.

Burns, D.A., Smith, M.J., and Freehafer, D.A., 2015, Development of flood regressions and climate change scenarios to explore estimates of future peak flows: U.S. Geological Survey Open-File Report 2015–1235, 11 p., http://dx.doi.org/10.3133/ofr20151235.

Burns, D.A., and Gazoorian, C.L., 2015, Estimates of natural streamflow at two streamgages on the Esopus Creek, New York, water years 1932–2012: U.S. Geological Survey Scientific Investigations Report 2015–5050, 20 p., http://dx.doi.org/10.3133/sir20155050.

McHale, M.R., and Siemion, Jason, 2014, Turbidity and suspended sediment in the upper Esopus Creek watershed, Ulster County, New York: U.S. Geological Survey Scientific Investigations Report 2014–5200, 42 p., http://dx.doi.org/10.3133/sir20145200.

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). Use of the NC StreamStats application outside of the USGS continues to result in positive feedback being received from external users.

In 2016, the USGS SAWSC Raleigh, North Carolina office continued analyses for 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 published an Open-File Report to document baseline bed-sediment chemistry and water-quality conditions and the associated circulation dynamics of Currituck Sound in northeastern North Carolina. These data were collected in the vicinity of the planned alignment of the proposed Mid-Currituck Bridge and 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). At the onset of this study, the start date for construction of the Mid-Currituck Bridge was planned for November 2012. The construction start date has been delayed multiple times, and the USGS ended the monthly data collection associated with the baseline characterization study in December 2013 (a final storm sample was collected in January 2015). As a result of this delay, the North Carolina Department of Environmental Quality (NC DEQ) has requested that the baseline study duration be extended to better account for any temporal variation and better represent conditions in the Sound closer to the onset of bridge construction. Therefore, Currituck Sound baseline water-quality sampling is being re-initiated at the end of 2016 for an additional 12 to 16 months.

Recent Publications

Wagner, Chad, Fitzgerald, Sharon, and Antolino, Dominick, 2016, Characterization of water-quality and bed-sediment conditions in Currituck Sound, North Carolina, prior to the Mid-Currituck Bridge construction, 2011–15 (ver. 1.1, July 2016): U.S. Geological Survey Open-File Report 2015–1208, 84 p., http://dx.doi.org/10.3133/ofr20151208.

North Dakota

Souris River Flood Risk Assessment: In response to the recent extreme flooding in the Souris Basin, the 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 describing the methods and results can be found at https://pubs.er.usgs.gov/publication/sir20155185 (contact: avecchia@usgs.gov).

Soil Water Balance Effects on Flood Reduction in the Red River of the North: The 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 infrastructure. USDA/NRCS will assess results of this project to possibly introduce programs to assist agricultural producers to 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/.

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.

Regional skew update: Ohio is working with the NY, MI, and PA Water Science Centers, as well as the USGS Office of Surface Water, to determine regional flood frequency curve skew for the 4-state area. Results of the regional skew effort will replace the current generalized skew map for OH.

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.

Flood inundation mapping and flood warning: A flood-inundation / flood-warning study is being done in Stark County, Ohio, on selected reaches of Nimishillen Creek. The study is being done in cooperation with the Muskingum Watershed Conservancy District and Stark County, Ohio.

Estimating streamflow non-exceedance probabilities: A study is nearly completed to test and develop techniques for estimating daily mean streamflow non-exceedance probabilities at ungaged locations throughout Ohio. The streamflow non-exceedance probabilities can act as precursors for estimating daily streamflow duration. The study is being done in cooperation with the Ohio Environmental Protection Agency.

Rainfall runoff and bridge/stream hydraulics: A HEC-HMS rainfall-runoff model is being developed for a portion of the Clear Fork Mohican River basin, near Bellville in Richland County, Ohio. In addition to the rainfall-runoff model, a HEC-RAS model is being developed to support a detailed flood-insurance study. This study is being done in cooperation with the Muskingum Watershed Conservancy District.

Stormwater best-management practices: Several studies have been conducted in Ohio to monitor and document the hydrology of stormwater best-management practices such as rain gardens, pervious pavers, etc. During FY2016, studies were being conducted in Cleveland and Columbus, Ohio. These studies were done in cooperation with the City of Columbus, Ohio, and the U.S. Environmental Protection agency.

Recent Publications

Huitger, C.A, Ostheimer, C.J., and Koltun, G.F., 2016, Hydrologic and hydraulic analyses for the Black Fork Mohican River Basin in and near Shelby, Ohio: U.S. Geological Survey Scientific Investigations Report 2015–5187, 39 p., 2 appendixes, http://dx.doi.org/10.3133/sir20155187

Darner, R.A., Shuster, W.D., and Dumouchelle, D.H., 2015, Hydrologic characteristics of low-impact stormwater control measures at two sites in northeastern Ohio, 2008–13: U.S. Geological Survey Scientific Investigations Report 2015–5030, 27 p., http://dx.doi.org/10.3133/sir20155030.

Whitehead, M.T., 2015, Flood-inundation maps for the Scioto River at La Rue, Ohio: U.S. Geological Survey Scientific Investigations Report 2015–5100, 11 p., http://dx.doi.org/10.3133/sir20155100.

Whitehead, M.T., and Ostheimer, C.J., 2014, Flood-inundation maps and updated components for a flood-warning system or the City of Marietta, Ohio and selected communities along the Lower Muskingum River and Ohio River: U.S. Geological Survey Scientific Investigations Report 2014–5195, 16 p., http://dx.doi.org/10.3133/sir20145195.

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 in 2015 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).

Building off the lessons learned in the earlier study by Risley and Granato (2014), the ODOT and the ORWSC were interested in learning how SELDM could be applied to larger watersheds, containing multiple highway storm-water points and multiple BMPs, for the purpose of developing guidance and protocols for mitigation strategies at the watershed scale. In FY 2016 the two agencies began a two-year $163,000 coop study with the following specific objectives:

- Develop and demonstrate techniques for geographic analysis that use the roadway and land use/land cover information in StreamStats to apply SELDM at selected points in the watershed. These techniques will include manual and batch-processing techniques to help model contributions of flows, concentrations and loads of storm water from highway sites and other upstream land uses. These techniques will be used to do mass-balance analyses in selected watersheds with SELDM based on the land use/cover percentages upstream of any selected highway site.
- Demonstrate methods for using SELDM with statistics on the quality and quality of runoff from highways and other land uses and BMP treatment statistics to model the cumulative effects of runoff from different areas at different points in a stream basin. ODOT can use these techniques to help identify mitigation measures that maximize benefits while minimizing effects of runoff on receiving streams within a watershed, and minimizing storm water BMP costs.
- Create guidance for watershed-scale analyses using SELDM that are based on results and experience from the previous objective and document this information in at least one report.

StreamStats: Currently the Oregon StreamStats viewer includes equations for estimating 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood frequencies in just western Oregon (Cooper, 2005); and low-flow frequency (7Q2, 7Q10) and flow duration (5th, 10th, 25th, 50th, and 95th) statistics (Risley and others, 2008) throughout the entire state.

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 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 2017 ORWSC hopes to start a bridge scour program with ODOT that will utilize newer data collection technologies.

Multi-Dimensional Hydraulic Modeling: ORWSC started a new multi-dimensional hydraulic modeling study in the Willamette River and the lower Columbia River tidal estuary. Although the study is not funded by ODOT, it includes 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.

In addition, a regional StreamStats application has been developed for the Delaware River Basin which can be used to determine extent of upstream water use in an ungaged watershed.

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, Milton, and Jersey Shore and for the Susquehanna River at Harrisburg on the USGS National Flood Inundation Mapping (FIM) Program and NWS Advanced Hydrologic Prediction Service web site (AHPS) (Lewisburg and Milton only available on FIM).

Flood flow statistics: Regression equations to estimate the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probabilities will be updated as part of a new study with the Federal Emergency Management Agency and Pennsylvania Department of Transportation. This work will include development of a regional skew for Pennsylvania and the investigation of possible effects of climate change on peak streamflows in Pennsylvania. The flood frequencies at over 400 streamgages across the Pennsylvania will be updated.

Stream Geomorphology: A refined set of regional curves are being developed to estimate bankfull channel geometry for the dynamic streams common to the glaciated portion of northern Pennsylvania. These revised regional curves are expected to be incorporated into StreamStats in 2017.

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

Low, D.J., Brightbill, R.A., Eggleston, H.L., and Chaplin, J.J., 2016, Physical, chemical, and biological characteristics of selected headwater streams along the Allegheny Front, Blair County, Pennsylvania, July 2011–September 2013: U.S. Geological Survey Open-File Report 2015–1173, 66 p., http://dx.doi.org/10.3133/ofr20151173.

Stuckey, M.H., 2016, Estimation of daily mean streamflow for ungaged stream locations in the Delaware River Basin, water years 1960–2010: U.S. Geological Survey Scientific Investigations Report 2015–5157, 42 p. http://dx.doi.org/10.3133/sir20155157.

Stuckey, M.H., and Ulrich, J.E., 2016, User's Guide for the Delaware River Basin Streamflow Estimator Tool (DRB-SET): U.S. Geological Survey Open-File Report 2015–1192, 6 p., http://dx.doi.org/10.3133/ofr20151192.

Suro, T.P., Roland, M.A., and Kiah, R.G., 2015, Flooding in the Northeastern United States, 2011: U.S. Geological Survey Professional Paper 1821, 32 p., http://dx.doi.org/10.3133/pp1821.

Puerto Rico

The Puerto Rico Authority of Highways and Transportation provides funding for streamflow and water-quality monitoring at selected sites (SW and QW network). Flood documentation, as part of the Dam Failure analyses project, was completed.

Flood inundation mapping: Flood inundation maps were 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.

Gómez-Fragoso, Julieta, and Torres-Sierra, Heriberto, 2016, Dam failure analysis for the Lago El Guineo Dam, Orocovis, Puerto Rico: U.S. Geological Survey Scientific Investigations Report 2016–5070, 49 p., 4 pls., http://dx.doi.org/10.3133/sir20165070.

Rhode Island

Highway Runoff TMDLs: The FHWA sponsored an analysis of runoff-quality yields and the potential effectiveness of mitigation measures for meeting TMDLs in Rhode Island and eastern Massachusetts. This effort resulted in the paper:

Granato, G.E., and Jones, S.C., 2017, Estimating long-term annual highway-runoff loads for total maximum daily load analyses with the Stochastic Empirical Loading And Dilution Model (SELDM): Proceedings of the 96th Annual Meeting of the Transportation Research Board, 16 p.

and a presentation of the same title in the AFB60 session 708, Solutions for Improved Water Quality on Tuesday January 10th from 3:45 to 5:30 PM.

Flood inundation map libraries for two USGS streamgage site (with collocated NWS flood forecast point) that can assist with highway, road, and bridge operations during floods was started in 2016. The flood-inundation studies are being done for the main stem of the Pawtuxet River in Cranston, Warwick, and West Warwick, Rhode Island and the Pawcatuck River in Westerly, RI and North Stonington and Stonington, CT. Both of these selected river reaches were extremely hard hit by the spring 2010 flood. The map library being done for the Pawtuxet River is being done in cooperation with the Rhode Island Emergency Management Agency, USACE, and FEMA. The map library being done for the Pawcatuck River is being done in cooperation with the Town of Westerly, Rhode Island. Both projects are scheduled to be completed in September 2017.

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 19 real-time continuous record streamflow stations, and 47 partial record crest-stage stations. (Number of gaging stations fluctuates slightly from year to year.)

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 bridge-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. Benedict and others (2016) synthesized the findings from the previous South Carolina bridge-scour investigations into a single guidance manual providing an integrated procedure for applying the South Carolina bridge-scour envelope curves. In addition, a companion spreadsheet was developed to facilitate application of this integrated procedure. Additional objectives of the investigation were to (1) evaluate the SC bridge-scour envelope curves by comparing them with bridge-scour data outside of South Carolina from previously published reports, (2) develop 500-year recurrence-interval flow bridge-scour envelope-curve coefficients for each scour component, and (3) merge the three previously published databases (Benedict, 2003; Benedict and Caldwell, 2006, 2009) into a format that later could be incorporated into an integrated Web-based GIS application such as StreamStats (Ries and others, 2008) to provide a used-friendly format for accessing the data.

Limited verification of selected envelope curves also was done by Benedict and others (2016) by comparing South Carolina data with previously published field data from sources outside of South Carolina, including the U.S. Geological Survey Nation Bridge Scour Database (U.S. Geological Survey, 2001), the U.S. Geological Survey 2014 Pier Scour Database (Benedict and Caldwell, 2014), and selected field measurements of scour from other States. In general, the comparisons showed similar trends in the South Carolina data and indicated that the South Carolina envelope curves were reasonable.

References:

Benedict, S.T., Feaster, T.D., and Caldwell, A.W., 2016, The South Carolina bridge-scour envelope curves: U.S Geological Survey Scientific Investigations Report 2016-5121, 96 p., http://dx.doi.org/10.3133/sir20165121.

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.

U.S. Geological Survey, 2001, National Bridge Scour Database, accessed October 15, 2008, at http://water.usgs.gov/osw/techniques/bs/BSDMS/index.htm.

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 2015, and two new bridges during calendar year 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.” SAWSC personnel assisted with data collection at two sites in South Carolina; the Black River at Kingstree, SC and Smith Branch at Columbia, SC.

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 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. This version

for South Carolina currently provides delineation only and is based on 30-meter DEM data developed from topographic maps.

Collection of high-water mark data at selected roadway crossings to document October 2016 flooding: Heavy rainfall from Hurricane Matthew occurred over the South Carolina Coastal Plain during October 7-9, 2016. The storm caused major flooding along several rivers, including the Lumber, Waccamaw, Little Pee Dee, Great Pee Dee and Black Rivers, and to areas along the South Carolina coast.

In response to the flooding, the U.S. Geological Survey (USGS) made about 74 streamflow measurements at 42 locations throughout the affected area). The USGS, in cooperation with the Federal Emergency Management Agency, also flagged and surveyed 376 high-water marks (HWMs) to document the extent of the flooding in selected urban and suburban areas. The S.C. Department of Transportation (SCDOT) needs additional flood documentation at selected bridge and culvert crossings in the Pee Dee region of the State. Therefore, the USGS is working in cooperation with the SCDOT to collect HWM data at 31 selected bridge or culvert crossings.

Real-time Scour Monitoring: The USGS SAWSC, in cooperation with the SCDOT, is installing/operating a network of 12 real-time scour monitoring stations located primarily in the South Carolina Coastal Plain. The stations will assist SCDOT with decisions regarding bridge closures, maintenance schedules, selecting weight limits, instating countermeasures, and bridge replacement. The stations will measure water-surface elevation, bed elevation (at multiple locations per bridge), and provide real-time video imagery from the sites.

Flood warning system: The USGS SAWSC, in cooperation with the SCDOT, operates a flood warning system on Rocky Creek at I-85 in Greenville County, SC. The system includes 2 real-time precipitation stations, and 1 station that continuously monitors water-surface elevation and provides real-time video imagery of the site via a user-controlled web camera.

SCDOT Culvert Assessment: Changes in streamflow, stream velocity, channel morphology, vegetation, and channel substrate have been demonstrated to occur by human-engineered modifications of stream channels. The South Carolina Department of Health and Environmental Control (SCDHEC) requires the South Carolina Department of Transportation (SCDOT) to evaluate the potential effects of culverts installation on streams based on the U.S. Army Corps of Engineers (USACE) guidelines for compensatory mitigation (U.S. Army Corps of Engineers, 2010). A study that assesses the changes in stream habitat, and aquatic biota community structure related to a range of culvert types would provide needed information to the SCDOT for its selection of the appropriate restoration and mitigation strategies at culvert locations. In April 2016, the U.S. Geological Survey (USGS), in cooperation with SCDOT, began a 4.5-year investigation to assess the effect of culverts on the ecological conditions of streams in South Carolina. This investigation is anticipated to end in December 2020. The results of this investigation will serve as a valuable tool to the SCDOT to better understand and evaluate such effects and enhance the efficacy of any stream restoration efforts needed due to culvert or pipe installations.

South Dakota

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

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 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 worked with a large block of contiguous states in the Great Plains and Upper Midwest to pursue a regional-scale effort for development of new skew coefficients that can be incorporated in the at-site frequency analyses. All of the participating states have now provided all of the necessary data sets, which consist of basin characteristics and preliminary flood-frequency analyses, all derived using consistent procedures. The regional-scale analytical efforts are underway and are being performed by USGS at the national level. Once completed, the new skew coefficients will be incorporated in the at-site flood-frequency analyses and statewide regional regression equations for South Dakota.

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 existence 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 several previous studies. The goal of this project will be to build upon those previous studies and improve quantitative capabilities through use of rainfall-runoff modeling.

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 is assisting by providing peak-flow information for use in hydraulic modeling and mapping of flood-prone areas that will 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 2016:

- 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 has continued through FY2016.
- 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: (FY2006–2016 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 FY2020. 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 mixture of telemetry and autonomous stage and rainfall for creation of rainfall and runoff data sets to drive the TxDOT research program in future decades. One site is operated as a continuous full-range streamgage. Over 830 measurements of peak discharge inclusive of 470 annual peaks have been made through about February 2016 with water year 2016 computations pending. Texas Water Science Center anticipates publishing a USGS Scientific Investigations Report as a mid-term product in early calendar year 2017.

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].

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.

Digital flood inundation libraries for a 100 mile length of Lake Champlain in northwestern Vermont and northeastern New York can assist with highway, road, and bridge operations during floods have been published. The flood-inundation maps are tied to the USGS lake gage at Rouses Point, New York (with collocated NWS flood forecast point). The map library was completed in cooperation with the International Joint Commission.

Flynn, R.H., and Hayes, Laura, 2016, Flood-inundation maps for Lake Champlain in Vermont and in northern Clinton County, New York: U.S. Geological Survey Scientific Investigations Report 2016–5060, 11 p., http://dx.doi.org/10.3133/sir20165060.

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

Vermont Flood Frequency Equations: A study to update equations for estimating the magnitude of 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent annual exceedance probability (AEP) floods was completed in 2014. This study was done in cooperation with FEMA. The updated equations were added to the USGS StreamStats application.

Olson, S.A., 2014, Estimation of flood discharges at selected annual exceedance probabilities for unregulated, rural streams in Vermont, with a section on Vermont regional skew regression, by Veilleux, A.G.: U.S. Geological Survey Scientific Investigations Report 2014–5078, 27 p. plus appendixes, http://dx.doi.org/10.3133/sir20145078.

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: https://sims.iseesystems.com/samuel-austin/sediment-

motion-in-streams-and-rivers/#page1, 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) and a Runoff from Roads and Highways Subgroup. The SWG 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, conducted water-quality and stream-ecology monitoring through December 2015, and is actively participating in the data analysis team in 2016-2017. For the RSMP Nearshore program, the USGS prepared the QAPP, assisted with marine sediment chemistry sampling during 2016, and will be actively participating in the data analysis team in 2017.

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 contributed to the RSMP to monitor additional parameters related to commonly-used roadside pesticides, and to monitor additional sites during 2015 and 2016.

USGS staff are also contributing to the planning and implementation of additional regional-scale stormwater monitoring efforts for permittees in southwest Washington, and in eastern Washington.

Flood Frequency: In cooperation with the Washington State Departments of Transportation and Ecology, a new publication, "Magnitude, Frequency, and Trends of Floods at Gaged and Ungaged Sites in Washington, based on Data through Water Year 2014" was published by the WAWSC. The report gave the results for the computed annual exceedance probability (AEP) statistics for 648 unregulated streamgages in and near the Washington borders. Regional regression equations were developed to

estimate flood frequencies and magnitudes in ungaged watersheds in Washington State. The report also details the development of a regional skew for a region that included Washington, Oregon, Idaho and western Montana that was used in the computation of the AEP statistics. The report contained a section on 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 nearly completed 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, with first-round data collection completed during 2016 and additional data collection planned for 2017.

Recent Publications

Mastin, M.C., Konrad, C.P., Veilleux, A.G., and Tecca, A.E., 2016, Magnitude, frequency, and trends of floods at gaged and ungaged sites in Washington, based on data through water year 2014 (ver 1.1, October 2016): U.S. Geological Survey Scientific Investigations Report 2016–5118, 70 p., http://dx.doi.org/10.3133/sir20165118.

West Virginia

The USGS Virginia-West Virginia Water Science Center (VA-WV WSC) and West Virginia Department of Transportation (WVDOT) will begin a project later in 2017 to verify time of concentration estimates for small streams in the Appalachian Plateaus. A network of four paired stream- and rain gages will be established on streams draining less than 200 acres. The network is to be operated for two years, and a report is planned for WY 2020.

A network of 8 crest stage gages will continue to be operated in cooperation with WVDOT as the monitoring phase of the ongoing flood frequency program.

WVDOT provides funding toward operating and maintaining a shared network of continuous streamgages as a partner with other state agencies and USGS.

Development of StreamStats in West Virginia began in 2014 and is ongoing.

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.

Flood Frequency Analysis in Wisconsin: The report documenting flood characteristics using data through the 2010 water year and presenting updated regression equations for ungauged rural sites was approved on September 29, 2016. The final report is expected to be published by the end of November. Work is underway to include the updated regressions and at-site flood-frequency values into the StreamStats application, which should go live with full capabilities by the end of the 2016 calendar year.

Flood Documentation, Bad River, July 2016: Period of record flooding occurred in the Bad River watershed during a storm that dumped 8-10 inches of rain in an 8-hr period, resulting in the peak of record for the site, which has continuous recording beginning in 1915. Subsequent field campaigns have flagged high-water marks, an indirect measurement was made, and a draft report documenting the

flood, including inundation maps, was produced. The report is in review, and is expected to be completed before the end of the 2016 calendar year.

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. The final report describing the project and findings is expected in 2017.

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-quantity and -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 response of each surface to various maintenance techniques.
- 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 for Windows (WinSLAMM) with results from the study.

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 response 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.

The WY-MT Water Science Center, Wyoming Department of Transportation, and other state and federal agencies are discussing updating streamflow statistics and developing StreamStats for WY. A proposal for investigating non-stationarity in peak flows in Wyoming, Montana, North Dakota, and South Dakota also is being developed.