The NHWC Transmission

January 2016

CONTENTS

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Strategic placement of green-infrastructure for urban flood control and combined sewage overflow

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In the USA, approximately 772 cities are served by combined sewer systems (CSS). CSS are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. During heavy rainfall or snowmelt, the system capacity can be exceeded, resulting in a combined sewer overflow (CSO) in which excess wastewater is discharged to nearby streams. CSOs create a major pollution concern. CSS are also characterized by frequent basement back-ups and street flooding causing serious public health issues. The federal Clean Water Act requires municipalities served by CSS to ensure attainment of applicable water quality standards and protection of designated water uses. However, many cities do not have the budget to fully replace or retrofit existing infrastructure. In those cases a mix of traditional gray engineering and strategically planned green infrastructure is required.

That is the case in Camden, NJ, a city with major flooding and CSO issues exacerbated by a quarter century of urban decay. The Camden Collaborative Initiative (CCI) is a solutions-oriented partnership formed to plan and implement innovative strategies to improve the environment and the quality of life of Camden's residents. CCI's goals include re-development of brownfields and vacant properties, and flood and CSO control. The Nature Conservancy (TNC) helped to develop an environmental solution that allows the combined lessening of both issues.

Urban green infrastructure (GI), such as bioswales and rain gardens, has the potential to mitigate floods and CSOs while providing multiple environmental, economic, and social benefits. GI is an ideal solution for some of the neighborhoods in Camden that experience serious stormwater issues yet contain a large number of publically owned vacant and slightly contaminated properties (brownfields) that can potentially be converted into GI. Many of these properties have no current plan or much pressure for redevelopment, so installing GI projects would not compete with other uses and would provide valuable green space that has environmental, economic, and social benefits for the nearby area.

GI projects are usually implemented in an opportunistic rather than strategic way. However, in a scenario where the opportunities are many, and economic resources are limited, the benefits of GI have to be maximized by strategically placing projects on the ground. TNC applied modeling tools to demonstrate the benefits of strategically placing multiple small-scale GI projects for 1) flood reduction and 2) CSO control. The final product of this study is a GI site priority list based on maximizing the return on investment (benefits/cost) for flood and CSO control.

Here we present the results of a pilot study developed for the Pyne Poynt neighborhood in Camden. TNC analyzed a total of 108 city-owned small-scale lots that could potentially be converted into bioswales and applied the EPA-SWMM model to quantify the benefits of GI for flood and CSO control. The project required tools developed in Python to automate the simulation of multiple scenarios, including different: 1) rainfall events (3-months to 5 years flood return period and long term simulations); 2) tidal effects (low and high tide, with and without sea level rise), and 3) green-infrastructure implementation (1 project site up to multiple GI sites). To be able to prioritize under different scenarios, TNC ran more than 2,000 simulations and selected high-performing sites from all of those scenarios. TNC quantified the benefits-to-cost ratio for flood and CSO reduction for each site and defined a list of project priorities based on maximizing return on investment (benefits/cost) (Figure 1).

Figure 1 (a) examples of vacant properties in Camden, NJ (b) Priority green infrastructure sites for stormwater control (based on maximizing the return on investment, i.e., selecting the places with the highest benefit/cost ratios among all scenarios run).

The study demonstrates the cumulative benefits of implementing green infrastructure in multiple small scale sites and proves that the sites identified as very high priority result in the maximum overall cumulative benefit when compared to randomly selected sites. Figure 2 shows plots of cumulative benefits for flood reduction and CSO control for strategically versus randomly (opportunistic) selected sites. The benefits for strategically selected sites are shown in blue (based on benefits) and red (based on the benefits/cost ratio). Best GI project opportunities were selected by evaluating the combined benefits for flood and CSO volume reduction.

In the implementation of urban GI for stormwater management, hydrologic and hydraulic models applied using a scenario based approach are essential tools to guarantee the best bang for the buck and maximum benefits to communities and river systems (water quality).

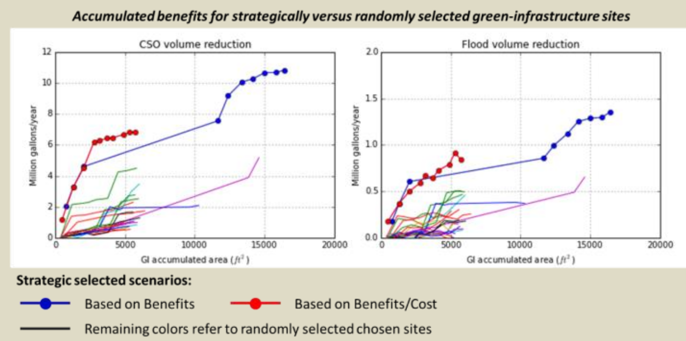

Figure 2: Accumulated benefits for strategically versus randomly chosen green-infrastructure sites. The benefits for sites selected based on maximizing benefits are shown in blue, and for sites selected based on maximizing benefits/cost are shown in red; all other colors represent scenarios with randomly selected sites. We selected the sites by evaluating the combined benefits for flood and CSO volume reduction. Note: in some instances, it is possible for the flood benefits (millions of gallons reduced per year) to actually decrease with the addition of acres of green infrastructure; these instances are because of nonlinearities in flood behavior, such as if water is held and released with sub-optimal timing, decreasing the amount of water that can be removed from the system.

Applications of Shuttle Radar DEM Data and Landsat-8 Satellite Imagery for HEC-RAS Floodplain Modeling

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Floods and hurricanes are the most frequent and widespread of all natural disasters, causing extensive damage to transportation infrastructure. During 2005-2014 floods contributed to $48 billion in damage, 3,816 deaths and $545 billion of economic loss in the United States (http://www.ncdc.noaa.gov/billions/events).

The primary objective of this paper is to present key results of the one-dimensional (1-D) HEC-RAS floodplain model using the Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) data[1] for 30 meter cell size and Landsat-8 imagery. The paper also compares the output results of the 1-D HEC-RAS flood models[2] with simulation output results of the two-dimensional (2-D) CCHE2D-FLOOD model[3, 4] using the same inflow hydrograph associated with a full spillway discharge from Sardis Dam on the Tallahatchie River developed in the 2-D flood simulation study[4, 5]. The results of such extreme flood simulations can be analyzed to calculate lateral hydrodynamic force and its impacts on the structural integrity of critical infrastructure.

Transportation infrastructure planimetric feature sets (Figure 1) for the Sardis site in Panola County, Mississippi were created from the Landsat-8 pansharpened multispectral imagery using ArcGIS/GeoMedia Pro geospatial software. The 1-D HEC-RAS software, developed by the U.S. Army Corps of Engineers, allows users to simulate one-dimensional steady flow and unsteady flow modeling [2]. The HEC-GeoRAS software was used for importing the SRTM 30 m cell DEM terrain data into the HEC-RAS flood model. Input data for HEC-GeoRAS included SRTM 30 meter DEM data with 30 meter cell size, river centerline, and 24 cross sections.

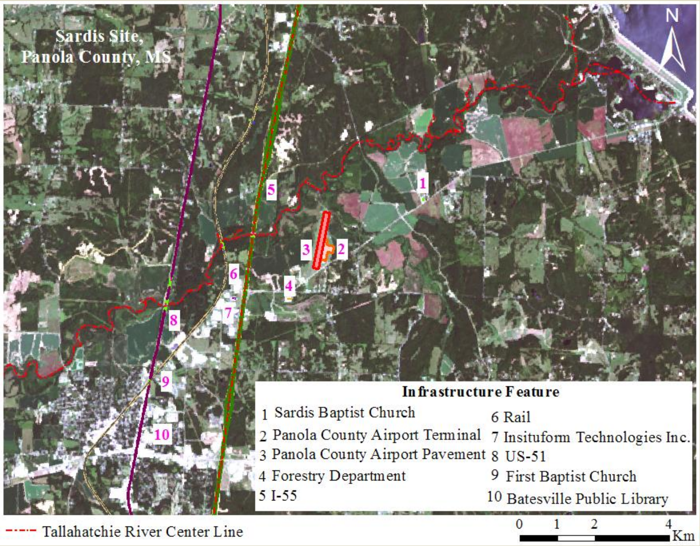

Figure 1. Landsat-8 pansharpened multispectral imagery at Sardis site with planimetric of infrastructure features and Sardis Lake Dam shown in the upper right

The SRTM 30 m DEM and HEC-RAS flood model was implemented at the Sardis site downstream of Sardis Lake on the Tallahatchie River using the same final hydrograph that was also used previously for the 2-D CCHE2D-FLOOD model (Figure 2). The key results of the HEC-RAS floodplain model using SRTM 30 m DEM (Figure 3) indicate that the 50.7 km^2 (19.6 sq. mi) area is inundated and that critical transportation infrastructure features (I-55, US-51, Rail, and Panola county airport) are located inside the inundation area.

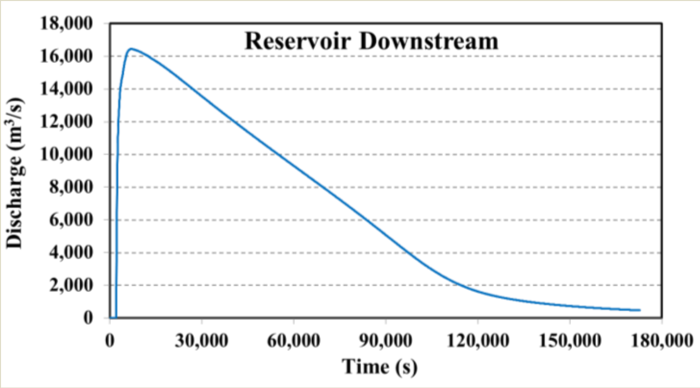

Figure 2. Full Spillway Flood hydrograph downstream of Sardis Dam

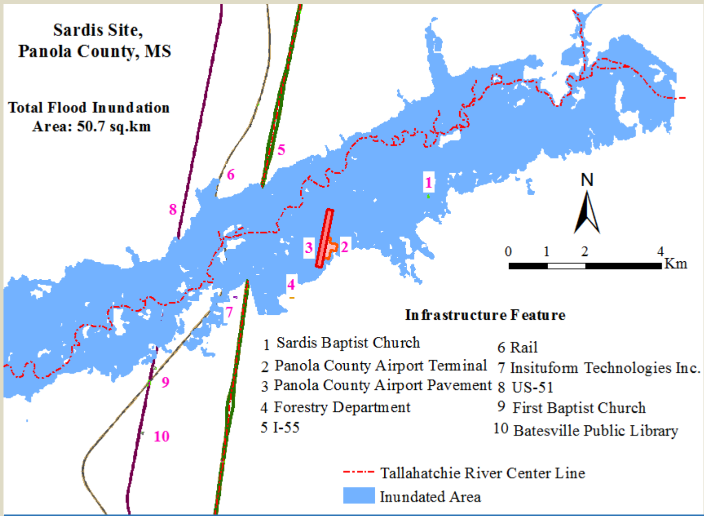

Figure 3. Flood inundation at Sardis Site along the Tallahatchie River with infrastructure features

Column F in Table 1 (next page) shows the output results of the HEC-RAS flood model using SRTM 30 m DEM. The maximum floodwater inundation depth reaches 10.4 m (34.1 ft) at I-55 (X14), 9.8 m (32.2 ft) at Rail (X15), and 9.6 m (31.5 ft) at US-51 (X18). Column H in Table 1 shows a comparison between the flood simulation results of the SRTM 30m DEM based HEC flood model and the results of the 2-D CCHE2D-FLOOD (10 m DEM CCHE2D) model. The 10 m DEM CCHE2D floodplain model used a 10 meter computational cell size in the study of the National Center for Intermodal Transportation for Economic Competitiveness (NCITEC) project 2012-25. Details of the 10 meter DEM based CCHE2D-FLOOD model are presented by Durmus et al.[3, 5] and in the final project report[4]. This model used elevations sampled at a spacing of 10 meters with 1.55 meter absolute accuracy of elevation and 0.81 meter relative accuracy of elevation. Maximum flow discharge input (Max Q Input) is

Table 1. Comparison between the results of 1-D HEC-RAS flood models and the simulation results of 10 m DEM CCHE2D-FLOOD model

A	B	C	D	E	F	G =100*(E-D)/D)	H =100*(F-D)/D)
HEC-RAS Layer name	Unit	Cross Section	10 m DEM CCHE2D	10 m DEM 1-D HEC	SRTM 30 m DEM 1-D HEC	% Difference between D & E	% Difference between D & F
Maximum	m	X14 (I-55)	7.9	7.7	**10.4**	-2.5	31.6
Channel	m	X15 (Rail)	8.0	7.9	**9.8**	-1.3	22.5
Depth	m	X18 (US-51)	7.5	7.7	**9.6**	2.7	28.0
Inundated Area	km^2		58.2	57.8	**50.7**	-0.7	-12.9
Max Q Input	m^3/s	X0	16,450	16,450	**16,450**		

the same in both 1-D and 2-D floodplain models.

Column G in Table 1 shows a comparison between output results of the 10 meter DEM HEC flood model and output results of the 10 meter DEM CCHE2D model. The 10 meter DEM HEC flood model is the 1-D HEC-RAS model using the same input data of the 10 meter DEM that was used for the CCHE2D model.

Table 1 shows that both the 1-D HEC-RAS model and the 2-D CCHE2D-FLOOD model using the same 10 m DEM data yield almost the same maximum channel depths (within 3% difference) and inundated area (less than 3% difference) when the same DEM, hydrograph and other input data are used. The percentage difference of maximum channel depth between the SRTM 30 meter DEM HEC-RAS flood model and the 10 meter DEM CCHE2D model is greater because the SRTM 30 meter DEM HEC flood model used DEM data of 30 meter SRTM (elevations sampled at a spacing of 30 meters, 9.0 m absolute accuracy of elevation, 7.0 m relative accuracy of elevation).

The results of the SRTM 30 meter DEM HEC flood model indicate that approximately 50.7 km^2 (19.6 sq. mi) is inundated by floodwater. The Inundation area matches reasonably well with the maximum difference of 12.9% between the 2-D model using10 meter cell and 1-D model using 30 meter computational cells (Table 1). Floodwater inundation depth at several important transportation features range between 9.6 meters (31.5 feet) and 10.4 meters (34.1 feet), which indicates that floodwater will wash over these features if this scenario of extreme flood actually happens in the real world. All three simulations also provide floodwater velocity at each output cross section, which can be analyzed to calculate lateral hydrodynamic force and its impacts on the structural integrity of the deck-girder-bearing superstructure on the top of pile caps.

These computational results demonstrate that the 1-D HEC-RAS flood modeling approach can be used with publicly free 30 meter cell DEM data and Landsat-8 satellite imagery for flood risk assessment of vulnerable population in affected cities and transportation infrastructure assets.

Acknowledgment:

The authors thank ERDC Hydraulic Engineer Vince Moody in the Hydrologic Engineering Center of the U.S. Army Corps of Engineers for support in using 1-D HEC-RAS.

References:

[1]U.S. Geological Survey. Shuttle Radar Topography Mission. http://srtm.usgs.gov/. Assessed October 1, 2014.

[2]HEC-RAS. http://www.hec.usace.army.mil/software/hec-ras/. Assessed May 1, 2014.

[3]Durmus, A., Q. Nguyen, M.Z. McGrath, M.S. Altinakar, and W. Uddin. Numerical Modeling and Simulation of Extreme Flood Inundation to Assess Vulnerability of Transportation Infrastructure Assets. 94th Annual Meeting of TRB, The National Academies, Washington DC, Online Proceedings, January 10-14, 2015.

[4]Uddin, W. and M.S. Altinakar. Final Report: Project 2012-25 Disaster Protection of Transport Infrastructure and Mobility Using Flood Risk Modeling and Geospatial Visualization. University of Mississippi Report UM-CAIT/2015-01, National Center for Intermodal Transportation for Economic Competitiveness (NCITEC), May 2015.

[5]Durmus, A. and W. Uddin. Extreme Flood Simulation and Inundation Impacts on Structural Integrity of Bridges. The NHWC Transmission, September 2015.

Flood Forecasting Using the Hydrologic Engineering Center's Real-Time System (HEC-RTS)

Jeff Harris, P.H., WEST Consultants

HEC-RTS is a complete river forecasting software suite available to support local flood warning operations. It is a product of the US Army Corps of Engineers' (USACE) Hydrologic Engineering Center (HEC). HEC-RTS is the public version of USACE's Corps Water Management System (CWMS).

HEC-RTS incorporates HEC-HMS (Hydrologic Modeling System), HEC-RAS (River Analysis System), HEC-ResSIM (Reservoir Simulation), HEC-FIA (Flood Impact Assessment) and HEC-DSS (Data Storage System). It provides an interface for the automatic interaction of these software packages and can manage forecasting for multiple river basins. A typical application of HEC-RTS will generally include at least HEC-HMS and HEC-RAS. In a forecast operation, the runoff hydrograph resulting from forecasted precipitation as provided from National Weather Service (NWS), or others is computed by HEC-HMS and subsequently used as input to a HEC-RAS model. HEC-RAS will then compute water surface profiles, and associated flooding. If an HEC-RTS application includes HEC-FIA, potential damages can be computed based on HEC-RAS forecasted flooding. HEC-FIA is a useful tool for planning and prioritizing ahead of a flood and can provide quick estimates of potential damage to support emergency declarations.

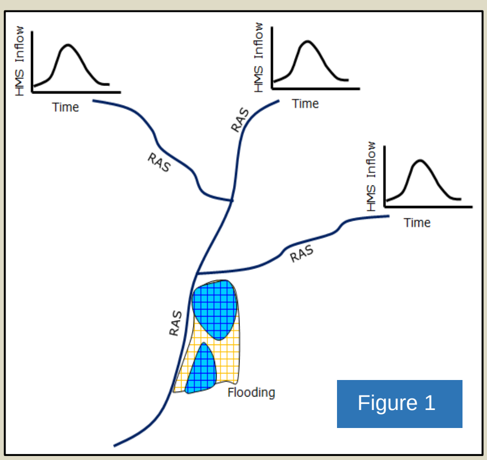

Figure 1 provides a simple HEC-RTS example in which a reservoir is located at the upstream end of one of the rivers. The HEC-HMS inflow is loaded to the Reservoir and the reservoir outflow hydrograph is the input to the HEC-RAS model.

The general method for developing the HEC-RTS application is to build the models separately and then import them into HEC-RTS. For example, the HEC-HMS model is developed and calibrated to historical flow events for the area of interest. Once the model is complete, it may be imported along with other finished models, including HEC-RAS, HEC-ResSim and HEC-FIA.

HEC-RTS includes four separate modules that provide access to watershed data. Each module has a unique set of commands accessible through menus, toolbars, and schematic elements within watersheds. The main difference between HEC-RTS and CWMS is that CWMS connects to a proprietary Oracle database. This connection does not exist in HEC-RTS. However, HEC-RTS can be connected to a local database to access real-time data to generate forecasts.

Within HEC-RTS, the user can separately generate, track and store multiple forecast scenarios. HEC-RTS contains an interface which allows the user to calibrate a model to current conditions at the start of the forecast. Alternately, the native interface of the desired model can be accessed through HEC-RTS to edit input parameters. Once the calibration is complete, the lookback period (Warm-Up) and the time of forecast are set. HEC-RTS then applies the forecasted precipitation to the HMS model and computes the forecast. HEC-HMS outflows are sequentially applied automatically to the HEC-RAS model for hydraulic computations and automated inundation forecasts.

HEC-RTS can be configured to generate automated warnings based on user-defined flood elevation thresholds. All critical locations and elevations in a system can be input in HEC-RTS. HEC-RTS will provide a report showing if, and when, these elevations will be reached, or exceeded, and by how much. Ultimately, it may be desired to visualize potential flooding based on a forecast. This could be flooding based on an actual rainfall forecast or based on a what-if rainfall frequency based event, such as a 1% (100-year) rainfall.

The City of Salem, Oregon and San Diego County, California are in the process of integrating HEC-HMS and HEC-RAS using HEC-RTS to improve their flood forecasting capabilities. HEC-RTS is publicly available free of charge, however, it must be requested from the HEC at:

Phone: (530) 756-1104
Email: Webmaster-HEC@usace.army.mil

Membership Renewal

It's time to renew your Annual NHWC Membership. New members are welcome. Click **here** to join/renew your membership.

Call for Abstracts

The ALERT Users Group is calling for Abstracts for presentations and workshops at the 2016 Flood Warning Systems Training Symposium. This year's theme:

Strengthening Your Flood Warning System.

Visit

http://www.alertsystems.org/

for information on symposium topics and instructions for submitting abstracts. We hope to see you at Tenaya Lodge at Yosemite, 19-22 April 2016.

2016 Critical Infrastructure Symposium

The 2016 Critical Infrastructure Symposium is sponsored by the Society of American Military Engineers (SAME) on April 3rd-5th, 2016 at the Charleston Marriott in Charleston, South Carolina.

www.same.org/tisp

Contact: Jacqueline Barrett
TISP Program Coordinator
Society of American Military Engineers

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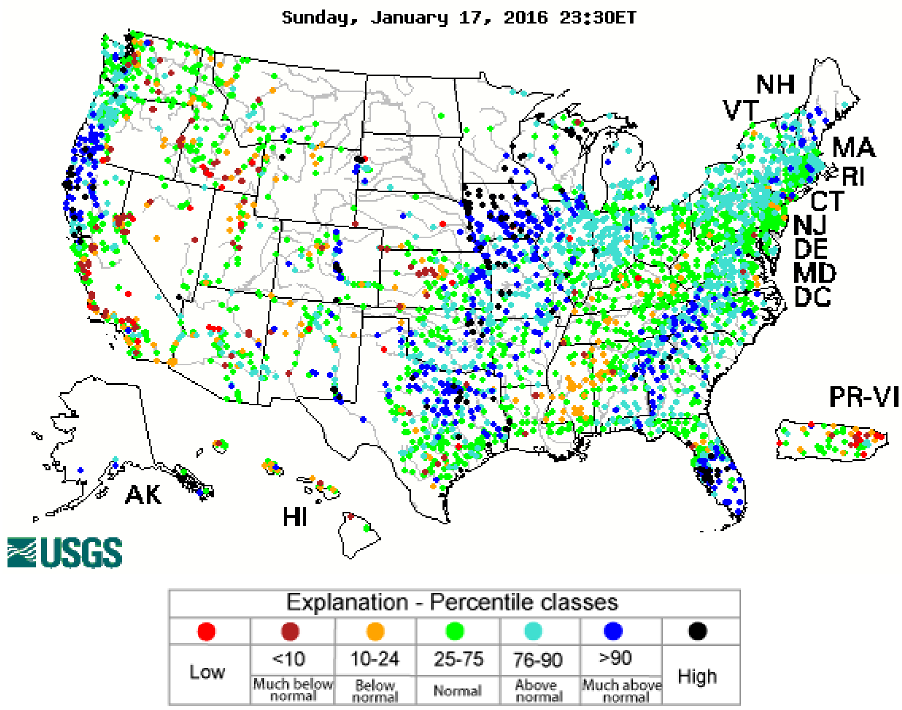
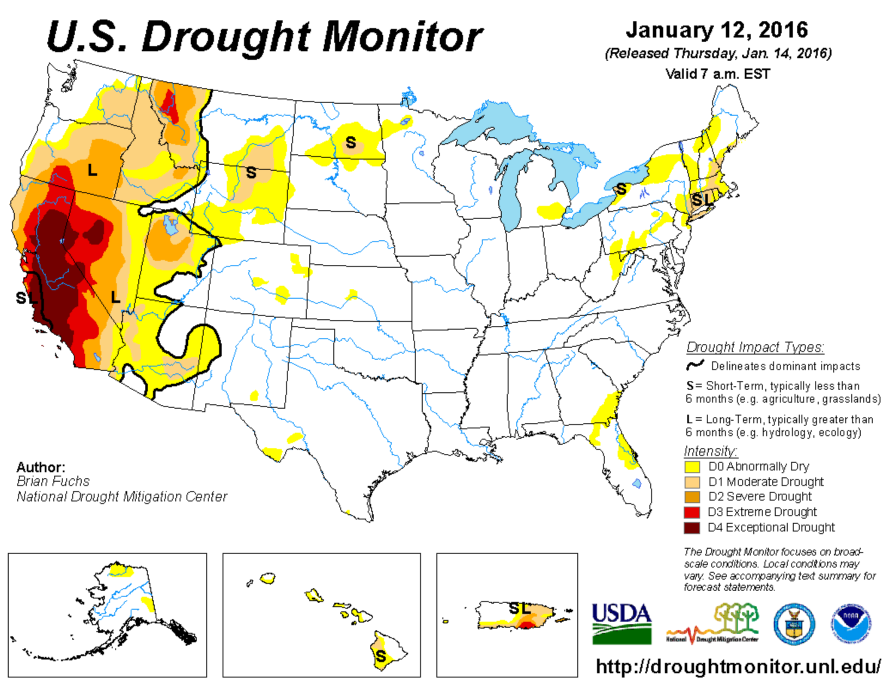
Hydrologic Conditions in the United States
Through January 17, 2016



Latest stream flow conditions in the United States. (courtesy USGS)



Latest drought conditions in the United States.
(courtesy National Drought Mitigation Center)

February Newsletter Articles Focus:

Data Collection

The NHWC is requesting articles that focus on practices, technologies and tools used to gather and disseminate real-time hydro-meteorological data.

Please consider writing an article that highlights how your organization collects and disseminates real-time data.

Submit your article to:

editor@hydrologicwarning.org

February 10th is the deadline for inclusion in the February issue.

Future Newsletter Articles Focus

To give you more time to prepare articles, below is the article focus schedule for the next four months:

Feb - Data Collection
Mar - Hydrology
Apr - Hazard Communication & Public Awareness
May - Modeling/Analysis

NHWC Calendar

September 20-21, 2016 - NHWC Regional Workshop, Albany, New York

General Interest Calendar

March 9-11, 2016 - 2016 West Regional Conference, Association of Dam Safety Officials, Sacramento, California

April 3-5, 2016 - 2016 Critical Infrastructure Symposium, Charleston, South Carolina

April 18-22, 2016 - ALERT Users Group Training Symposium and Preparedness Workshop, Tenaya Lodge at Yosemite National Park, California

June 19-24, 2016 - ASFPM 2016 40th Annual National Conference, Grand Rapids, Michigan.

September 28-October 1, 2016 - ASCE National Conference, Portland, Oregon

(see the event calendar on the NHWC website for more information)

Parting Shot

New Urban Drainage and Flood Control District ALERT2 Station on Coal Creek at McCaslin Boulevard

This ALERT Station was installed December, 2015 for the Urban Drainage and Flood Control District, Colorado

Data produced by this station may be observed at the following locations:

http://alert5.udfcd.org/maps/
http://udfcd.onerain.com.

Photo Courtesy Scott Bores
OneRain, Incorporated

National Hydrologic Warning Council

Providing Timely, Quality Hydrologic Information to Protect Lives, Property, and the Environment

http://www.hydrologicwarning.org