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Upper Susquehanna River CWMS Implementation

Michael Bartles, USACE Hydrologic Engineering Center

Several significant flooding events within the past 75 years impacted millions of residents living and working within the Susquehanna River watershed. Due to the watershed's large size, location relative to nearby moisture sources, and predominant weather patterns, flooding can occur year round. Stalled frontal systems, summer-time thunderstorms, tropical and extra-tropical storm systems, and rainfall-augmented snowmelt produced disastrous flooding events in March 1936, June 1972, January 1996, September 2004, June 2006, and September 2011. Long term droughts also impact extremely productive industrial, commercial, municipal, and recreational operations throughout the watershed.

The 27,500 square mile Susquehanna River watershed is the second largest watershed east of the Mississippi River. Originating in New York State and flowing through Pennsylvania and Maryland, the Susquehanna River flows in a southerly direction for approximately 630 miles before emptying into the Chesapeake Bay. Major tributaries to the Susquehanna River include the Chemung River, West Branch Susquehanna River, and the Juniata River. The Upper Susquehanna watershed (as defined by CENAB) encompasses the Susquehanna River watershed above the Chemung River confluence near Waverly, New York. (Figure 1).

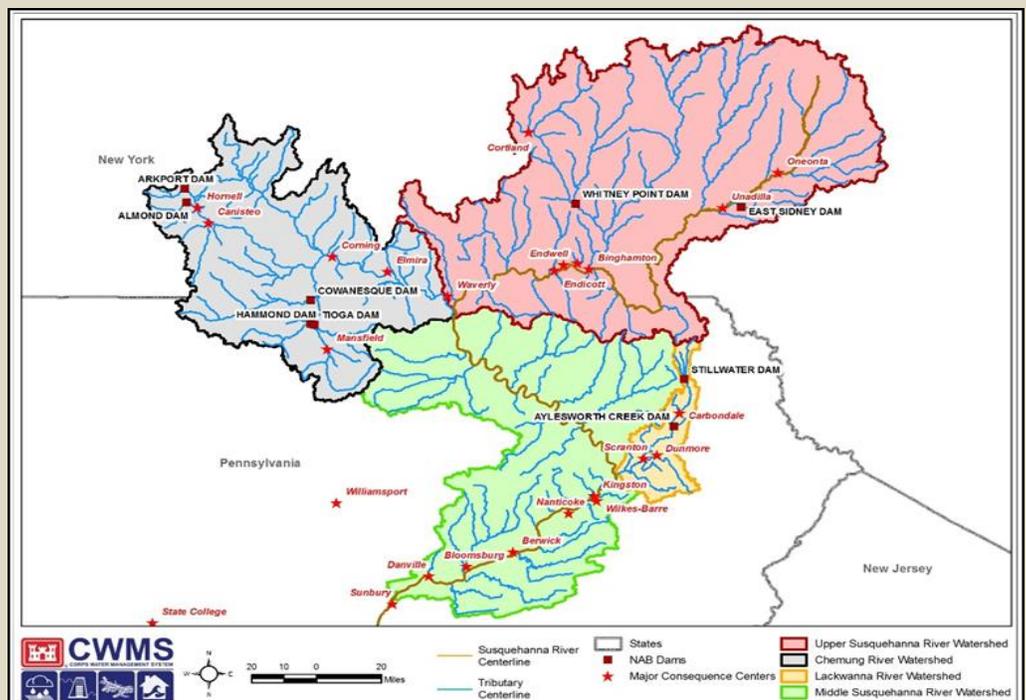


Figure 1 - Susquehanna River Watershed Upstream of Sunbury, PA

The U.S. Army Corps of Engineers (USACE), Baltimore District (CENAB) operates numerous multi-purpose dams, reservoirs, levee systems, and other projects throughout the Susquehanna River watershed to achieve flood control, recreation, water supply, and environmental benefits.

The Hydrologic Engineering Center (CEIWR-HEC) is actively engaged in the development and distribution of the Corps Water Management System (CWMS) software throughout the entire USACE field of operations. CEIWR-HEC personnel assist USACE Districts and Divisions to create individual hydrologic (HEC-HMS, Hydrologic Modeling System), reservoir operation (HEC-ResSim, Reservoir System Simulation), hydraulic (HEC-RAS, River Analysis System), and consequence models (HEC-FIA, Flood Impact Analysis) that form the "backbone" of the CWMS software.

Starting in March 2015, an HEC-HMS model was constructed to simulate the rainfall to runoff and hydrologic streamflow routing processes within the Upper Susquehanna River, Chemung River, and Lackawanna River watersheds along with all other areas contributing to the Susquehanna River above the West Branch Susquehanna River confluence near Sunbury, Pennsylvania. The HEC-HMS model included limited reservoir operations at all nine USACE-built dams and reservoirs located within the Susquehanna River watershed above Sunbury, Pennsylvania.

Additional reservoir operations were simulated at several non-federal dams and reservoirs in and around major consequence centers. The HEC-HMS model was built with real-time forecasting and reservoir operation decision making in mind. The model was also built for use in dam and levee safety studies that are ongoing in addition to basin-wide flood risk management planning studies. A total of 331 subbasin and 207 routing reach elements were used to estimate flow and reservoir stage hydrographs within the 11,300 square mile modeling domain.

An HEC-ResSim model was constructed for the four USACE-built dams and reservoirs located within the Upper Susquehanna River and Lackawanna River watersheds. Complex system-wide operations were built into the HEC-ResSim model to achieve the maximum possible benefits for population centers such as Binghamton, NY,

Endicott, NY, and Johnson City, NY as well as the Scranton/Wilkes Barre, Pennsylvania metropolitan areas.

An HEC-RAS model was constructed to simulate the complex streamflow routing processes within approximately 220 miles of streams within the Upper Susquehanna River watershed. Five large federally-constructed levee systems at major population centers were included within the HEC-RAS modeling domain in addition to numerous non-federally constructed levee systems.

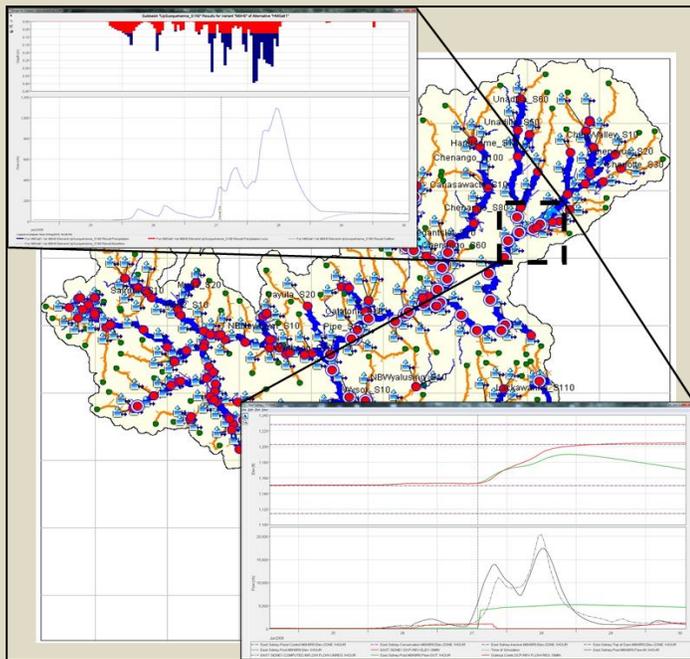
To verify that these models were able to produce accurate flow and stage hydrographs as well as credible economic damages/benefits, all models were calibrated and validated using historical flooding and drought events, such as those that occurred in 1972, 1996, 2001, 2005, 2006, and 2011. The 2011 results are shown in Figure 2.



Figure 2 - Computed & Observed Flow Hydrographs at Wilkes Barre, PA

The HEC-HMS, HEC-ResSim, HEC-RAS, and HEC-FIA models were then integrated into a CWMS watershed (Version 3.0). Real-time data feeds were incorporated using data obtained from the National Weather Service (NWS) including observed/forecasted precipitation, observed/forecasted temperatures, and observed snow water equivalent for use as boundary condition input within rainfall, rain-on-snow, and snowmelt-only simulations/forecasts.

Stage data feeds providing from the United States Geological Survey (USGS) were also integrated in order to calibrate the component models. Additional reservoir stage and snow water equivalent data from NAB were also assimilated. Outputs from the Upper



Susquehanna River CWMS modeling suite include gridded precipitation forecasts, reservoir inflow hydrographs, reservoir release decisions, flow and stage hydrographs downstream of the system of reservoirs, inundation extents and depths, economic damage, and project benefits, all in real-time. An example of this output is shown in Figure 3.

This suite of models provides an accurate and efficient way of regulating the system of dams, reservoirs, and local flood protection systems within the Susquehanna River watershed. These models can also be used to simulate "what-if" scenarios during floods to inform and improve how USACE operates these projects.

Figure 3 (at left) - Susquehanna River Watershed - CWMS Model Outputs

Hurricane Season is Here. Urge Your Residents to Protect What Matters.

FloodSmart

At best, hurricane season predictions are uncertain. However, the National Oceanic and Atmospheric Administration (NOAA) is indicating a transition from El Niño to La Niña conditions this year. La Niña typically creates hurricane-friendly conditions in the Atlantic Basin, which leads to a more active season. The hurricane experts at Colorado State University's Department of Atmospheric Science have similar thoughts and predict a 97 percent chance that a named storm makes landfall in the United States this summer. On the other hand, if El Niño lingers, it could lead to more heavy rainfall across the South, which has already seen devastating flooding in Texas, Mississippi and Louisiana.

Hurricanes have caused eight of the 10 costliest natural disasters in U.S. history. Although hurricanes are most known for their wind damage, they also cause flooding as a result of storm surge, heavy rains, and flash floods—often in areas far from the coast. Even with a near certainty that a named storm will strike the US coast this year, forecasters still aren't able to accurately predict a specific location of landfall more than a few days in advance.

No matter the forecast, it is important to ensure that your community is ready for every possibility. Now is the time to take action and encourage your residents to financially prepare for

the next flooding event. Help residents understand the risks facing their homes by directing them to the [One-Step Flood Risk Profile](#) at [FloodSmart.gov](#). Here they will also be able to find an agent that sells flood insurance in your community.

Without flood insurance, home owners will have to carry the heavy burden of repairs. From 2011 to 2015, the average National Flood Insurance Program (NFIP) flood claim was more than \$46,000. Yet in 2015, the average NFIP premium was about \$700 a year. FloodSmart's interactive [Cost of Flooding Tool](#) helps illustrate how much it could cost to repair damage to a home that has been flooded.

FloodSmart has several [tools and resources](#) that you can use to educate home owners and residents in your community:

- [Consumer](#) and [business](#) checklists to help residents prepare before the next disaster strikes.
- Seasonal [social media messages](#) that you can share through your own Facebook and Twitter platforms to educate residents.
- Marketing [webinars](#) that review FloodSmart's tools and resources and how to use them in your outreach efforts.

Registration is Open for NHC Northeast Regional Workshop

The National Hydrologic Warning Council is presenting

“Prepare to Protect, Advancing Community-Based Flood Warning”

at the Desmond Hotel and Conference Center in Albany, New York, September 20 – 21, 2016

The workshop is intended for flood warning professionals, emergency managers, public works officials, and owners and operators of high hazard dams and levees.

The 2-day workshop has a low registration fee of just \$75 for NHC members and \$100 for non-members. Exhibiting and sponsorship opportunities are also available. Keep watch at this [location](#) for the latest information. To register, use this [link](#).

Save the Date

The **ALERT Users Group Fall Training & Meeting** will be held October 20th, 2016 at the San Diego County Flood Control Facility located at 5500 Overland Ave., Room 120 in San Diego, California

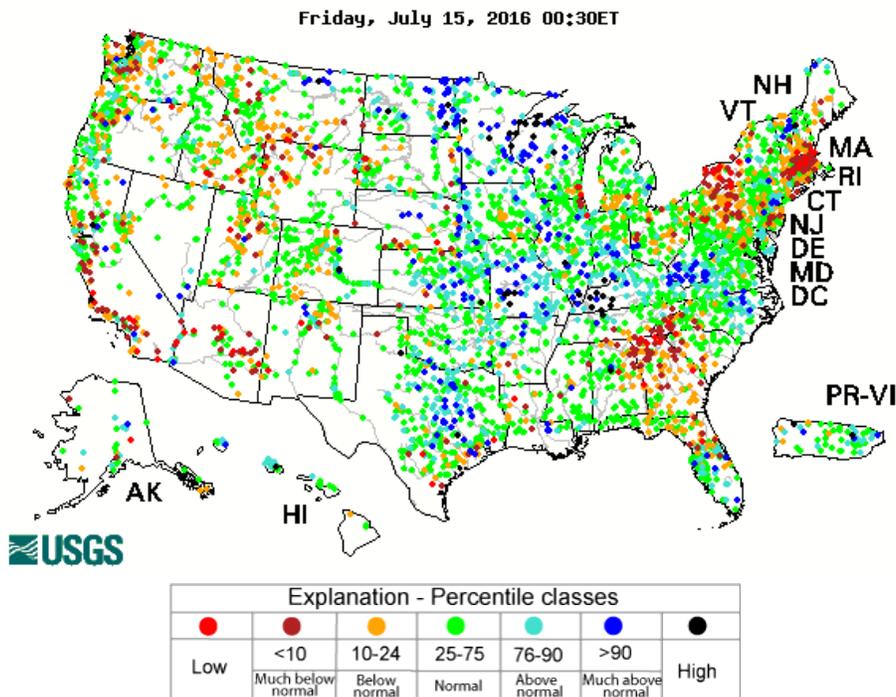
Emphases of this year’s meeting will be ALERT 2, and interagency coordination and preparation for this coming winter. An afternoon technical workshop will include presentations related to ALERT system maintenance.

The workshop will finish with user reports and vendor announcements. The AUG board members are looking forward to seeing you there.

To register, please RSVP to Robert Laag at: relaag@rcflood.org or call him at (951) 955-1232 by October 14, 2016.

Download the [workshop flyer](#) for more information.

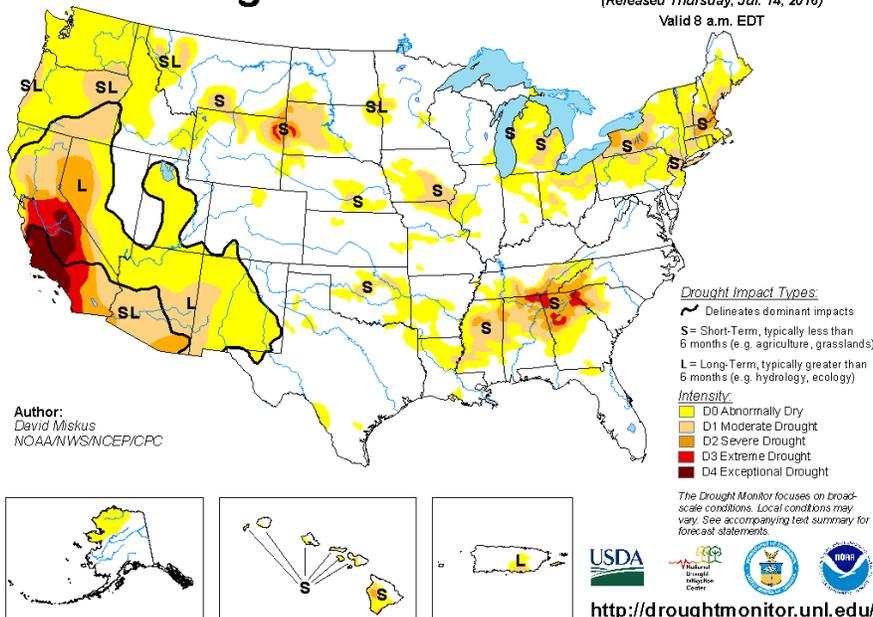
Hydrologic Conditions in the United States Through July 12, 2016



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

U.S. Drought Monitor

July 12, 2016
(Released Thursday, Jul. 14, 2016)
Valid 8 a.m. EDT



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

August Newsletter Articles Focus: Hazard Communication & Public Awareness

NHWC is requesting articles that focus on getting the word out.

Please prepare an article that explains how your organization gets the right real-time data and information to the right people for the right response.

Submit your article to:

editor@hydrologicwarning.org

August 5th is the deadline for inclusion in the August issue.

Future Newsletter Articles Focus

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

Aug- Hazard Communication & Public Awareness
Sep- Modeling/Analysis
Oct - Data Collection
Nov- Hydrology

NHWC Calendar

September 20-21, 2016 - [NHWC Northeast Regional Workshop](#), Albany, New York

June 5-8, 2017 – [NHWC 2017 Training Conference & Exposition](#), Squaw Valley, California

General Interest Calendar

August 8-11, 2016 – [2016 International Atmospheric Rivers Conference](#), La Jolla, California

August 22-25, 2016 – [National Association of Flood & Stormwater Management Agencies Annual Meeting](#), Portland, Oregon

October 20, 2016 – [The ALERT Users Group Fall Training and Meeting](#),  San Diego, California

(See the [event calendar](#) on the NHWC website for more information.)

Parting Shot



July, 2016 Flooding in Wuhan, China

Video (original source unknown) courtesy Henry Hu, WEST Consultants

National Hydrologic Warning Council

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

<http://www.hydrologicwarning.org>