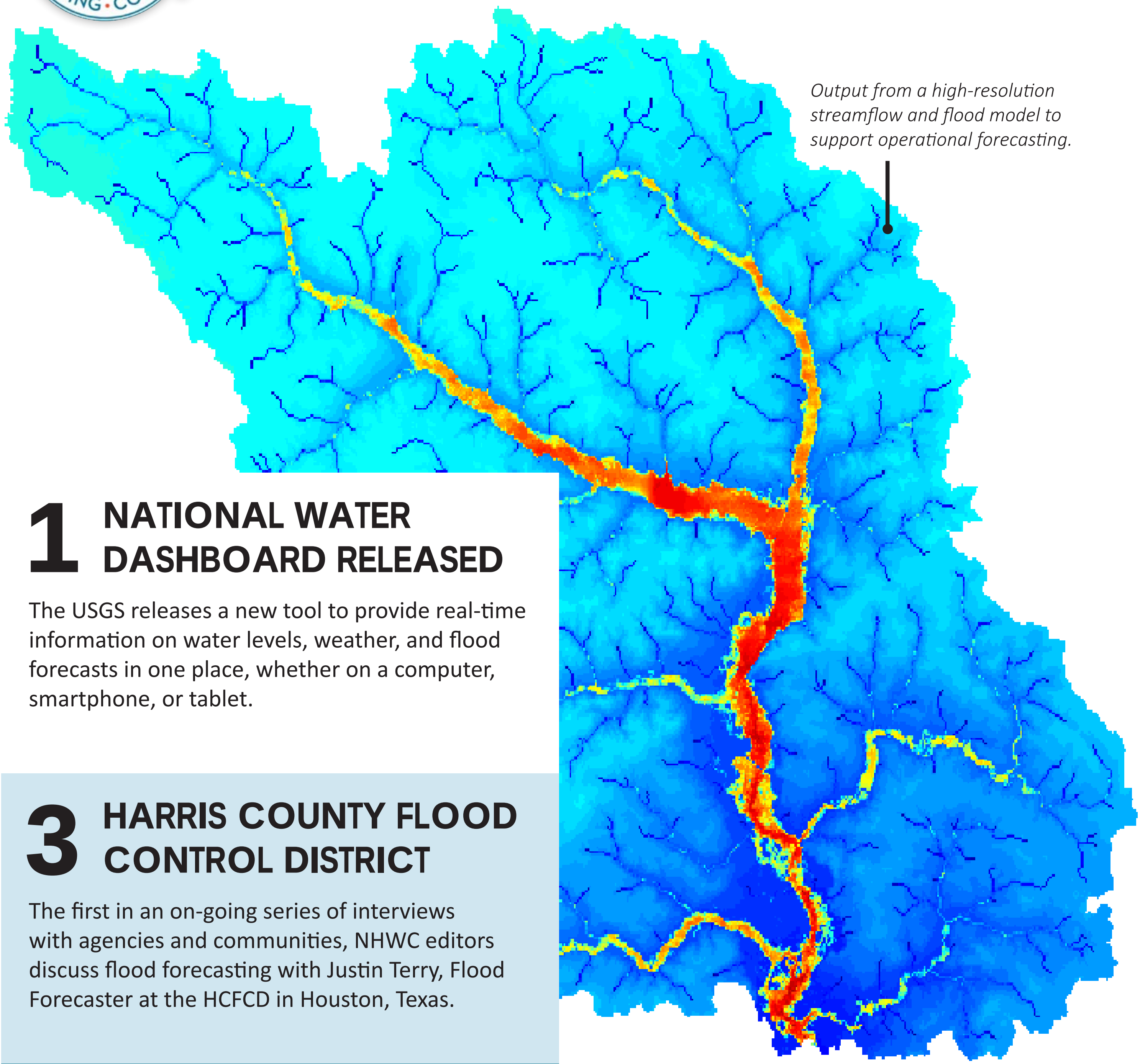
NHWC Transmission

Winter 2021



Output from a high-resolution streamflow and flood model to support operational forecasting.

1 NATIONAL WATER DASHBOARD RELEASED

The USGS releases a new tool to provide real-time information on water levels, weather, and flood forecasts in one place, whether on a computer, smartphone, or tablet.

3 HARRIS COUNTY FLOOD CONTROL DISTRICT

The first in an on-going series of interviews with agencies and communities, NHWC editors discuss flood forecasting with Justin Terry, Flood Forecaster at the HCFCD in Houston, Texas.

15 ADVANCES IN MODELING FOR FLOOD FORECASTING

Baron Services, Inc. provides a detailed anlaysis of their high-resolution streamflow and flooding models to support operational forecasting.

29 NEWS, WEATHER AND EVENTS

The NHWC Flood Warning Systems webinar series launched in January and a tough call was made to postpone the 2021 National Conference. Drought deepens in the West and Texas experiences extreme winter weather.

USGS RELEASES NATIONAL WATER DASHBOARD

official press release

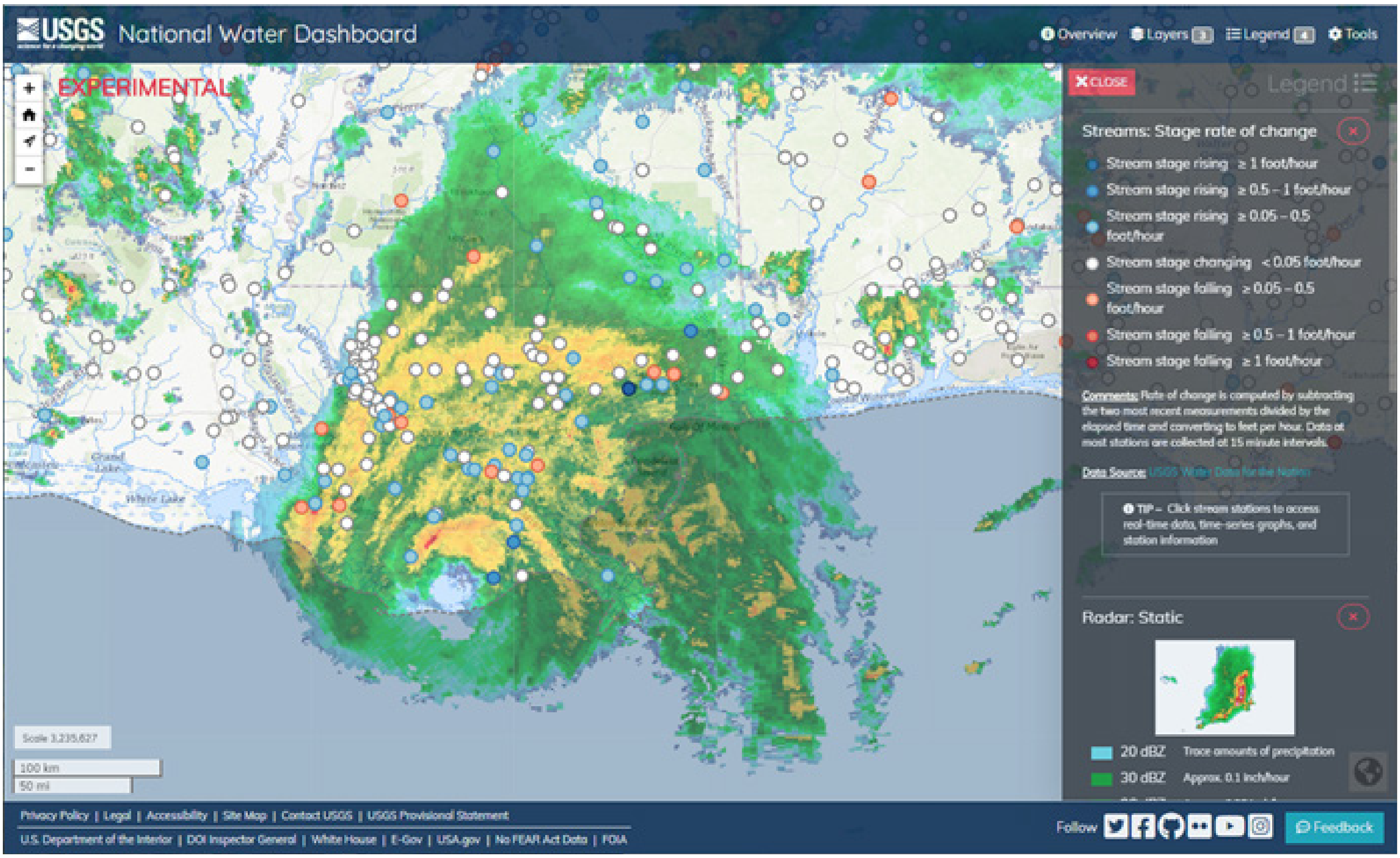


Figure 1 - Streamgauge water level changes during Hurricane Zeta landfall in October 2020

On October 30, 2020, the U.S. Geological Survey (USGS) announced the release of a new mobile tool that provides real-time information on water levels, weather and flood forecasts all in one place on a computer, smartphone, or other mobile device. The new USGS National Water Dashboard (NWD), provides critical information to decision-makers, emergency managers and the public during flood events, informing decisions that can help protect lives and property. The USGS over the next few years will work to incorporate all available USGS water data into the NWD and it will act as a one-stop resource to be used by the public. Information from the NWD will help inform forecasting, response and recovery efforts for agencies such as the National Weather Service (NWS), the Federal Emergency Management Agency, the U.S. Army Corps of Engineers (USACE), and other federal, state and local agencies. The tool can be used by forecasters and local emergency managers as they issue flood and evacuation warnings, verify safe evacuation routes and coordinate emergency response efforts. The NWD can assist the USACE as they manage water supplies in river basins and operate flood-control reservoirs. During a drought, the tool can help state resource managers identify areas where water supplies are at risk.

The NWD presents real-time stream, lake and reservoir, precipitation and groundwater data from more than 13,500 USGS stations across the country. This information is shown with the National Oceanic and Atmospheric Administration (NOAA) weather data such as radar, watches and warnings, past precipitation totals, precipitation forecasts and drought conditions from other open water-data sources. The NWD also links to the USGS WaterAlert system, which sends out instant, customized updates about water conditions.

> ***"Expanding this tool nationwide will increase the ease and ability for the public to have access to USGS real-time water data at all times to help make informed decisions regarding the safety of their families and homes."***
>
> ***Don Cline, Ph.D., USGS Associate Director for Water Resources***

"The NWD builds on the USGS Texas Water Dashboard that was created in 2016," said Don Cline, Ph.D, USGS Associate Director for Water Resources. Flow conditions can be explored by clicking on the option in the Layers menu, along with other datasets such as weather radar and Geostationary Operational Environmental Satellite (GOES) data (Figure 1). Clicking on the legend button will bring up information about the symbols used in the map. In addition to current conditions provided by USGS stations, the NWD allows you to connect with valuable forecast information from the NWS (Figure 2). The NWD allows users to monitor a variety of natural hazards, including real-time fire warnings from the NWS. The Drought Monitor is a useful index to understand the impact of drought conditions on streamflow statewide or within individual basins. Figure 3 shows areas in the

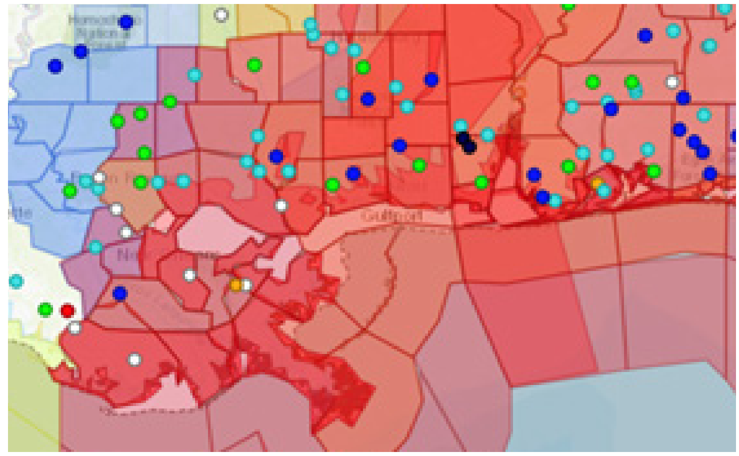


Figure 2 - Streamflow and NWS Watches during Hurricane Zeta

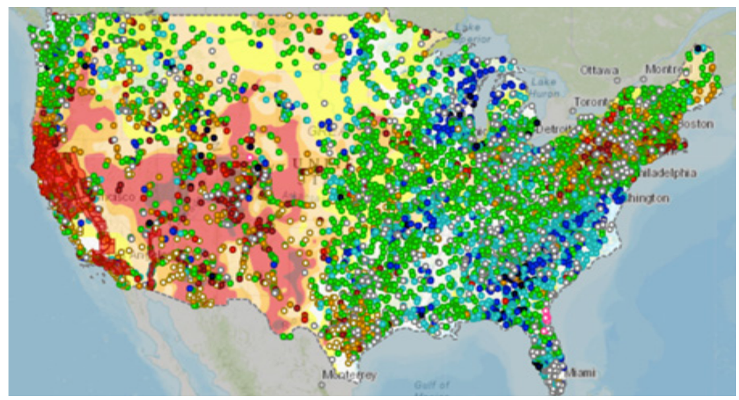


Figure 3 - Streamflow and Fire Warnings on October 27, 2020

Western and Northeast U.S. on October 27, 2020 that are experiencing lower flows and significant drought conditions.

The dark red boxes along the West Coast are fire warnings posted from the NWS as a result of the ongoing drought conditions. The red colored dots represent the low streamflow conditions at USGS gauges.

The NWD uses real-time data from the USGS National Water Information System (NWIS). NWIS is the world's largest authoritative enterprise water information system, which is foundational to advancing USGS science priorities and meeting the needs of stakeholders. Data in NWIS have been collected from more than 1.9 million sites through time, with some real-time stations in operation for more than 100 years.

USGS science for a changing world

Visit https://www.usgs.gov/news/usgs-unveils-mobile-flood-tool-nation for more information.

INTERVIEW: HARRIS COUNTY FLOOD CONTROL DISTRICT

with Justin Terry, P.E., CFM / Flood Forecaster / Harris County Flood Control District

by Lee von Gynz-Guethle, P.E., CFM / NHWC Transmission Co-Editor / WEST Consultants

The following is the first in a series of interviews by the NHWC Transmission Editors with communities or agencies that share our mission. If you would like to be part of this series, please contact the Editors at Editor@HydrologicWarning.org.

The Harris County Flood Control District (District) provides flood damage reduction projects that help manage flooding for more than 4.5 million people across Harris County, including the City of Houston. The District's flood control infrastructure is extensive, including more than 1,500 channels totaling about 2,500 miles in length. The HCFCD does "not" have sole jurisdiction over flood-related matters in Harris County, but must work alongside local communities and 34 floodplain administrators to address flood risk in Harris County.

In 2017, the District began the process of developing a county-wide, real-time automated flood forecasting system. This effort built on prior work to monitor, predict, and communicate flood risk during storm events. The initial phase of the effort is now operational. The system acquires gauged stage, flow, and rainfall data, Gauge-Adjusted Radar Rainfall (GARR) products, and National Weather Services (NWS) forecasts and simulates flood conditions throughout Harris County. Real-time gauge data and estimated inundation areas are displayed publicly at https://www.harriscountyfws.org/.

The following is an interview with Justin Terry, who helped develop and now leads the day-to-day operation of the District's flood forecasting system. We talked about Justin's career, how he ended up at the District, and how the District's flood forecasting system is operated and used to assess real-time flooding in Harris County.

Justin Terry, P.E., CFM, Flood Forecaster, Harris County Flood Control District

Can you share a bit about your background and how you ended up as a Flood Forecaster for the District?

I actually started off in school as a math education major. In the last six months of my undergraduate program I realized I was losing interest and couldn't see myself teaching long term. So one day I decided to make the change, walked over to the Engineering department, and changed majors. Initially, my interest was in structural engineering, but I couldn't get into a course during the summer, and so I ended up in water resources.

I don't think most people go into civil engineering with a specific focus in mind, like flood management or wastewater treatment plant design. I don't think you start to realize your interests until you start practicing and get exposure to different things. For example, my background in water resources prior to this role is broad. With the exception of sanitary wastewater, I did a bit of everything (water distribution systems, highway drainage, bridge improvements, development projects, and watershed studies).

It is interesting how a minor decision or situation can direct your career.

How I got involved in this project was a bit by chance as well. I was a consultant with the firm hired by the District to evaluate flood warning and forecast systems across the country, identify an approach that would work for the District, and start development. At the time, we were extremely busy and working to progress many projects at a time. I was fortunate to have some availability and be a part of the team selected to work on the project.

I was given this unique opportunity where I got to start a project from the consulting side and continue it on the owner side. I thought this was incredibly important because systems like the flood warning and flood forecast system require maintenance and ownership. In order for something like the flood forecast system to be successful and function as intended, you have to own it, understand the intricacies of the system, and be a part of that process. That's the only way to take something like a flood forecast system, which can be as simple or as complex as you want it to be, and continue to make it successful and reliable. So the main reason I made the transition from consultant to managing the system at the District was because it's an opportunity to be a part of something that has a lot of potential to provide a lot of benefit, rather than just a job.

I liked the idea of taking the product development and continuing to grow it, rather than the typical consulting project where you do the work and then it gets stored on a drive or put on a shelf until the next person picks it up a couple of years down the road.

Also, it's important to say this is a group effort. That includes the consultants and individuals at the District who helped evaluate, plan, and implement the system. It's not by any means one person's effort. It's everybody that's been a part of the project at any point that has helped make the system a success.

What are some things you've learned since taking over the system? Is there anything you didn't expect?

In consulting, you're in a position where you're often handed a project and responsible for meeting the client's goals on-time and within budget. With a project like this, I'm responsible for growing the system and program to where the County needs it, based on guidance from Jeff Lindner, Director of Hydrologic Operations. When we started this effort, we defined a goal to forecast water surface elevations over time. We had to figured out how to achieve that. Now that we've achieved that, we look at our list of planned improvements and identify how we can grow and expand the system. So you're deciding the direction of the project. That's quite different from consulting and I've had to get used to it.

> ***"I was given this unique opportunity to start a project from the consulting side and continue it on the owner side. I thought this was incredibly important because a flood warning system requires maintenance and ownership."***
>
> ***Justin Terry, Flood Forecaster, Harris County Flood Control District***

Which means I'm solely responsible for moving the system forward at the necessary pace. We have to meet deadlines. Getting Version 1.0 of the system completed was critical due to recent flooding we'd had. Now we have to establish more deadlines to ensure we're progressing within a reasonable amount of time. Having a goal in mind, a plan, and being able to implement that plan is critical to the overall success of this project.

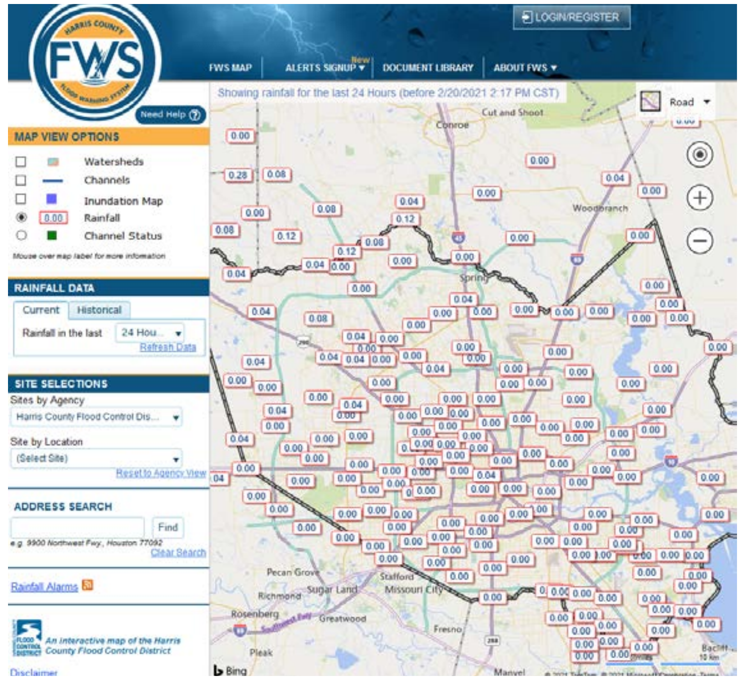


Figure 1 - Flood Warning System Public Dashboard

When you're on-call, I heard you practically live off coffee for 48-hours. Are you enjoying the operational aspects?

I do enjoy the operational aspects. If something could potentially happen, I'd rather just be there than not be there. We are in the process of developing a team and filling positions so we can alleviate some of the stress and effort associated with operations. I went 48 hours straight for the last event. Leading up to it I was on for 12 hours or 16 hours and then took a nap and came back on. After 48 hours of being awake, you want to shower and you're ready for something other than a granola bar and coffee. But it's a challenge and that's what I hoped for when I joined the District.

We try to plan vacations, but there are no guarantees that an event won't happen around that time. Holidays are often a good time to take time off, but anyone from Houston knows that most of our events happen at night, over the weekend, and on holidays.

Can you talk about how the flood forecasting system operates, what software you use, etc.?

Let's first step back a bit and look at the history of the project. We started our development with an evaluation to identify what application we wanted to use and to set a road map. Basically, how could we approach this project logically and make sure that we were successful in that process? So we evaluated available applications and talked to other agencies that run forecast systems. We asked what they've done that's been successful, what were their lessons learned, and how much did it cost. The District also had experience in flood forecasting, so we weren't starting from scratch. We had successfully developed a system in the past that was more detailed than this system, but not necessarily more complex. It only looked at a single watershed, while this time we're looking at the entire County.

We decided to use HEC-RTS and HEC-HMS, both of which are developed by the US Army Corps of Engineers Hydrologic Engineering Center (USACE-HEC). HEC-RTS is a data aquisition and decision support tool that couples HEC software. In our case, HEC-RTS runs HEC-HMS and we use HEC-RTS to view data and results. The HEC-HMS model has rating curves and reach routings derived from HEC-RAS models and from observation data from field measurements that we or the USGS take (i.e., rating curves). Then we went through a calibration process with multiple storms, ranging from long-duration, regional Harvey-type events to short-duration, localized events. So the HEC-HMS model is a runoff model and estimates flow, then predicts stage through rating curves. So it has some limitations that go along with that process.

You originally had 22 HEC-HMS models, one for each watershed. Some watersheds are inter-related either at confluences or due to diversions. Did you combine the watersheds into one HEC-HMS model? (Harris County has 22 watersheds covering 1,777 square miles under the District's authority)

We originally combined it into a single HEC-HMS model with a total of 1,163 sub-basins and around 800 routing reaches, but we found we couldn't run a forecast with more than a two day window, meaning 24 hours prior to "now" and 24 hours out in time. If we tried to run anything longer, or if the amount of rainfall increased regionally such that the time series became more complex because it had more data (vs. zeros), then HEC-HMS would stall, requiring the program to be reset. So we decided to split the model into two regions (see Figure 2 and Figure 3). In doing so, we added code to handle the results from the two models and allow us to scale the system as we add more complexity and further subdivide the regions. So if we want to integrate a HEC-RAS model, which is going to increase the computation time and data

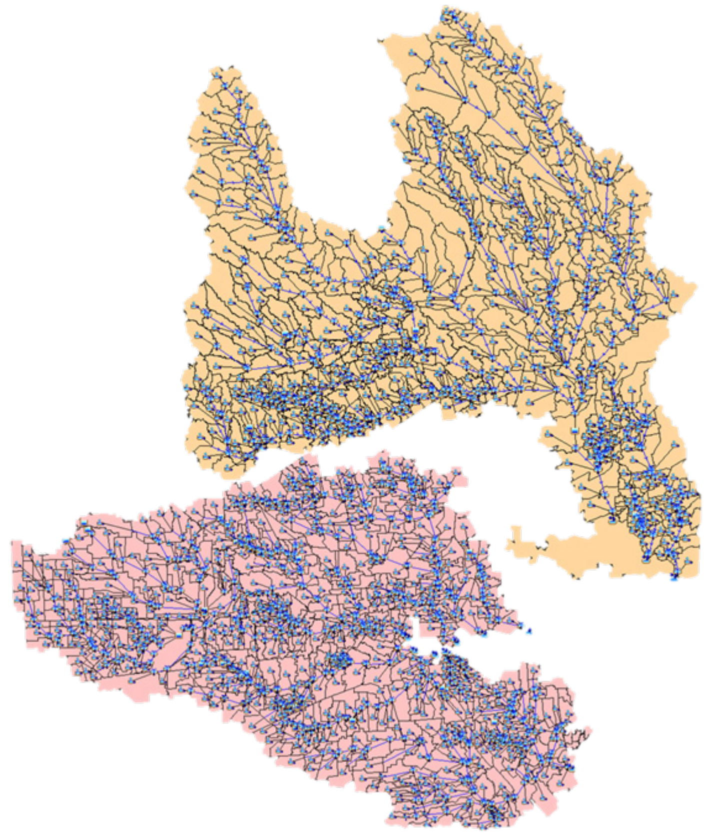


Figure 2 - HEC-HMS Model Schematics

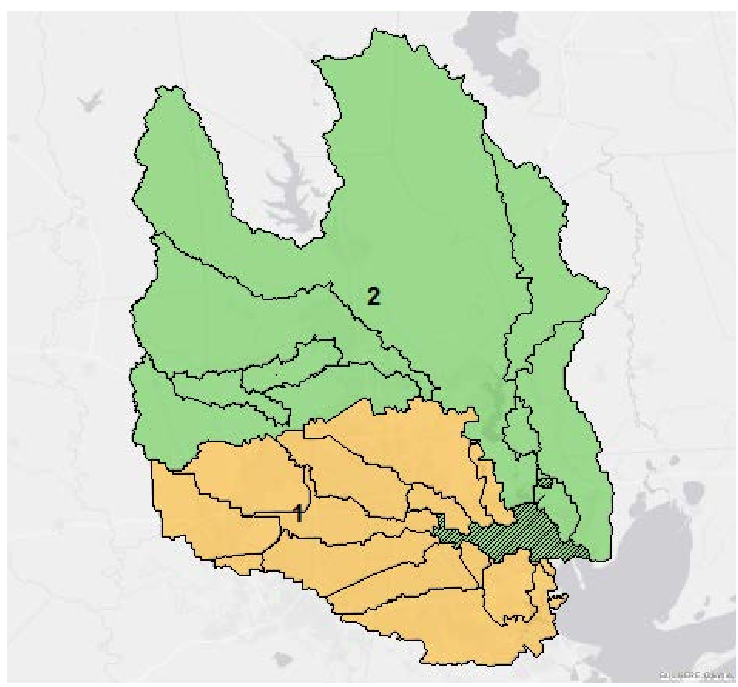


Figure 3 - Zone 1 and Zone 2 Watersheds

requirements, we can do that because we are running it on a regional basis. That was really important. That was the biggest challenge of trying to run this HEC-HMS model. It was just so big it could not run what we were doing.

Throughout the process, we have had conversations with the USACE Hydrologic Engineering Center (USACE-HEC) and various USACE Districts about what we could do to resolve issues that we have experienced while running the models and to identify opportunities to improve our overall system performance. They recommended a single sub-basin per gauge. We have around 163 forecast points based on 180 gauges, which means 163 sub-basins vs 1,163 sub-basins. Although practical for larger river systems and reservoir management, that approach would grossly under-represent the County's topography, development level, and drainage network. Would that be sufficient for general situational awareness? Possibly, but it would mean additional calibration and undoing a lot of what we had already done.

Ultimately, the system design and level of detail all depends on your goal. Our goal was to produce a forecast every 30 minutes. That includes downloading the data, formating it for the model, running the model, and then viewing and assessing the results. On a 30 minute timescale, is it realistic to view and monitor 163 forecast points? Probably not. Not as one person, maybe not even as two or three people. But having that latest information in your model is good when it comes time to reviewing it on an hourly or two hour timescale. At that point you at least know you have recent data. To give a sense of processing time, we can run the HEC-HMS model for both regions in 15-25 minutes, while the single HEC-HMS model with all watersheds takes up to an hour, depending on the event.

What is your modeling process for a typical storm event? How far back do you initialize the model and how far forward do you go?

We use real-time rainfall data from multiple sources, including our gauges, the National Weather Service, and a third party GARR vendor. Our standard look back period is two days, but for an event that's multiple days, we have to increase our look back period to make sure we capture the initial condition.

In some areas of Harris County water can remain in the system for weeks. How do you address these situations?

At times, water can remain in ditches and channels for some time. So we have that look back period which is variable, but it's typically a two or three day period. And then we have a forecast period of two to three days that really depends on the watershed. For our small tributaries, our response time can be as little as 15 minutes and the recession period may only be a couple hours. On larger watersheds and more rural watersheds, our response time might be 6 hours to 18 hours and the recession time might be longer than a week. So it all depends on which watershed you're on and so we have to adjust the model run periods based on the event. We typically start small and tend to adjust our runs as the event unfolds.

During the forward looking period, are you applying rainfall forecasts or are you running the models only with the rainfall that has hit the ground?

During Tropical Storm Beta (2020) we used a portion of the NOAA HRRR (High-Resolution Rapid Refresh) forecasts, which looks at up to 48 hours out, to produce contingency forecasts. On Tuesday night, water levels were nearing bank and in some areas were out of bank, then it started to come back down and we were expecting another wave Wednesday afternoon. Working closely with the National Weather Service local office and the West Gulf River Forecast Center in Fort Worth, we ran the simulation. It suggested we would have problems on portions of Greens Bayou, Hunting Bayou, Cypress Creek, and at the confluence of Little Cypress Creek and Cypress Creek. We felt that even if the volume is off and the location is off, it would give us an idea of where we could generally expect issues, and it ended up matching pretty well.

So we've utilized it before but it's not something that is used regularly by default because forecasted rainfall changes. In the case of the HRRR, it is changing hourly. Some of the other forecasts change every six hours or longer. In Harris County, the location of the forecast rainfall, volume, orientation, and the intensity all matter a lot because of the shape, size, and response time of the watersheds. Importantly, the watersheds are very sensitive to the orientation of storms. If the forecast rainfall is off by 5 miles, it can be in a completely different watershed. So we have to take care when considering rainfall forecasts.

Is the system running 24/7?

We don't run it 24/7 because of the scale of the models. It boils down to whether you need to run it on a sunny day. If we have an unexpected event that starts to unfold, we can download the last several days of data and run the model within an hour. There's a data management issue running 24/7 because every forecast generates 2 gigabytes of data. For T.S. Beta we generated a TB of data. For sunny days, it doesn't make sense to store all those zeros.

We will run it if there's scattered showers just to confirm everything is running correctly, because when things sit, sometimes something breaks the code or there's a hangup somewhere.

For example, if unrelated software is updated and there's a conflict that causes issues?

Right, or I made updates and tested it when we had a period without rainfall, and it all worked fine in testing. Then comes the event and you start running real-time data, and as it starts to come in, that's when you start to find errors. You never find all the errors during development, you only find them after release and you're running it in the real world.

To address this, we have multiple versions of the model. We have our operational model that is the long term support model and we know is working well. Then we have our draft models that we play around with.

The FWS website includes inundation areas (see Figure 4 on the following page). As I understand, this reflects current flood conditions based on GIS interpolation methods?

Yes, we interpolate water levels between gauges. We have HEC-RAS models for each channel with the 10-year to the 500-year Annual Recurrence Interval (ARI) events already run. We use the HEC-RAS output and the observed water level at gauges to interpolate water levels along the stream. Then we generate contours in GIS along the cross section lines, convert those to rasters, and mosaic them to create the inundation shown on the FWS website. That happens every 45 minutes. We also processed a lot of our major historic storms, so those are viewable through the historic viewer.

Are you integrating the flood forecasting system output into the public dashboard? For example, providing forecasted elevations, inundation areas, or simplified warnings?

We don't share the raw outputs publicly. We do share some information, but how it's shared is filtered. We are in the process of building an internal dashboard that we would use as our operational interface with forecast and real-time data. After that, we will have the tools available to us to be able to inform and share information with our partners. The goal is to make it available to select partners, but it's a challenge because we want it to be meaningful and we want them to be able to understand and digest it.

In order for the forecast to be available publicly, we have to educate our audience. Otherwise there is greater potential for the information to be misinterpreted. So it's definitely a challenge and we have to be very considerate of how we share the information.

Eventually it's likely that the forecast information will be visible on a public facing website. Whether that's a line on a hydrograph or an inundation map, I think that we have to be very considerate and thoughtful about how we present that data. My personal favorite is the cone of uncertainty for hurricane forecasts. I think we can present flood forecasts in a similar way where we show the arrival time of the peak with a range of possibilities or the maximum inundation shown as a likely area. Also, when someone goes to our website, if they haven't been there before, it has a basic education piece (see Figure 4). It describes what you're looking at, what buttons, etc. We have to be thoughtful in how we present the data because the data is complex. With a range of forecasts, someone might interpret it wrong and then start to lose faith. So we need to educate and build trust.

I would think it is tough to get general feedback on the FWS website, alerts, etc. to determine it's effectiveness.

We rely on feedback and one way that we get that feedback is through a comment section on FWS where you can submit email. Often feedback is related to an issue on the site or with alerts. We occasionally get feedback from people when they call during events to get information on flooding in their area. In most cases, people are concerned about how high the water will get or when it will go back down.

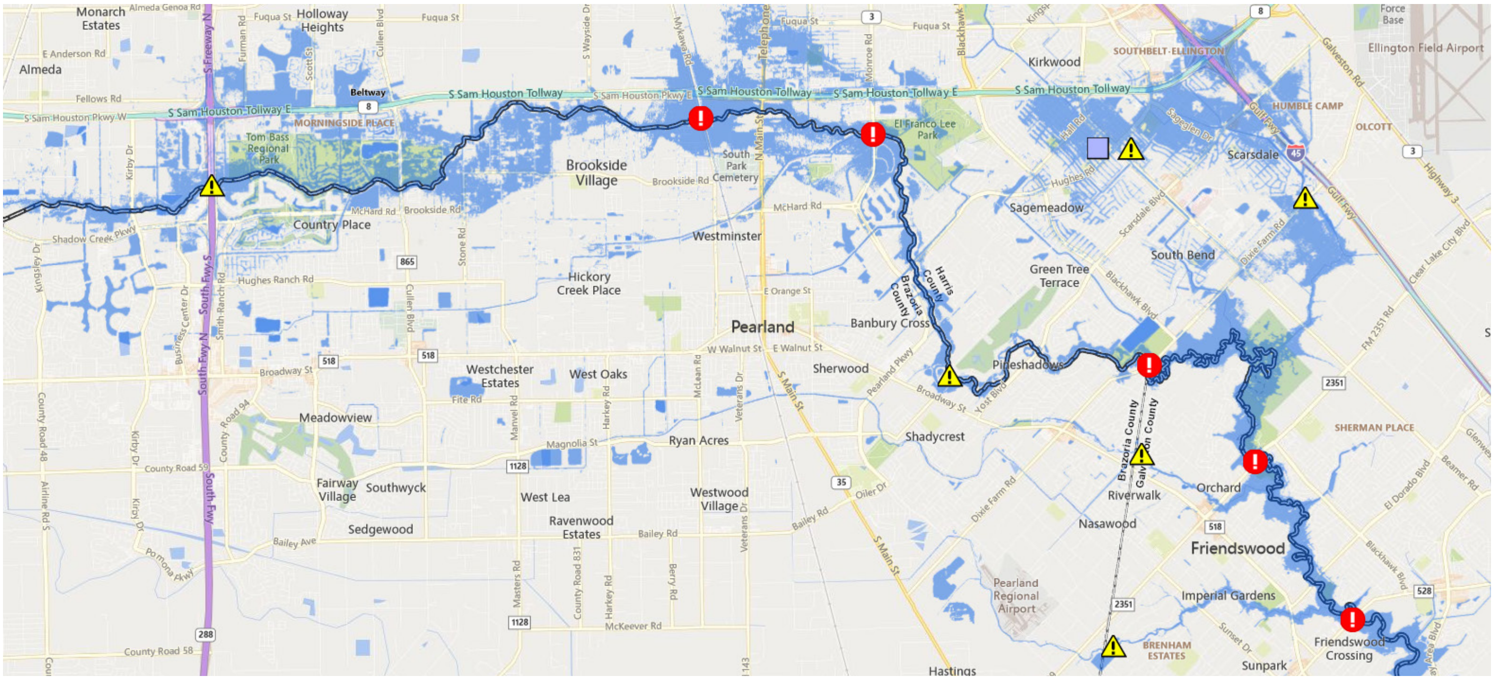


Figure 4 - Gauge-based, GIS-derived Inundation Mapping, Flood Warning System Public Dashboard, September 22, 2020

People seem grateful to have reached someone for information, even if it is not always good news.

We also have our public outreach meetings, workshops, and social media. So there are multiple ways for us to get that feedback.

Would you ever consider creating a focus group comprised of a diverse range of users? You could follow up with them during and after an event over a year to gauge the effectiveness of your communication tools.

It's something to consider when it comes time to share our forecasts. We'll go through the process with our partners because our partners are not all flood experts, for example the police. Not everybody knows about flooding, just like I don't know about policing and firefighting, and so it would be so silly for me to try to read a map about fire response and I don't even know what type of information you see on a fire operations dashboard. It's not my area of expertise so I require education on that.

The District has many neighboring communities and agencies with overlapping jurisdiction. How are you collaborating with these organizations?

We have partner gauges that are a part of our flood warning system. The District has 180 gauges but on the FWS you'll see 350 gauges. In general, we use all available data. We don't ingest inflow data from upstream river systems, but that's because it is usually minor. For example, the flow out of Lake Conroe is typically pretty marginal, but during larger events we could take that data and pull it in through the USGS gauge.

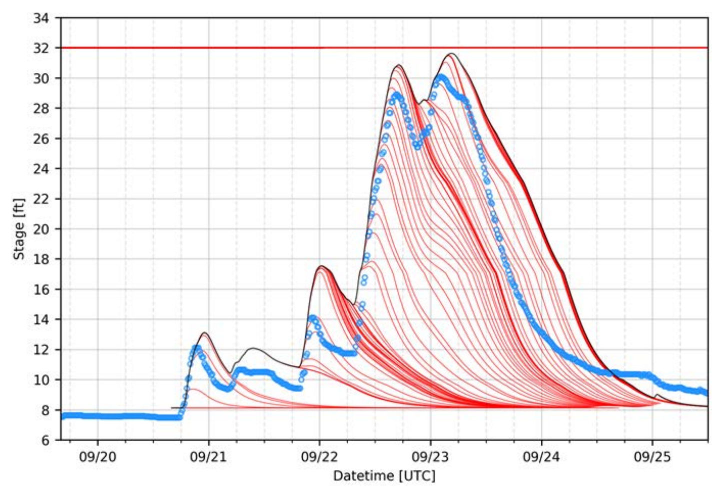


Figure 5 - Sample forecasts with observed stage (blue), individual forecasts (red), joint peak of all forecasts (black), and top of bank (red horizontal line)

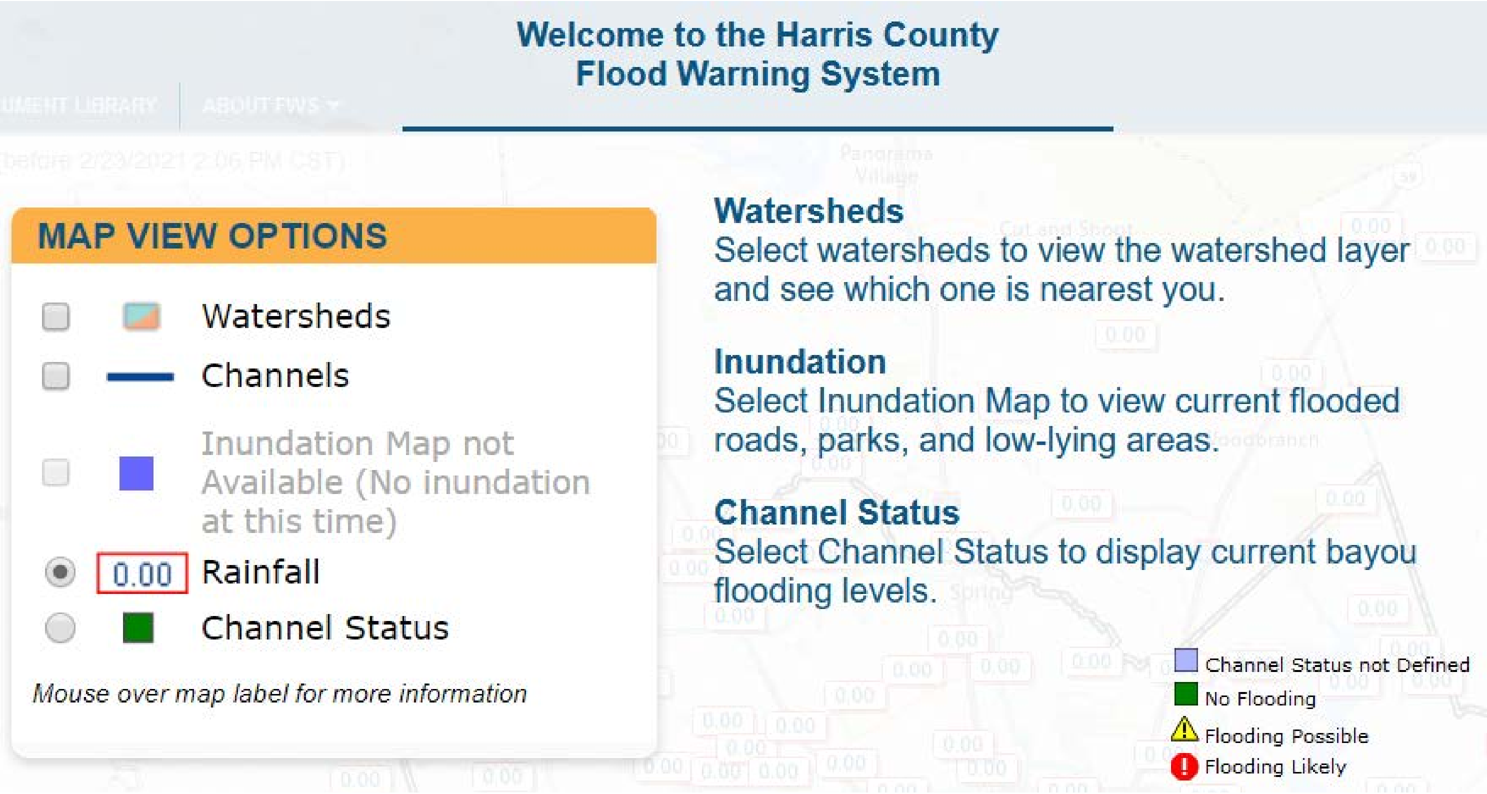


Figure 6 - Flood Warning System Public Dashboard Welcome Screen for New Visitors

The San Jacinto River Authority (SJRA), who manages Lake Conroe (north of Houston), is developing a HEC-RTS system. Did you share your experiences with them?

We met with them early on in their process to share our experiences. My initial recommendations to them and any one interested in building a system, is that our system is just one example of how to approach forecasting, and that our experiences provide lessons learned, rather than an absolute approach. An owner has to consider their operational objectives and build a system to meet those needs. In the case of SJRA, their objectives are very different from ours in that their interest is in reservoir operations, while ours is water level at each of our gauge sites.

You also have the Barker and Addicks reservoirs operated by the USACE, located in the middle of the County and upstream of downtown Houston. Do you collaborate with the USACE?

Our typical coordination occurs during the briefings provided by the USACE every 12-24 hours during events. We have been engaged in a partnership with them through the Silver Jackets program, where they helped support the development of our system. We are thinking about future efforts on trying to improve coordination. It hasn't been defined, but I think it would be wise for us to focus on how do we share this data and make it more available between the two agencies. Honestly though, for us during a typical flood event, the reservoirs rarely play a role because they're shut off and don't release. It's usually after the event when they start releasing that it becomes a factor. Obviously, the exception are the extreme events like Hurricane Harvey.

Are the reservoirs in the HEC-HMS models?

They are a part of the model but they have not been included as a part of the calibration or forecast process. We do produce forecasts for the gauges located upstream of the reservoirs and take into consideration any overflow from the Cypress Creek watershed.

So if you wanted to include releases from the reservoirs, you could adjust the model and have that information in your back pocket?

Yes, HEC-RTS and HEC-HMS is setup to allow that. We could apply a specific time series from the gauge, linked in real-time. We're not doing it by default but it is an option.

What are you considering for the future?

Our long term goal would be to expand the forecasting capabilities beyond just our individual gauge points. We have around 180 now, but there's a lot of stream crossings and channel between those points. So the next logical step for us, from a major system upgrade, is to incorporate an unsteady hydraulic model so that we have a forecast along the entire stream. There are several challenges that are presented with that upgrade, such as runtime stability. All the factors that affect a model, and so by going to that next step you are adding an opportunity for some failure during real time. That would be a big effort but would provide us with an integrated hydrologic and hydraulic modeling process.

Now you're back to what tool do you need. Has the HEC-HMS based system met expectations, does it provide you what you wanted, and if so then you're in good shape. If you're looking for something else, like more detail along the system, then there is a point where you may need a hydraulic model. Then you have the question of is it worth the money, the time, the effort, the knowledge. A hydraulic model, in general, is more complex and requires another set of operator skills. So it complicates the system on multiple levels. It's not just a linear increase, it's like when you have one kid and then you have two kids. Two kids is not twice the effort of one kid, it's more like quadruple.

I completely agree. This goes back to the whole baby steps in the phased approach to doing this development. The ultimate goal would be to integrate HEC-HMS and HEC-RAS and to have a forecast similar to what the National Weather Service and River Forecast Center call a total water level forecast, which provides a forecast along the whole stream. That's the big next milestone. That's maybe a multi-year effort, assuming we aren't using multiple consulting firms to do it like we are with MAAPnext.

The District will have their MAAPnext models soon (these are County-wide HEC-HMS models with newly delineated watersheds and HEC-RAS 1D/2D unsteady-state models using the latest topography). They are developed with the goal of an hour run-

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Justin Terry, Flood Forecaster, Harris County Flood Control District

time for each watershed, for a 24-hour storm. They have high levels of accuracy and they are reasonably stable, but a stable model doesn't mean it's going to run perfectly all the time. An alternative to using those would be to build new models suited to real-time simulations. Are these options being considered?

Every time I give a talk, someone asks whether we're going to use the MAAPnext models for forecasting. My answer was originally it's something that we will have to explore, but my answer now, is that it just isn't practical. Even if we can run an entire watershed in one hour, then we're talking 22 hours for the entire County.

And that's for a 24 hour or maybe 36 hour simulation.

Right, so you could even do a hot start from observed data or from a prior model run and maybe get by with running a 24 hour simulation. But you still have to do it for 22 watersheds. Assuming you're running it on all 22, you could simplify it. You could say we only have three or four watersheds that are being impacted, and just run it on those. So what is the cost of the hardware associated with running like that? Do we really need that level of detail to get the information we need? Then there is the uncertainty of the observation data and the forecast data that goes into it.

So there's a lot of questions. That doesn't mean that a 1D/2D model is not the solution for us, but from an operations aspect, is it overkill? Possibly it is. I think first we need to identify locations that require an unsteady hydraulic model. That's mainly backwater areas that have tidal or coastal influence or are located at confluences of major streams, particularly where we have bridges and looped rating curves. For these areas, we could also look at a simplified approach. A kind of midway between running a hydraulic model in real time vs a sort of interpolation like we use for the mapping process. So there's lots of ways that we could do full channel forecasts, but for all of them we are going to have to balance time vs accuracy.

One project we are working on is our internal dashboard so we have an operational interface other than HEC-RTS. We plan to have that set up by hurricane season 2021. That would give us a means of really looking at the data and having it at a system wide level. We could then easily drill down and look at individual sites. It would also give us a bit more statistical based information rather than just looking at a plot or trying to look around the model. There's also the maintenance aspects of the system, like on-going calibration, that we are always involved in.

What has been the most challenging test of the system? How did the team and stakeholders manage? Has Houston even had a major event since implementation?

We haven't had that major event yet. We had Tropical Storm Beta which was our biggest threat this past hurricane season in terms of a rain event. So we had a good opportunity to stress test the system. It's interesting to see things that are not obvious during calibration and development. We realized we have better performance in urban environments than rural because of the amount of data that's available in urban areas. It's been gauged much longer, so we have more discharge measurements and observation data. We also noticed certain flow regimes where our model performs better than another flow regime, which comes back to the calibration and which storms we calibrated to. As you recall, our calibration was based on major, moderate, and minor events.

The District was particularly focused on calibrating to events that were at or near bank, because that is a critical point. After that, flooding typically begins, at least in dense urban areas. Can you talk to that point?

Knowing whether we will reach bankfull or we will go out of bank is really important. Once you get beyond that, there's a lot more uncertainty because of differences in infrastructure, topography, and other factors. It's as important to have accuracy in the channel, because that's leading up to flood conditions.

Are you sharing forecast results with the National Weather Service (NWS)?

We actively coordinate with the National Weather Service during events and meet with them periodically throughout the year to discuss our coordination process. As part of our coordination process, we have put in place systems that allow us to share our forecast data and display NWS data in our system.

Now when you drive around Houston and look up at the clouds or review the radar, I assume you have a different perspective?

During an event you have to maintain situational awareness by checking the radar regularly and monitoring our system. You can't rely on the view outside the window. It's kind of an interesting experience because living on the South side of the County, it could be overcast like it is today, but it could be pouring rain somewhere else, and so you can't be fooled by what you see locally.

That's a major challenge in Houston. Someone leaves to go across town and it's sunny when they leave and get hit in a storm on the road. They had no idea because it wasn't raining where they left and they didn't check the radar.

That happened with Tropical Storm Imelda where 40 inches of rain had fallen outside of the eastern portion of the County, and some of the upper portions of the watersheds over there. Then 24 hours later a band comes through and traps everybody on the roads like you said, because we got 9 inches over a couple of hours in West and central Harris County.

That's a challenge. In operations, you're sitting in a dark room because it's designed for disasters so it doesn't have a lot of windows. You have to get used to digesting information from a screen and not from your surroundings. It's a learning process for sure.

You have a lot to accomplish down the road, but it sounds exciting. Especially the dashboard, because that will expand the user base and hopefully generate broad internal interest. It will also make the system more effective and efficient in daily operation.

You called this project low hanging fruit, and it is, in the sense that it has potential to provide a lot of benefit. The project is very intangible, and sometimes we tend not to value intangibles as much as we do something we can touch or see in action, like a mitigation basin that also serves as a park. You don't see a forecast system in action unless you watch it change.

The goal with a flood warning and forecast system is to inform users about potential flooding problems, so that hopefully users are more aware of potential flooding and risk. With sites like FWS, they can then access information that hopefully is helpful for their situation. Over time, they can learn and better understand flooding. It's our job to ensure the system is accurate and reliable and to demonstrate the value that it provides to users.

For More Information Visit:
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ADVANCES IN MODELING FLOOD INUNDATION FOR OPERATIONAL FORECASTING

by John McHenry, M.Sc. / Chief Scientist, Advanced Meteorological Systems / Baron Services, Inc.

High-resolution streamflow and flooding models that include continuous soil-moisture accounting are becoming more widely used in the operational community. Based on the National Center for Atmospheric Research (NCAR) Weather Research and Forecast Model Hydrologic modeling system (WRF-Hydro) model, the National Water Model (NWM) is an example of the first such system to have been deployed over the continental United States without sacrificing model resolution. Prior to that however, Baron Services' (https://www.baronweather.com) hydrological modeling group – working together with NCAR and NASA – developed a similar model called the "LIS-NOAH-V2" (LN2). Embedded within an early version of NASA's Land Information-System (LIS; https://lis.gsfc.nasa.gov) framework, the LN2 was operationally deployed at 100-meter DEM resolution (finer-scale than the NWM) using explicit "in-grid" streamflow routing over the entire country of Romania in the 2008-2012 timeframe (Matreata et al., 2013). Further, it was certified for operational use by the Romanian National Institute of Hydrology and Water Management based on calibration and regionalization results for >20 representative catchments across 11 major basins (McHenry and Burnet, 2011). The LN2 design effort contributed greatly to the eventual release of the community WRF-Hydro® model (Gochis et al., 2013).

While the LIS framework which runs LN2 has not been updated at Baron, the model itself, now called "LN2-Flood" (LN2-F) has been. It distinguishes itself from WRF-Hydro in (at least) two important ways: (1) for any given basin or system of basins: stream-channels, lakes, reservoirs, and their flow-networks are fully burned into the model's digitally derived terrain surface while using power-law relations to estimate the smooth changes in (average, trapezoidal) channel-dimensions proceeding upstream from any discharge location. Thus, entire networks become "embedded" in the modeled land-surface – as they are in nature. Bankfull flow can then be explicitly modeled with respect to the terrain (DEM) used to route the water over the land-surface; (2) utilizing these GIS methods, the dynamic model itself includes an option to feed-back bankfull overtopping flows onto the land-surface (and vice-versa). This allows the direct "on-line" estimation and spatiotemporal evolution of the (forecast) "inundated flood wave" vis-à-vis the DEM.

The approach requires no post-run processing such as the "HAND" method (Johnson et al., 2019; refer to Figure 1a). Using "raw" NWM discharge outputs at stream-junctions, the HAND algorithm provides inundation estimates that "could have reasonably" occurred had the NWM been able to simulate the inundation directly. Importantly, the HAND method does not account for the re-infiltration of inundated water on the land-surface, nor does it account for the slower progression of the entire floodplain wave as it evolves downstream. The LN2-F does both.

To demonstrate this capability, the massive inland flooding caused by Hurricane Florence (Sept. 15-18, 2018) was simulated using several LN2-F configurations deployed upstream of USGS Gauge 021080000 near Chinquapin, North Carolina. Chinquapin lies along the NE Cape Fear River, which "rose rapidly, flooding countless roadways and homes along and far away from the river with numerous tributary streams flooding as well (NWS, 2018)." Aerial video of the extensive rooftop - level flooding can be viewed at https://www.youtube.com/user/LiveStormsNetwork/playlists (Live Storms Media, 2020).

Figure 1 - USGS Hurricane Florence Event support map and aerial view (inset) of portions of Chinquapin NC near the confluence of Muddy Creek and the NE Cape Fear River in the wake of Hurricane Florence (image courtesy "LiveStormMedia").

Accounts from personnel at the Chinquapin Volunteer Fire and Rescue Squad noted that it was not until September 22 – five days after the event – that water receded from the NC-Hwy 50 roadway near the Rescue Squad facility (Figure 1; USGS Flood Event Viewer, 2020; Michael Casey, 2020). The gauge was destroyed during the event (Figure 2; USGS, 2020). Location of the gauge with respect to the full Cape Fear River basin is shown in Figure 3, and estimated total precipitation amounts and Hurricane Florence storm track are shown in Figure 4.

Six years of discharge data along with NLDAS-2 (https://ldas.gsfc.nasa.gov/nldas/v2/forcing) meteorological forcing data were used to calibrate the model, deployed at 100-meter scale based on the National Elevation Dataset (NED, 2020) and latest available WRF-based soils, land-use, and land-cover maps. The 20-day (Sept. 10 – Oct. 1, 2018) period surrounding the Florence event was omitted from the calibration analysis. This resulted in a set of model parameters "optimized" for the Chinquapin sub-basin. "Apriori" model parameters were selected from a previously calibrated Romanian basin similar in size and terrain characteristics.

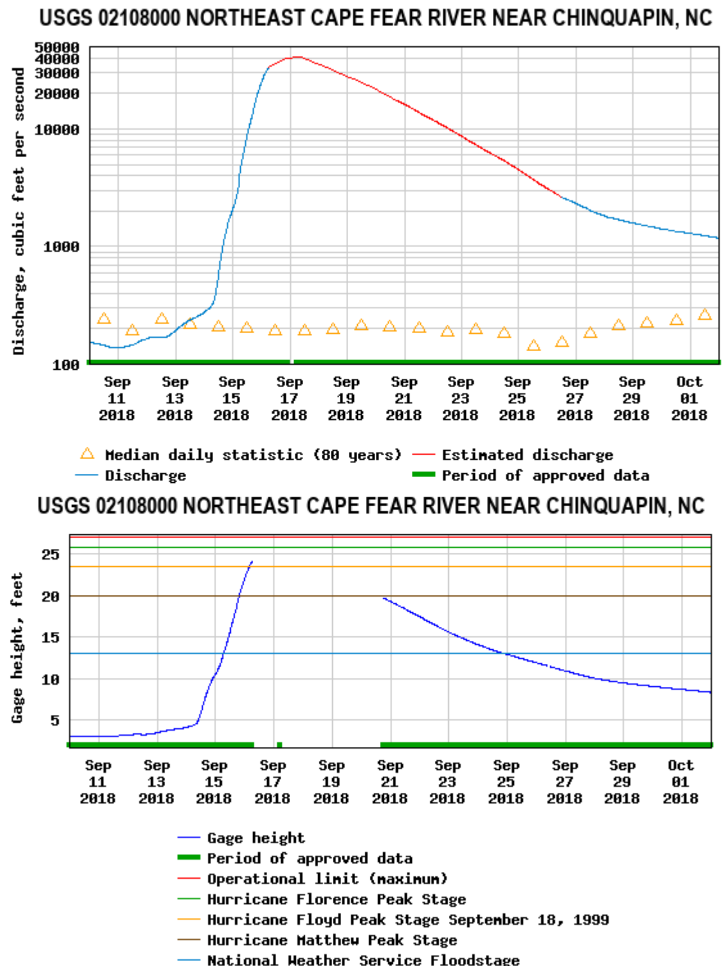

Figure 2 - Discharge (top) and Stage (bottom) near Chinquapin, NC, during the 20-days around Hurricane Florence. Gauge washed away on Sept. 16. Data suggest that near the gauge, the NE Cape Fear River did not recede to flood-stage until Sept. 25th. Due to saturation, low-lying areas remained flooded for days thereafter.

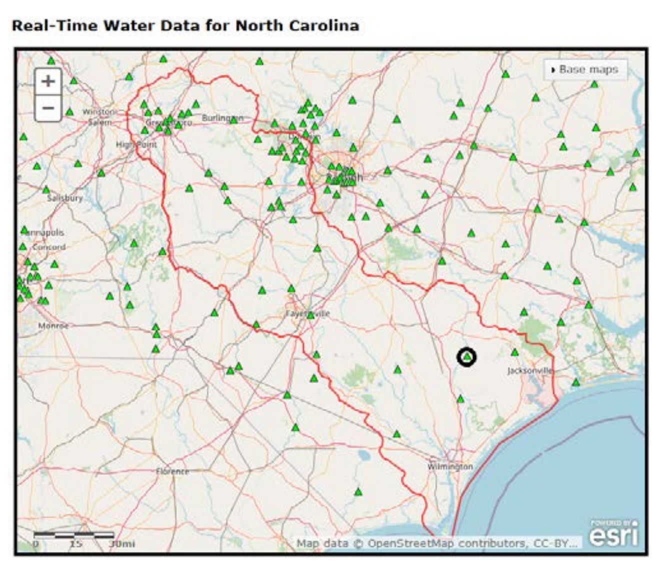

Figure 3 - Cape Fear River basin (outlined in red), showing location of USGS Gauge 021080000 (Chinquapin), circled in black.

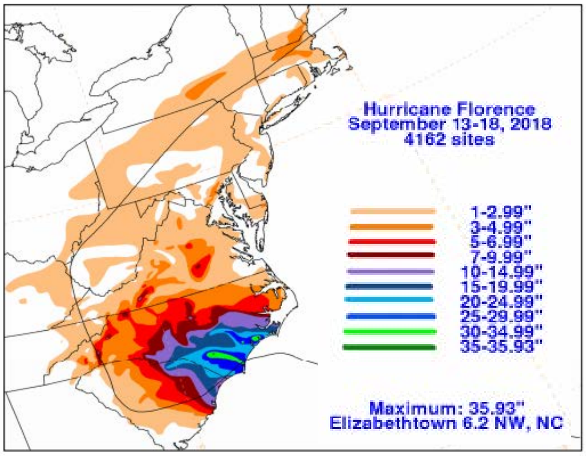

Figure 4 - Hurricane Florence track and Cumulative Precipitation Estimates (source: NWS and NOAA Weather Prediction Center).

Four model configurations resulted:

Model Parameter Settings:	Inundation Feedback Switch	
Apriori	(1) Off	(2) On
Calibrated	(3) Off	(4) On

For the six-year calibration period, the apriori (**1-Off**) Nash-Sutcliffe index was 0.065 and the calibrated (**3-Off**) NSE was 0.820. For the latter, Figure 5 shows the Levenberg–Marquardt fit (after including the Florence period) for monthly-mean total observed versus modeled discharge in cubic meters-per-second at the gauge.

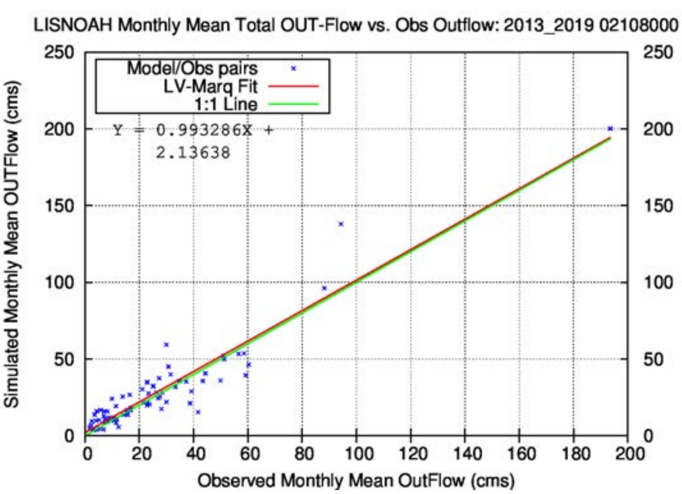

Figure 5 - Calibrated model results including the Hurricane Florence period for the water years 2013-2019, showing Levenberg-Marquardt fit of monthly mean discharge, modeled versus observed. The best-fit line has a slope near 1.0 with an extremely small low-flow bias (intercept).

The full USGS dataset used to calibrate the model and validate results is shown in Figure 6. Note that calibration is conducted with respect to discharge only, not stage.

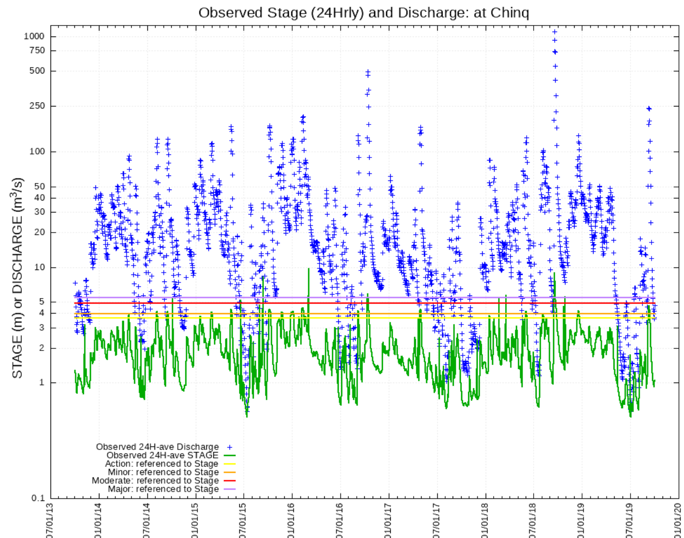

Figure 6 - Full USGS Discharge Observational Dataset used to calibrate and validate the LN2-F model. Corresponding stages are plotted in green.

Results with Inundation Feedback Turned Off

Following calibration, USGS approved/estimated discharge data during the Florence 20-day period were used to assess model performance with the inundation switch turned off (configurations 1 and 3). When the switch is off, the model's channel geometry is allowed to extend above bankfull "as if" the channel were as deep/wide as needed to convey the flood-wave. Keeping the switch off is important for calibration because once a flood-wave has inundated, stage-discharge relationships become less certain (Buahin et al., 2017; Muste and Hoitnink, 2017).

Figure 7 (on the following page) shows the apriori-uncalibrated (**1-Off**) versus calibrated (**3-Off**) results for model-predicted discharge during the 20-day period surrounding the Florence event. The Nash-Sutcliffe indices for these two configurations were 0.601 and 0.871 respectively.

Although the model does not allow inundation per-se in configurations **1** and **3**, water does accumulate on the land-surface and flows into (but not out of) the channel. Thus, it has some residence time (ponding) on the land-surface and for large events can transiently accumulate.

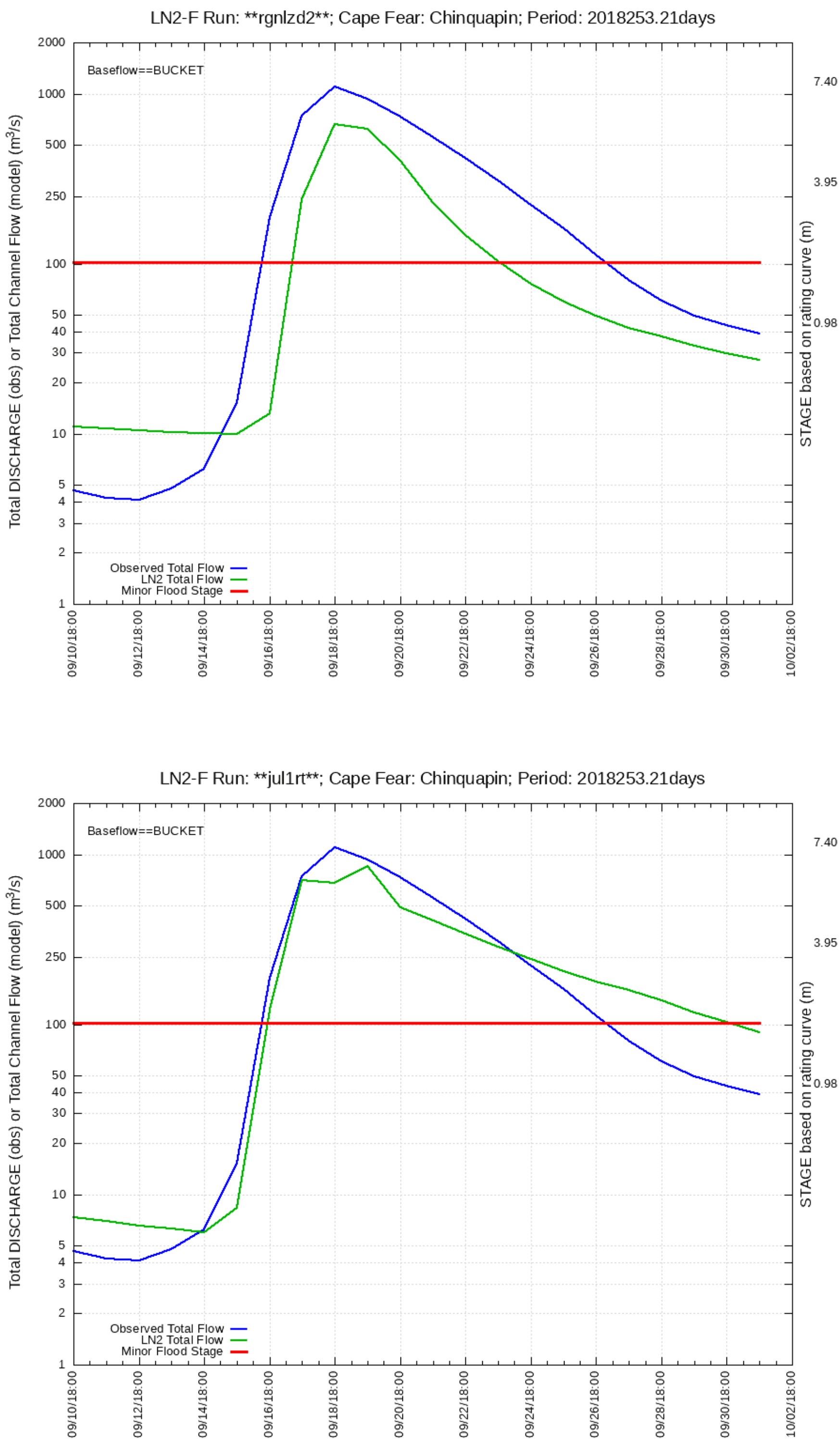

Figure 7 - Apriori-uncalibrated (1, top) versus calibrated (3, bottom) results for model-estimated discharge in cubic meters per second during the exclusive Florence 20-day period; the Nash-Sutcliffe index for these two configurations was 0.601 and .871 respectively. The red line marks National Weather Service minor flood stage in meters.

To portray this, it is convenient to construct a combined "inundation-function (**IFn**)" as (1) the Logarithm-base-10 (Log10) of the ponded water in inches when there is ponded water on cells not containing streams; plus (2) Log10 of the terrain-surface in decameters above MSL when the land-surface is dry; plus the following when model grid cells contain streams: (3a) Log10 of the stream-stage in feet when not above bankfull, or, (3b) Log10 of the depth above bankfull in inches when the stream is above flood-stage. For configurations **1** and **3** there is no excess above bankfull in the streams; thus, values shown are simply Log10 of the stream-stage in feet for stream-containing model grid cells.

The **IFn** is valuable in quickly assessing model performance and characteristics. Proceeding in the discussion using the calibrated model only, Figures 8a and 8b show configuration **3** results for pre-storm (September 14) and late-storm (Sept 17) days (24-hr averages). Differences between the unflooded pre-storm model environment and the flooded late-storm environment are evident only through close comparison of the images. On Sept. 17, ponded water emerges in lighter blue colors having "replaced" the terrain surface in the image, and the much deeper stream-stages (reds) are obvious. The approximate location of the Chinquapin gauge is marked with a star. By September 19th, all ponded water was either re-infiltrated or had reached the channel network, indicating no remaining inundation (not shown). In many areas of the basin however, inundation did not fully recede until more than two-weeks after precipitation ended.

Because the calibrated model time-integrated discharge is quite accurate for the 20-day Florence period (Figure 7 bottom), we have confidence that when inundation feedback is activated and bankfull is exceeded, the total water discharged onto the land-surface will be reasonable.

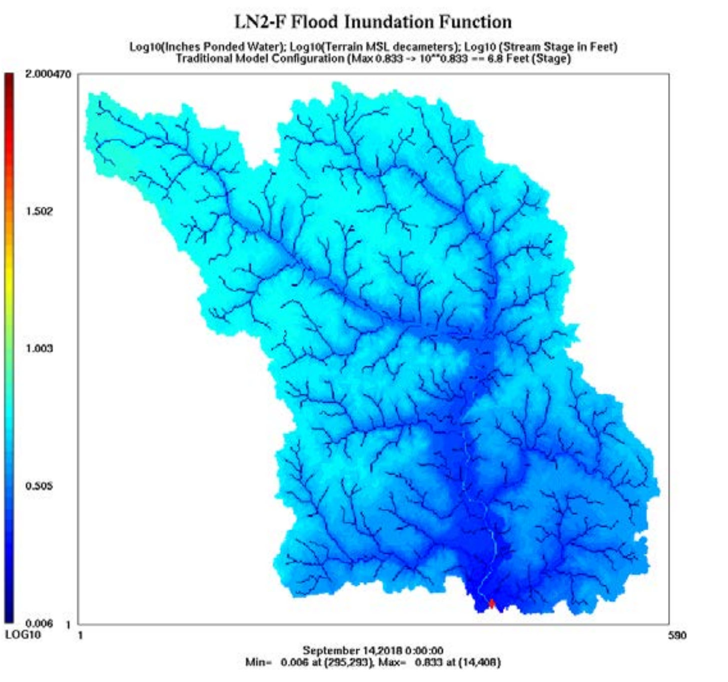

Figure 8a - LN2-F Inundation Function for calibrated traditional configuration, showing pre-storm NE Cape Fear River sub-basin results on September 14, 2018. The stream-network / DEM relationship is easily visible, with maximum channel stage of $10^{0.833}$ = 6.8 feet, well-below flood level. Gauge location is starred.

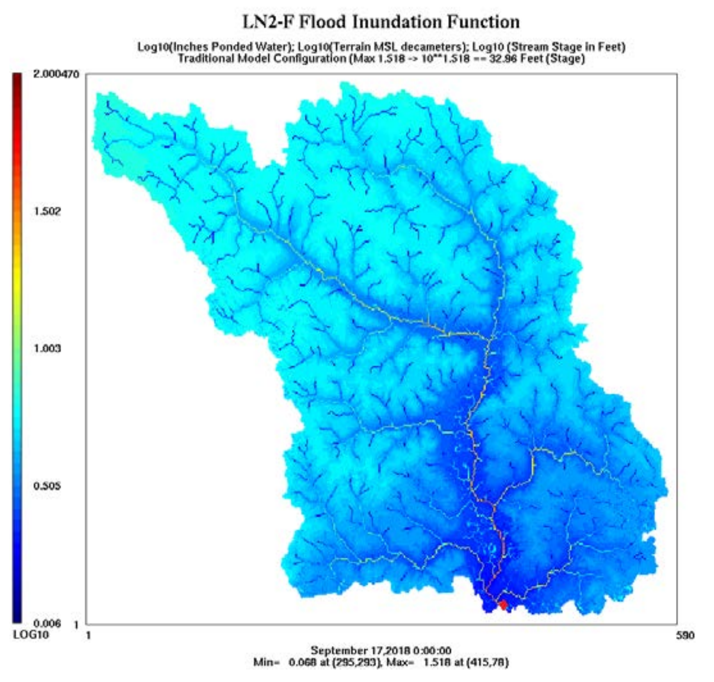

Figure 8b - LN2-F Inundation Function for calibrated traditional configuration, showing late-storm NE Cape Fear River sub-basin results on September 17, 2018. The stream-network / DEM relationship is still easily visible, but ponded-water areas emerge mainly along the riparian river/stream banks and flood-plains (e.g. light blue colors near main stem, with Log10 (depth-inches) ~ $10^{0.75}$ ~ 6-inches of ponded water. Observed inundation depths were up to (at least) 8-feet in some areas. The plot also shows maximum channel stage of $10^{1.518}$ = 32.96 feet above bed-level, slightly higher than but consistent with USGS estimated stage (following destruction of the gauge, see Figure 2, bottom panel).

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Results with Inundation Feedback Turned On

As expected in the pre-storm environment, configuration **4** results are essentially identical to configuration **3** results (see Figure 8a). However in the late-storm environment, the **IFn** reveals significant inundation along the main stem and various sub-basin tributaries that cannot be estimated without the feedback switch (Figure 9).

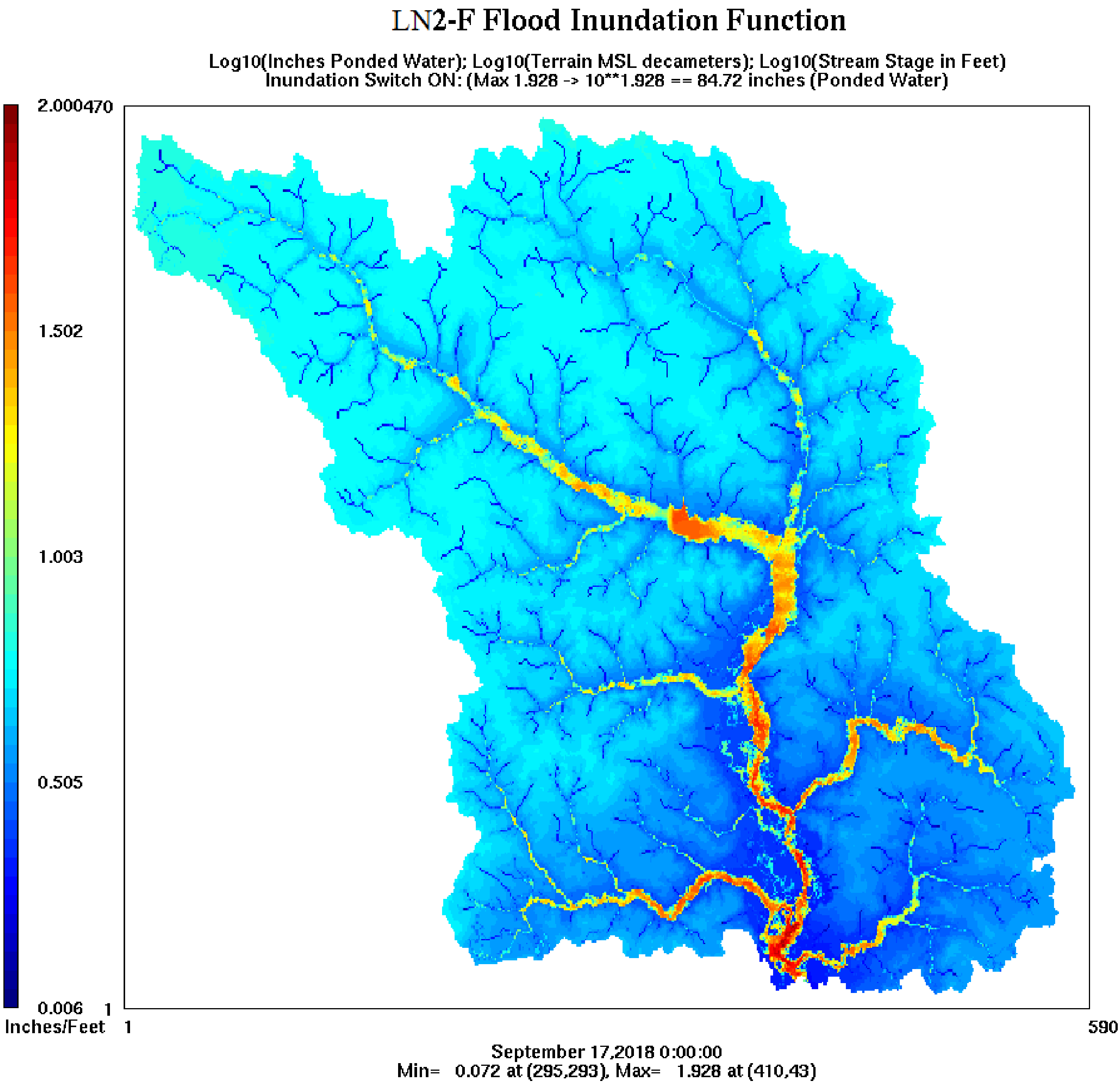


Figure 9 - As in Figure 8b, but with the inundation feedback switch turned on. Areas of likely inundation become obvious as the model forecast progresses. Using an 8-hour centered in time average valid at 00UTC on September 17th, a maximum value of $10^{1.928}$ = 84.72 inches of ponded water above the terrain surface / river-bankful is estimated. Areas of the plot with less than 1-inch of ponded water are shown as Log10 (Terrain surface in decameters). This nicely reveals the topography of the unflooded parts of the basin.

As the event unfolds in the post-storm environment, inundation is seen to evolve in a manner generally consistent with observations. A sequence of modeled 8hr-centered-average **IFn's** is shown to be valid at 00UTC on September 18, 19, 20, 21, 25, and Oct 1 in Figure 10.

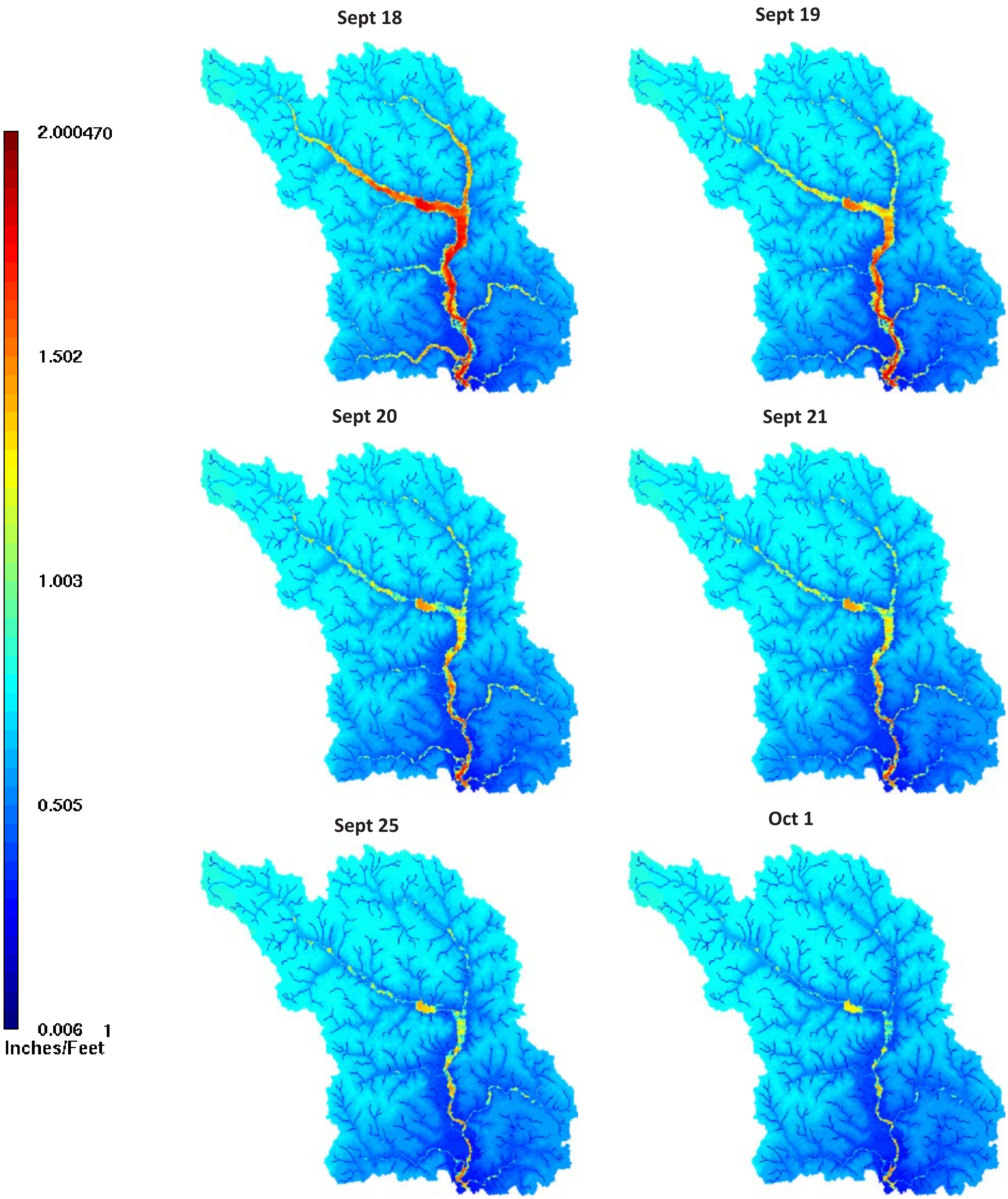


Figure 10 - LN2-F 8Hr-avg Inundation function valid at 00UTC Sept 18-21, 25, and Oct 1, 2018, proceeding from top left to bottom right.

These figures can be compared with [AER's "FloodScan"] maximum inundation map for the event (Figure 11, Galantowicz, 2018). The data reveal significant agreement between the LN2-F and satellite derived maximum inundation throughout the entire basin.

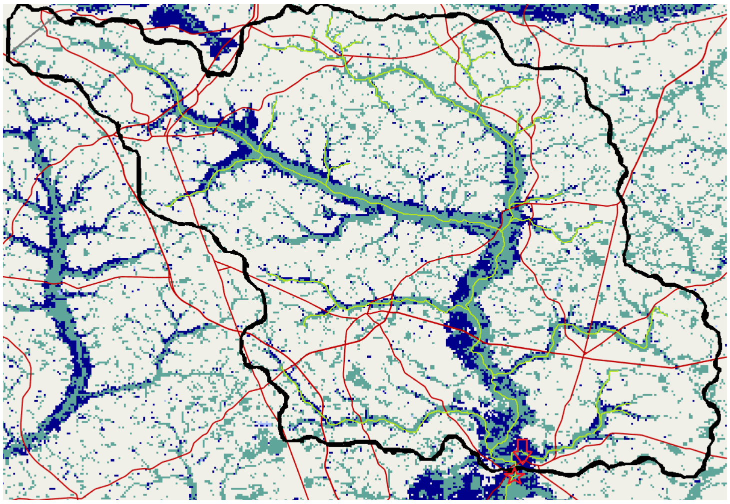
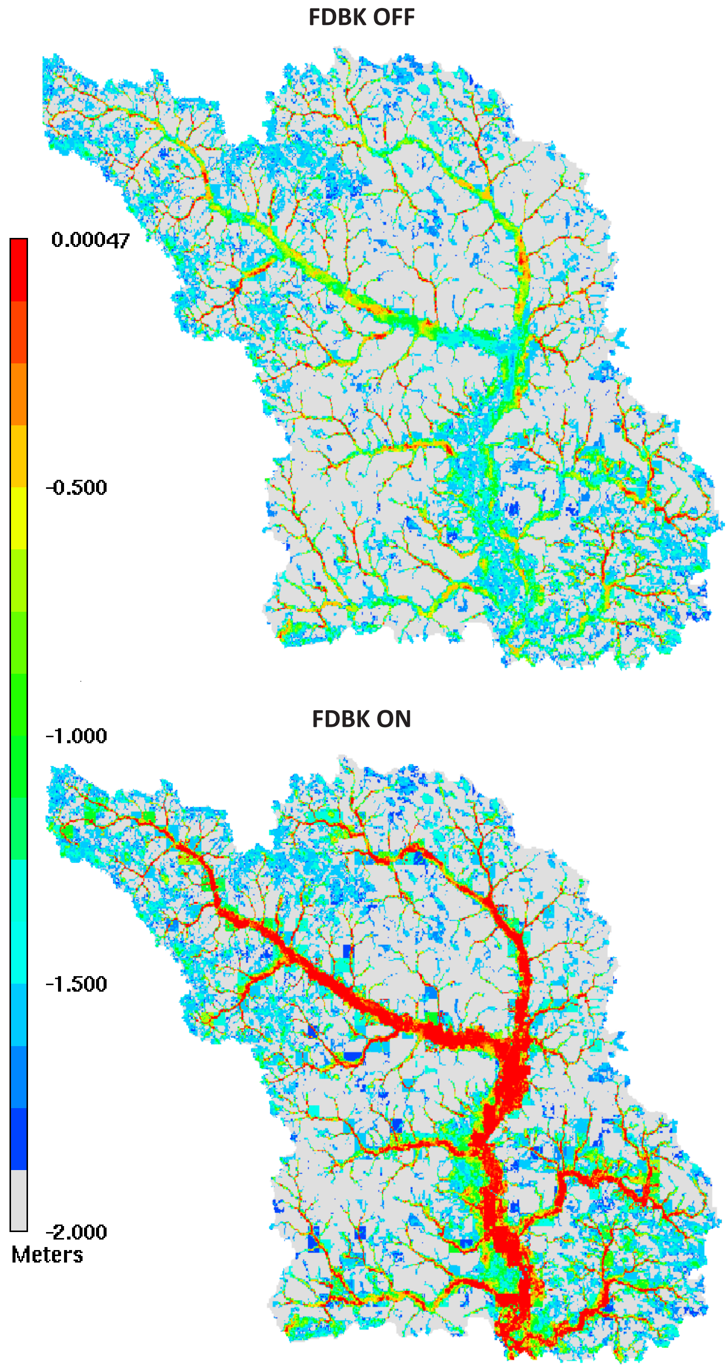


Figure 11 - "FloodScan" (AER, Inc.) satellite-derived maximum inundation estimates for the NE Cape Fear River basin upstream of Chinquapin. The LN2-F modeled area is outlined in heavy black, the town of Chinquapin is located near the arrow, and USGS Gauge 021080000 is located near the star. River/stream centerlines are shown in yellow, known-flood plains are shown in green, and dark blue shows the observed extent of inundation beyond the known flood-plains.

Another way to look at the differences between configurations **3** and **4** is to compare depth to the shallow water table. Results for Oct 1, 2018 – two weeks beyond the end of precipitation – are shown in Figures 12a and 12b. Depths equal to zero indicate the water table is at or above the land-surface, and depths of negative 2-meters indicate the water table is at or below the bottom of the modeled soil-column. Clearly, turning on inundation feedback yields saturated riparian zones consistent with the long-lasting nature of the observed inundation.

The large geographical extent of the Florence event triggered numerous high-resolution aircraft overflights conducted by the National Geodetic Survey in conjunction with NOAA and FEMA (NOAA, 2020). Figure 13 (next page) shows the survey locations. The survey corresponding to the Chinquapin area was conducted on September 18th. Figure 14 (next page) shows relevant imagery comparing pre-storm (top) and Sept 18th overflight (bottom) environments from



Figures 12a and 12b - Comparison of depth to the shallow water table between inundation switch off (top) versus on (bottom) for Oct 1, 2018. With the switch on, the soil columns throughout most of the sub-basin flood-plain (including tributaries) are saturated; however, with the switch off, significant post-storm soil drying is already occurring. Flood waters did not recede for more than two weeks in many areas.

aloft.

The red line on the bottom panel (Figure 14) depicts the boundary of the aerial photography; the mid-line of the NE Cape Fear River is shown in yellow on both frames. We compared the survey imagery with LN2-F inundation results valid at 12UTC on Sept 18, shown in Figure 15 (on the following page). Model results are qualitatively like the photographic evidence, with large swaths of inundated land on both sides of the NE Cape Fear River channel as well as areas on both sides of Muddy Creek (reference location in Figure 1) proximate to the town of Chinquapin.

Figures 16 and 17 (on the following pages) compare photographic and modeled event-maximum inundation zoomed in near the Muddy Creek/NE Cape Fear River confluence. Geo-location of the USGS stream-gauge is starred in both figures. In Figure 16, the extent of significant inundation along and either side of North Carolina Highway 50 is easily seen (compare against Figure 1). In Figure 17, LN2-F clearly under-predicts the maximum inundation in and surrounding the western half of the village (outlined/hatched in pink). The most significant contributor to this under-prediction is likely the formulation of the modeled outflow (flux) boundary condition, which is tuned to not allow bankfull overtopping at a channel discharge terminus (grey arrow, Figure 17, top). However, in nature, extensive long-lasting inundation occurred at and well downstream along southern sections of the NE Cape Fear River not included in the model domain. The result of the “default” boundary condition was to discharge water at an unrealistically large rate below the gauge location, preventing additional inundation from occurring proximate to the Chinquapin area.

Thus, we are studying options to improve the formulation and we expect these to be useful in future applications, including direct coupling to ocean-hydrodynamic/tidal models. Notwithstanding, these results represent a vast improvement over those available from the standard configuration **3** version of the model. Despite the flaw in the channel discharge boundary condition, the model performs extremely well (better!) when compared to the official NOAA AHPS flood inundation 100-year recurrence map for this gauge (Figure 17, bottom). Taken over the whole basin, the event maximum inundation also compares extremely well with satellite-based observations.

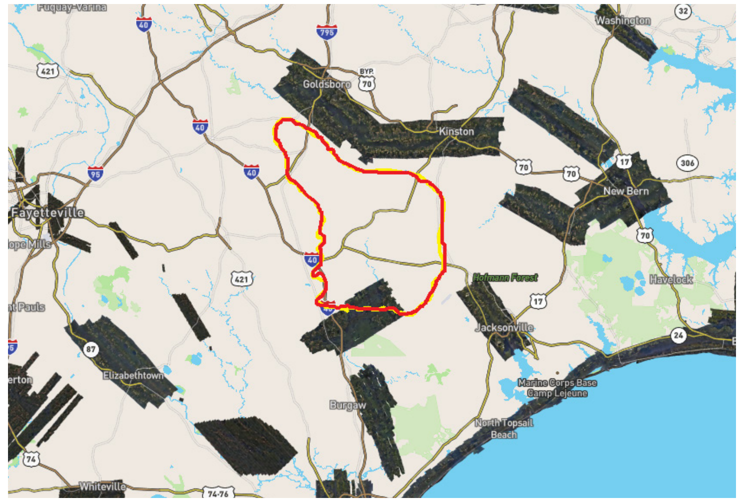


Figure 13 - National Geodetic Survey aerial imagery/survey locations collected as a result of Hurricane Florence. The NE Cape Fear River basin upstream of Chinquapin is outlined in red. The corresponding survey was conducted on September 18.

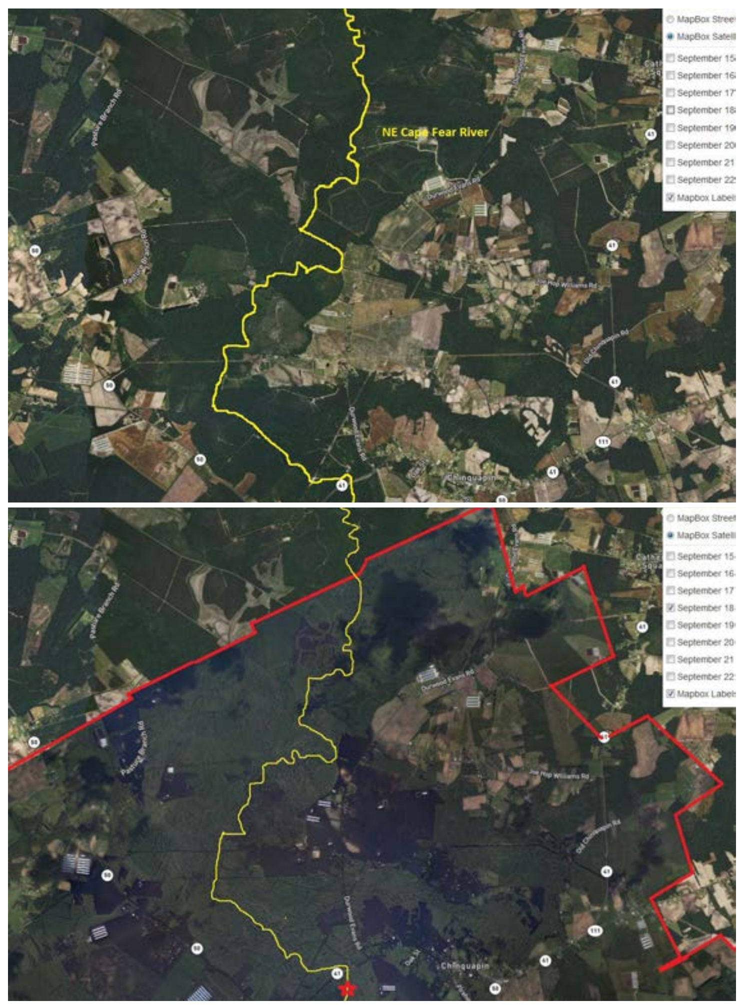


Figure 14 - National Geodetic Survey aerial imagery comparing pre-storm (top) and Sept 18th overflight (bottom) environments from aloft. The red line on the bottom panel depicts the boundary of the aerial photography; the mid-line of the NE Cape Fear River is shown in yellow.

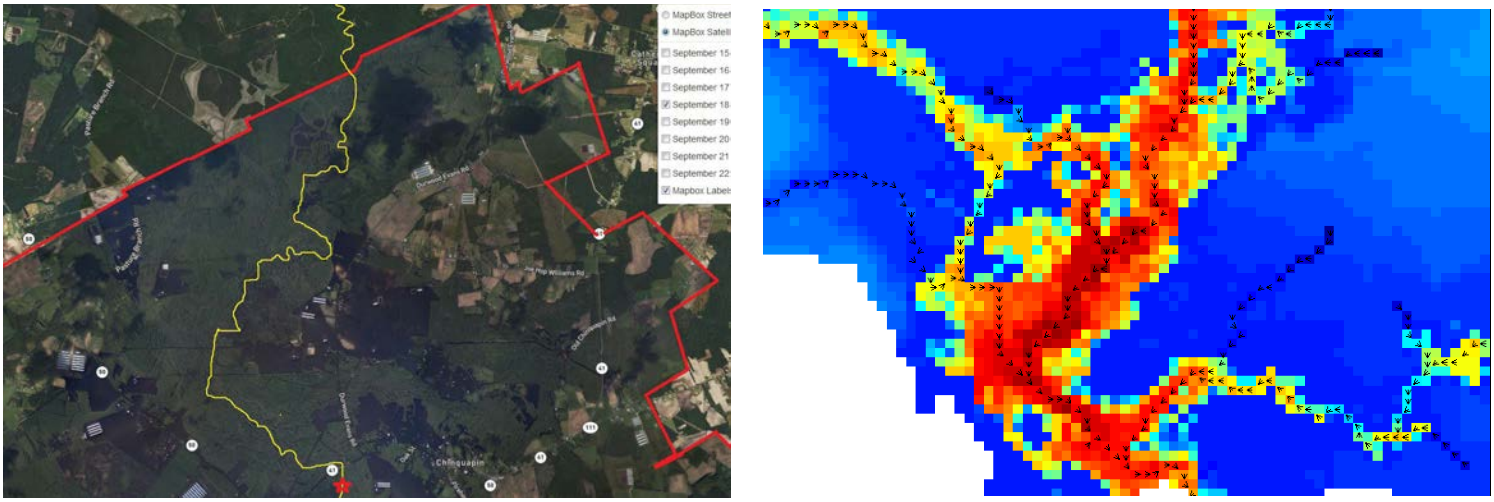


Figure 15 - National Geodetic Survey inundation imagery on Sept 18th within red boundary near and north of Chinquapin (left); and model-estimated inundation for same approximate area (right) valid 12UTC, Sept 18. Gauge location is starred (left).

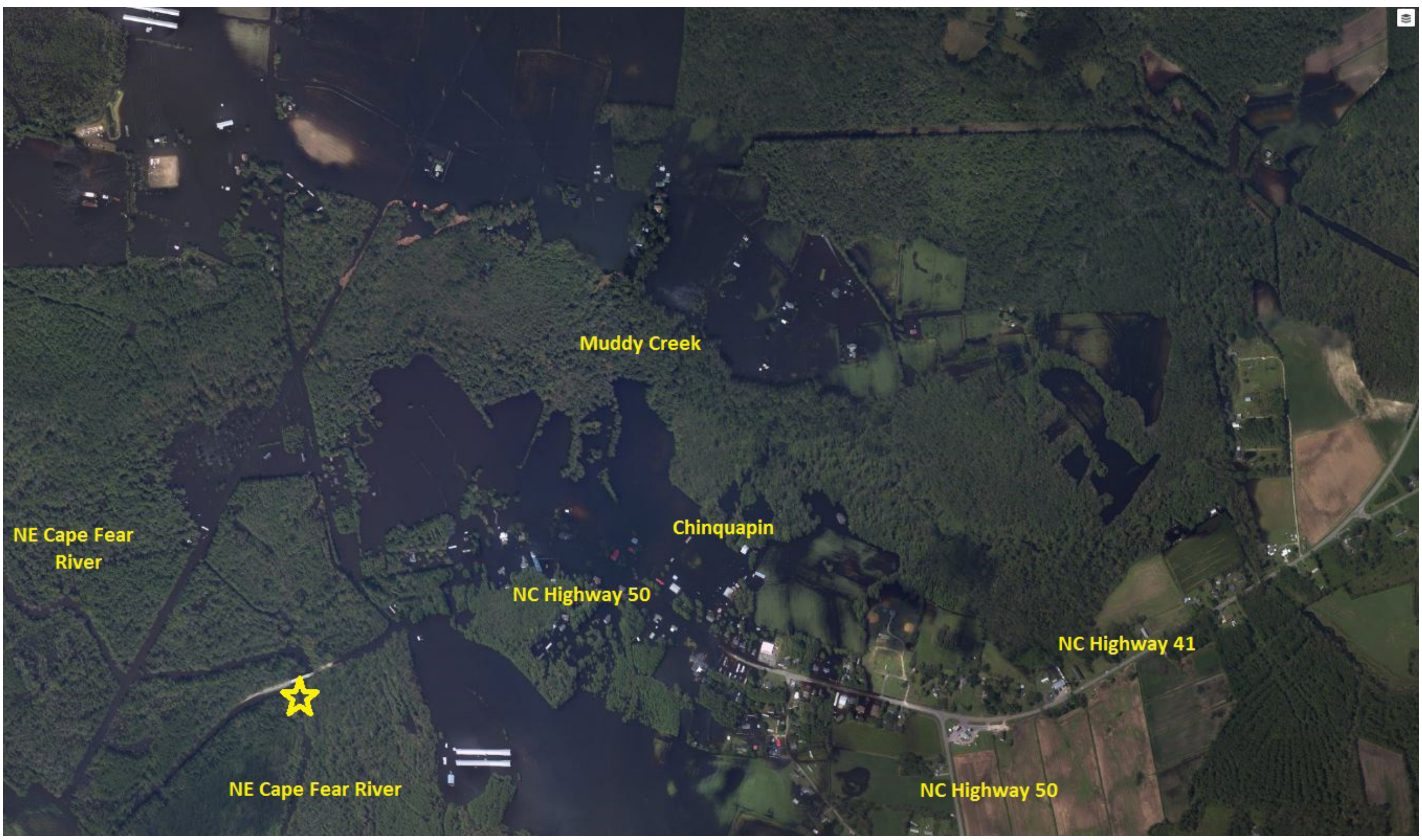


Figure 16 - National Geodetic Survey imagery zoomed in to the town of Chinquapin on Sept 18th. (Cross reference against the pre-storm imagery shown in Figure 1).

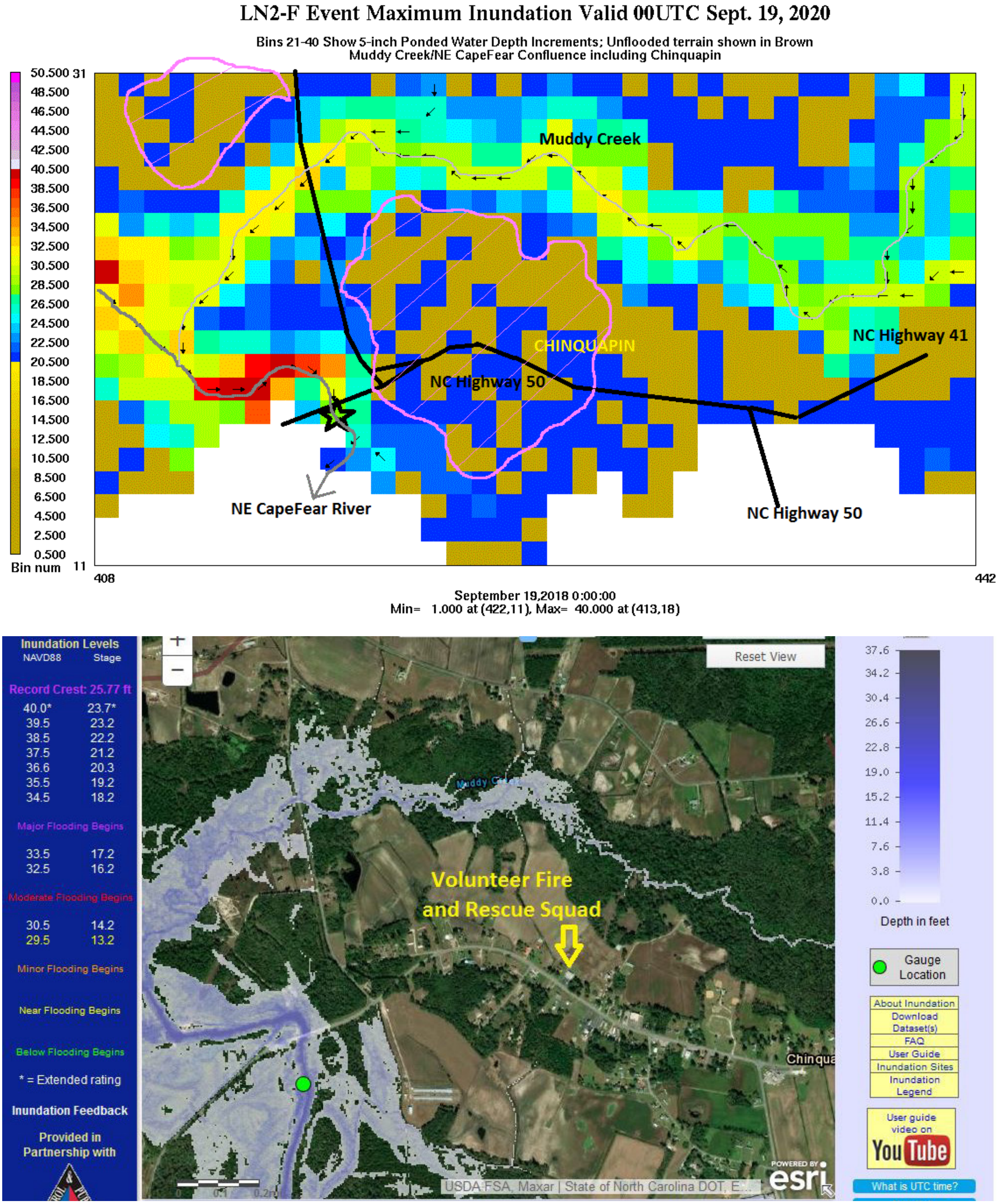


Figure 17 - Top: LN2-F event-maximum inundation (blue/green/yellow/red color bins) in 5-inch increments, with ½ inch minimum; darkest red >= 100 inches. Bounded hatched pink represents areas of inundation under-prediction compared to overflight imagery shown in Figure 16. The model outflow location is shown with the grey arrow; geo-referenced gauge location is starred. Highway/road locations are approximate. Bottom: NOAA Advanced Hydrologic Prediction Service 100-year recurrence flood inundation estimate for the gauge at Chinquapin.

Conclusions

In this short article, we have described a novel implementation among the family of models closely related to WRF-Hydro. The LN2-F version allows for tight internal coupling between streamflow routing and overland flow routing, permitting the simulation of flood inundation fully online. Taken over the whole basin, the event maximum inundation compares extremely well with the satellite-based observations (Figures 18, 11).

Two important advancements are presented:

(1) as in nature, stream-stage greater than bankfull is allowed to directly spill-back onto the modeled land-surface, while at the same time ponded water on the land-surface is allowed to spread as well as flow downstream through the modeled floodplain, including the portion in the channel not above bankfull. This coupling occurs within the internal computational solver at a modeled timestep on the order a few seconds;

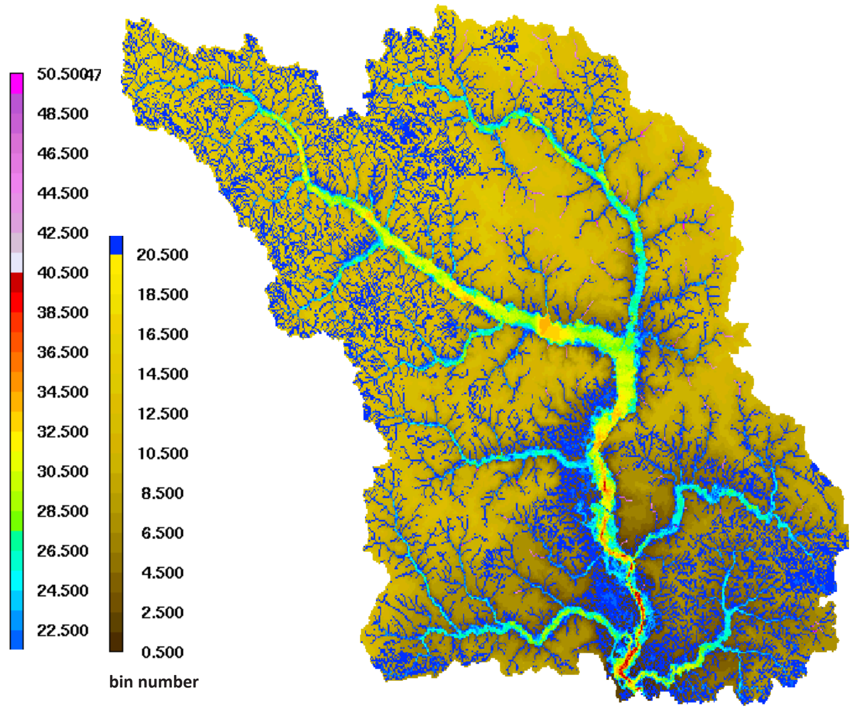


Figure 18 - LN2-F simulated event-maximum inundation over the entire basin. Brown hues portray terrain heights (bins 1-20) in 10-feet increments where inundation did not occur; blue-through-red hues (bins 21-40) represent inundation depths between 0.5 and 100.5 inches, and light-through-dark pink hues (bins 41-50) represent stream-pixels that did not overflow, showing maximum fraction of bankful stage in percentages between 0-99.99%. Compare with Figure 11 satellite observations.

(2) as a result, inundation-water also continually infiltrates the soil-column and moves downward through it into the groundwater store. As in nature, this allows some inundated water to not arrive at downstream locations. This stands in contrast to traditional configurations including the NWM in which all water that drains off the land-surface into a channel remains confined to the channel via extension or abstraction of channel geometry.

Note that because the geometry of the modeled floodplain is limited by DEM resolution, it is expected that finer resolution simulations will provide more exact inundation extents and modeled depths. Planned improvements to the outflow boundary condition will also contribute to more accurate results. Together, these two advancements contribute to improved science-process reality and the possibility of using the model to directly forecast real-time inundation events and their long-lasting extents with no post-processing required (Figure 18).

For more information on the modeling system for operational application, please email the author at: john.mchenry@baronweather.com

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NEWS & EVENTS

2021 National Conference Postponed

Unfortunately, we have not seen sufficient improvement in Covid-19 numbers or lifting of related travel restrictions to allow us to effectively plan or meet safely in-person in June 2021. We will be working to secure new dates in late Spring/early Summer 2023 in Breckenridge, CO. Keep an eye on your email and our conference page!

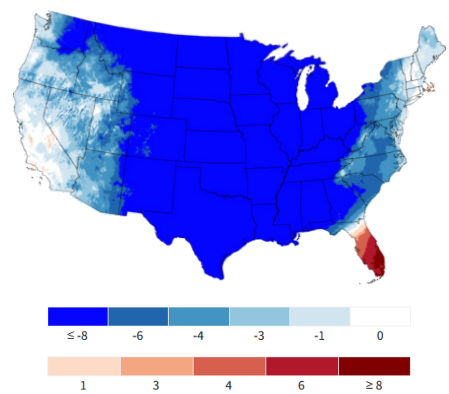
NHWC Transmission Face Lift

The Transmission has received a face lift! This includes a modern design, an updated Hydrologic Conditions dashboard, a new Interview series, and a bit more detail on our Parting Shot. We welcome feedback and ideas on how to provide you with relevant, useful content. Contact the editors at Editor@HydrologicWarning.org to provide feedback, offer help, submit an article, or propose an interview.

Record Freeze Shuts Down Texas

A record freeze caused widespread failure of Texas' power and water systems. Millions went without power and/or water for up to a week. The 30-day departure from normal temperature shows the story, with most of the country experiencing temperatures greater than 8°F lower than normal. Houston experienced a record low of 13°F and remained below freezing for 20-hrs at George Bush International Airport (IAH). Dallas experienced a low of -2°F and pools froze over.

30-day Depature from Normal Temperature as of Feb. 21, 2021



NHWC Calendar

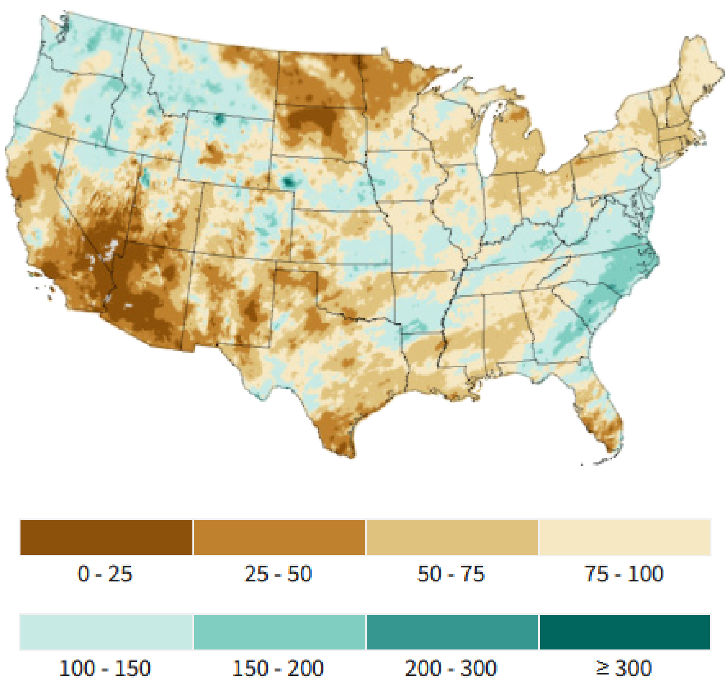
March 31, 2021	FWS Webinar Series - Collecting Rainfall
April 28, 2021	FWS Webinar Series - Collecting Stage
May 26, 2021	FWS Webinar Series - Other Data Collection
October 13-14, 2021	Texas Workshop, San Marcos, Texas (in-person)

General Interest Calendar

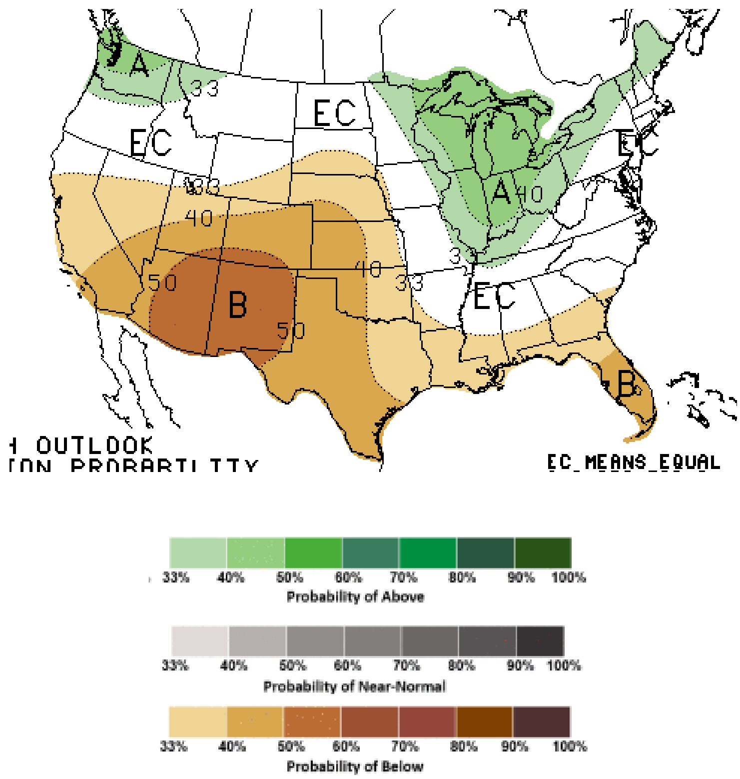
May 9-13, 2021	American Meteorological Society Conference on Hurricanes and Tropical Meteorology, Virtual
May 10-14, 2021	ASFPM, National Conference, Virtual
May 11-12, 2021	American Meteorological Society 13th Fire and Forest Meteorology Symposium, Virtual

HYDROLOGIC CONDITIONS

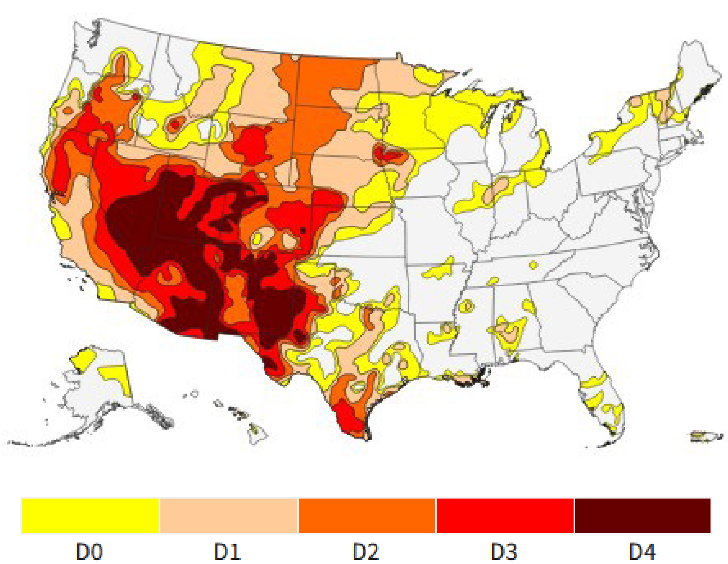
60-day % of Normal Precipitation
Last Updated 03/06/21



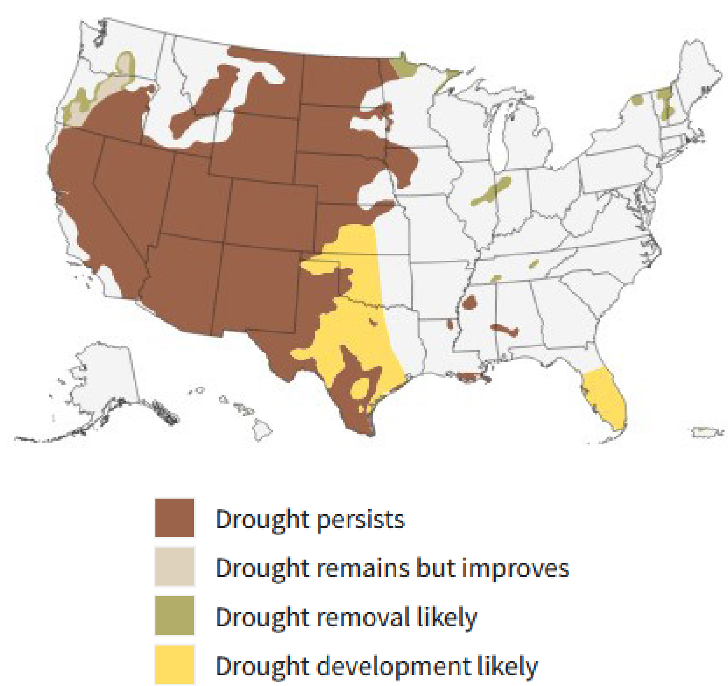
3-mo Precipitation Outlook
Last Updated 02/18/21



Current Drought Conditions
Last Updated 03/02/21



3-mo Drought Outlook
Last Updated 02/18/21



Sources: https://www.drought.gov/forecasts
https://www.cpc.ncep.noaa.gov/

TEXAS WORKSHOP

OCTOBER 13-14, 2021 / **EMBASSY SUITES** / San Marcos, Texas

CONFERENCE TOPICS

- Field Maintenance and Procedures
- Lessons Learned from Flood Events
- ALERT, ALERT2, Radio & Satellite Telemetry
- Advances in Hydrologic Technology
- Modeling and Flood Forecasting
- Inundation Mapping
- Communication Before, During, and After Weather Events
- Dam Safety

Call for Abstracts - September 13, 2021 Deadline

The National Hydrologic Warning Council invites engineers, meteorologists, and hydrologic staff to submit abstracts for presentation at our 2021 Texas workshop in San Marcos, TX. This workshop will feature a range of exciting talks, discussions, and networking opportunities with experts, vendors, and up-and-coming leaders to assist managers and operators of hydrologic warning systems. Due to the postponement of the 2021 National Conference, we are considering extending the workshop to include October 12th, so please let your voice be heard if you plan to attend or present.

> *"I recognized a surge of energy ... in the jam-packed technical agenda, the networking, the conversations in the hallway, ... and the enthusiasm of attendees. Our conference ... provided all attendees ample opportunity to learn and grow as professionals."*
>
> *Ben Pratt / NHWC Treasurer*
>
> *2019 National Conference Committee Member*

Conference Abstract Submission

Abstracts and biographies must be submitted by September 13, 2021 online using the Abstract Submission Form Link (currently being setup).

Presentations are 30 minutes, including a Q&A period.

FLOOD WARNING SYSTEM WEBINAR SERIES LAUNCHES

WEBINAR TOPICS

Overview of Flood Warning Systems

Basic Hydrology

Collecting Rainfall

Collecting Stage

Other Data Collection

Battiers and Solar Panels

Transmitting Data

Data Evaluation

Upgrades & Installation

Flood Modeling & Forecasting

Communicating Data

The mission of the NHWC is to provide education, training, and standards for the generation, delivery, and use of timely, reliable hydrologic information. With the ongoing Covid-19 pandemic, the NHWC Board of Directors recognized the need to provide more frequent training and professional development opportunities to members and non-members alike. The Board decided to reform the Training & Professional Development Committee, and put out a request for volunteers to assist with the advancement of our professional development program by planning and executing workshops, webinars, training courses, and other professional development opportunities throughout the year.

The Committee would like to thank everyone that responded to the training survey. The survey was well received with a lot of great feedback from members. Based on the survey, the committee decided to move forward with a monthly webinar series about Flood Warning Systems. The series provides a basic overview of Flood Warning Systems and the topics that are fundamental to planning, operating, and maintaining those systems. Our first three webinars in January, February, and March were a huge success, with over 150 attendees at each webinar!

"Outstanding!!! Best webinar I have ever watched and extremely solid advice on what is needed to build and sustain an effective LFWS. I think you guys pretty much covered it all in such a nice concise way. Wow!"

Interested in Speaking?

Contact Josh Herbert, Training and Professional Development Committee Chair at:

jherbert@calcasieuparish.gov

PARTING SHOT

DECEMBER 17, 2019 / TIDE GAUGE / Newport Beach, California / 33.609736° , -117.894865°

by Jeffery Budnick / Hydrologist & Scientist / WEST Consultants, Inc.

The tide gauge was installed for the City of Newport Beach, CA to provide local water level monitoring in Newport Bay. The gauge gathers data that is specific to Newport Bay and helps the City better understand events that lead to flooding, which is especially important as King Tides now approach the top of the seawall at some locations in the Bay. Prior to installation, the nearest tide gauge was in Los Angeles, CA (23 miles away).

Send Us Your Best Shot!
Editor@HydrologicWarning.com

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