



Real-Time Flood Resilience for TxDOT

- Presented by David R. Maidment
Center for Water and the Environment
University of Texas at Austin
- Based on TxDOT RTI Project 0-7095 “Evaluate Streamflow Measurement at TxDOT Bridges” (2021 – 2023)
- Project partners: Center for Water and the Environment, US Geological Survey, Kisters, Aqua Strategies



TxDOT Priorities

✓ SAFETY

- Our staff, our community
- Emergency response

✓ CONNECTIVITY

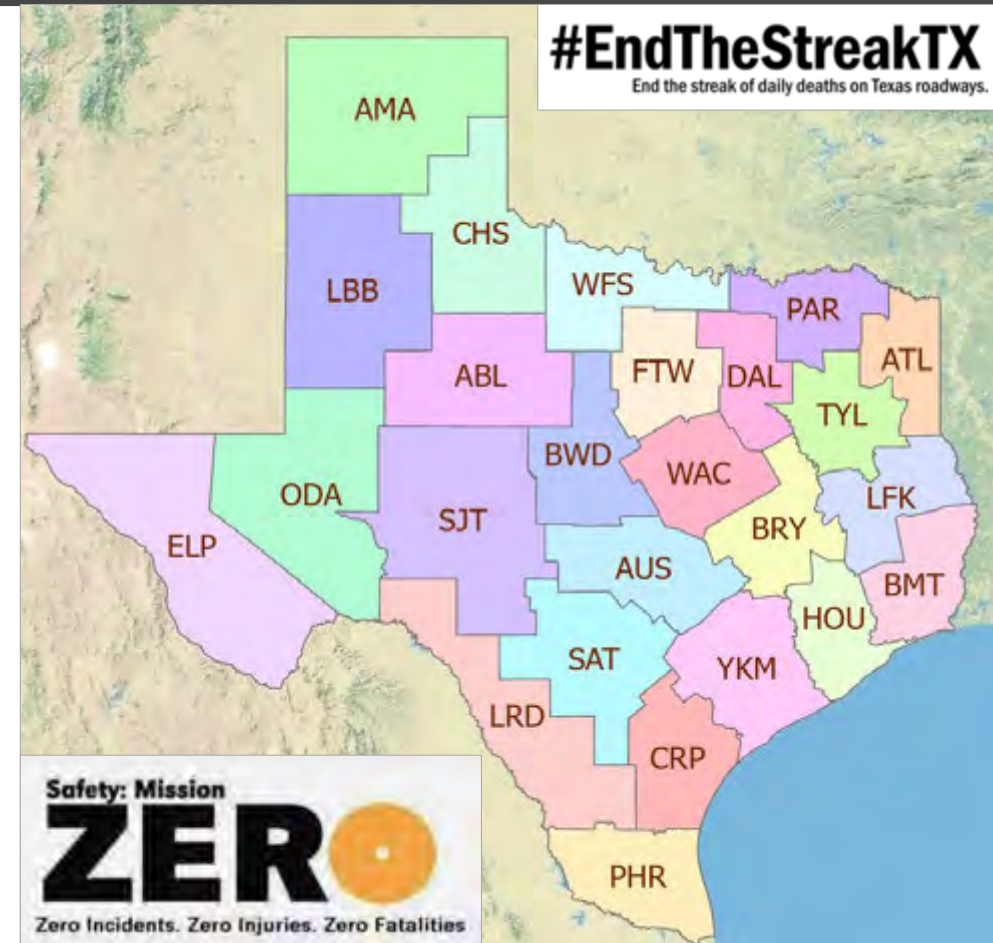
- Reliability of the transportation network

✓ Asset management

- *BRIDGES*

✓ Efficiency and efficacy

- For TxDOT
- For other/all jurisdictions



Connecting
You with **TEXAS**

TxDOT Project Management Committee



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H&H Section Director
DES



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H&H Engineer
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TPP



Abderrahmane Maamar-Tayeb
H&H Section Team Lead
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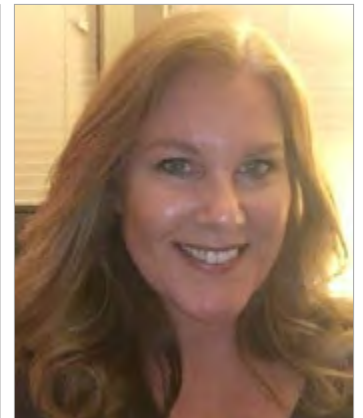
Valerie Taylor
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Dir of Trans Plan & Dev
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Andrew Lee
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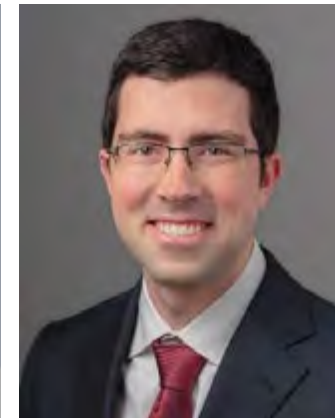
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Bridge Info Grp Lead
BRG

Project Advisory Committee

NOAA National Weather Service	State and Local Agencies
Jason Johnson , West Gulf River Forecast Center	Peter Smith , former TxDOT Director TPP
Paul McKee , Southern Region HQ	Justin Terry , Harris County Flood Control District
Paul Yura , Austin/San Antonio Weather Forecast Office (WFO)	Jorge Urquidi , City of Austin, Flood Early Warning System
Jonathan Brazzell , Lake Charles, LA, WFO	Christina Bryant , City of Austin, Flood Early Warning System
Katie Landry-Guyton , Houston/Galveston WFO	Sam Marie Hermitte , Texas Water Development Board
Amanda Schroeder , Dallas/Fort Worth WFO	

Infrastructure Investment and Jobs Act

Definition of Resilience

“Ability to anticipate, prepare for, and adapt to changing conditions, and to withstand, respond to, and recover quickly from disruptions.”

Flood Resilience

- Real-time (focus of this presentation)
- Long-term



Move from Reactive response to Proactive response

Reactive Response

Maintenance Staff
observing **current**
flood conditions



EOC staff



Decisions based on
current conditions

Move from Reactive response to Proactive response

Proactive Response

Maintenance Staff observing **current flood conditions**



EOC staff



Predictive Storm and Flood Maps



Decisions based on current and predicted conditions

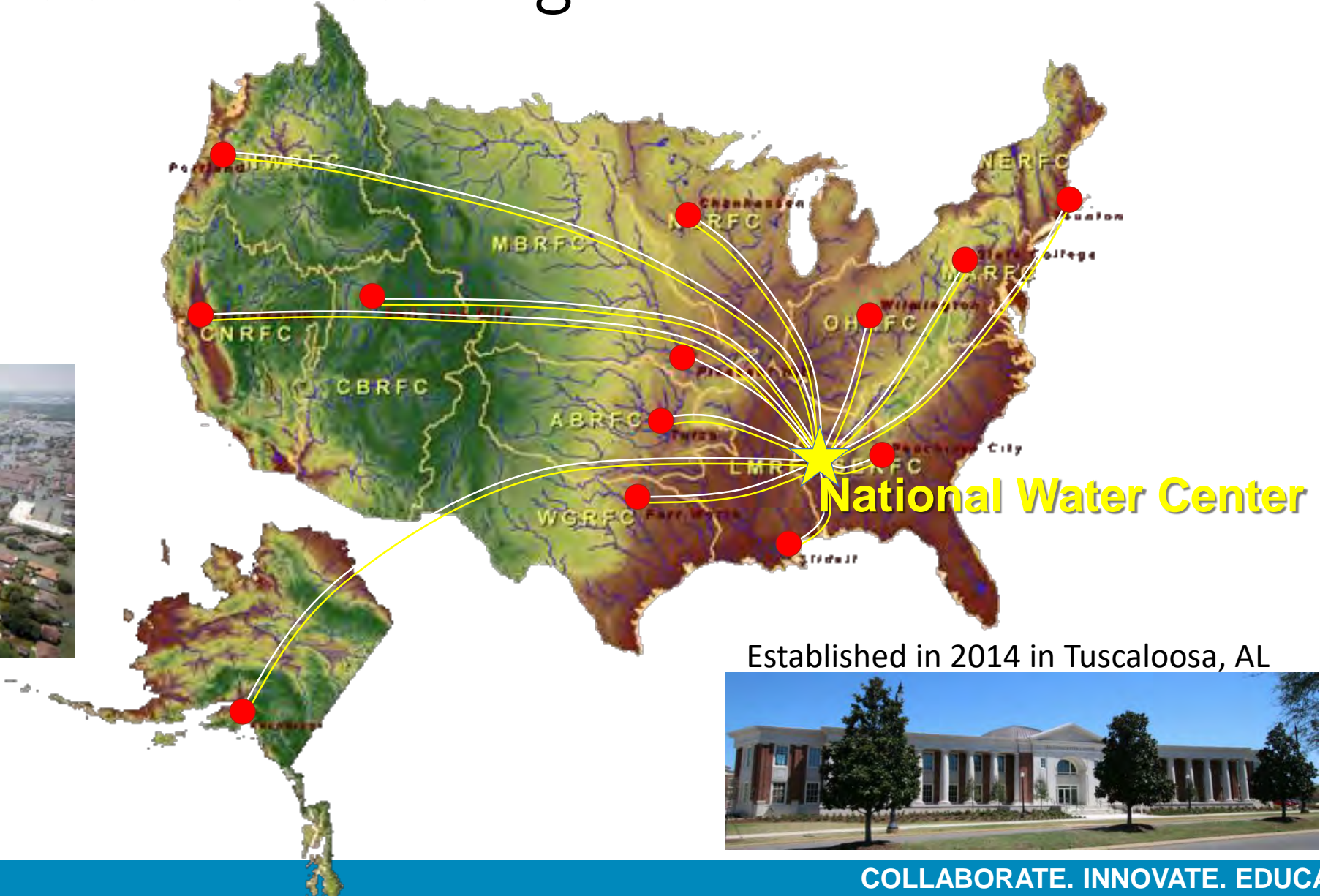
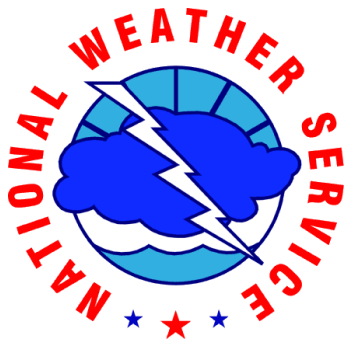
Advance warning of location, extent and severity of flooding

Real-Time Flood Resilience for TxDOT

Flood Forecasting ...



National Flood Forecasting



National Water Model

Water forecast like weather 24/7/365

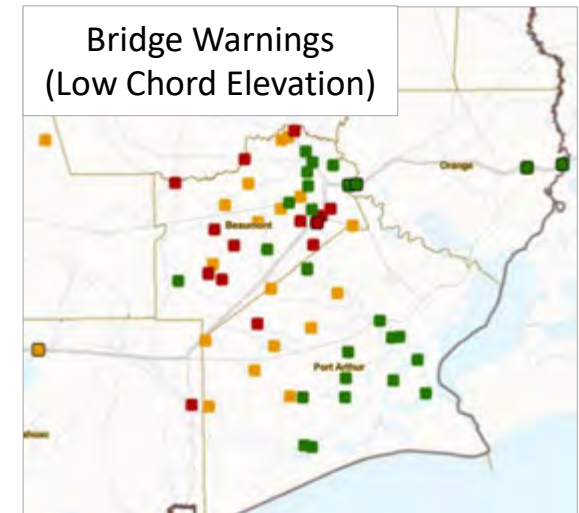
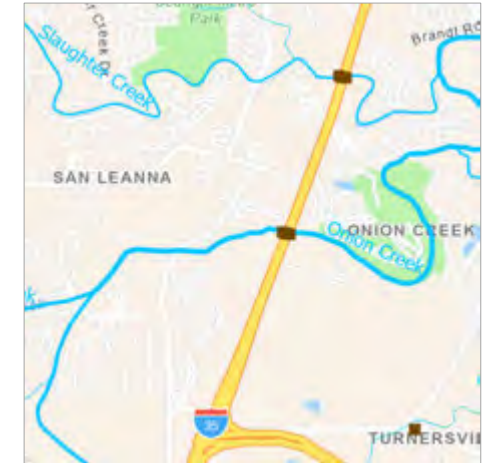
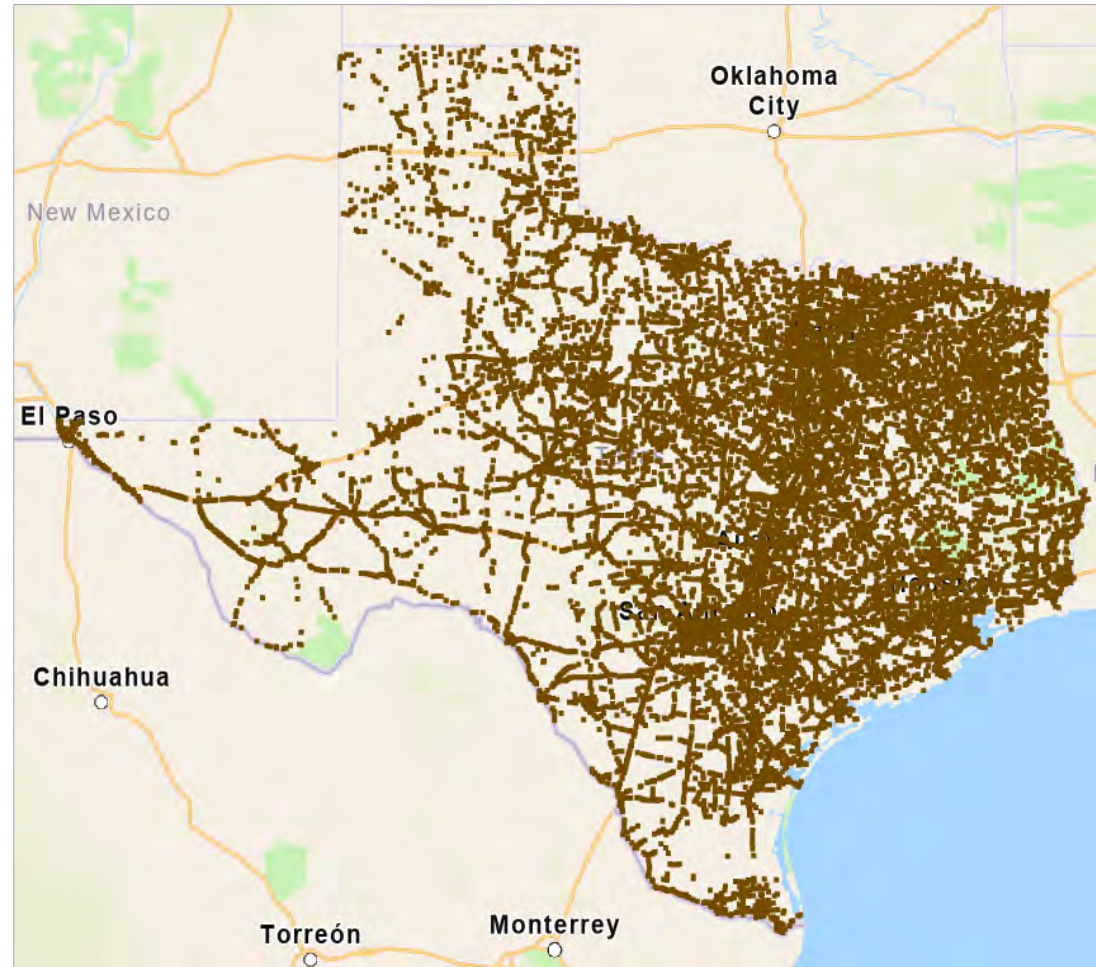
Four model outputs:

- **Assimilation** (Current conditions)
- **Short Range Forecast** (18 hours ahead)
- **Medium Range** (10 days ahead)
- **Long Range Forecast** (30 days ahead)



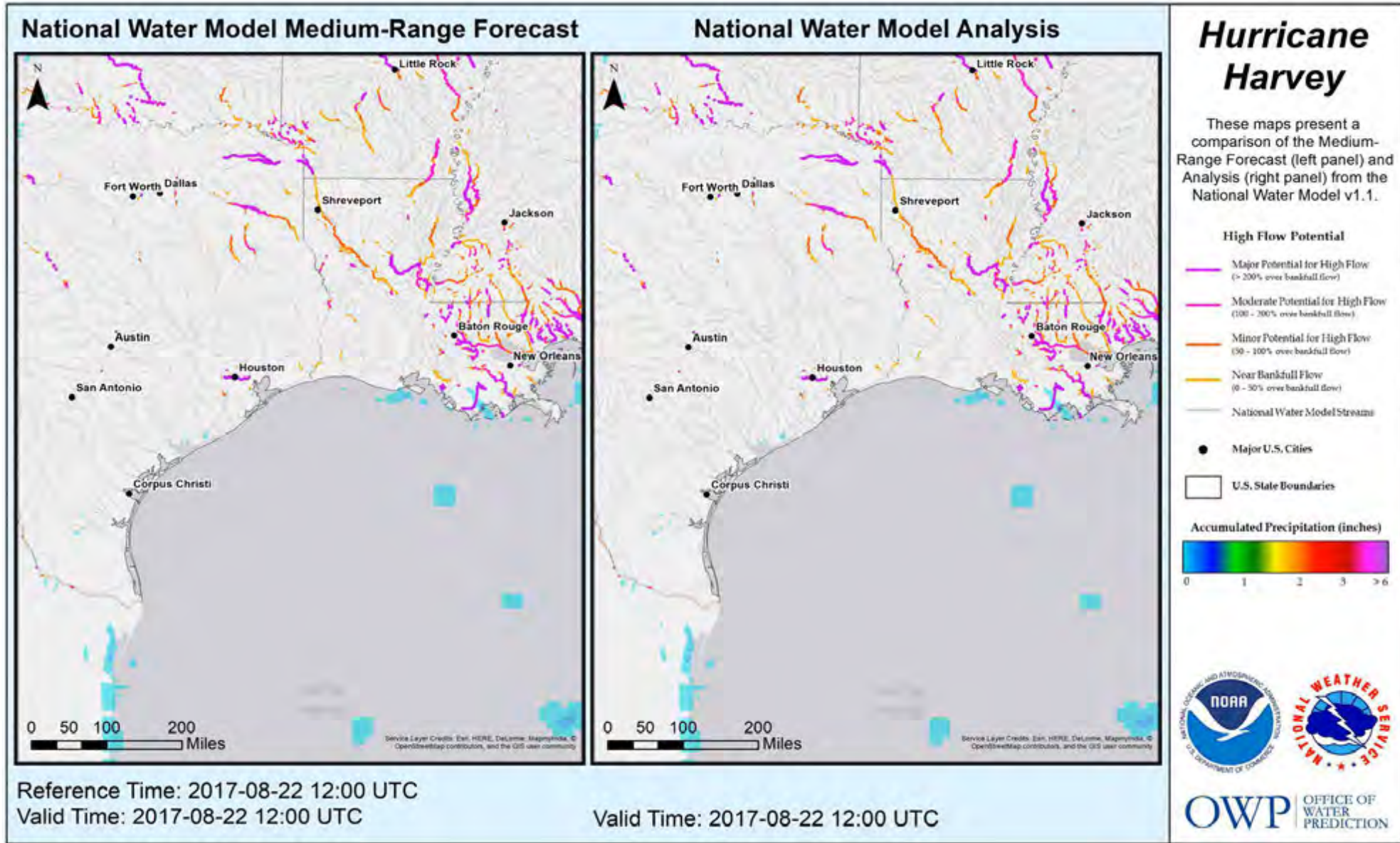
Water flow forecasts on 190,000 miles of streams and rivers in Texas

Provide Forecasts for 26,000 TxDOT On-System Bridges



10-day Ahead Forecast

Actual

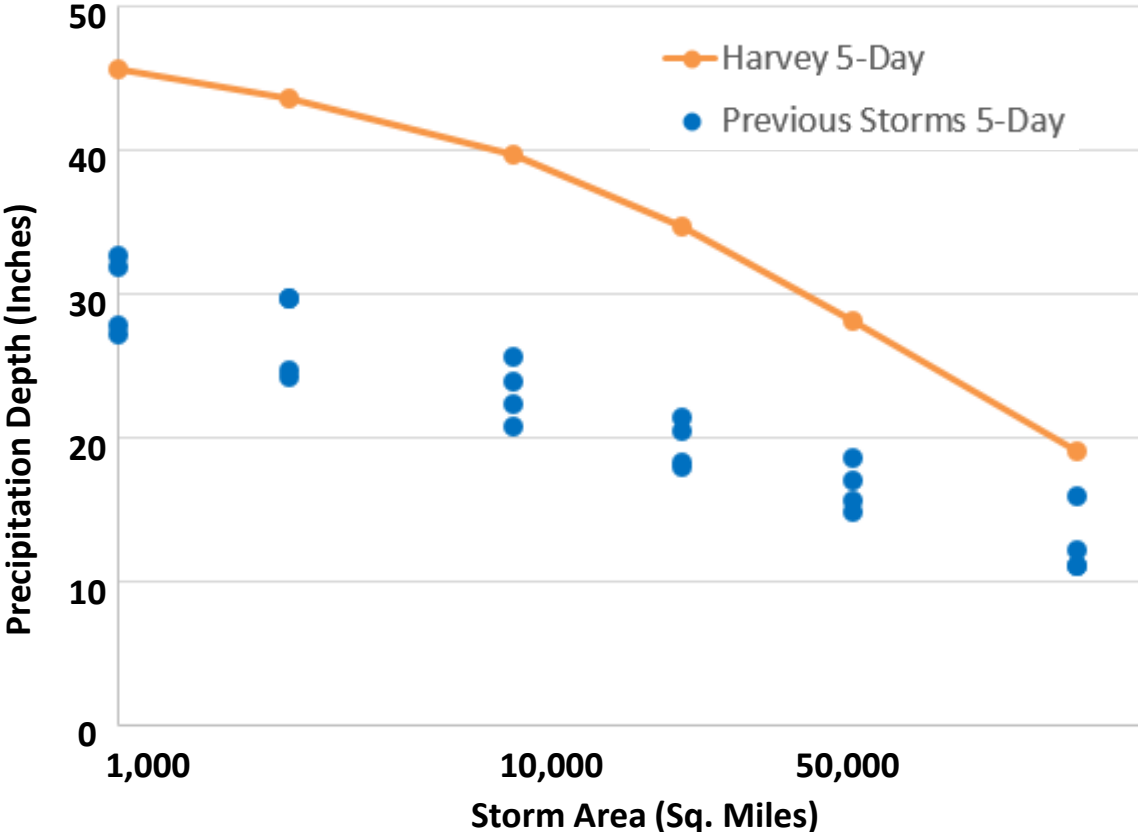
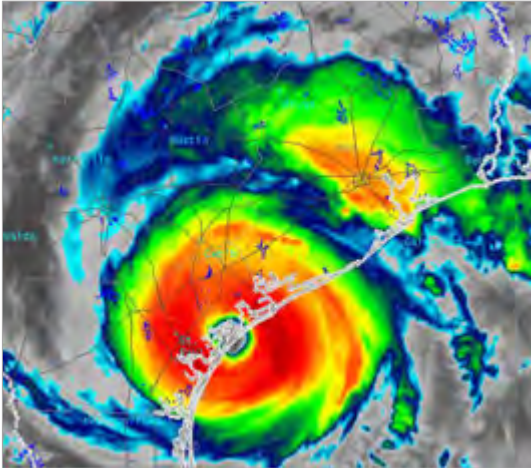


Hurricane Harvey – Record Precipitation

Harvey **2-day** precipitation was the **worst recorded storm in US history**

Harvey **3-day** Precipitation averaged **5 inches more** than previous worst storms

Harvey 5-day Precipitation averaged 11 inches more than previous worst storms



Data Sources: NWS River Forecast Centers;
 Applied Weather Associates, Inc., NASA.
 Analysis: John Nielsen-Gammon and Brent McRoberts, Texas A&M University



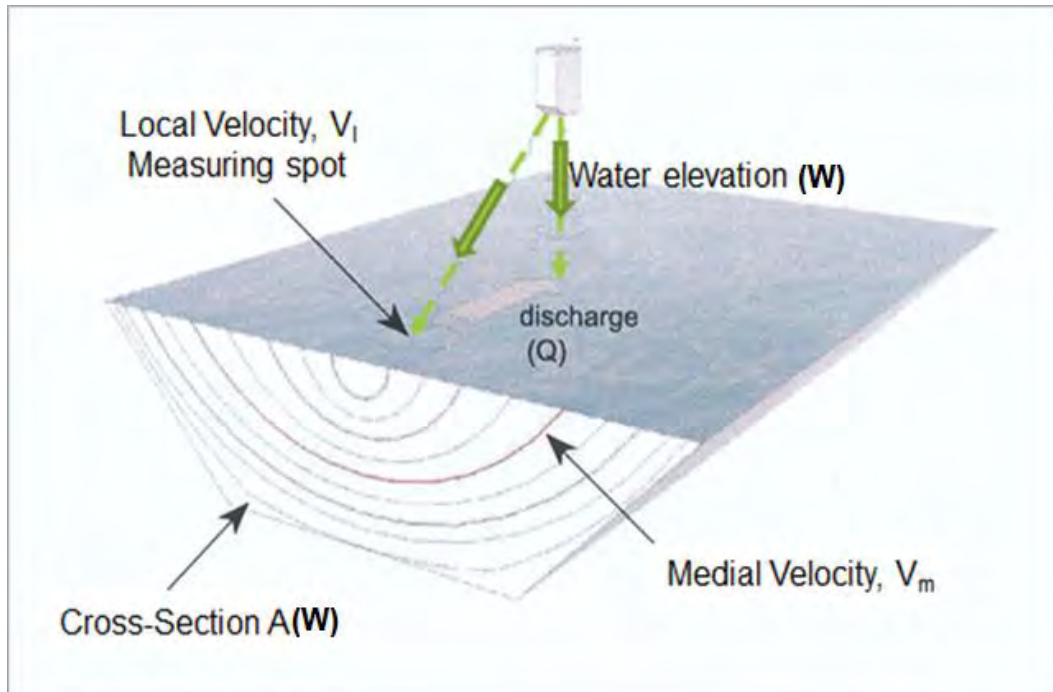
Real-Time Flood Resilience for TxDOT

Flood Forecasting ...

Streamflow Measurement...

TxDOT Radar Gauges

Installed and Maintained by US Geological Survey



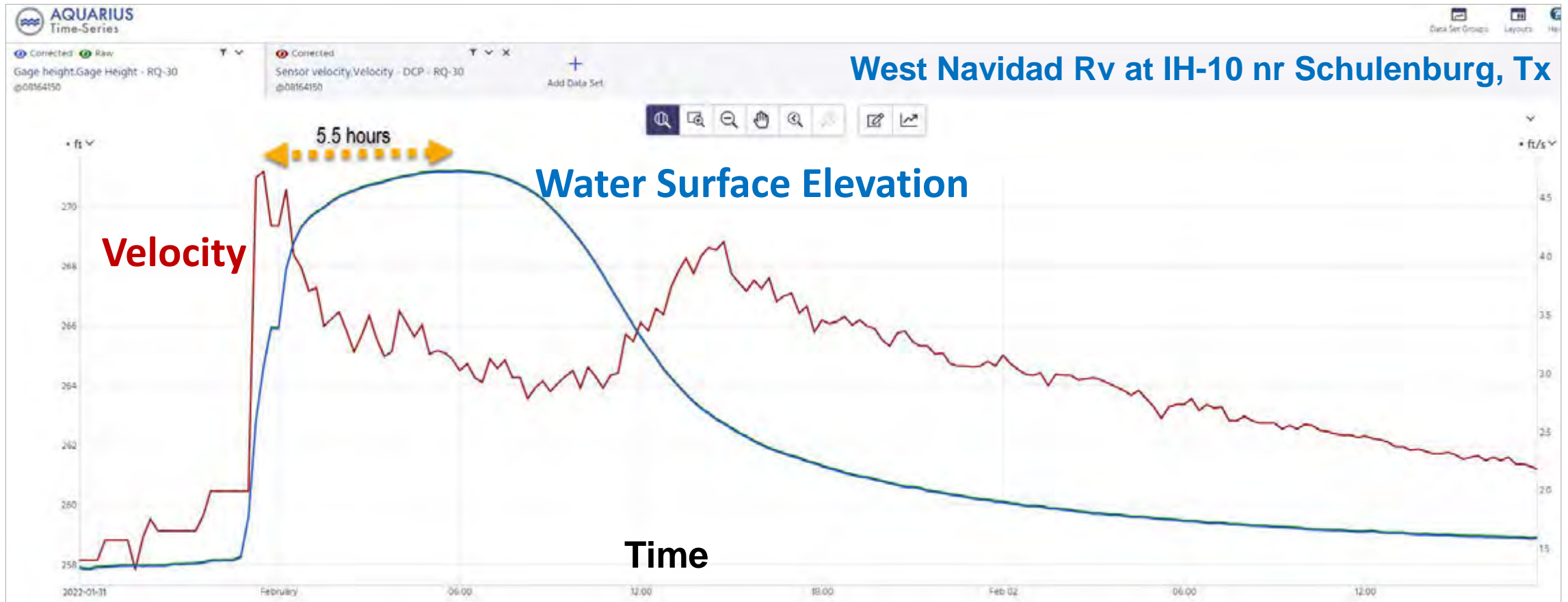
$$\text{Discharge} = \text{Cross-Section Area} * \text{Medial Velocity}$$



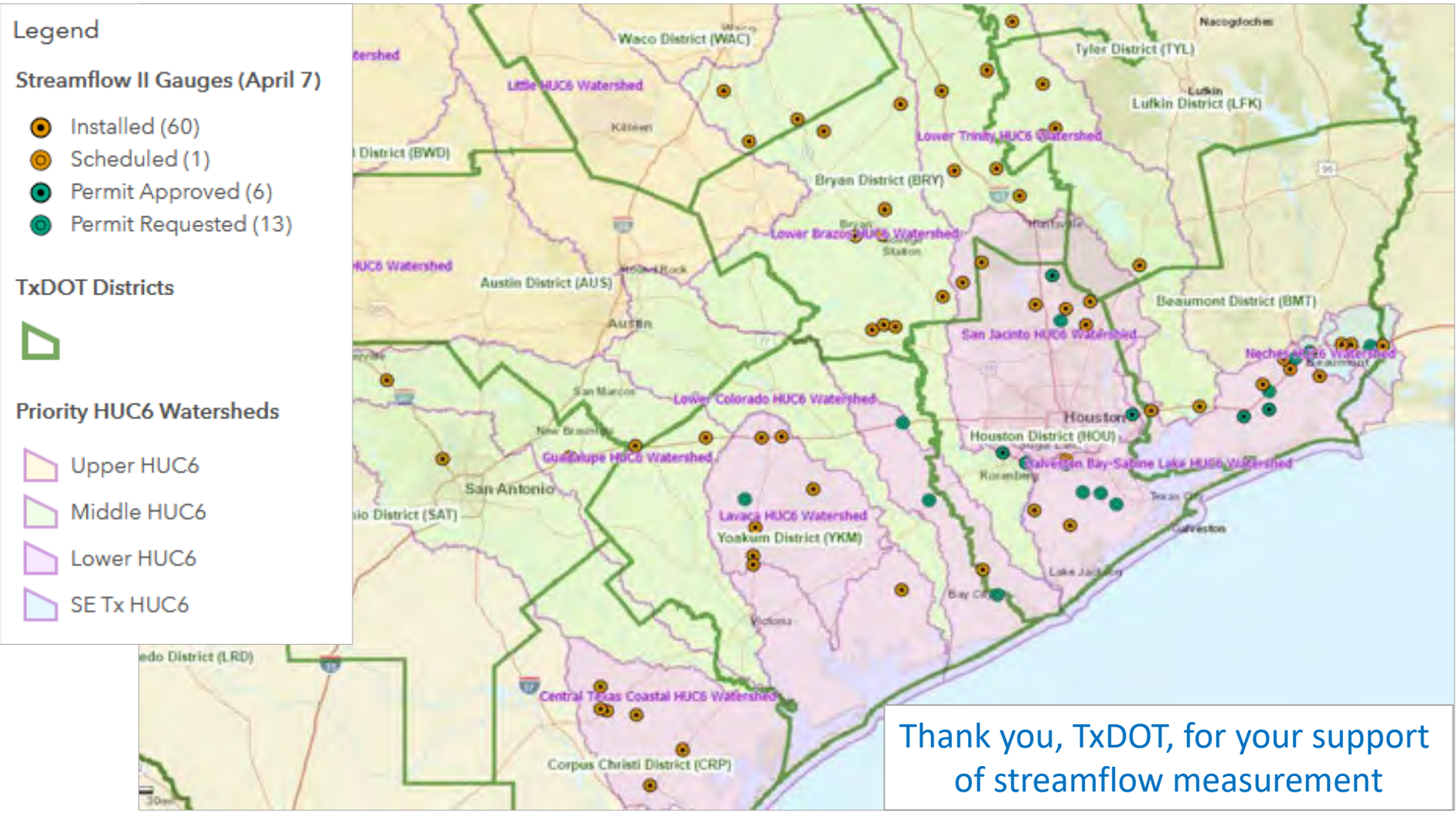
**Radar gauges measure both
water surface elevation and velocity**

Initial Velocity Wave

Provides advance warning of rising water levels



TxDOT Flood Data Network



Legend

Streamflow II Gauges (April 7)

- Installed (60)
- Scheduled (1)
- Permit Approved (6)
- Permit Requested (13)

TxDOT Districts

Priority HUC6 Watersheds

- Upper HUC6
- Middle HUC6
- Lower HUC6
- SE Tx HUC6

Main Districts impacted:

Beaumont
 Bryan
 Corpus Christi
 Houston
 Yoakum

Some gauges in:

Austin
 Lufkin
 San Antonio
 Tyler
 Waco

Thank you, TxDOT, for your support of streamflow measurement

Real-Time Flood Resilience for TxDOT

Flood Forecasting ...

Streamflow Measurement...

Emergency Response...

Flood Emergency Response Exercise (22 Feb)



Harry Evans



Christine Thies



Larry Jantzen

UT Austin Flood Emergency Response Team



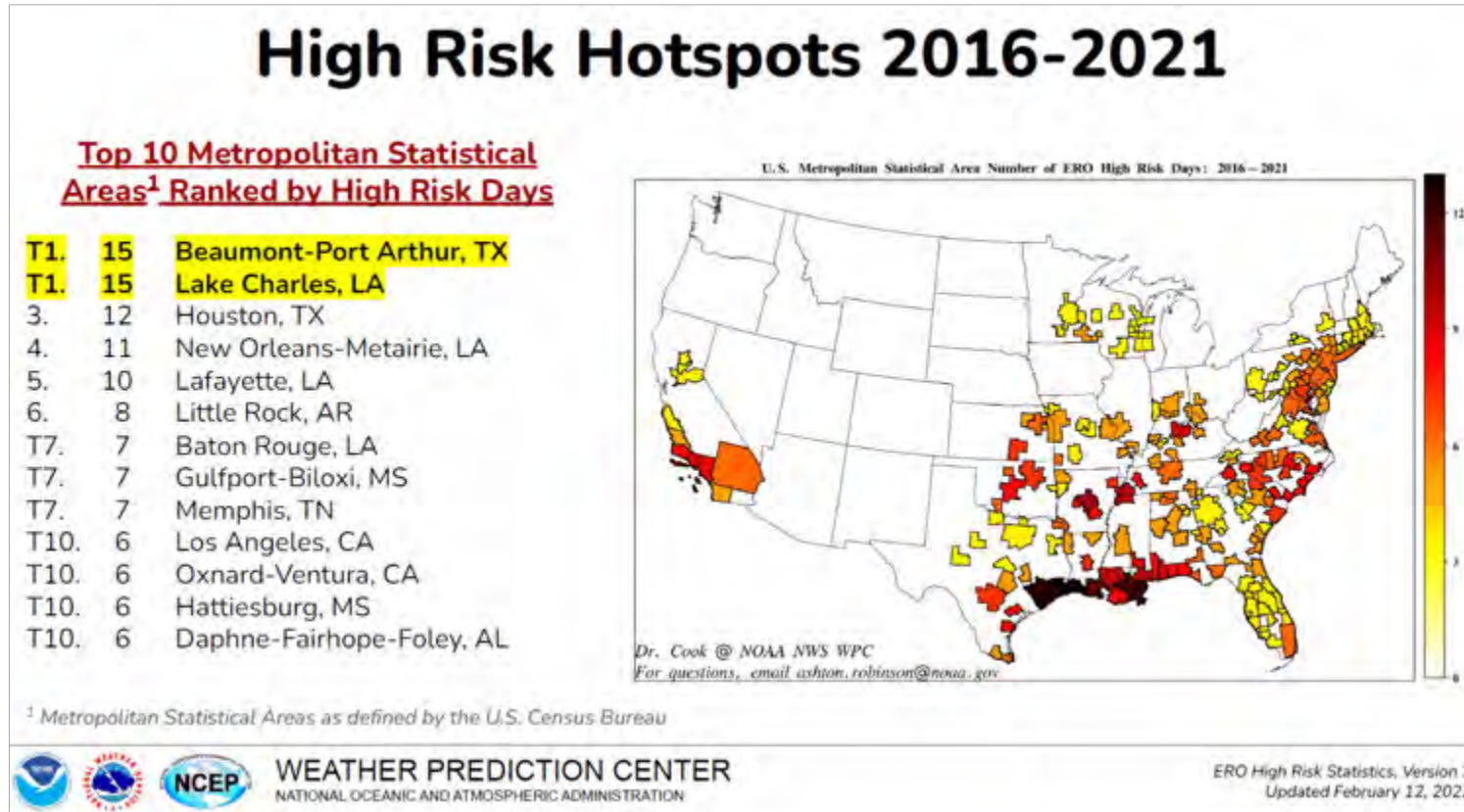
**Beaumont District
Maintenance Section**



Flood Risk in Beaumont District

High risk of excessive rainfall causing flood deaths and damage

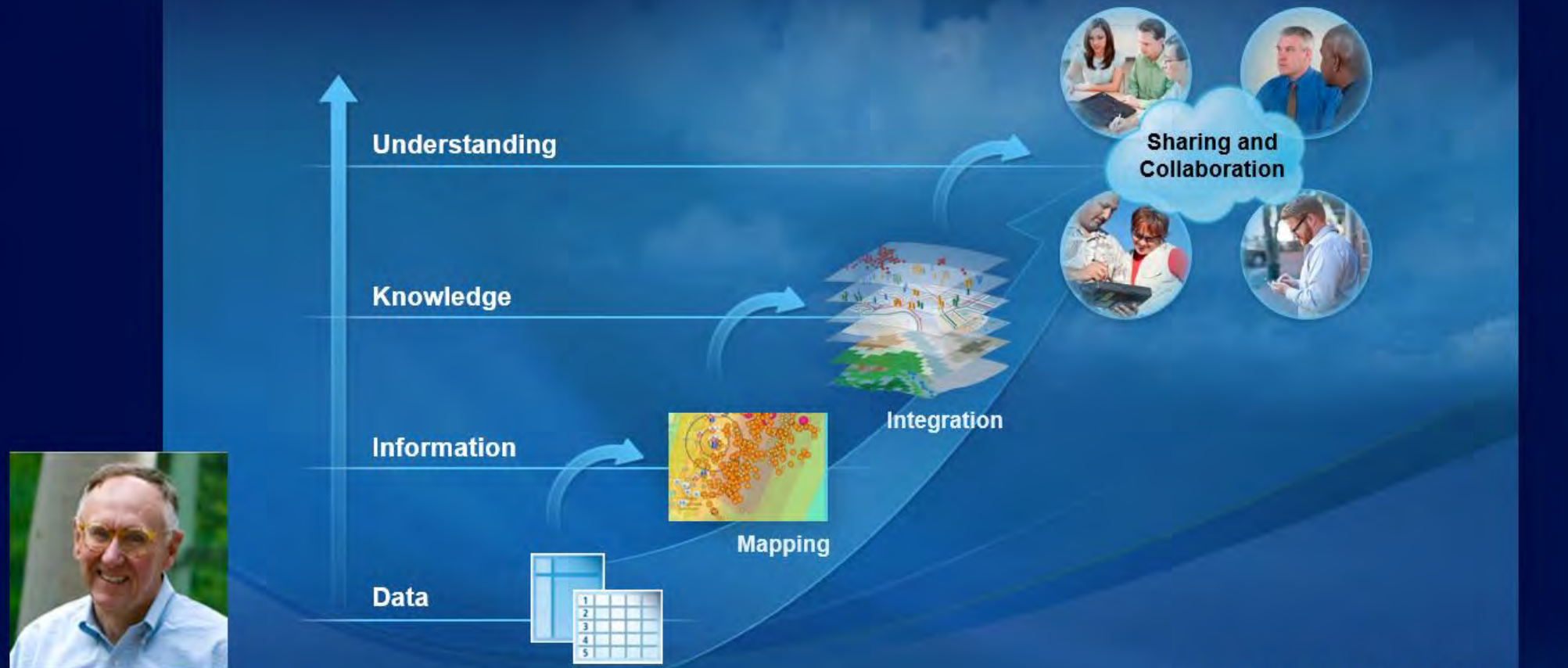
IH-10 closed three times in 2016 – 2021



from “Excessive Rainfall Outlook High Risks (2010-2020)”

Source: Jonathan Brazzell, NWS Lake Charles WFO

Geospatial Systems Are Helping Us Understand

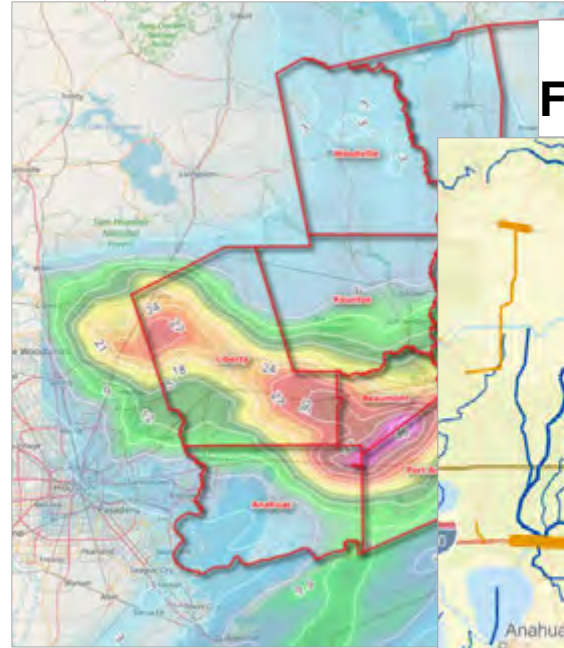


Slide: Jack Dangermond, ESRI President

... Helping Us Make Better Decisions

Rainmap in the Sky to Floodmap on the Ground

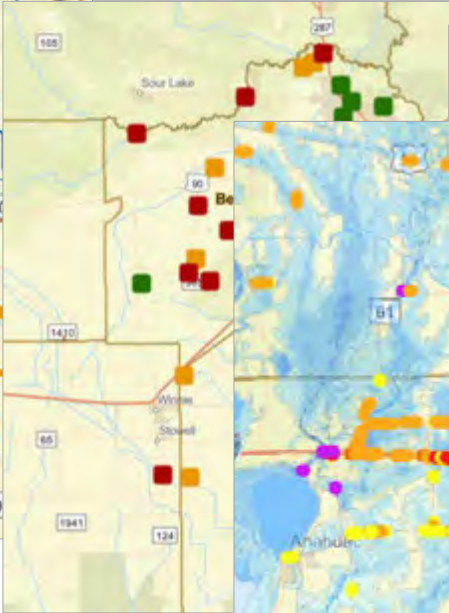
Forecast Rain Map



Bankfull Streams and Flooded Roads (HCRS-API)



Bridge Warnings



Flood Inundation Map



Web Communication to TxDOT (TxERA)



Maps accessible through ESRI StoryMap
<https://arcg.is/0LLLXX>

Demo by Tim Whiteaker

Forthcoming: Real-Time Demonstration Prototype

Goal: A real-time prototype to be tested during the 2022 summer storm season

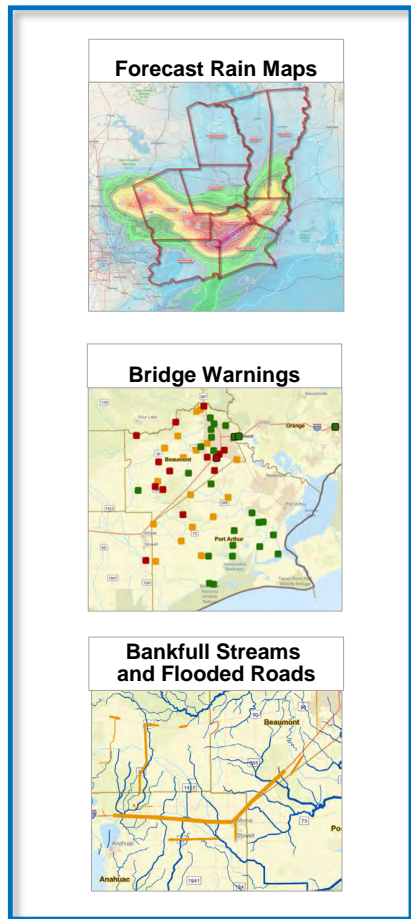


Field Observations

Observations



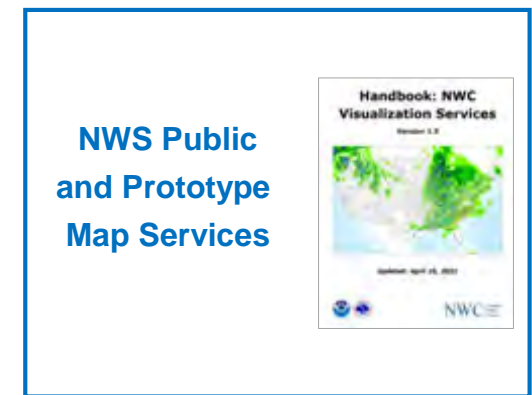
Data and Map services



Data and Map services



Forecasting



TxDOT Radar Stream Gauges



Real-Time Flood Resilience for TxDOT

Flood Forecasting ...

Streamflow Measurement...

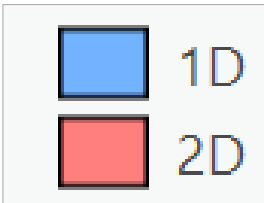
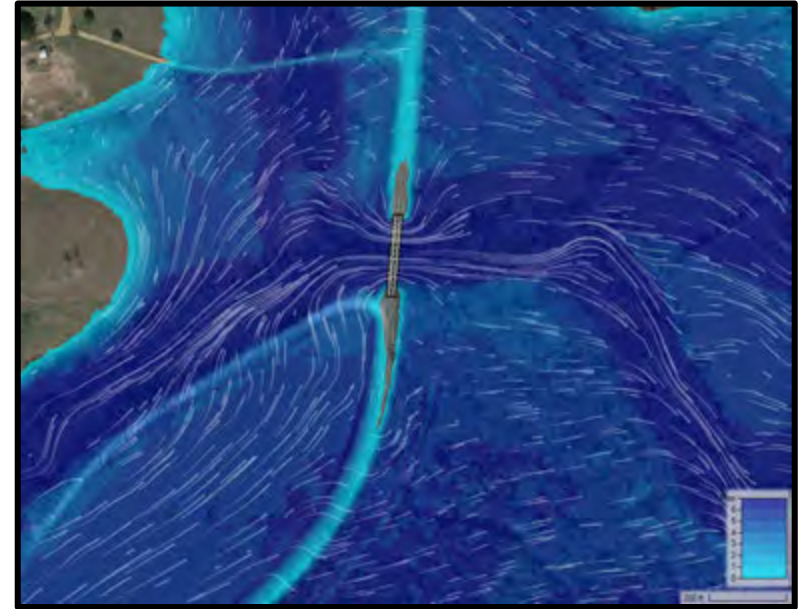
Emergency Response...

Bridge Hydraulics...

Base Level Engineering Flood Hydraulic Modeling

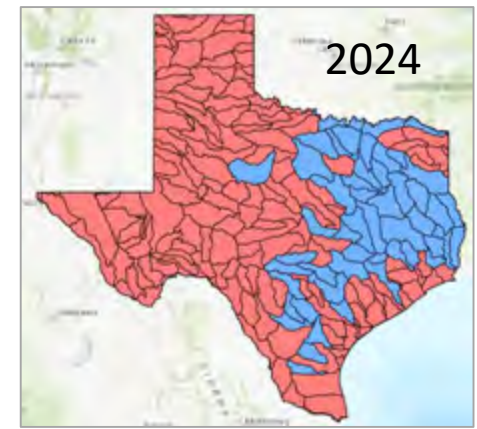


\$40 million investment



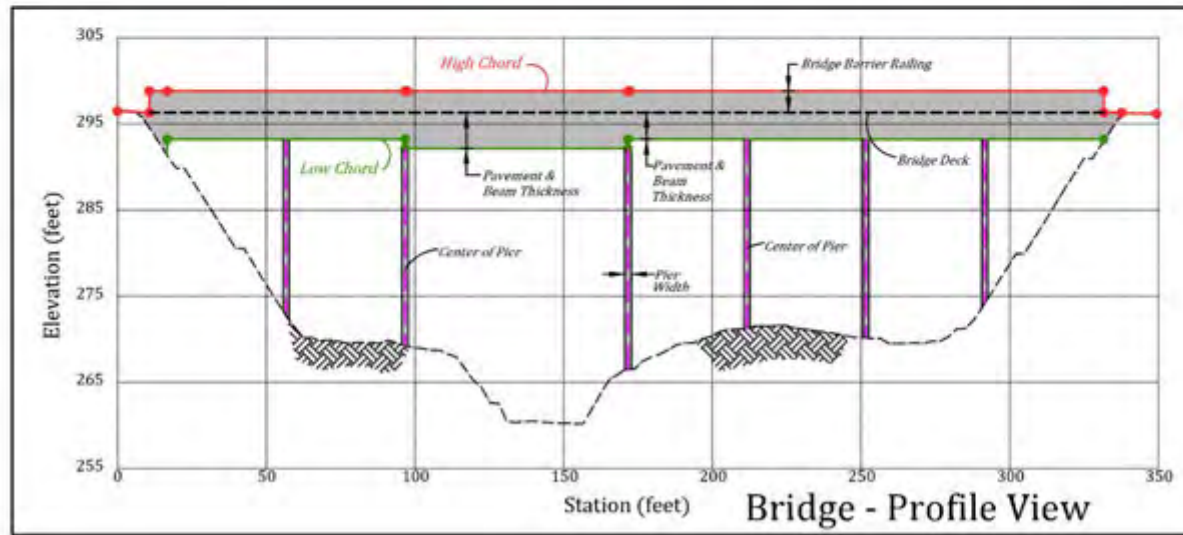
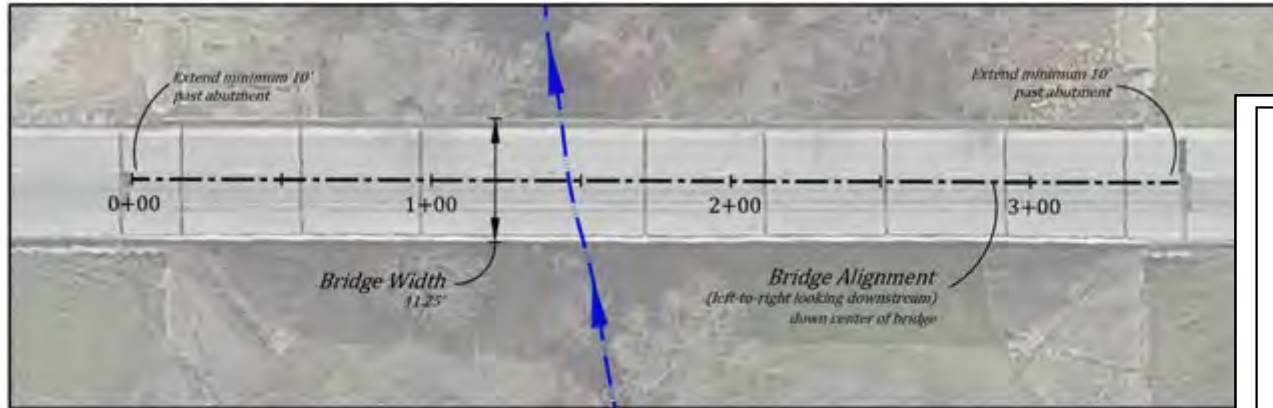
HEC-RAS

Bridges need to be added



Detailed Bridge Object Model Developed From TxDOT Bridge Plans

Bridge - Plan View



Bridge Object Model

Geospatial Line down center of road - 'left-to-right looking downstream'

Line Parameters

bridge_width (ft)	41.25
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High Chord - Table

Station (ft)	Elevation (ft)
0	296.47
10.68	296.31
10.69	298.81
16.69	298.81
96.69	298.81
96.7	298.81
171.69	298.81
171.7	298.81
331.69	298.81
331.7	296.31
337.69	296.31
339.5	296.25
349.4	296.17

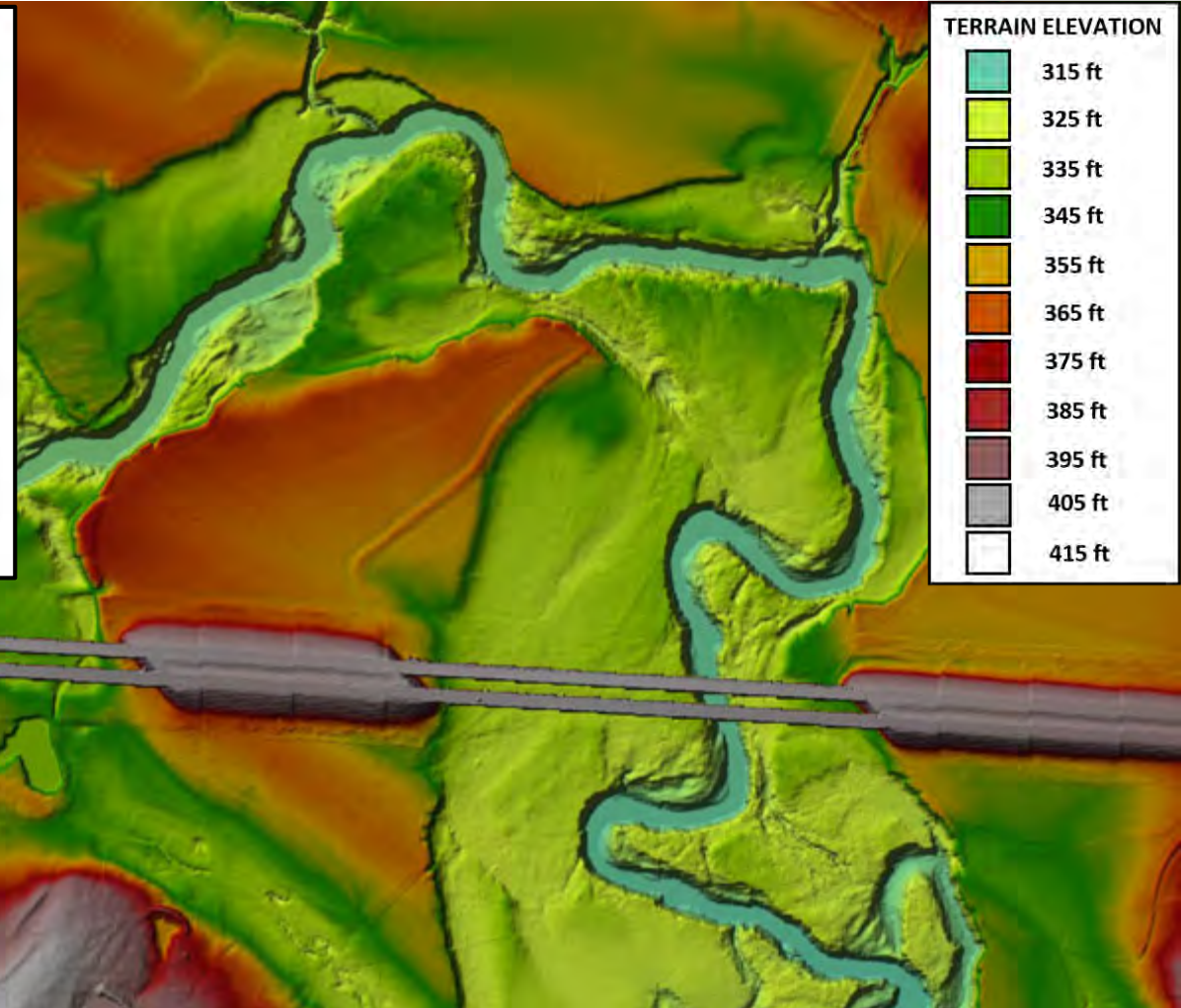
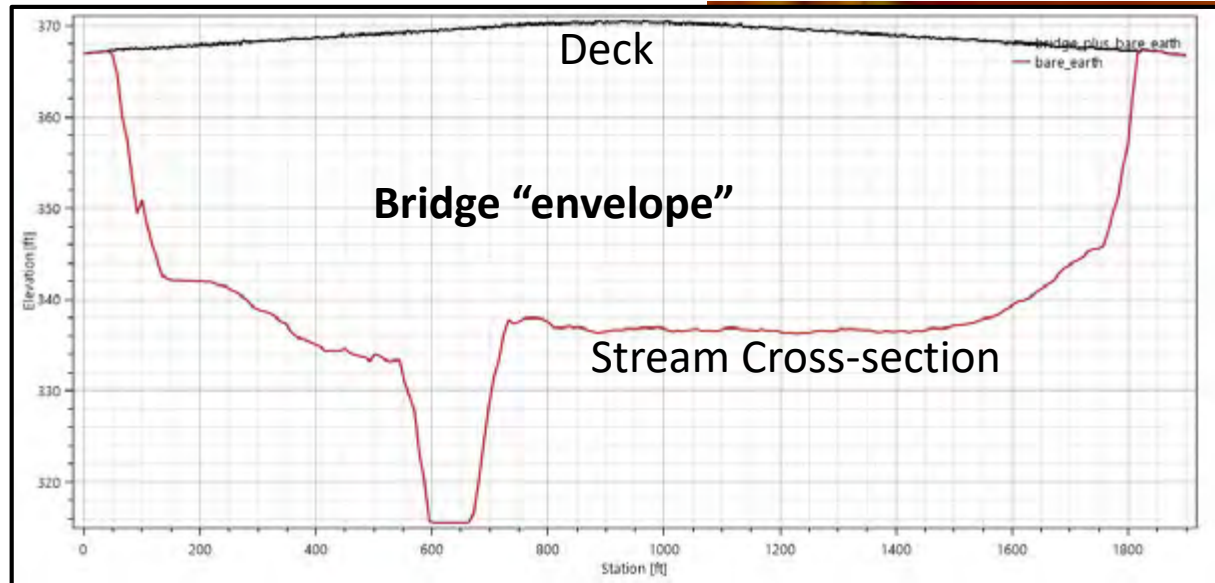
Low Chord - Table

Station (ft)	Elevation (ft)
16.69	293.21
96.69	293.21
96.7	292.143
171.69	292.143
171.7	293.21
331.69	293.21
331.7	293.21

Pier - Table

Station (ft)	Width (ft)
56.69	2
96.69	2
171.69	2.5
211.69	2.5
251.69	2
291.69	2

Simplified Bridge Object Model Developed Automatically from LIDAR



Add **bridge deck thickness**
based on bridge type
(with help from BRG Division)

Flood Depth Mapping for Roads



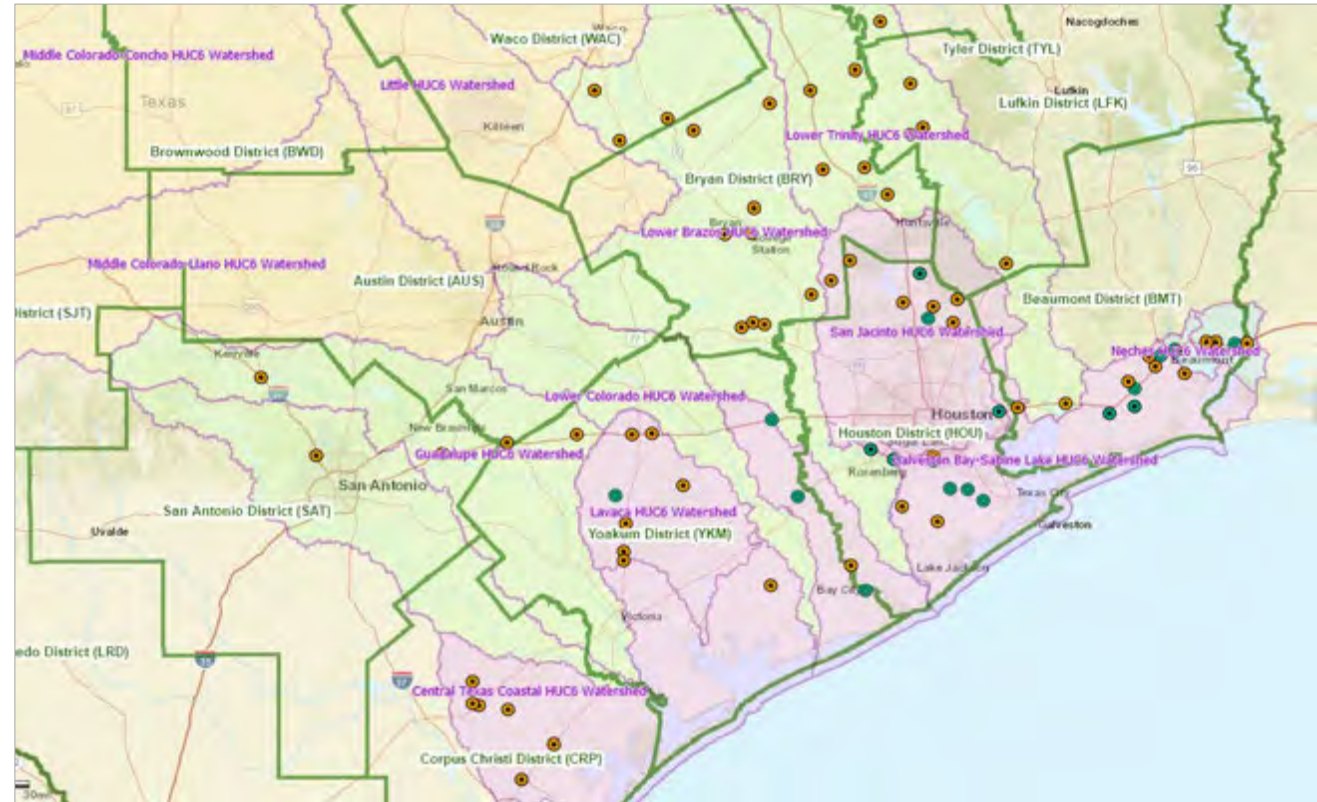
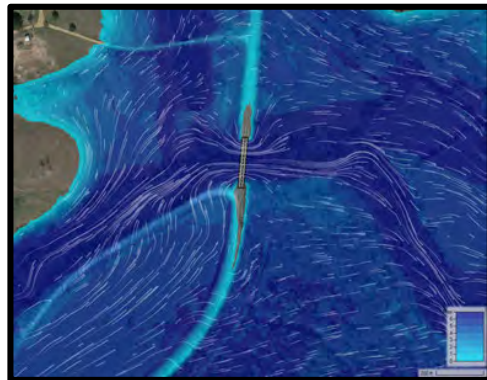
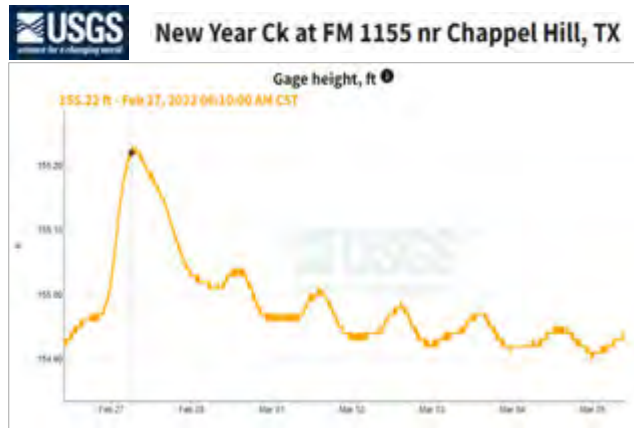
FIMAN Flood Inundation Mapping and Alert Network

This map and summary table are drawn from the **FIMAN-T** system developed by the North Carolina DOT
 Source for Images: David Key, ESP Associates

Roadway Flood Depth Range	Estimated Inundated Lengths (Miles)				
	Total	Interstate	US Highway	NC Highway	Local Roads
0 - 0.5ft	1.4	0.0	0.0	0.0	1.4
0.5 - 2.0ft	4.8	0.0	0.0	0.5	4.2
2.0 - 5.0ft	3.1	0.0	0.0	0.1	3.0
5.0+ ft	0.7	0.0	0.0	0.0	0.7
Total	10.0	0.0	0.0	0.7	9.3

Roadway classification and flood inundation values determined by using NCDOT LRS datasets overlaid on NCEM QL1 and QL2 raster datasets. All lengths are in miles.

Forthcoming: Measurement, Modeling and Mapping at 80 TxDOT Gauges



Creates accurate measurement of flow conditions at bridges

..... and accurate mapping of flooded road depths near bridges

Observational Flood Mapping with a Cell Phone Application



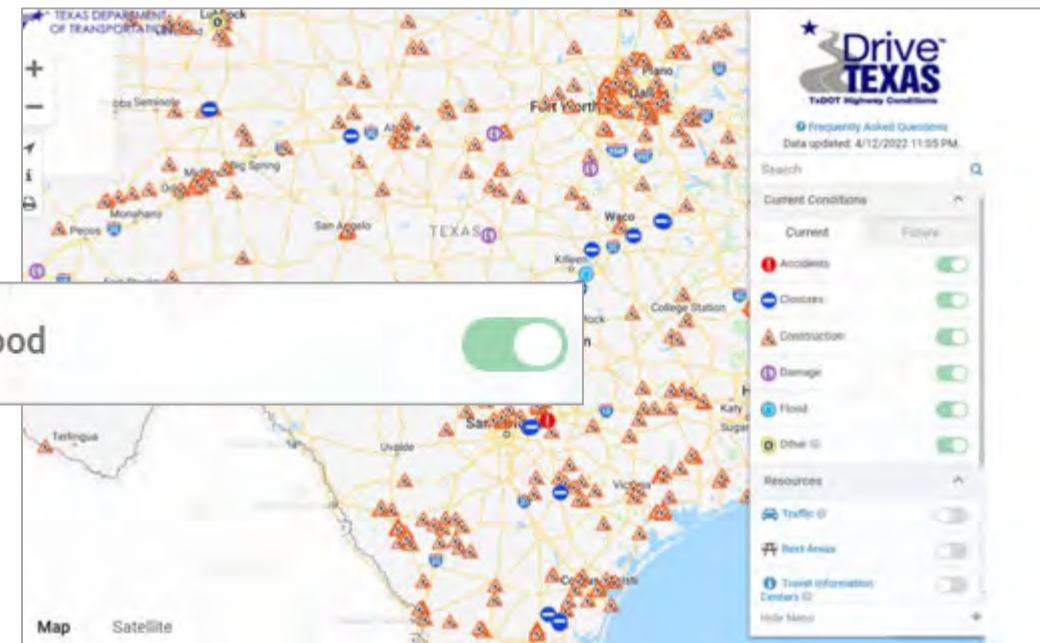
Suggestion 1 for TxDOT: Field Data Collection during Floods

Automated method for field staff to record flood conditions

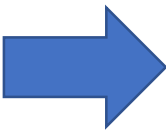
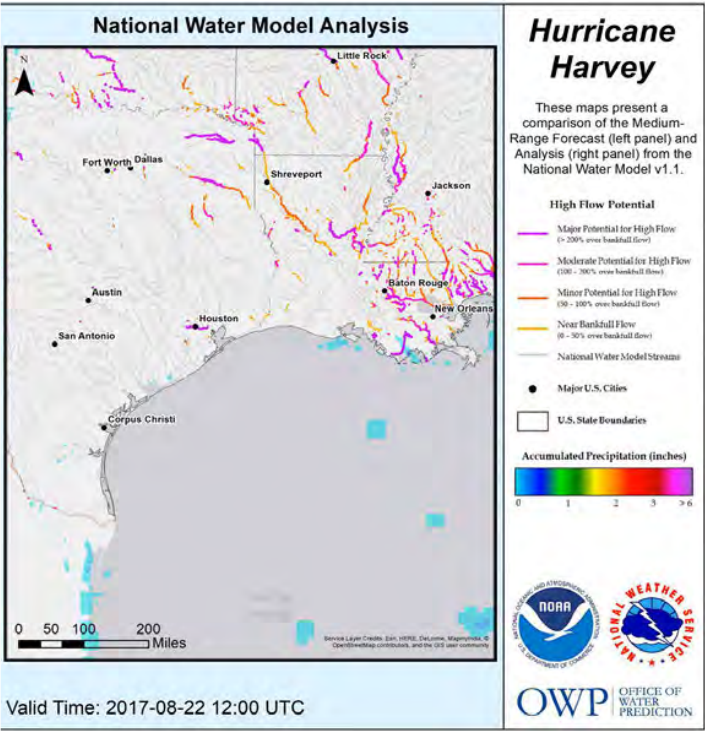
Possibilities:



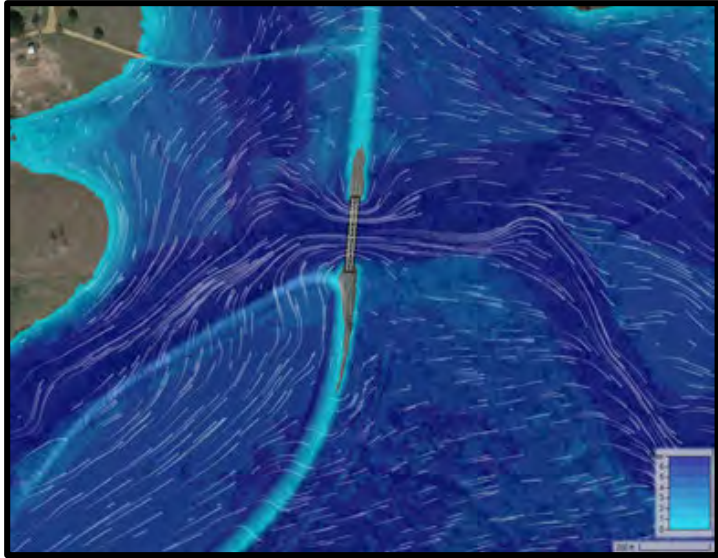
Flood Information in Highway Conditions Reporting System (HCRS)



Suggestion 2 for TxDOT: Long-Term Flood Resilience



Impact on Transportation System



Large scale storm simulation for historical and possible future storms

Conclusions

- Moving from **reactive to proactive response** to flooding
- **National Water Model** provides continuous forecasting on 190,000 miles of streams and rivers in Texas, including 26,000 on-system bridges
- Radar gauges on 80 TxDOT bridges measure **water surface elevation and velocity**
- Flood emergency response with **web map overlays** in TxERA
- **Automated hydraulic modeling of bridges** using LIDAR and HEC-RAS
- Connecting **large-scale hydrology** with **local-scale hydraulics** for Texas

We are half-way through a three year project (2021-2023)

We are happy to talk with you about our work: maidment@utexas.edu