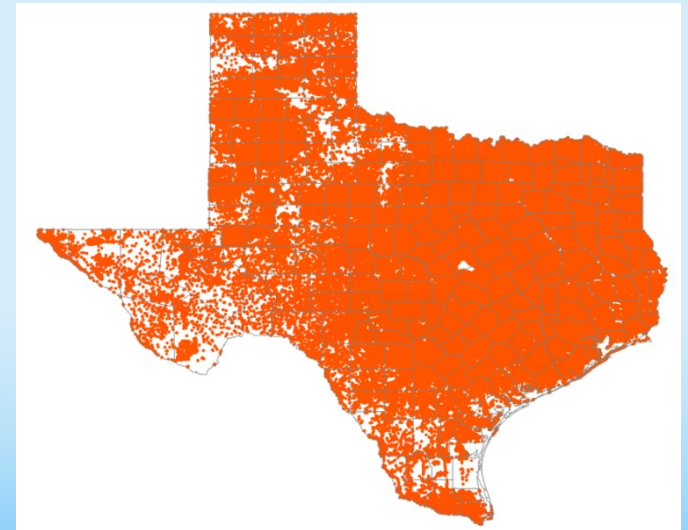
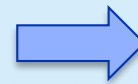
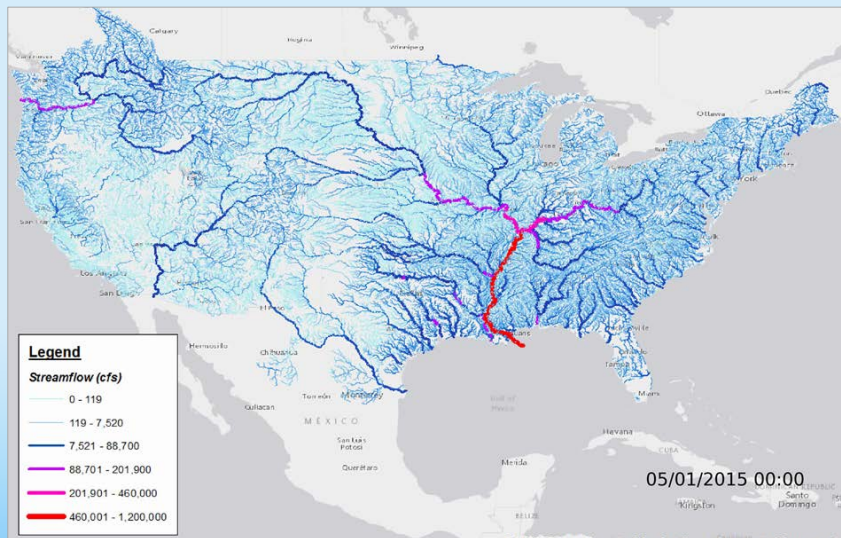


# Texas Flood Response System

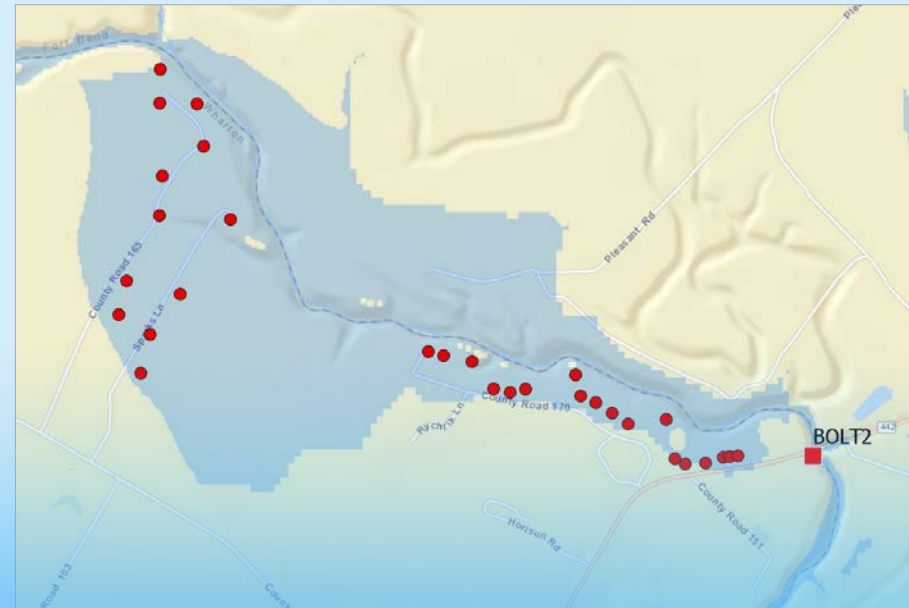
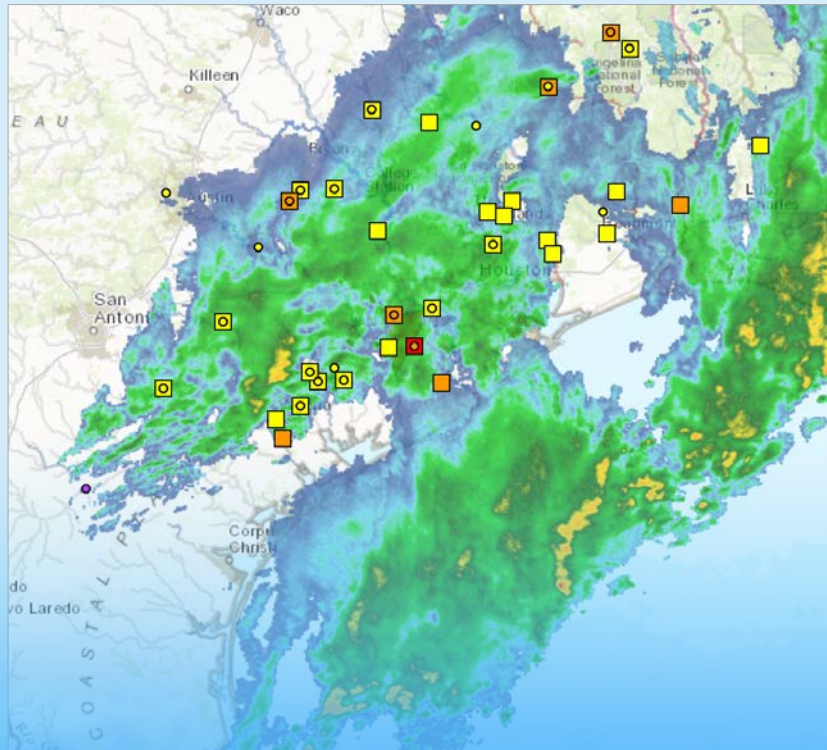
David R. Maidment  
Center for Water and Environment  
University of Texas at Austin



ESRI User Conference, Water Meeting, San Diego, CA, 8 July 2017

Acknowledgements: National Water Center, NCAR, Texas Division of Emergency Management, City of Austin, National Science Foundation, NCSA, ESRI, Kisters, Harry Evans, David Arctur, Xing Zheng, Yan Liu, Dean Djokic, Matt Ables, Michael Ouimet, Jeanette Chamorro, Ed Clark, Fernando Salas.

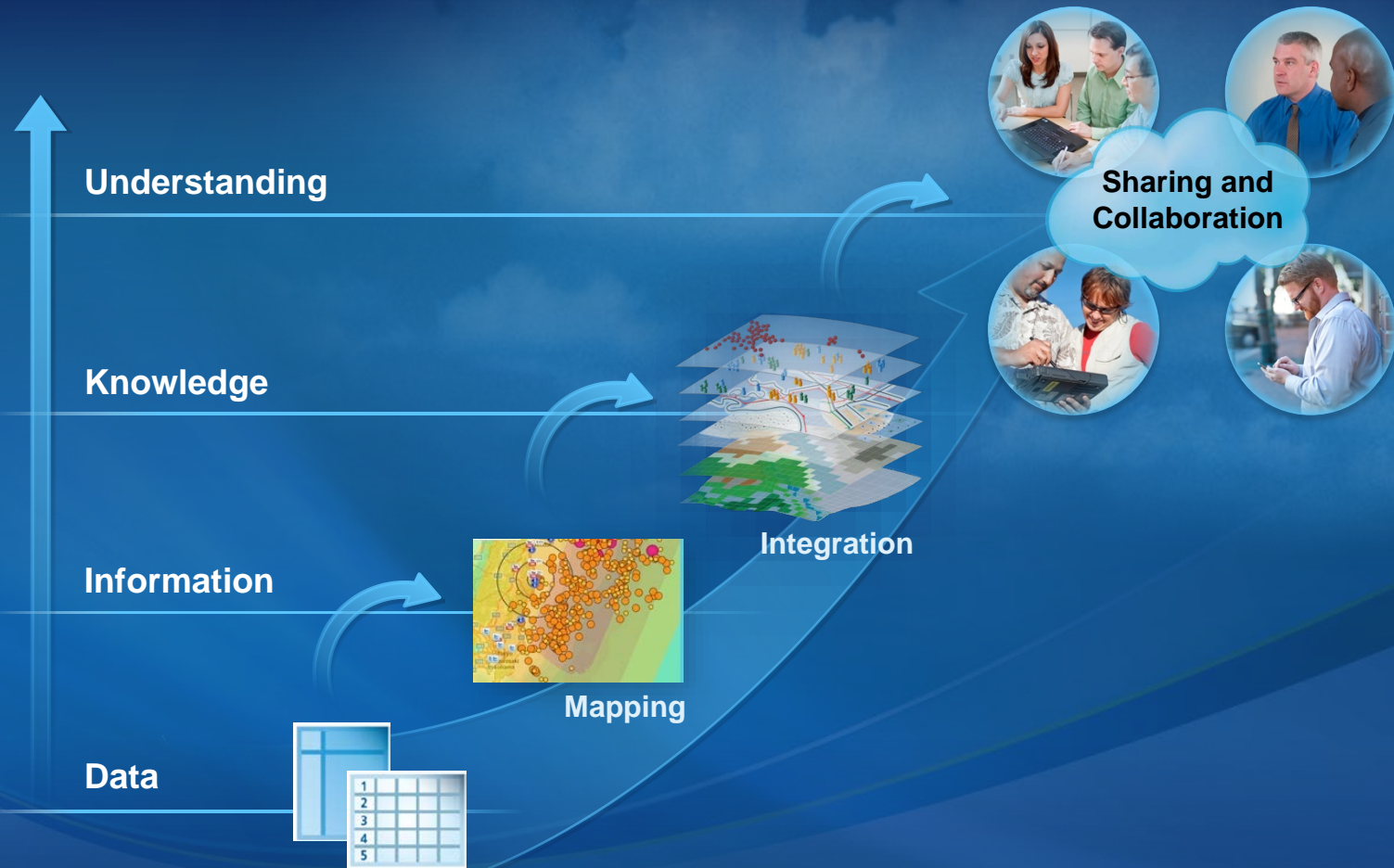
# Texas Flood Response System



The QUESTION is: How do you go from a radar rain map to flood inundation map showing impacts?

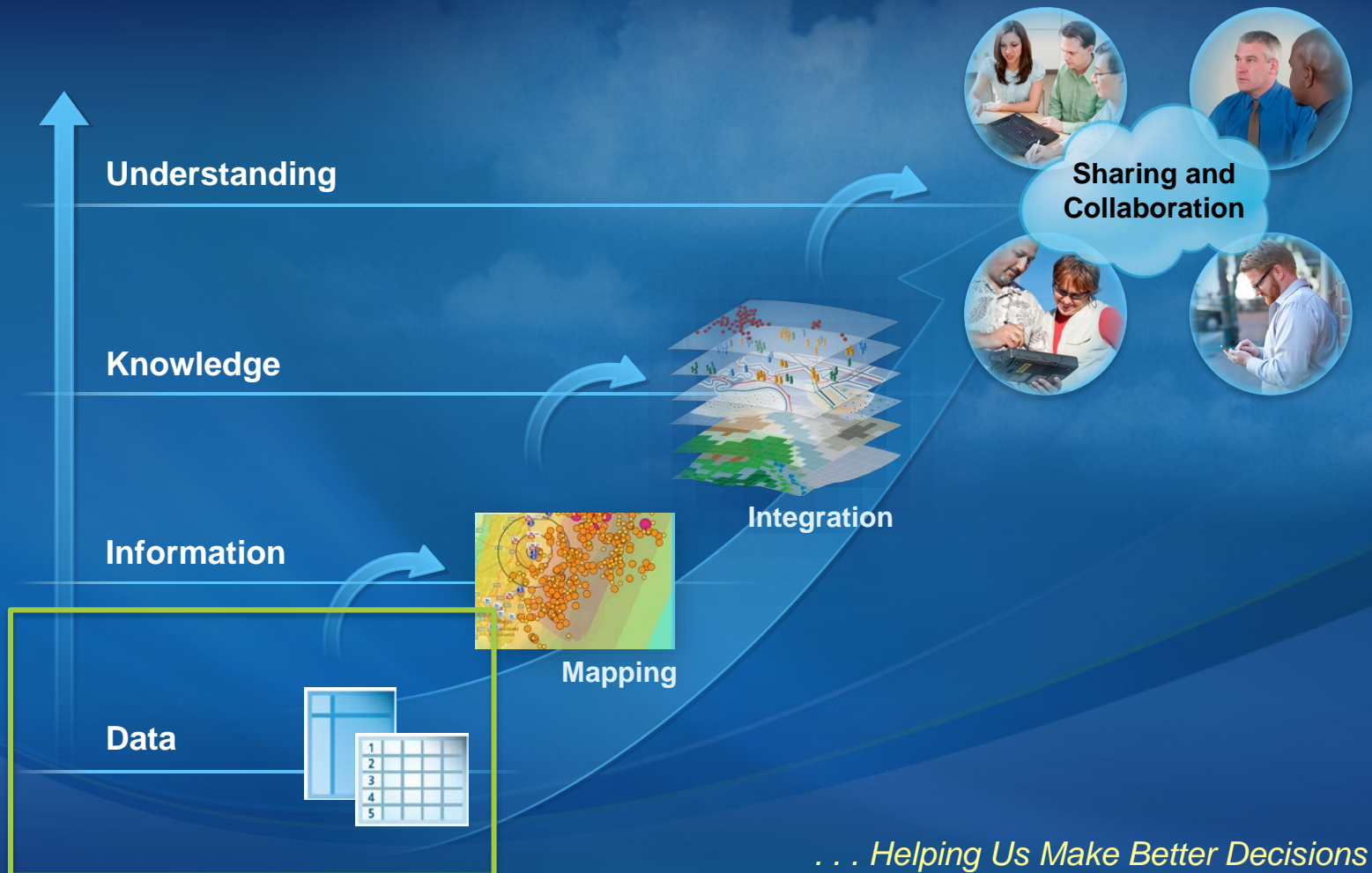


# Geospatial Systems Are Helping Us Understand



*... Helping Us Make Better Decisions*

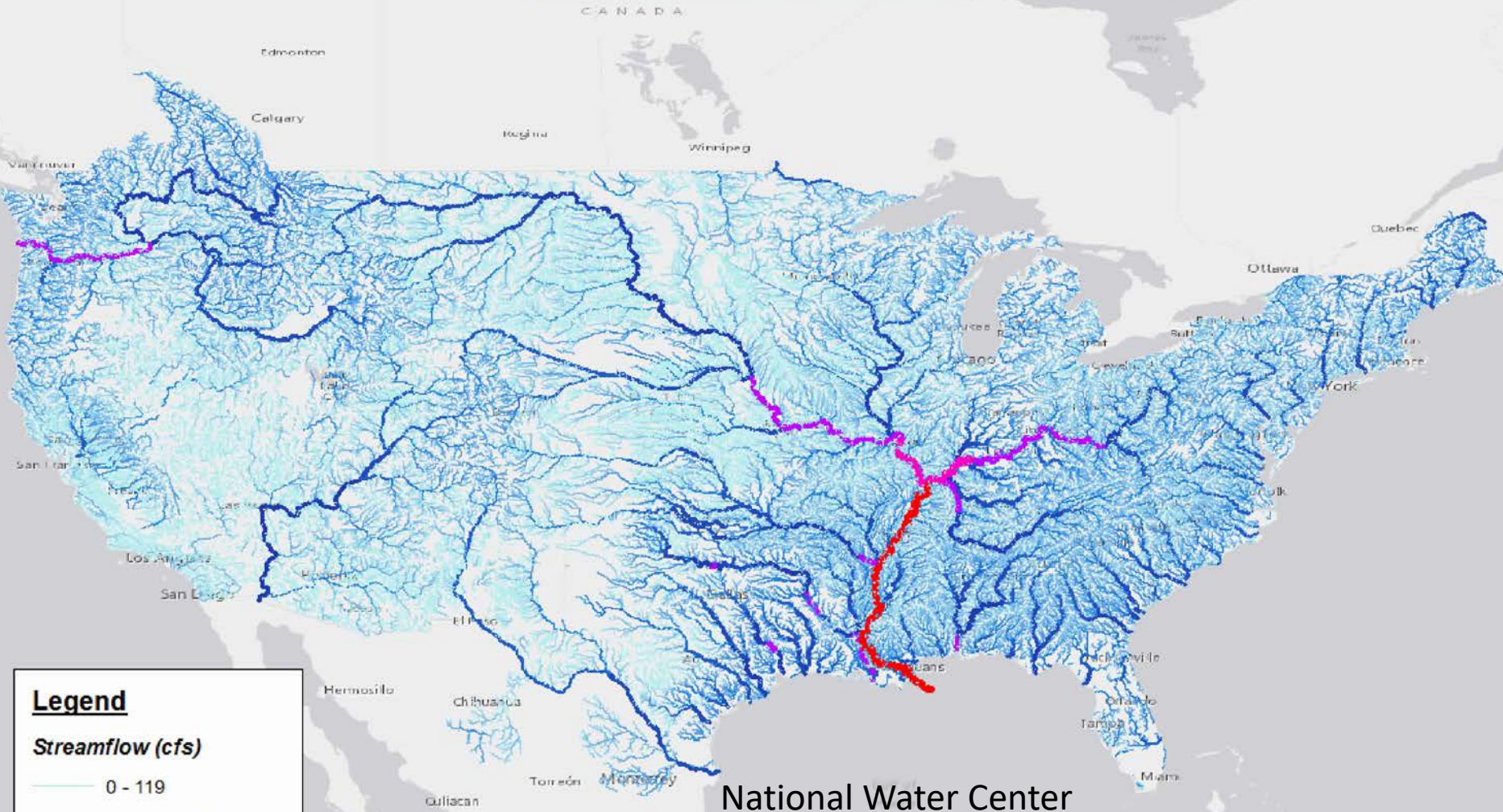
# Geospatial Systems Are Helping Us Understand



*... Helping Us Make Better Decisions*



# National Water Model



**Legend**

**Streamflow (cfs)**

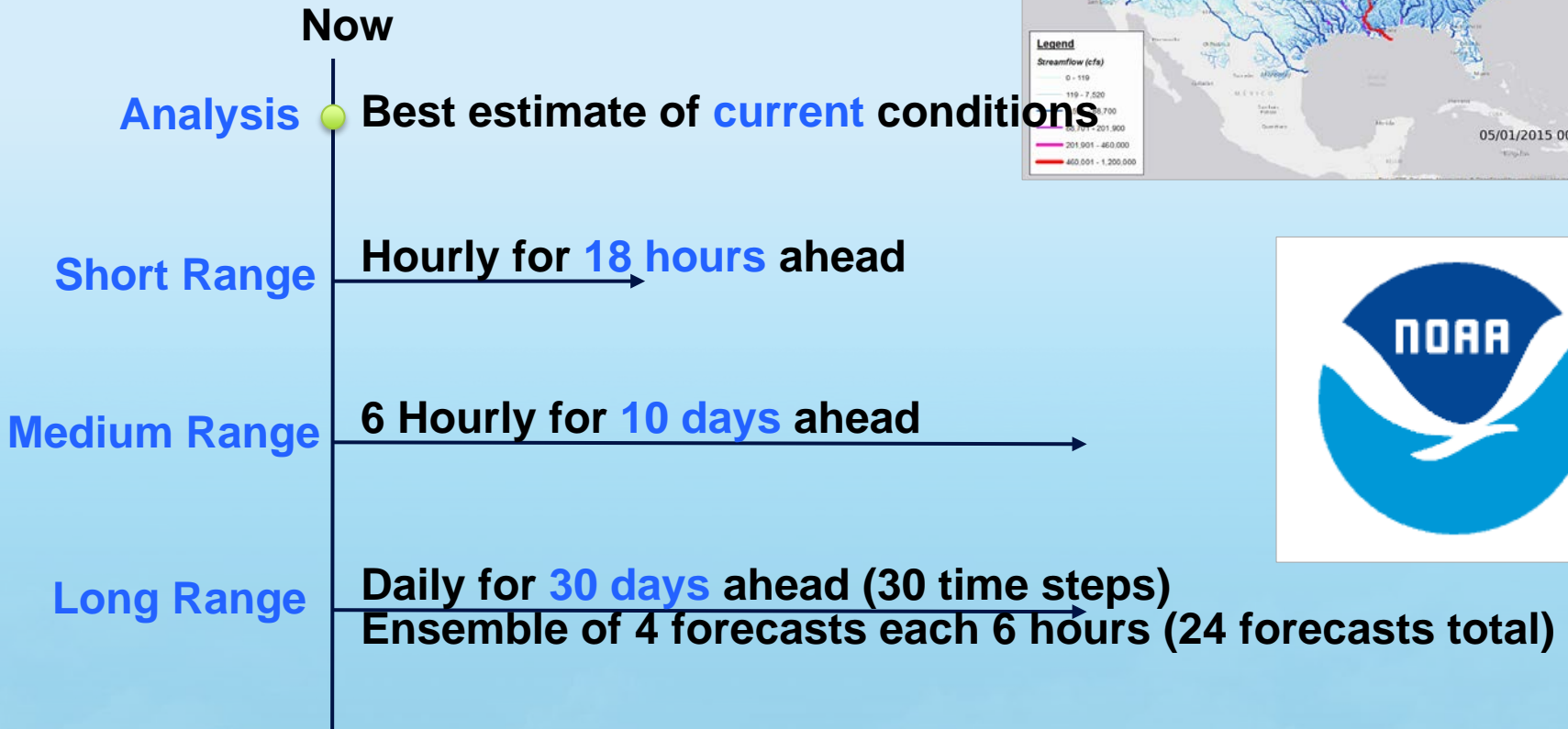
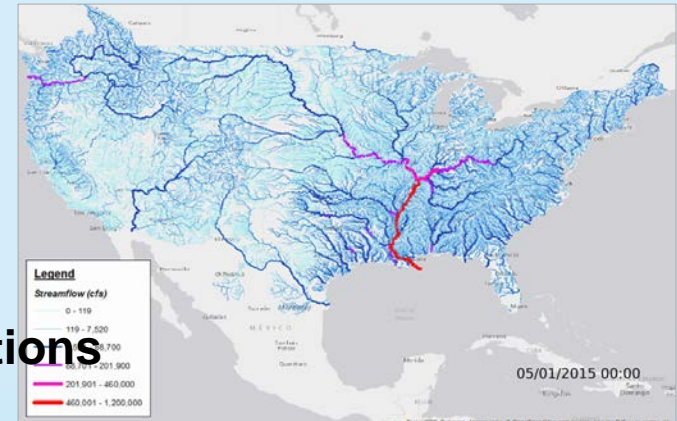
- 0 - 119
- 119 - 7,520
- 7,521 - 88,700
- 88,701 - 201,900
- 201,901 - 460,000
- 460,001 - 1,200,000

National Water Center



05/01/2015 00:00

# Forecasts



FTP directory /pub/data/nccf/com/nwm/prod/nwm.20170709/medium\_range/ at [ftp.ncep.noaa.gov](ftp://ftp.ncep.noaa.gov)

[Up to higher level directory](#)

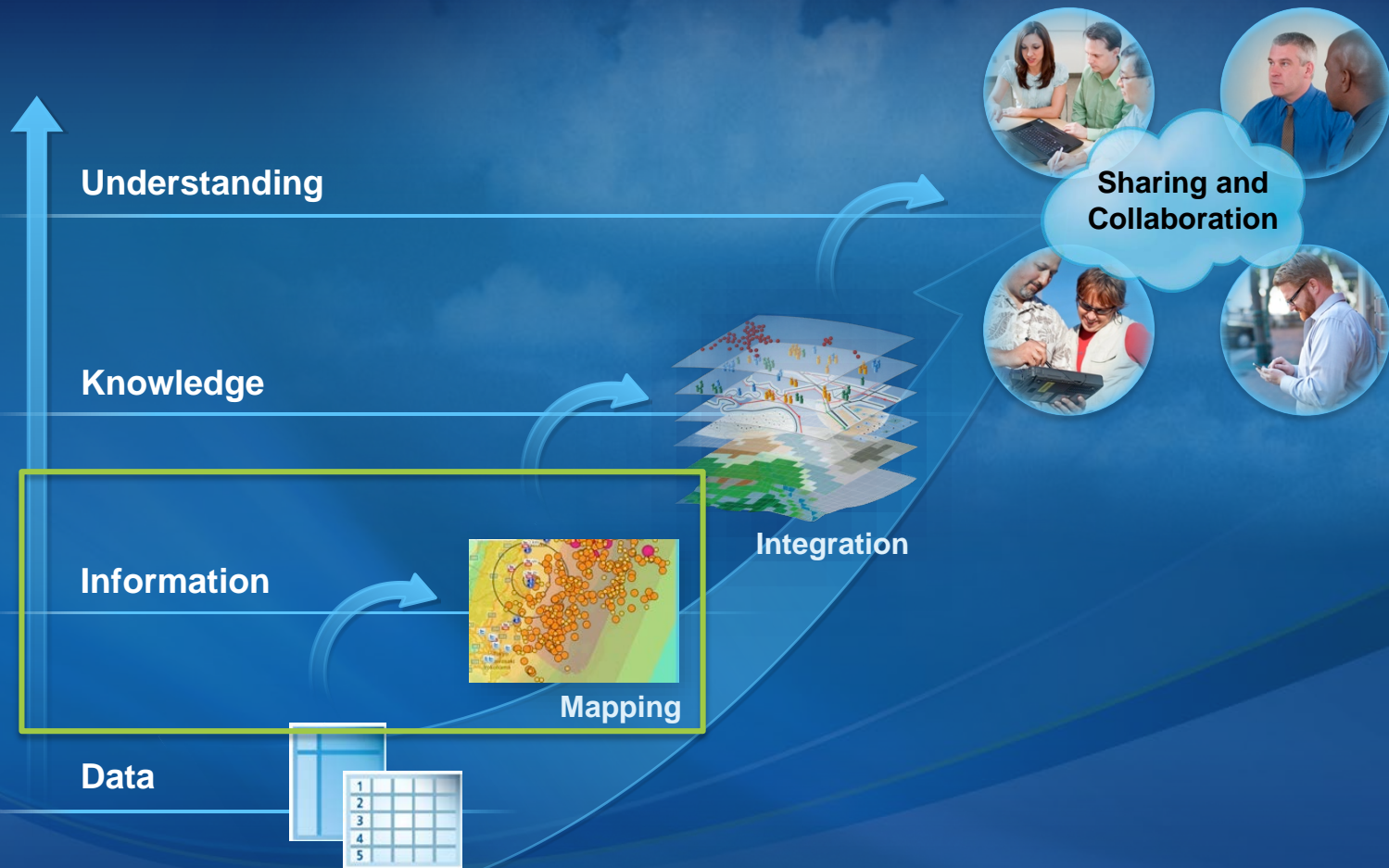
07/09/2017 06:23AM	4,077,847	<a href="#">nwm.t00z.medium_range.channel_rt.f003.conus.nc</a>
07/09/2017 06:23AM	4,048,145	<a href="#">nwm.t00z.medium_range.channel_rt.f006.conus.nc</a>
07/09/2017 06:23AM	4,038,504	<a href="#">nwm.t00z.medium_range.channel_rt.f009.conus.nc</a>
07/09/2017 06:23AM	4,036,145	<a href="#">nwm.t00z.medium_range.channel_rt.f012.conus.nc</a>

**Today's forecast information  
(5 TB)**

<ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/nwm/prod/>



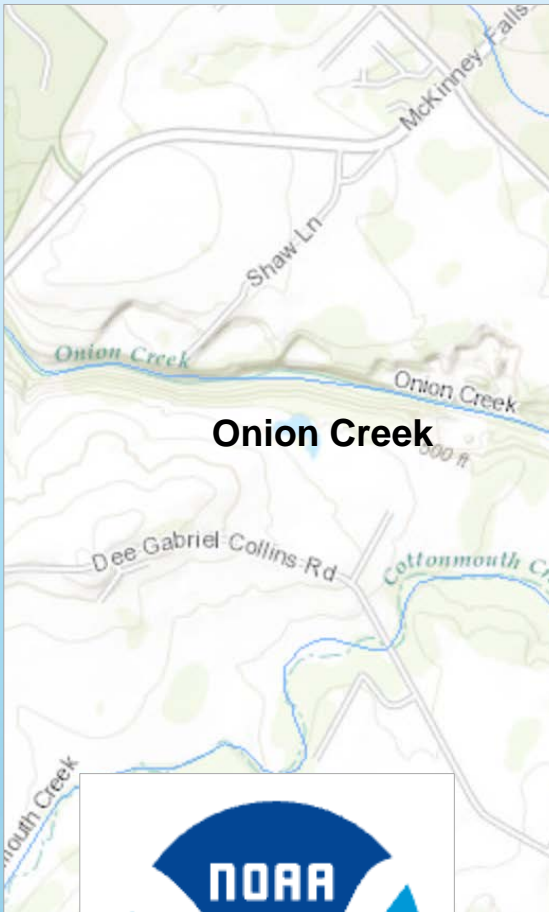
# Geospatial Systems Are Helping Us Understand



*... Helping Us Make Better Decisions*

# National Water Model Forecasts on a Map

<http://water.noaa.gov/map>



**Onion Creek**

Onion Creek - Austin (78744), Texas

Configuration

Metadata

Hide

Variable

Streamflow

Time Series ⓘ

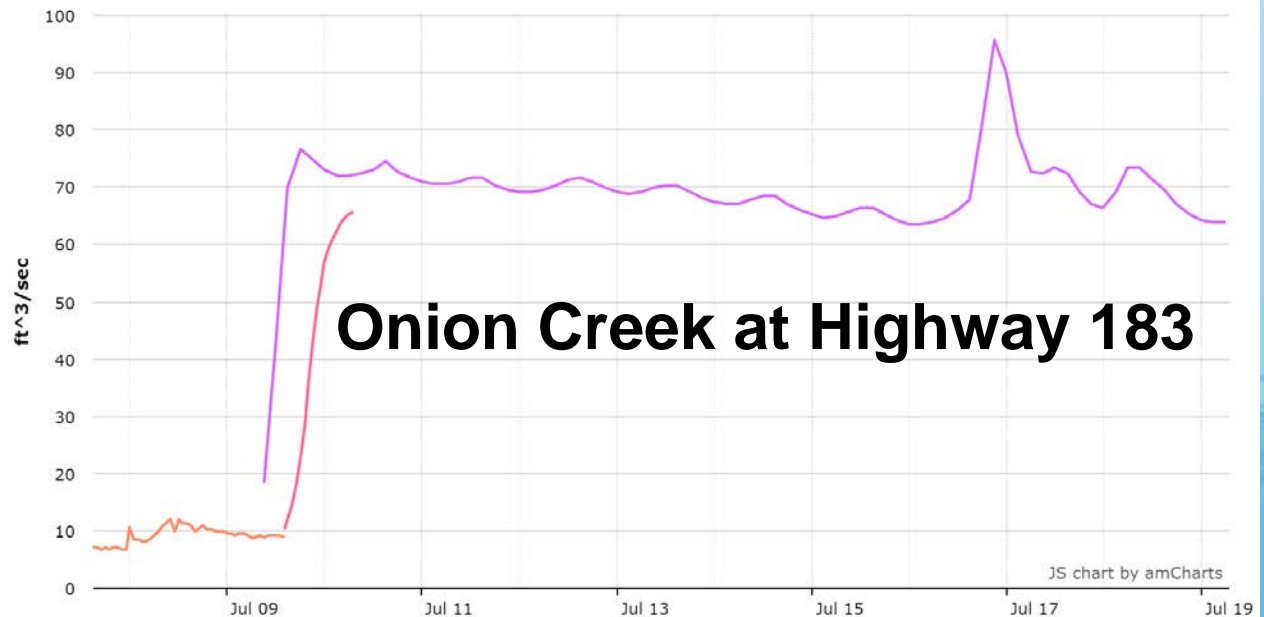
Analysis

Short Range

Medium Range

Long Range

Rebuild



**Onion Creek at Highway 183**

JS chart by amCharts





# National Water Model in ArcGIS Online

The screenshot displays the ArcGIS Online interface. At the top, the text "ArcGIS My Map" is visible. Below this, there are navigation and utility icons: "Details", "Add", "Basemap", "Save", "Print", "Measure", and "Bookmarks". A search bar on the right contains the text "Find address or place".

The main map area shows a topographic view of the central United States, including parts of New Mexico, Texas, Oklahoma, Arkansas, and Louisiana. Major cities like Santa Fe, Albuquerque, Amarillo, Lubbock, Fort Worth, Dallas, Austin, Houston, San Antonio, El Paso, and Juarez are labeled. The map features a network of rivers and topographic features like the Red Hills, Ozark Plateau, and Ouachita Mountains. A thick black line highlights a specific river path, likely the Mississippi River.

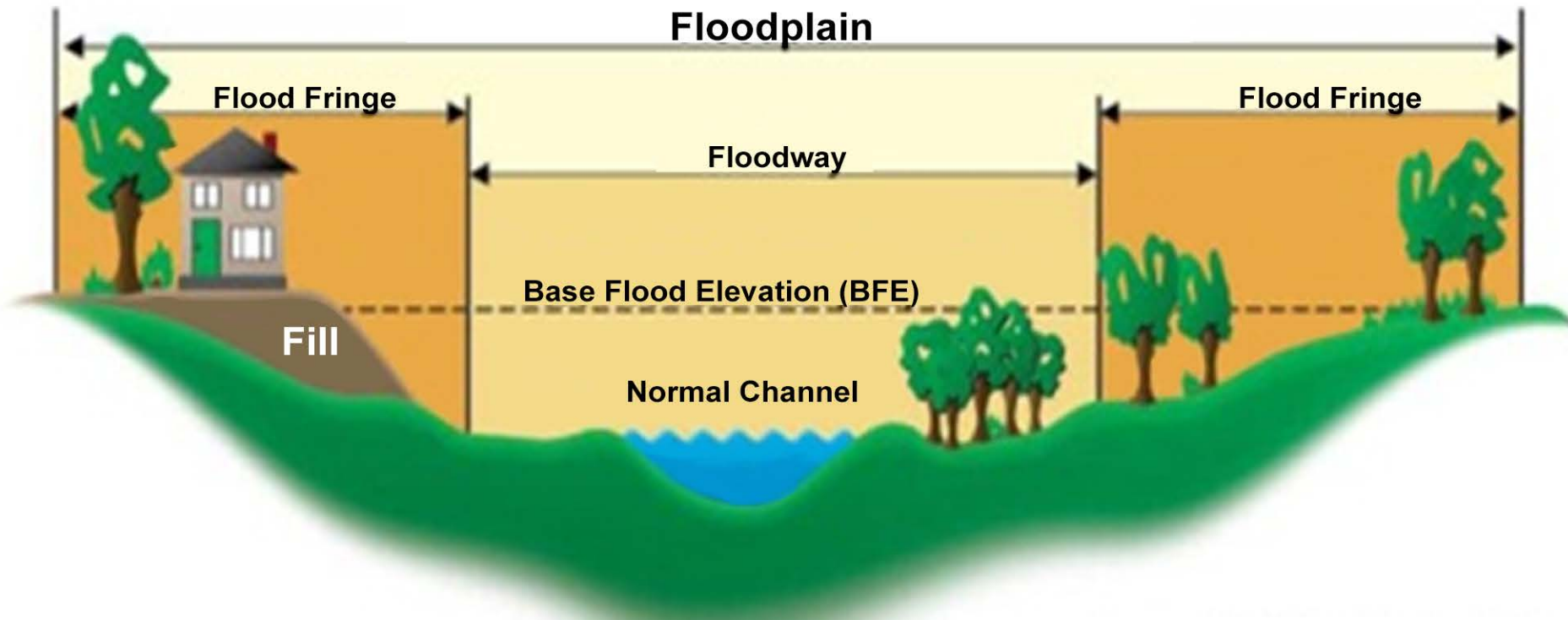
On the left side, the "Search for Layers" panel is open. It shows a search for "national water model" with 457 results found. The "USGS - National Hydrography Dataset (NHD) WM" layer is highlighted with a green box. Other layers listed include "Digital Elevation Model Global Mosaic (Color Shac)", "National Water Model (10 Day Forecast)", "National Water Model (Hourly Anomaly Forecast)", "National Water Model (10 Day Anomaly Forecast)", "USGS National Hydrography Dataset (NHD)", "USGS National Hydrography Dataset (NHD) - Ext", "Framework: Hydrography", and "Hydrography".

How to move from forecast discharge .....

..... to forecast *flood inundation mapping?*

# FEMA Floodplain Mapping

## Characteristics of a Floodplain

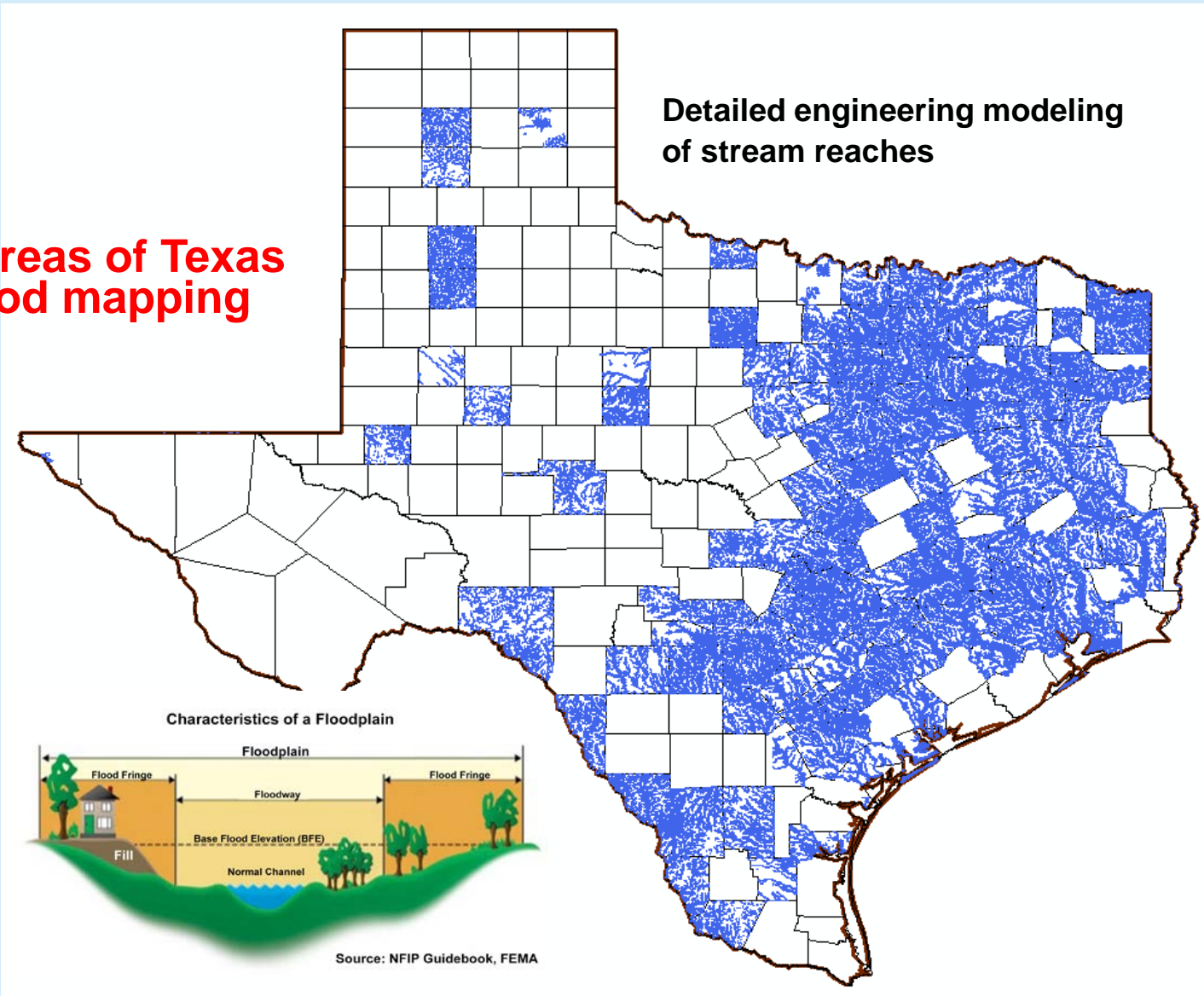


Source: NFIP Guidebook, FEMA



# FEMA National Flood Hazard Layer in Texas (~ 120 counties)

Large areas of Texas lack flood mapping

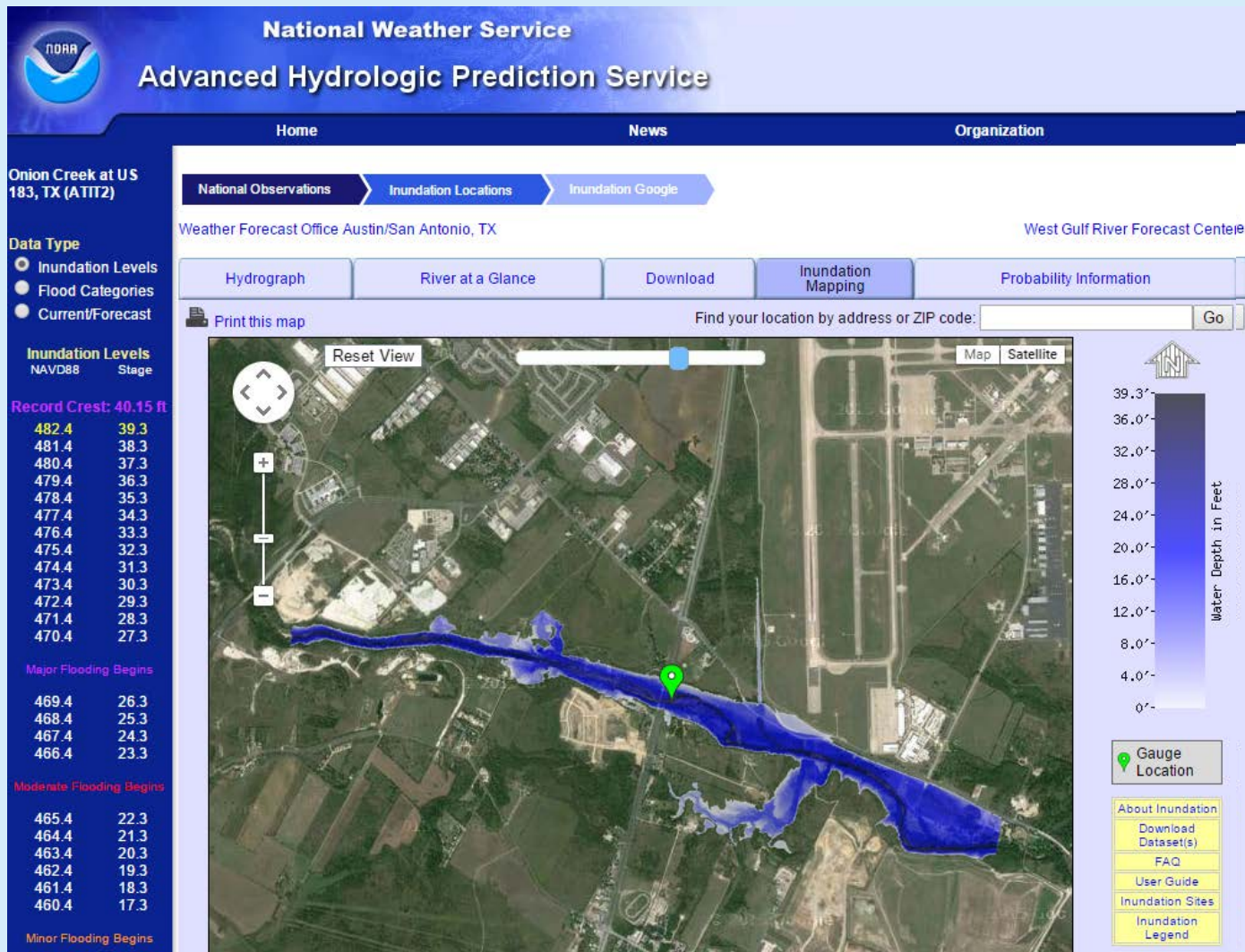


# National Weather Service Flood Inundation Maps for the US (130 in total)





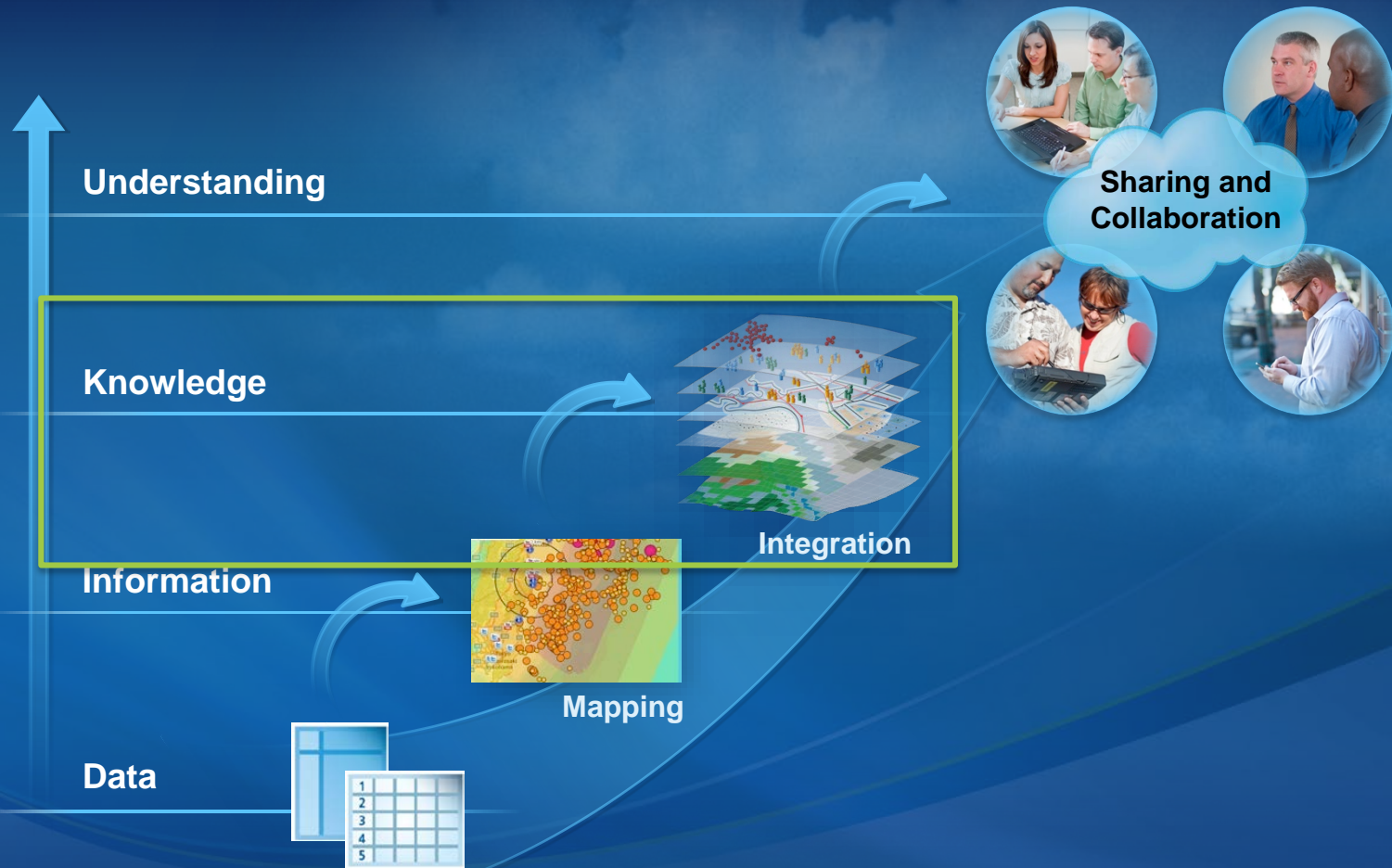
# Real-Time Flood Inundation Mapping Onion Creek at Highway 183



[http://water.weather.gov/ahps2/inundation/inundation\\_google.php?gage=atit2](http://water.weather.gov/ahps2/inundation/inundation_google.php?gage=atit2)

**Cost per map: \$40,000 – \$160,000**

# Geospatial Systems Are Helping Us Understand



*... Helping Us Make Better Decisions*



# EleHydro

Combine hydrography and elevation to define river channel geometry and flood inundation extent for 5 million km of stream reaches over continental US



**National Hydrography Dataset**

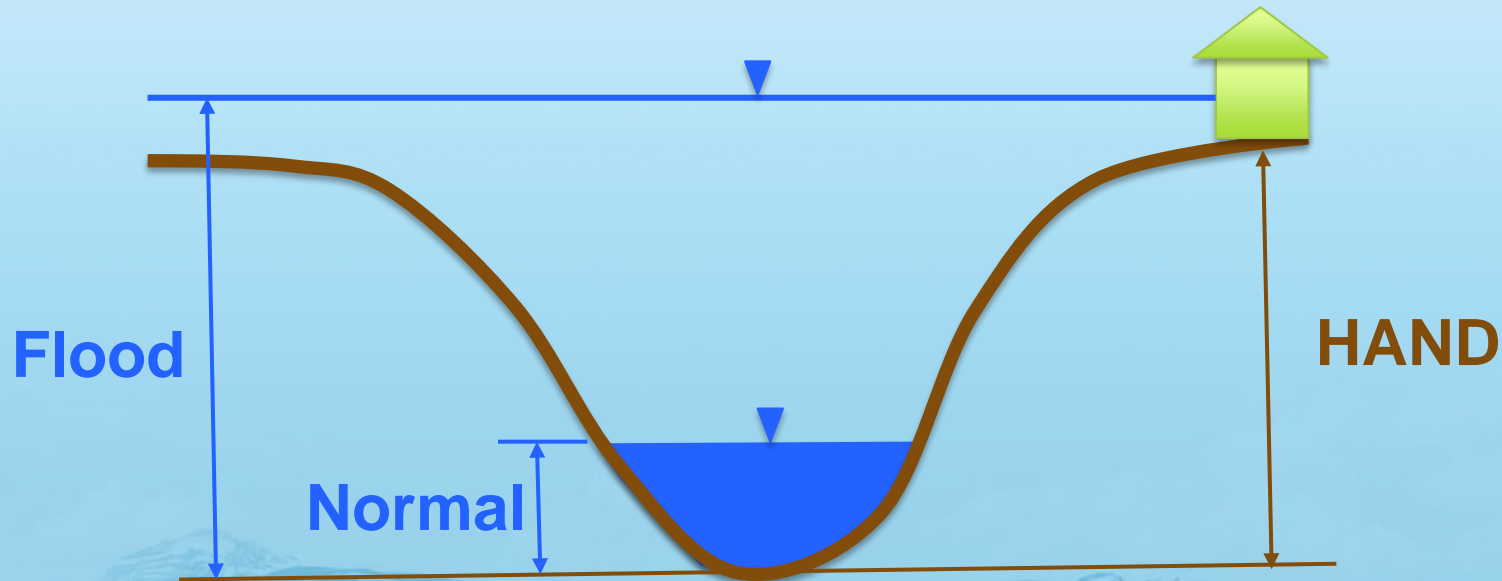


**National Elevation Dataset**

Use the [CyberGIS](#) computing facility  
at the University of Illinois at Urbana-Champaign

# Method for Determining Flood Risk: Height Above Nearest Drainage (HAND)

*Flooding occurs when **Water Depth** is greater than **HAND***





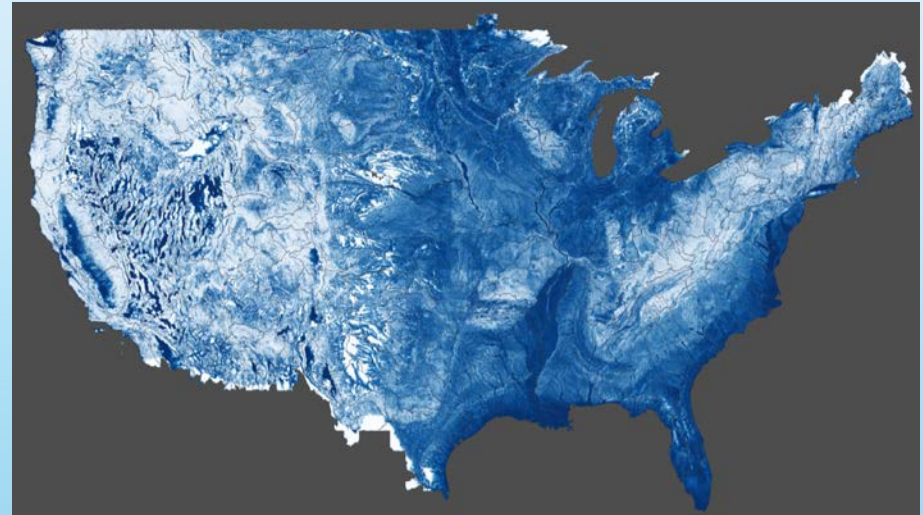
# Continental-Scale Flood Inundation Mapping



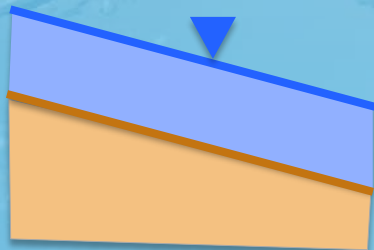
Catchments and Flowlines



Digital Elevation Model



Height Above Nearest  
Drainage (HAND)  
(relative elevation of land  
surface cell above cell in  
stream to which it flows)



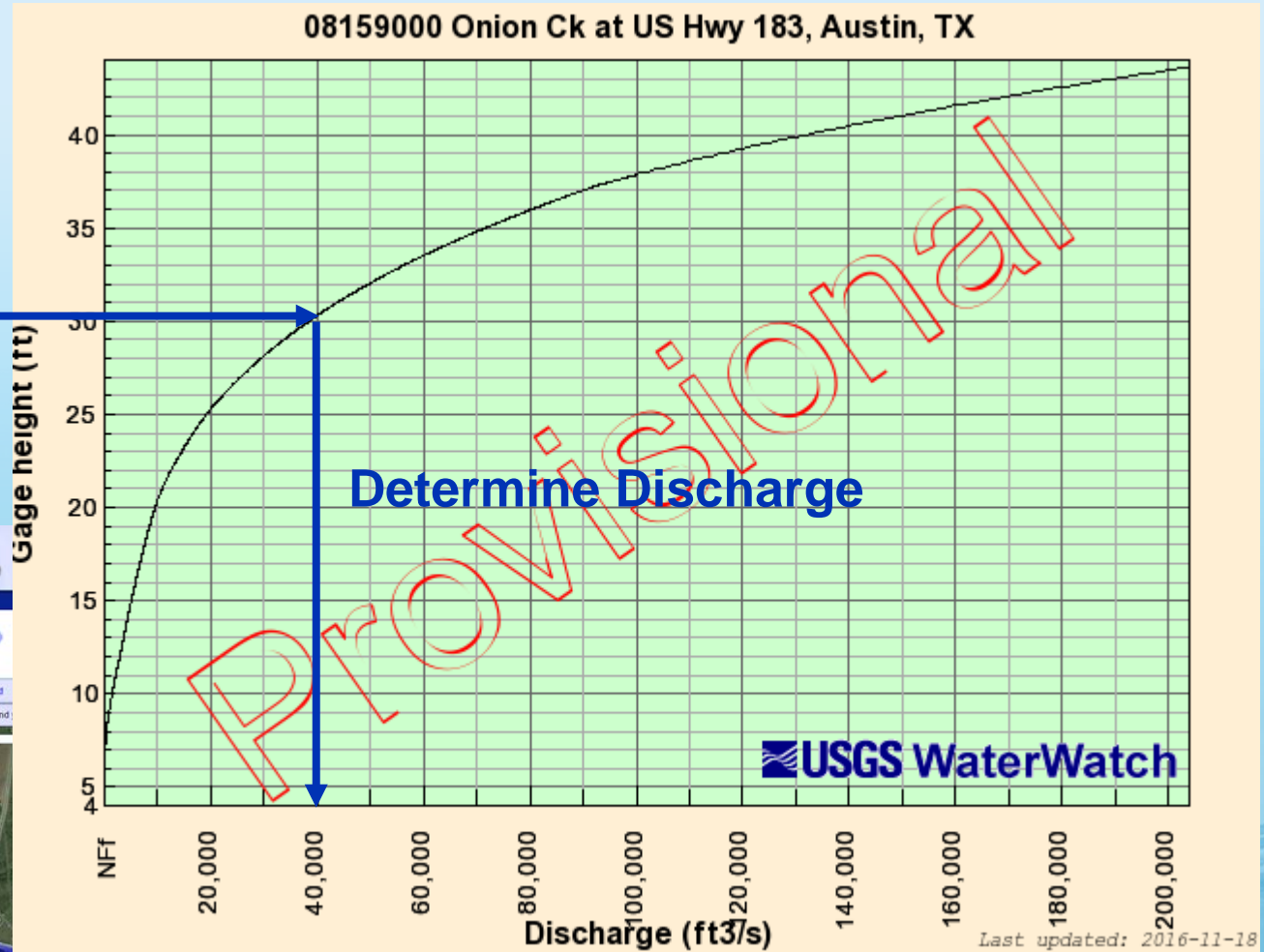
CyberGIS Facility  
University of Illinois at Urbana-Champaign



# USGS Rating Curve at a Stream Gage

## Union Creek at Highway 183

Measure  
Water Level



National Weather Service  
Advanced Hydrologic Prediction Service

08159000 Union Ck at US Hwy 183, TX (AT172)

Data Type  
Inundation Levels  
Flood Categories  
Current Forecast

Record Crest	Stage
482.4	39.3
481.4	38.3
480.4	37.2
479.4	36.3
478.4	35.3
477.4	34.3
476.4	33.3
475.4	32.3
474.4	31.3
473.4	30.3
472.4	29.3
471.4	28.3
470.4	27.3

Main Flooding Begins

469.4	26.3
468.4	25.3
467.4	24.3
466.4	23.3

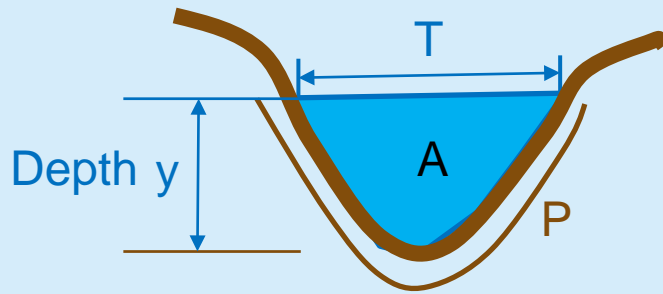
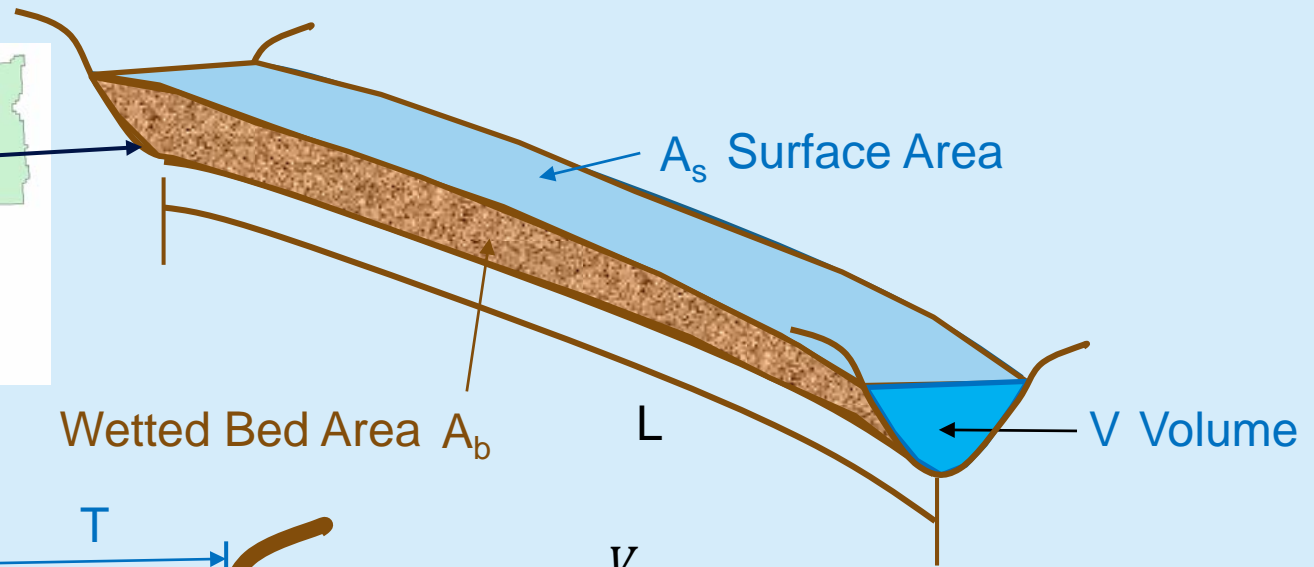
Minor Flooding Begins

465.4	22.3
464.4	21.3
463.4	20.3
462.4	19.3
461.4	18.3
460.4	17.3



# Reach Hydraulic Parameters

Comid	y	A	R	P	T	V	Ab	As
5781175	3							
5781175	4							



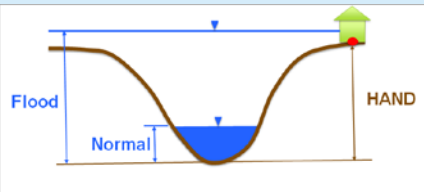
$$A = \frac{V}{L} \quad \text{Cross Section Area}$$

$$P = \frac{A_b}{L} \quad \text{Wetted Perimeter}$$

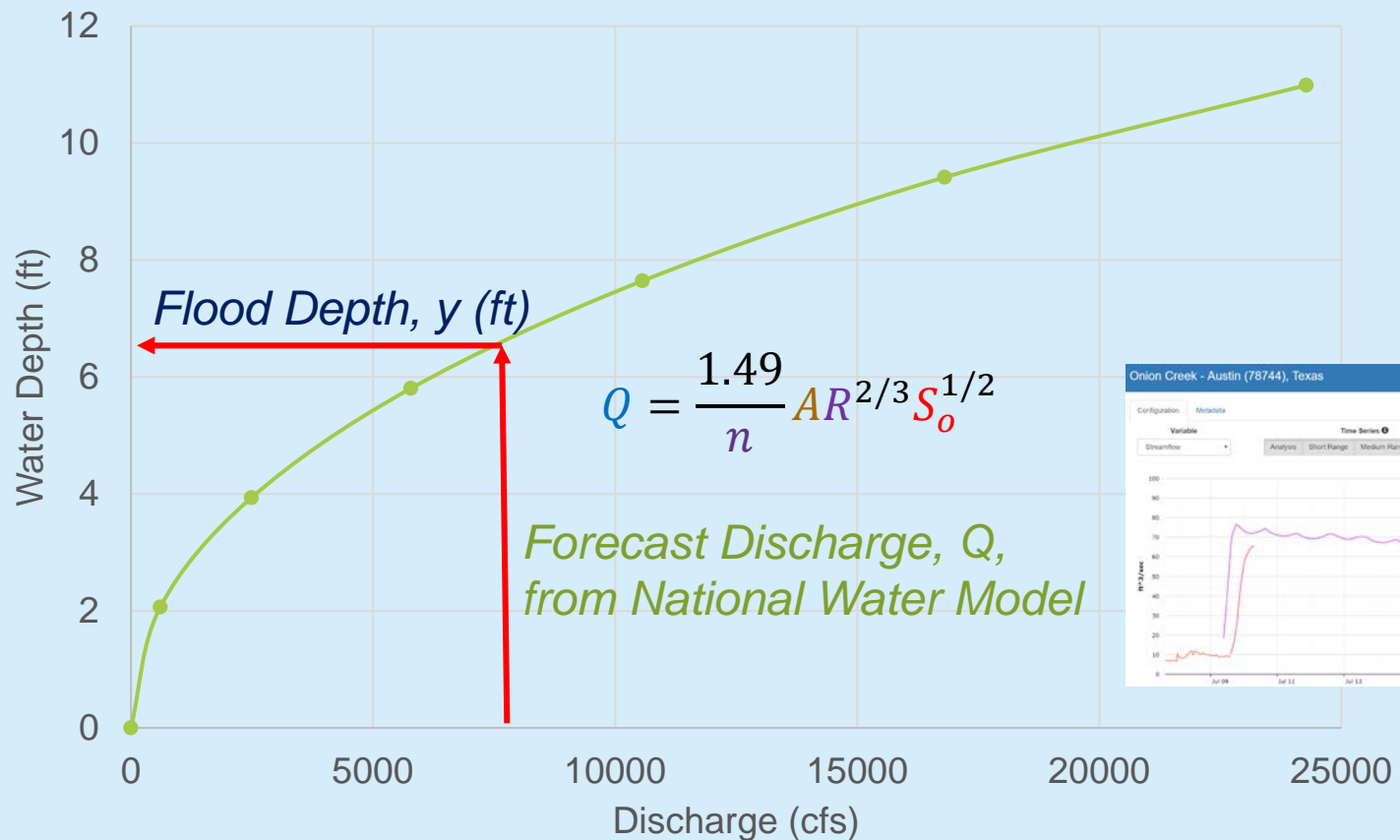
$$T = \frac{A_s}{L} \quad \text{Top Width}$$

$$R = \frac{A}{P} \quad \text{Hydraulic Radius}$$

# Rating Curve – Connects Discharge with Depth

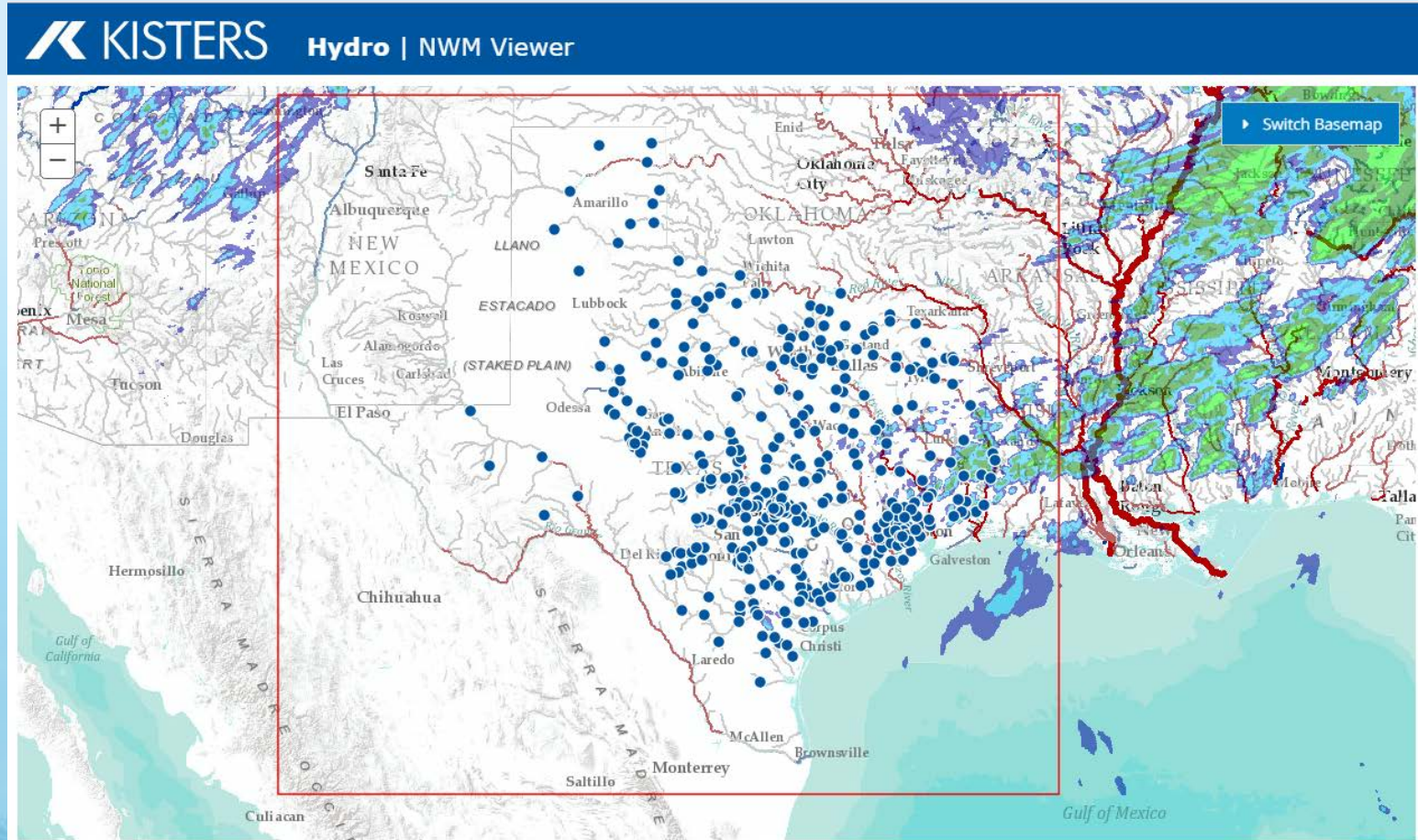


Rating Curve for Eanes Creek, ComID = 5781289





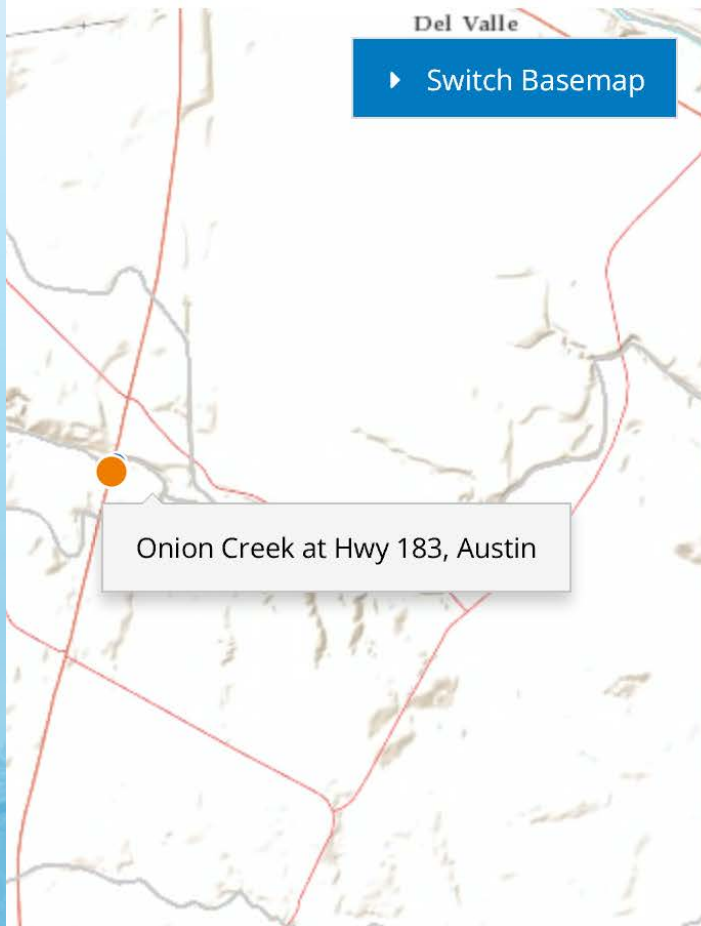
# National Water Model Viewer



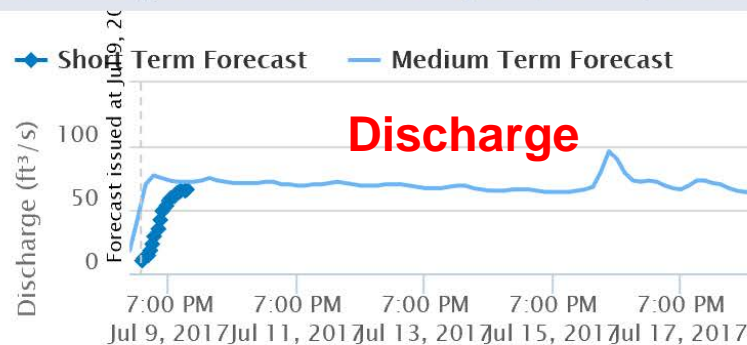
<https://nwm.kisters.de/applications/index.html?publicuser=publicuser#NWM/main>

# Forecast Discharge and Water Depth Onion Creek at Highway 183

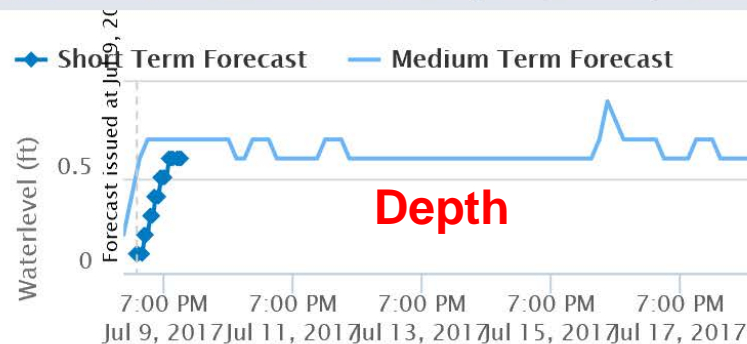
**KISTERS** Hydro | NWM Viewer



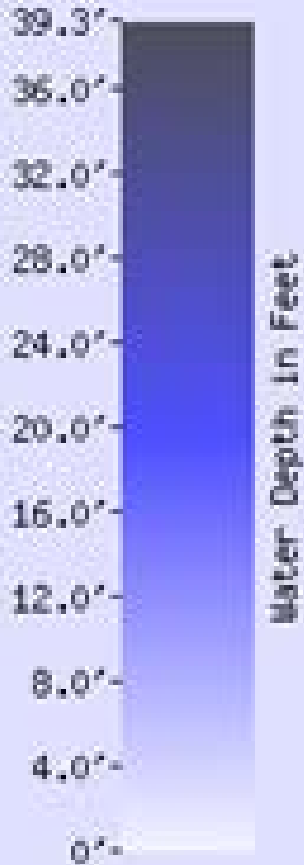
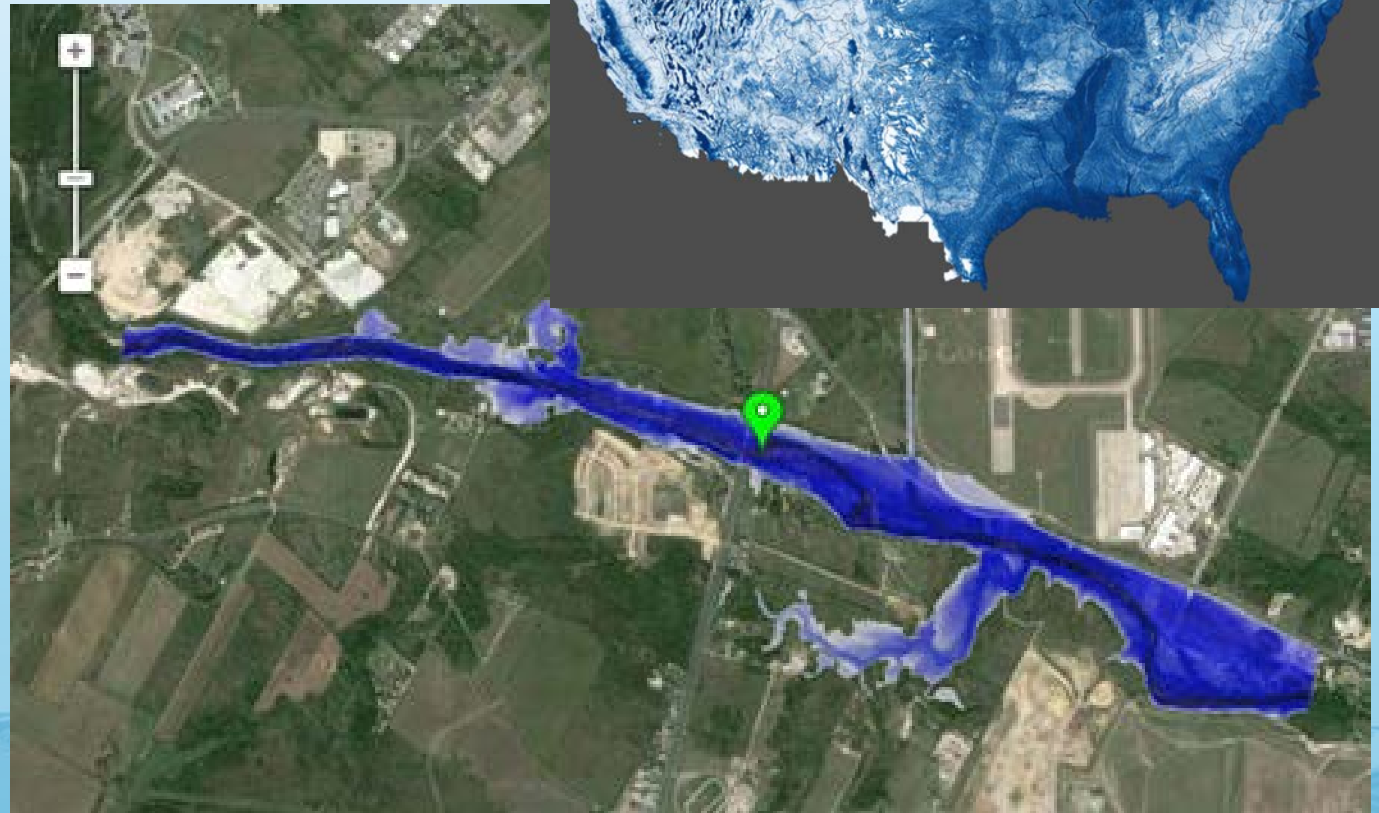
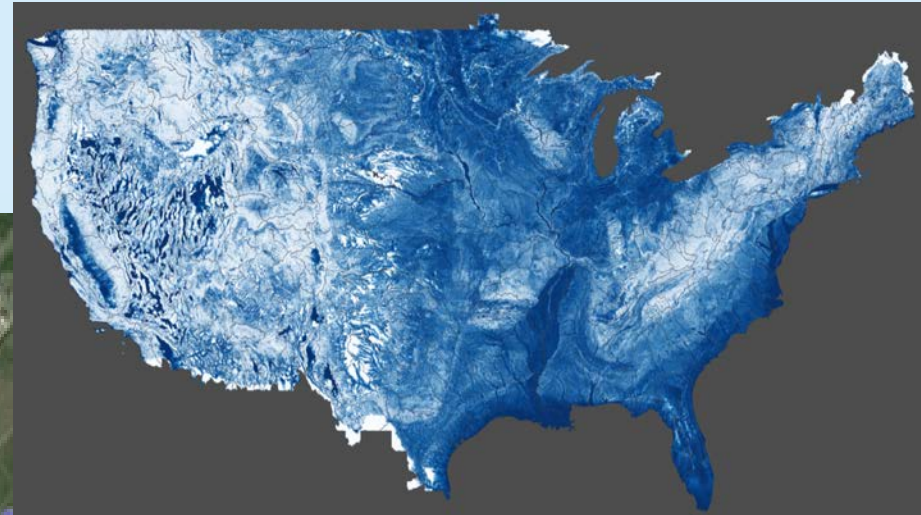
Discharge at Onion Creek at Hwy 183, Austin (5781369)



Waterlevel at Onion Creek at Hwy 183, Austin (5781369)



# From Depth to Inundation



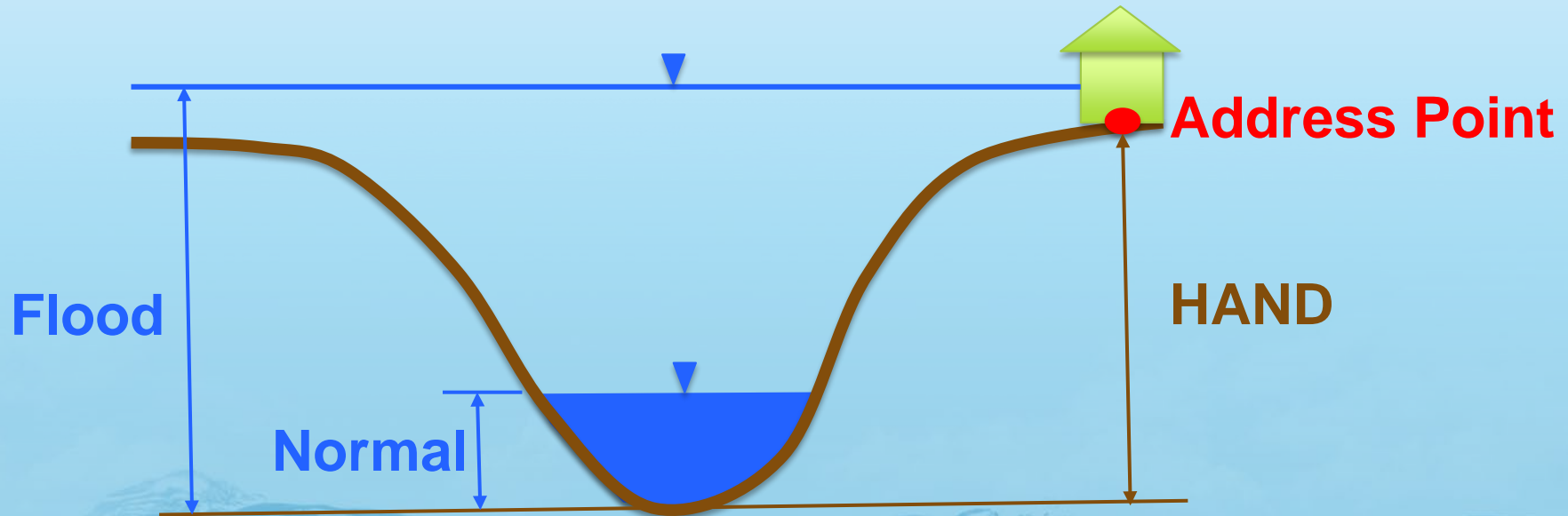
 Gauge Location

Identify Inundation Zone from the HAND raster



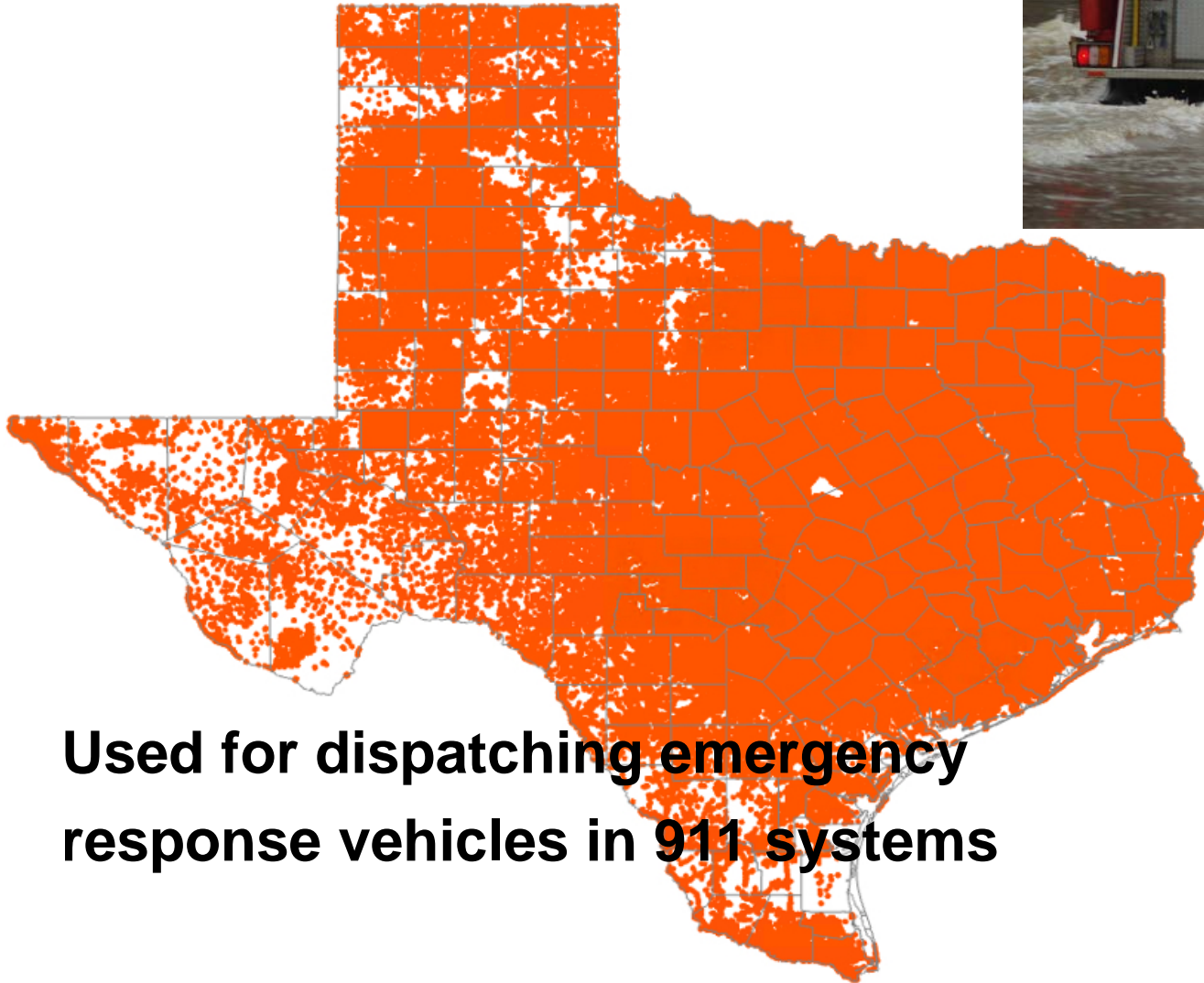
# Method for Determining Flood Risk: Height Above Nearest Drainage (HAND)

*Flooding occurs when **Water Depth** is greater than **HAND***



# Texas Address Points

9.1 million points



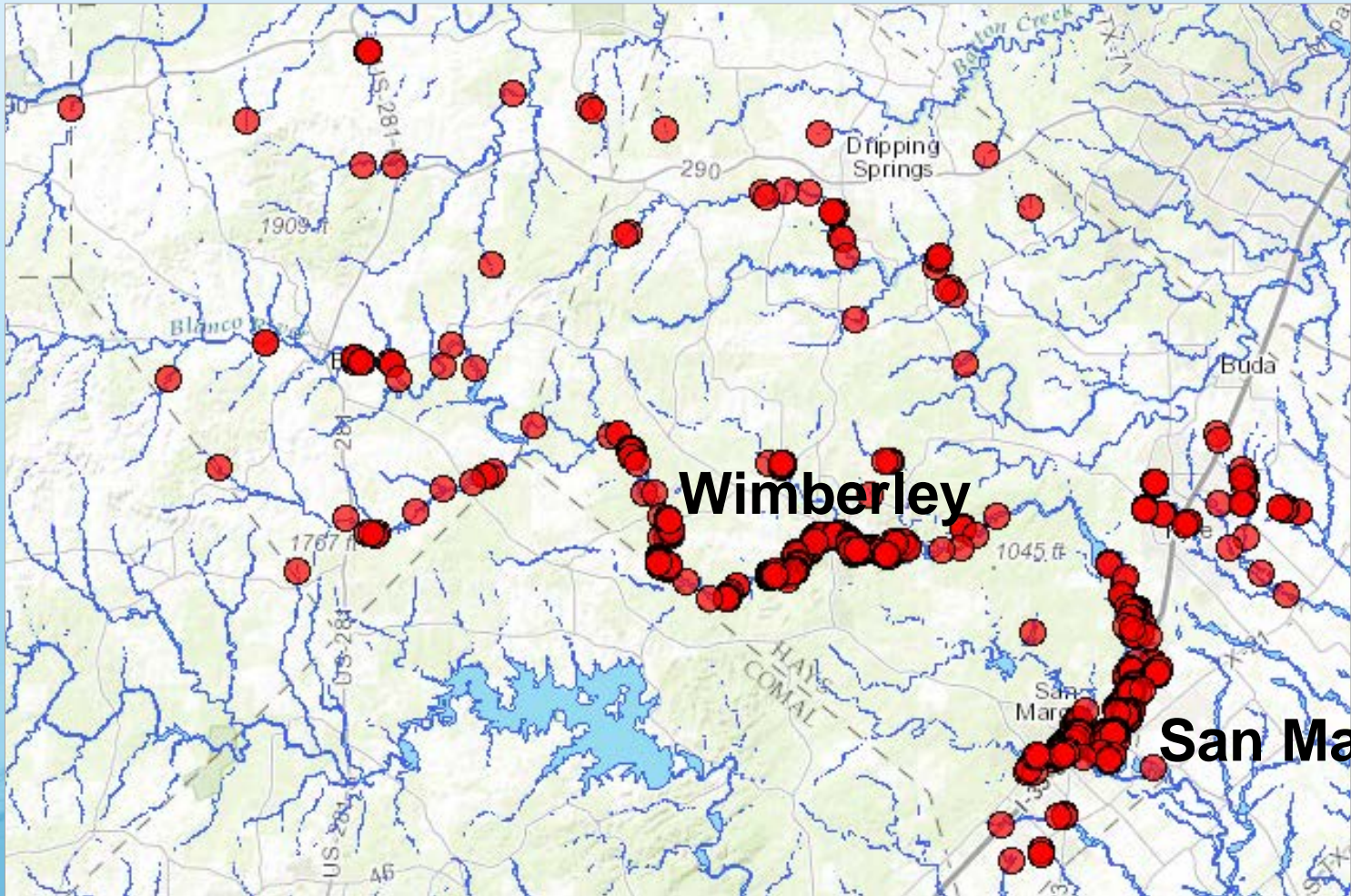
Data compiled by  
Emergency  
Communications  
Districts

Used for dispatching emergency  
response vehicles in 911 systems



# Flood Inundation Mapping

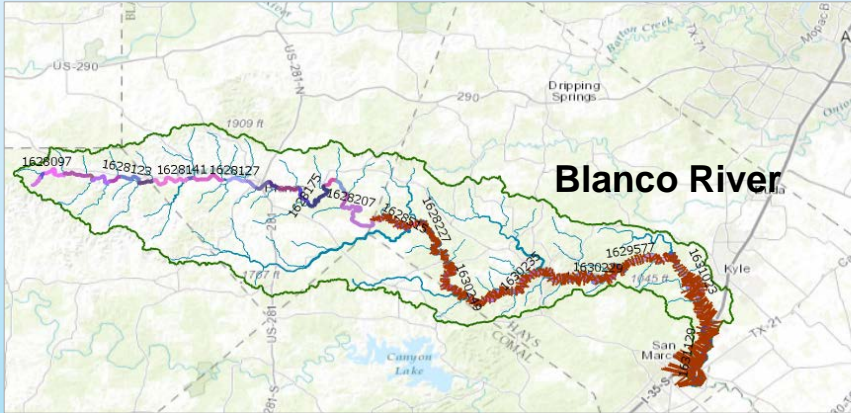
## May 2015 Flood, Blanco Basin





# Integrity Checking

Comparing with USACE flood models

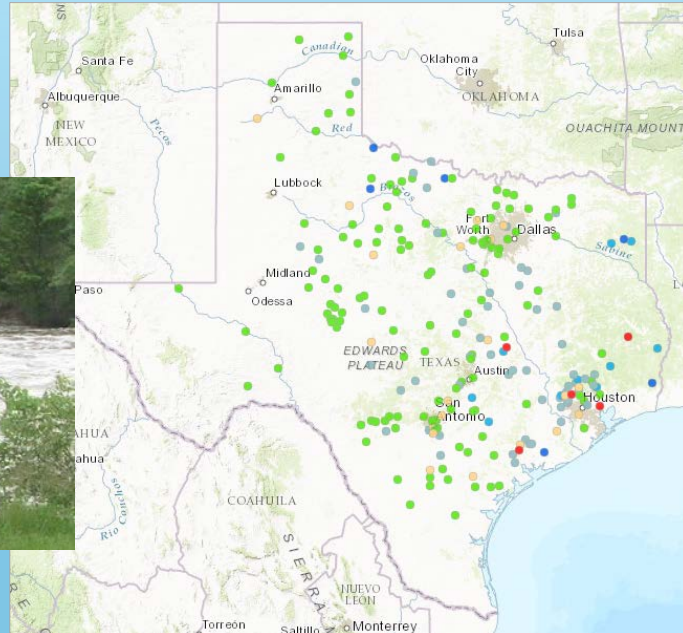


**US Army Corps of Engineers**  
Hydrologic Engineering Center

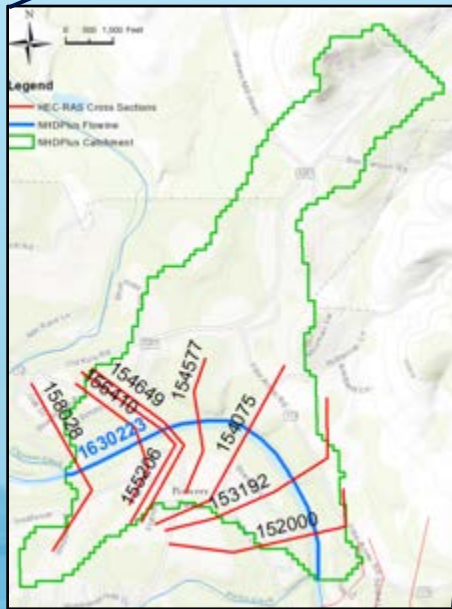
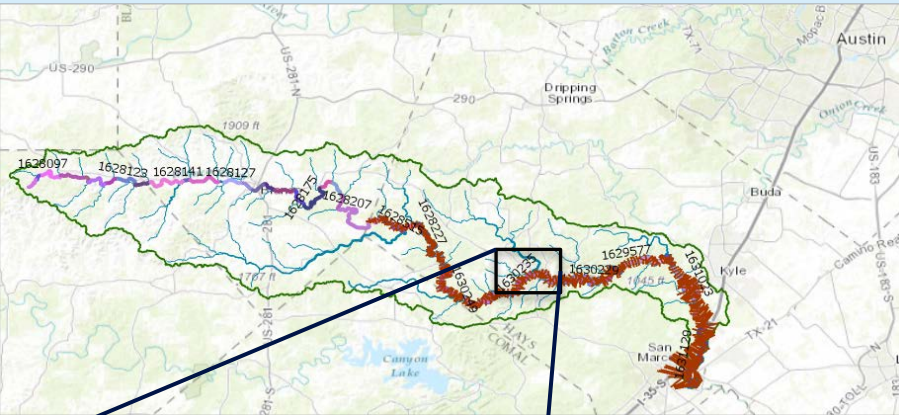
## HEC-RAS River Analysis System

A black and white illustration showing a river flowing through a landscape. In the background, there are mountains. In the foreground, there are buildings, a dam, and a bridge. The river is shown in a cross-section view, flowing from left to right.

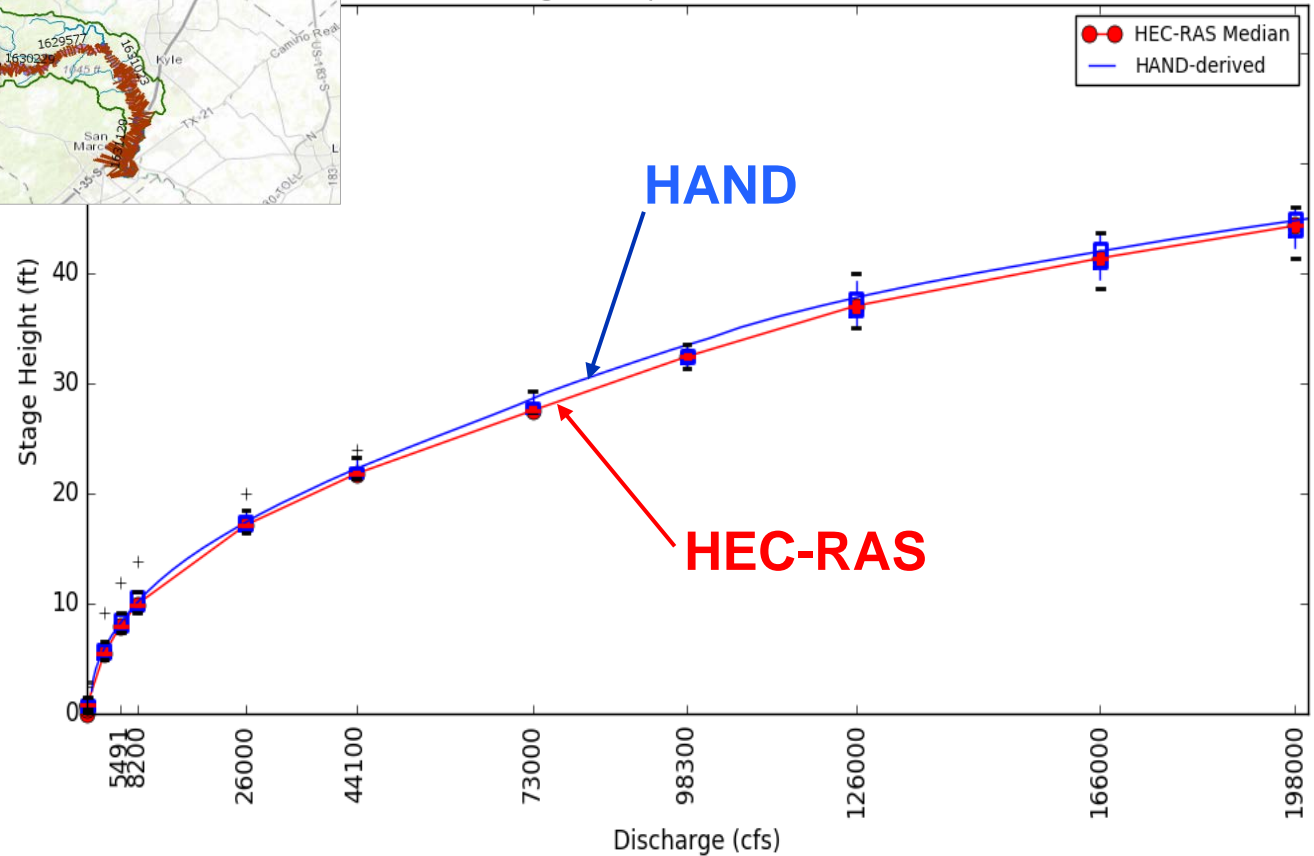
Comparing with observed water depth at USGS, LCRA and other gaging sites



# Comparing Rating Curves from HEC-RAS and HAND

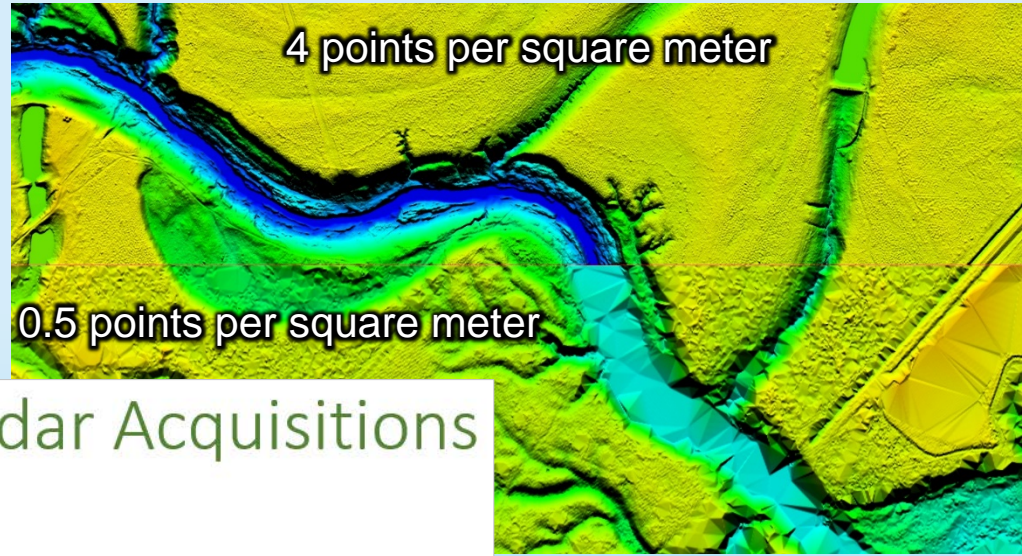


Rating Curve Space of Reach 1630223

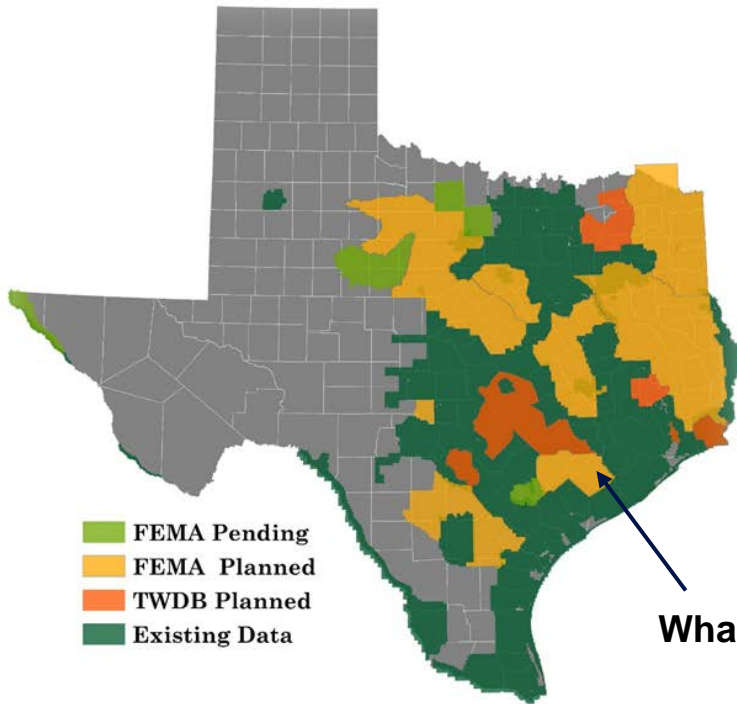




# LIDAR Terrain Mapping



## Texas 2016-2017 Lidar Acquisitions

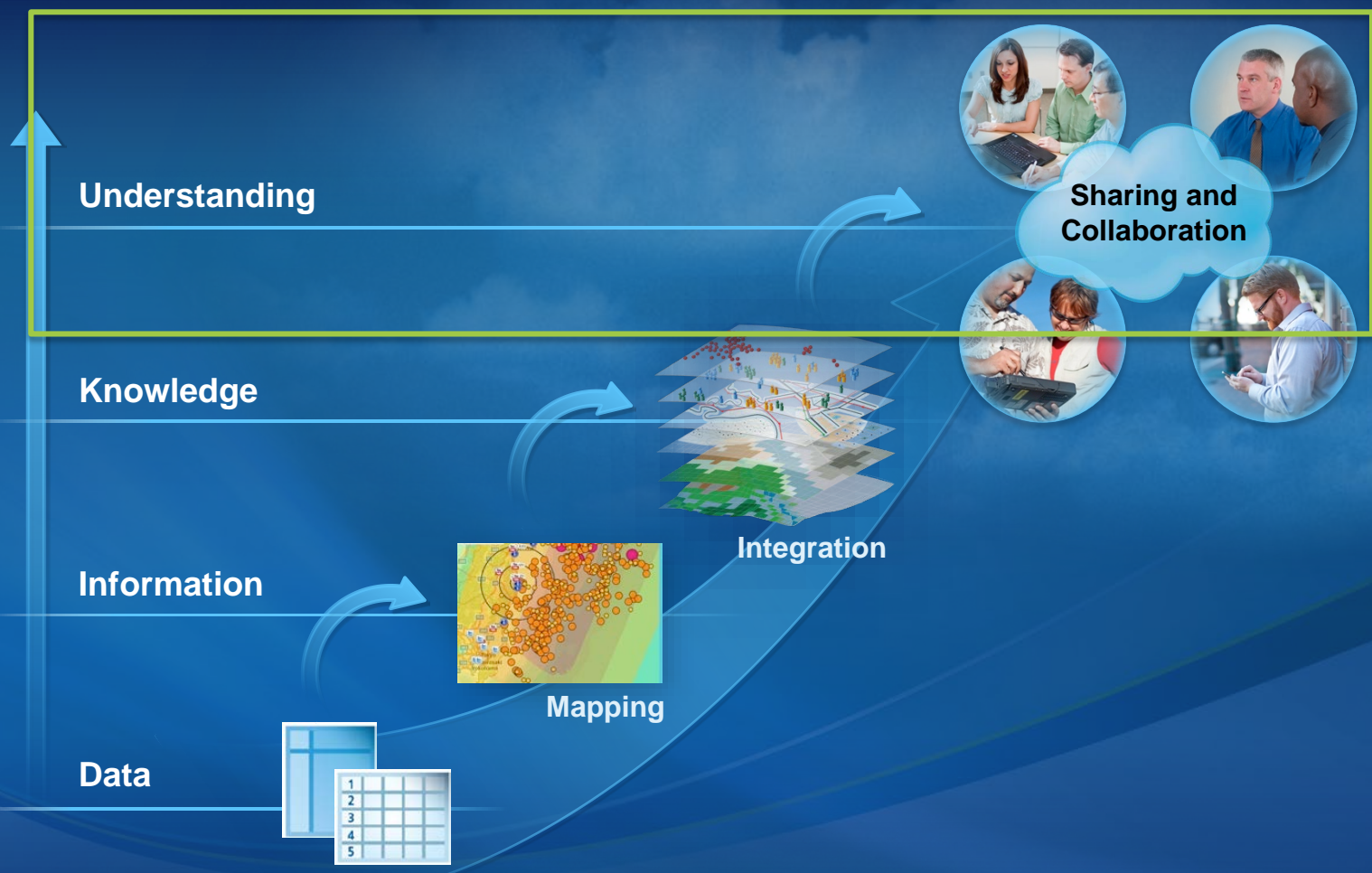


TWDB and StratMap partners are acquiring 11,000 square miles winter 2016-2017

FEMA is acquiring over 50,000 square miles winter 2016-2017



# Geospatial Systems Are Helping Us Understand



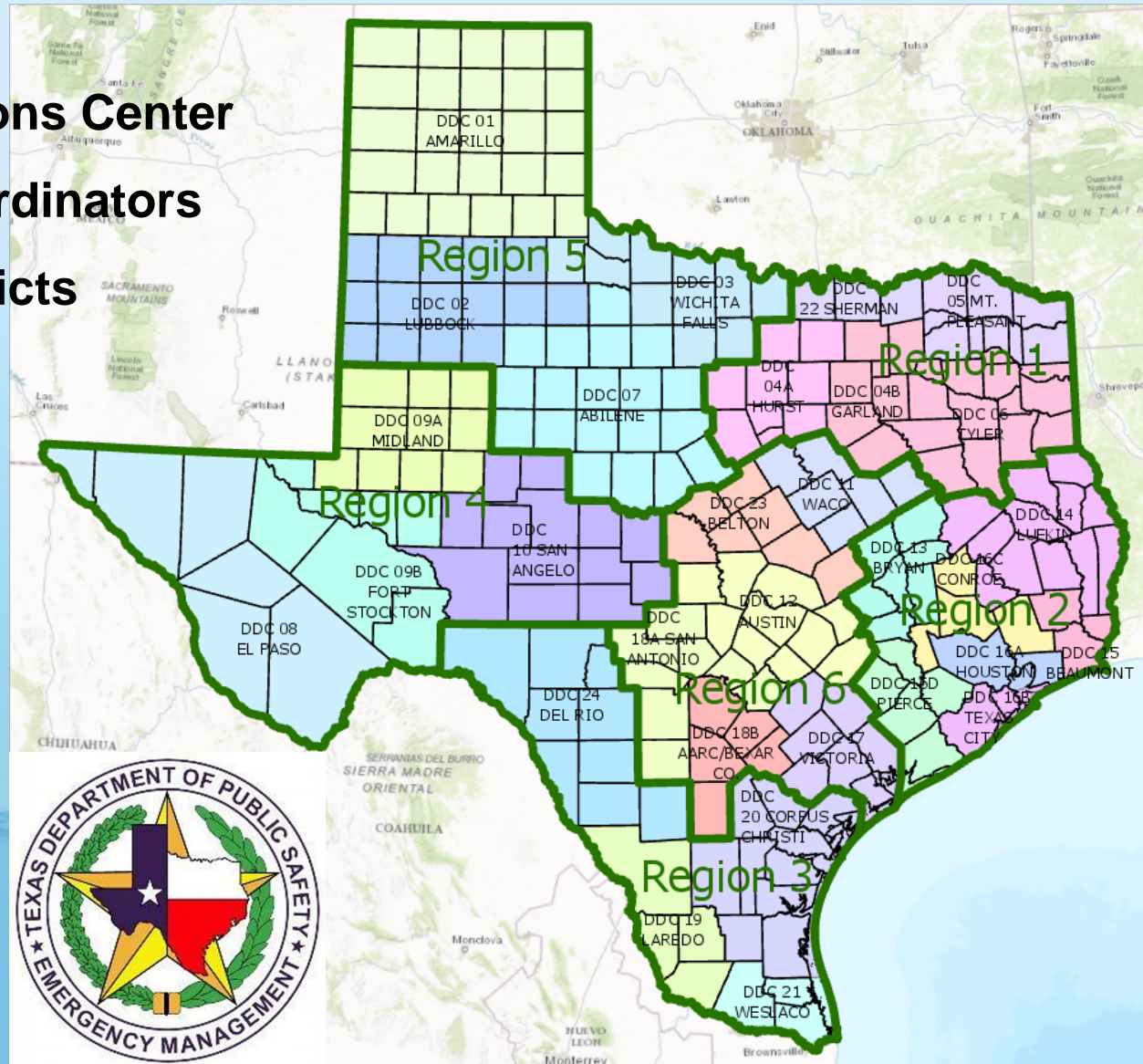
*... Helping Us Make Better Decisions*

# Texas Division of Emergency Management

- State Operations Center
- Regional Coordinators
- Disaster Districts
- Counties



Chief Nim Kidd  
Director, TDEM



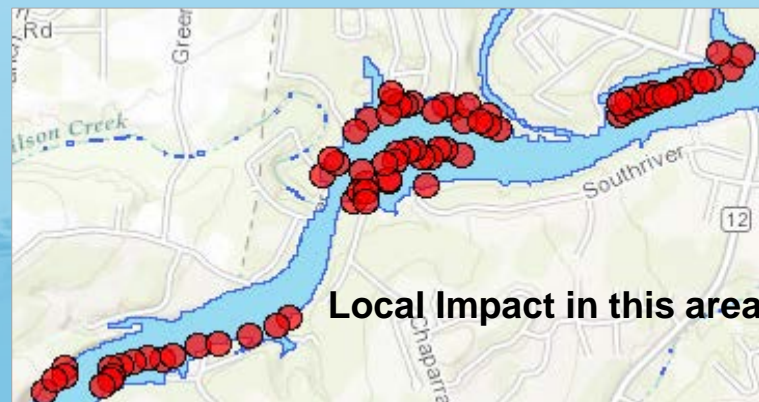






# First Responder Input to Inundation Mapping

Rock on road at current water level → Point location sent in by text → Inundation map

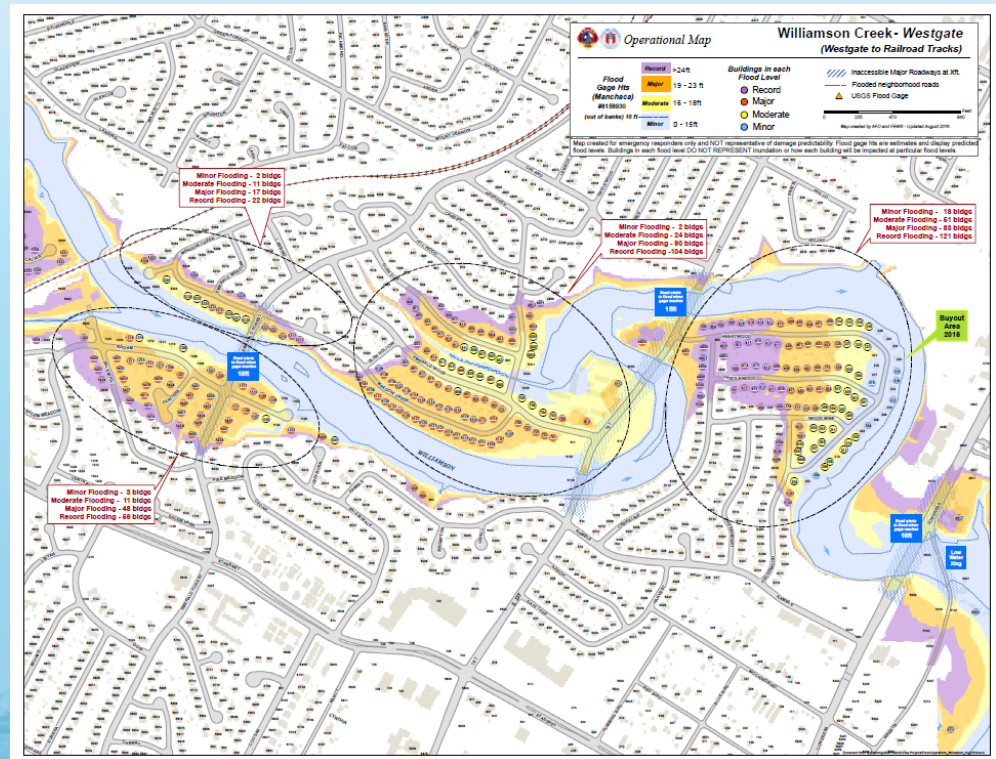


Chief Todd Pomroy, Austin Fire Department



# Operational Map

- Collaboration between Austin Fire Dept and Flood Early Warning System
- Flood operational maps for 23 Austin creeks
- Tested in six table top exercises over last 2 years
- Now being deployed in fire trucks in paper and pdf format





# Flood Operational Maps

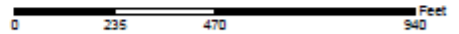


## Operational Map

## Williamson Creek - Westgate (Westgate to Railroad Tracks)

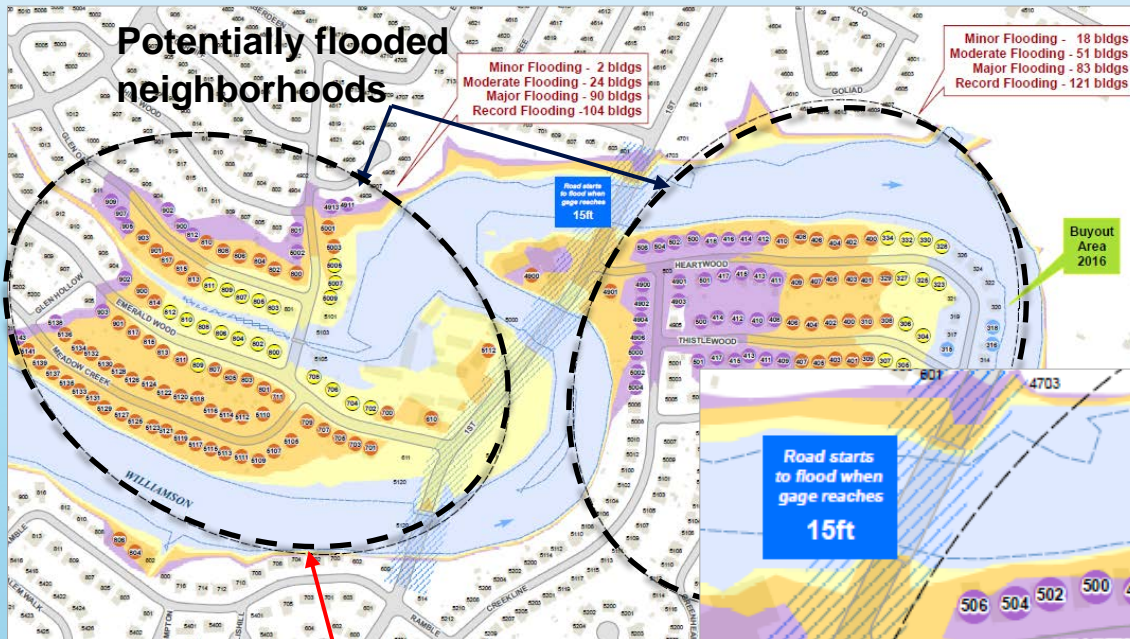
Flood Gage Hts (Manchaca) #8158930 (out of banks) 10 ft	Record	>24ft	Buildings in each Flood Level
	Major	19 - 23 ft	Record
	Moderate	16 - 18ft	Major
	Minor	0 - 15ft	Moderate
			Minor

- Inaccessible Major Roadways at Xft.
- Flooded neighborhood roads
- USGS Flood Gage



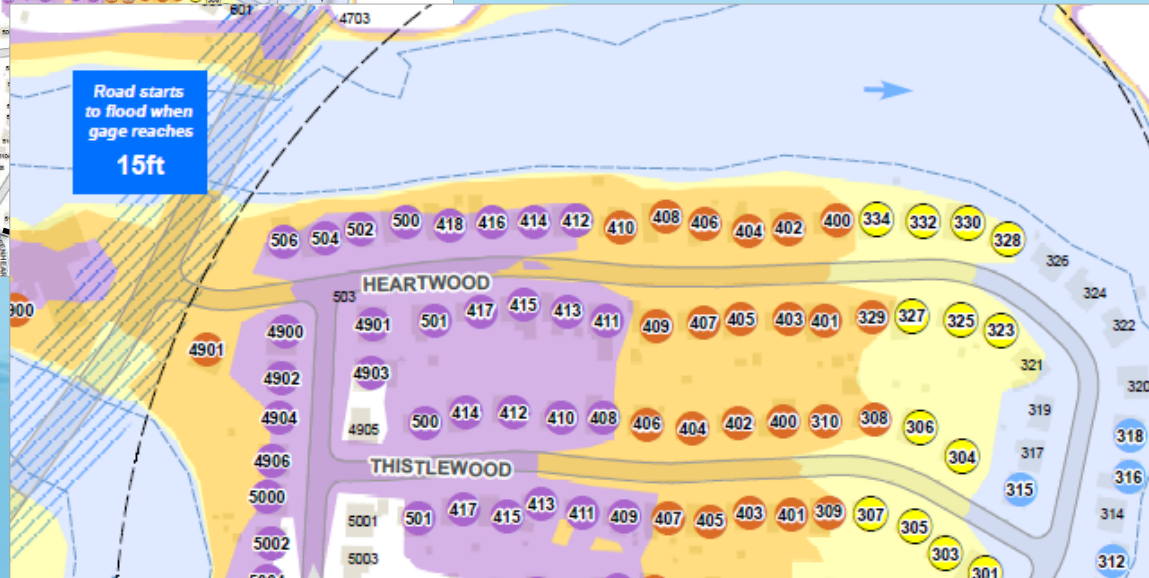
Map created by AFD and FEWS - Updated August 2016

Map created for emergency responders only and NOT representative of damage predictability. Flood gage hts are estimates and display predicted flood levels. Buildings in each flood level DO NOT REPRESENT inundation or how each building will be impacted at particular flood levels.



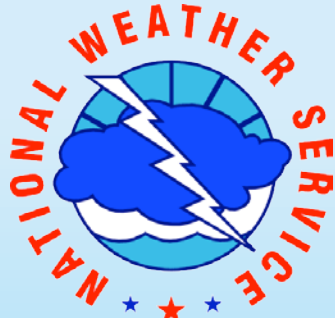
Flood Level	Flood depth in houses
Major	3ft
Moderate	6" - 3 ft
Minor	< 6"

Minor Flooding - 2 bldgs  
Moderate Flooding - 24 bldgs  
Major Flooding - 90 bldgs  
Record Flooding - 104 bldgs





# Information Flow During a Flood Emergency



West Gulf River  
Forecast Center



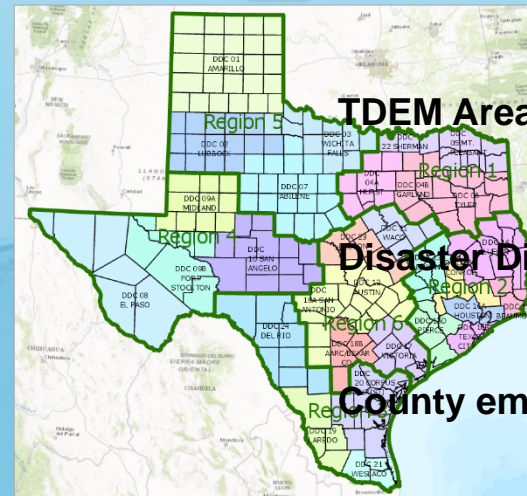
Weather and  
Flood Forecasting



State Operations Center



Flood Impacts

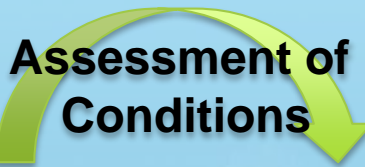


TDEM Area coordinators

Disaster District coordinators

County emergency managers

Communications  
Cycle



Assessment of  
Conditions

Emergency  
Response

# Flood Impact Dashboard (ESRI)

Texas Flood Impact Dashboard Impacts based on NWM forecasts, 911 address points, and census data

HELP

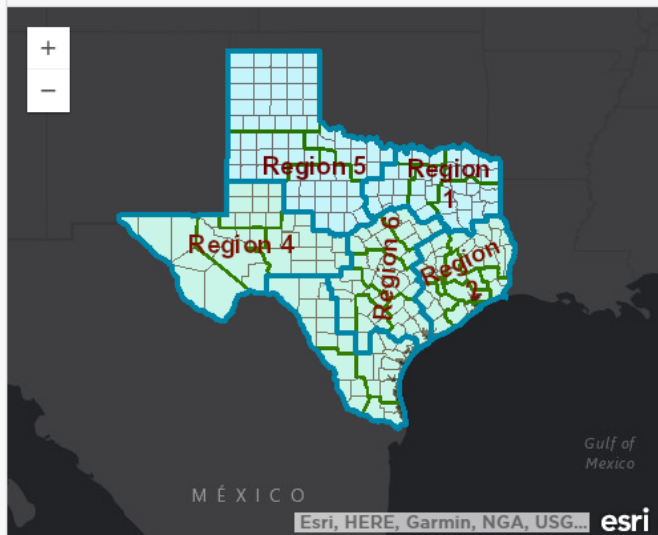
## Filters

Model: NWM - Memorial Day

5/22/2015 0:00:00 AM

REFRESH STATISTICS

## Map



## Statistics

TOP DIMENSIONS

COUNTIES

CHARTS

DETAILS

Region	Address Count
Region 6	4857
Region 2	329
Region 3	77
Region 4	13

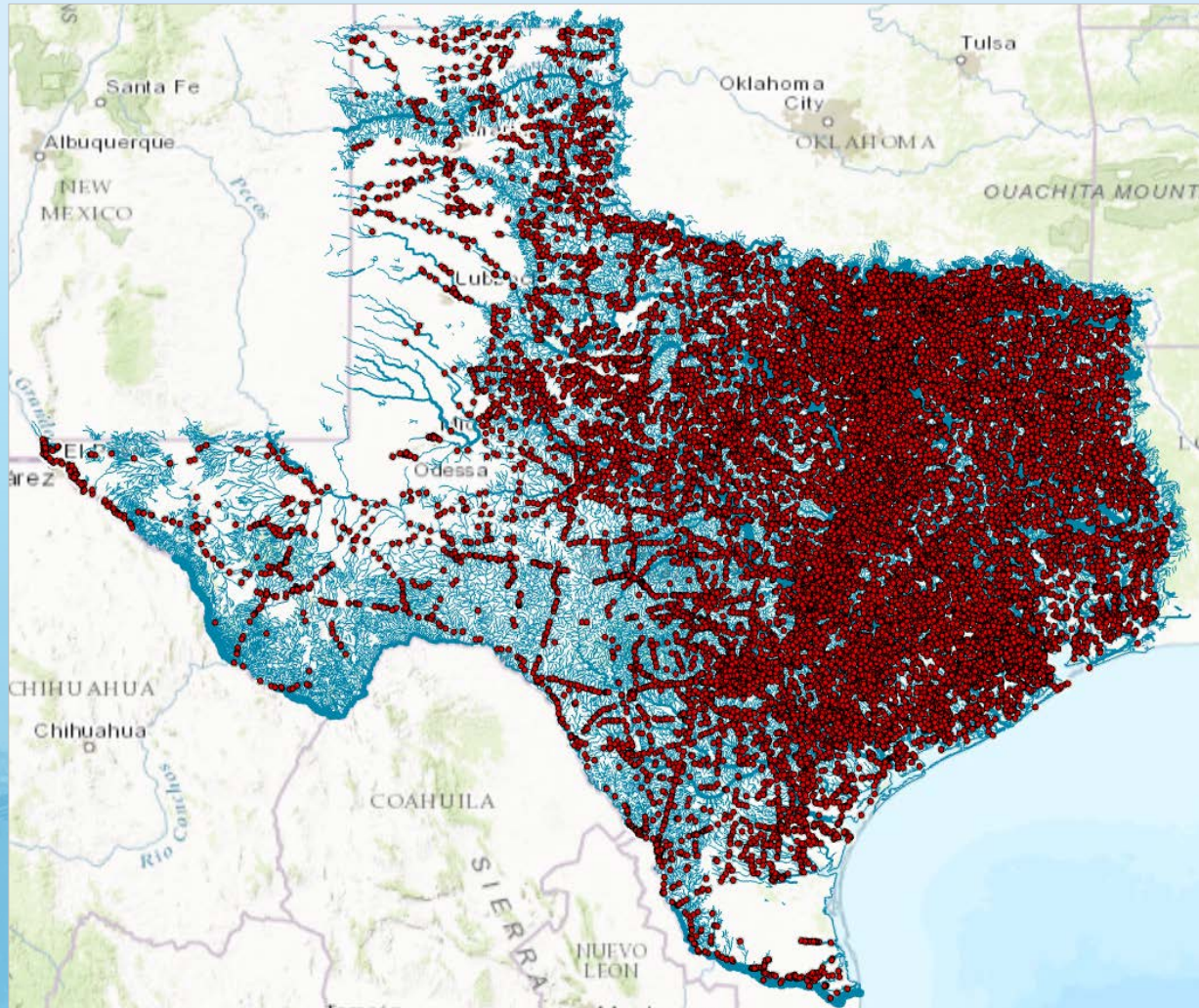
1 - 4 of 4 results

District	Region
DDC 12 AUSTIN	Region 6
DDC 18B AARC/BEXAR CO.	Region 6
DDC 18A SAN ANTONIO	Region 6
DDC 17 VICTORIA	Region 6
DDC 23 BELTON	Region 6

1 - 5 of 5 results

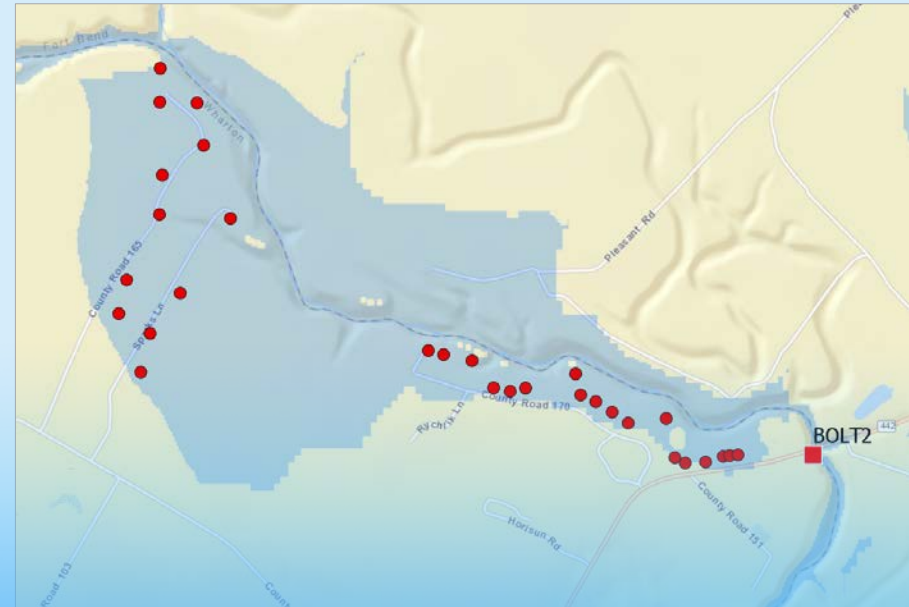
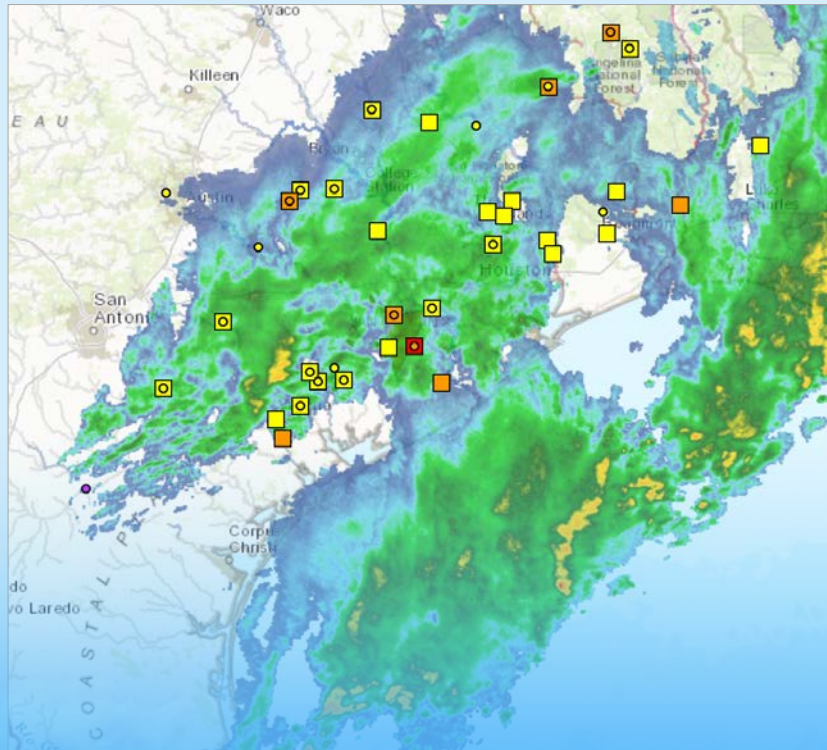
<http://txfloodata.esri.com/FloodDashboardmemday/>

# 27,000 Texas Bridges on 15,700 stream reaches forecast by the National Water Model



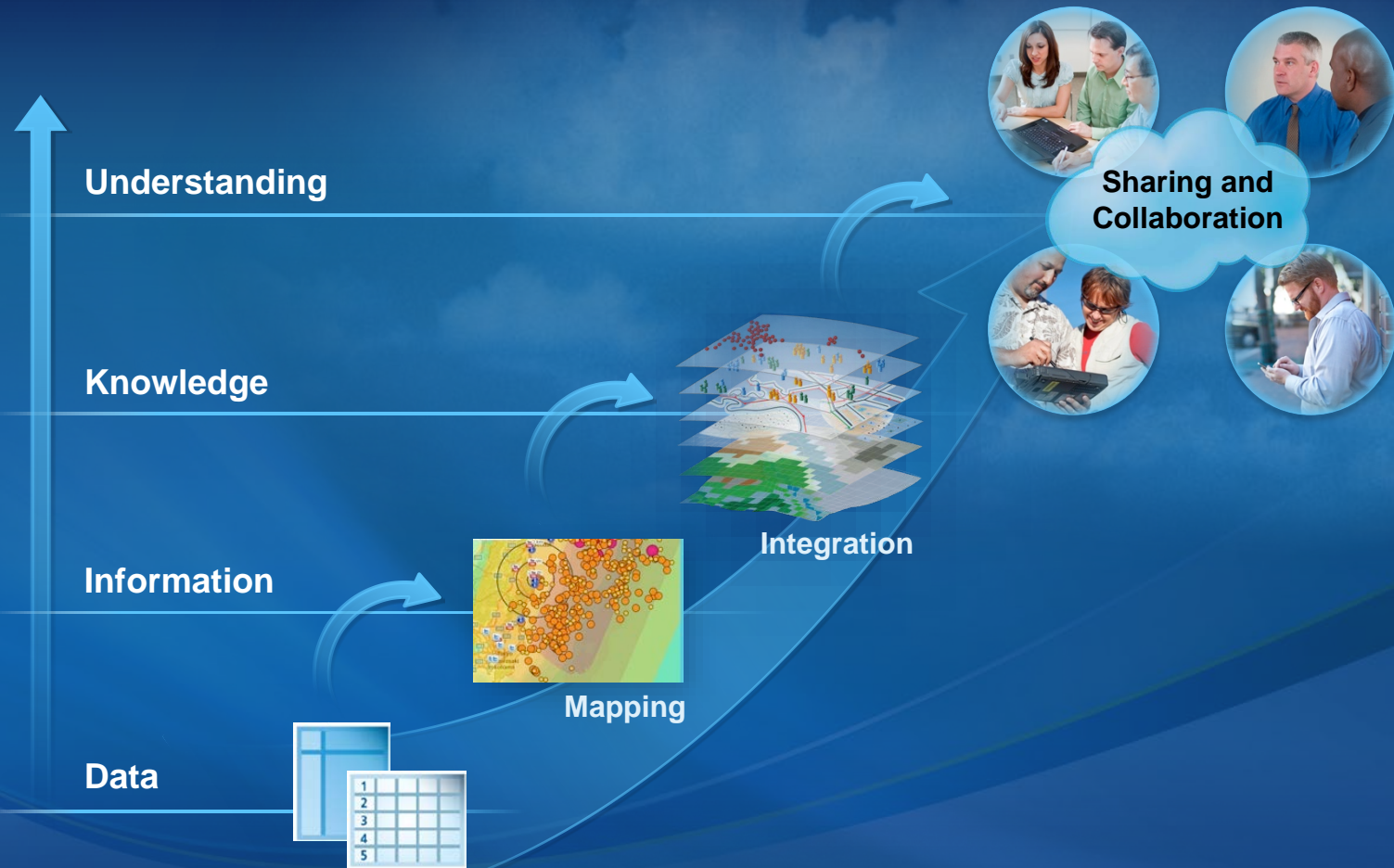


# Texas Flood Response System



The QUESTION is: How do you go from a radar rain map to flood inundation map showing impacts?

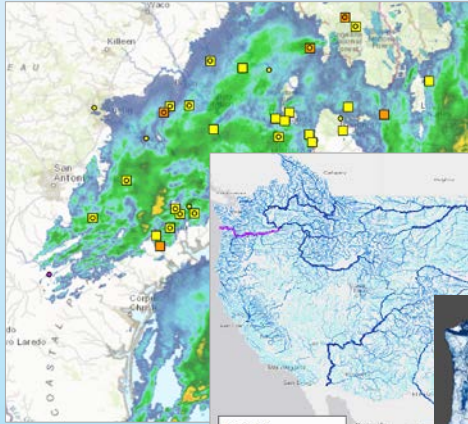
# Geospatial Systems Are Helping Us Understand



*... Helping Us Make Better Decisions*

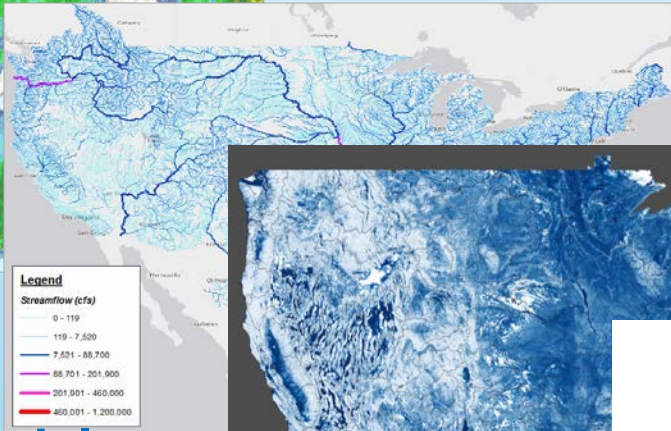


# Rain Map to Flood Map



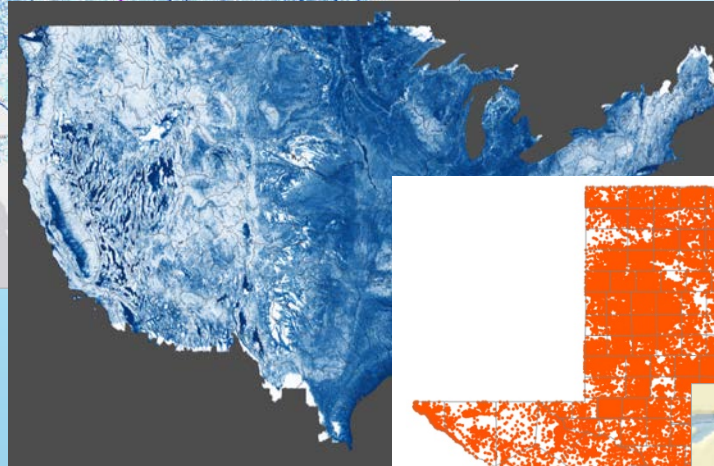
Precipitation

Flow

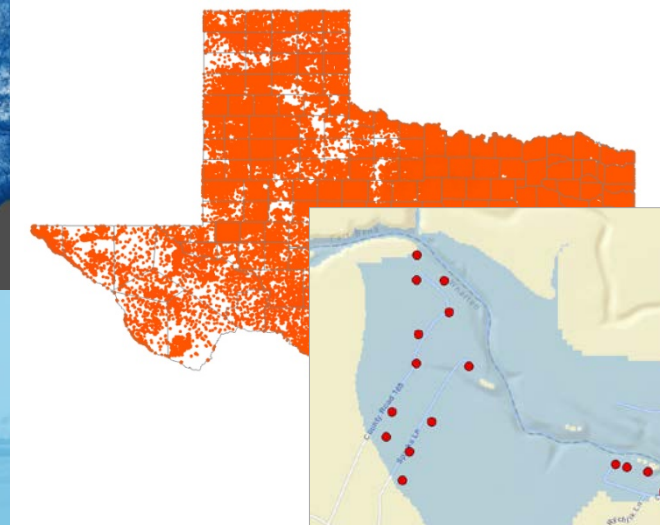


National Water Model

Height Above Nearest Drainage



Inundation



Impact

Address Points

Flooded Homes

