

HDR

# **Flood Forecasting in “Real Time” Using Modern Hydrodynamic Tools and Collaborative Science**

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- Tim Bardsley - National Weather Service



# Outline

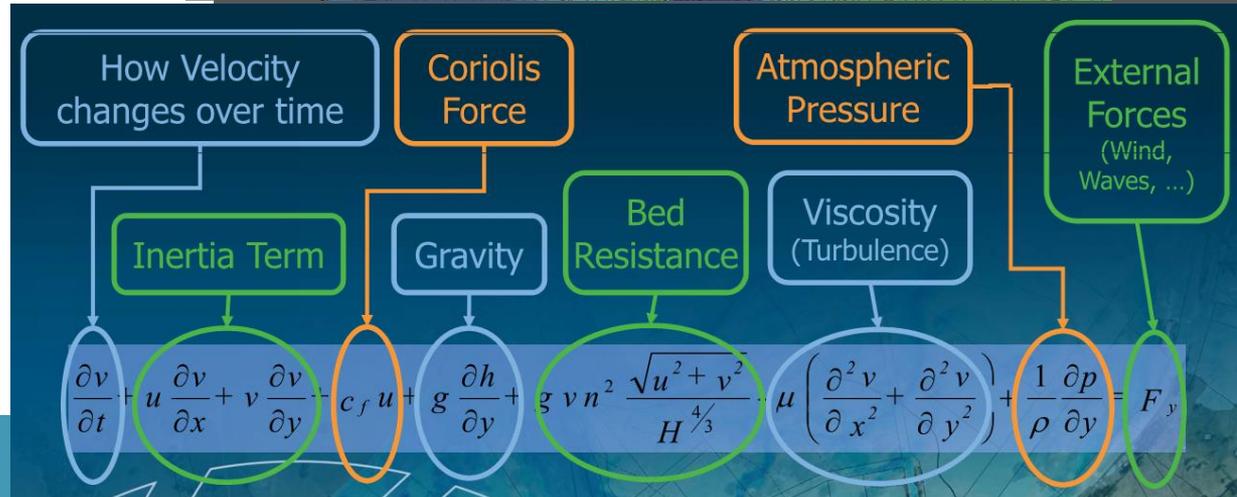
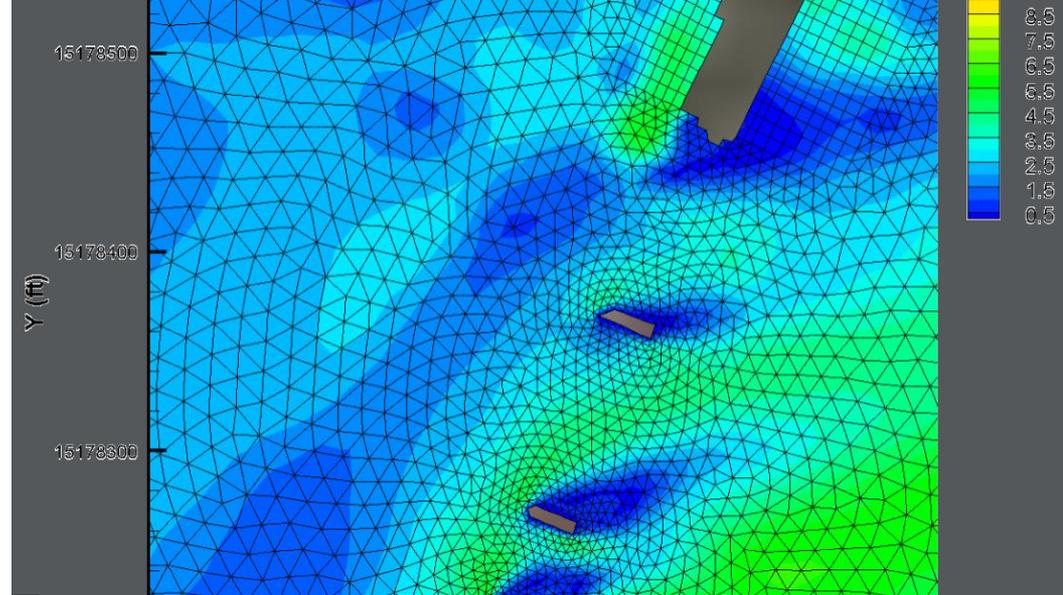
- Hydrodynamic Tools
  - HEC-RAS 5.0.7
- Historic Flood Events
- 2017 Event
  - National Weather Service Forecast Center
- Truckee River
  - Truckee River Flood Management Authority
- Carson River
  - Carson Water Subconservancy District



# 2D Modeling

## Advantages

- Dispersive shallow flow
- No guessing at cross section orientations
- More informative static and dynamic mapping
- Modeling in multiple directions
- Timing and volume changes quantified



# 2D Modeling in 2019

- Government Agencies Investing in 2D Models
  - FHWA - SRH2D
  - US Army Corps – HEC-RAS
- Computer Hardware
  - Processing speeds
  - Computations spread over multiple cores
  - 64-bit processing
  - Increases in RAM
- Cheaper Storage
  - Terabytes of data



US Army Corps  
of Engineers  
Hydrologic Engineering Center



Generalized Computer Program

## HEC-2 Water Surface Profiles

User's Manual

September 1990  
Revised: September 1991

# HEC-RAS 5.0.7

- 1D/2D Integrated Hydrodynamic Model
- Regular or Irregular 2D Grid Cells
- Finite Volume Solution
- Full Saint Venant or Diffusion Wave Equation Solution Options
- Unstructured or Structured Computational Meshes
- Detailed Hydraulic Table Properties for Computational Cells and Cell Faces
- RAS Mapper



US Army Corps  
of Engineers  
Hydrologic Engineering Center

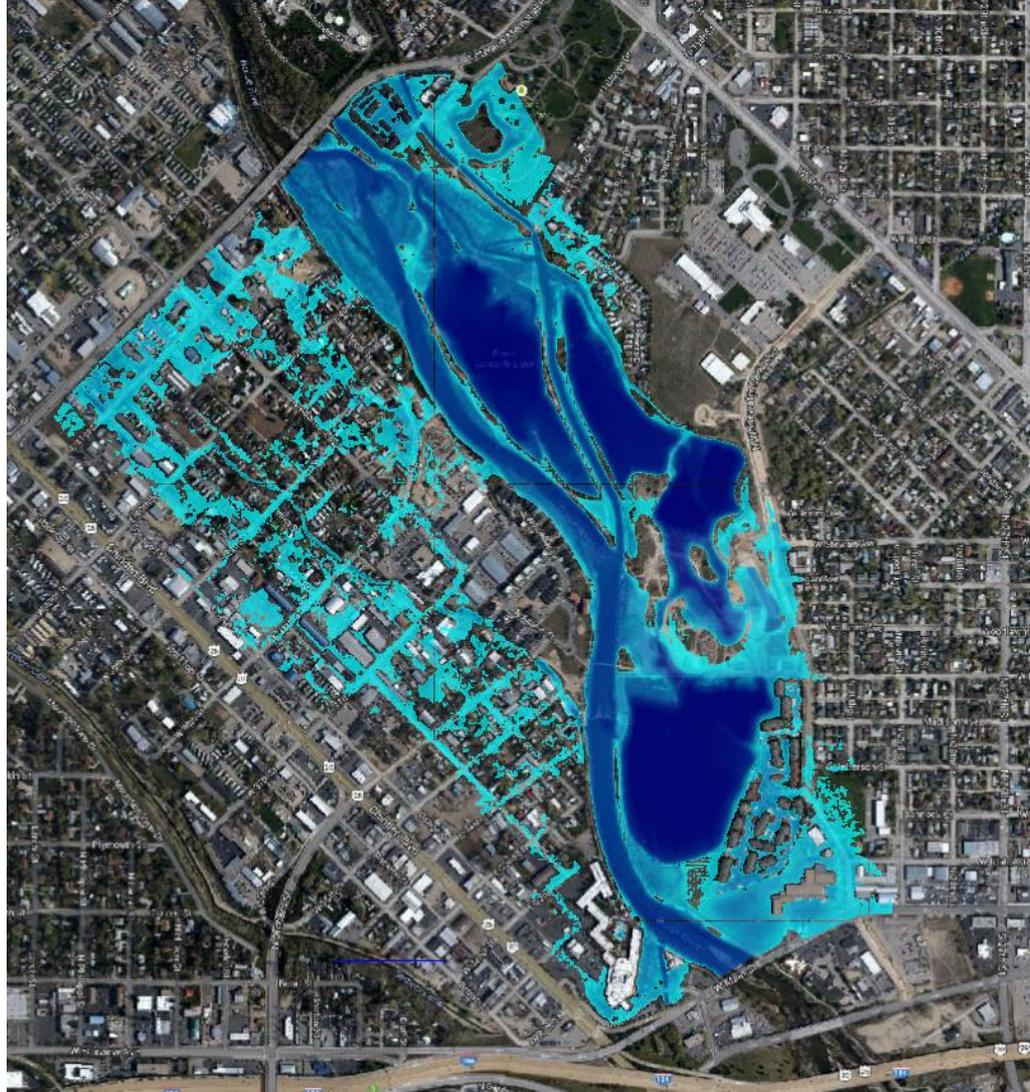
## HEC-RAS River Analysis System

### *Release Notes*

Version 5.0.7  
March 2019

# Why HEC-RAS 5.0.5

- Public Domain
- Extensively Tested
- Computationally Efficient
- New Codes
  - Not repackaging existing codes
- Unique Approach to 2D Solution
  - Sub grid cell detail
  - Pre-processes hydraulic tables
  - Lookup tables during run
- Upwardly compatible
  - Previous or new studies integrated into model



# Northern NV Flood History



2006

<u>Date</u>	<u>Truckee River At Reno</u>	<u>Carson River Carson City</u>
March 1907	18,500 cfs	-----
January 1909	10,100 cfs	-----
March 1928	18,800 cfs	-----
November 1950	17,000 cfs	15,500 cfs
December 1955	20,800 cfs	30,000 cfs
February 1963	18,400 cfs	21,900 cfs
February 1986	14,400 cfs	13,200 cfs
January 1997	23,200 cfs	30,500 cfs
December 2006	16,400 cfs	11,900 cfs
Jan/Feb 2017	12,800 cfs	10,500 cfs

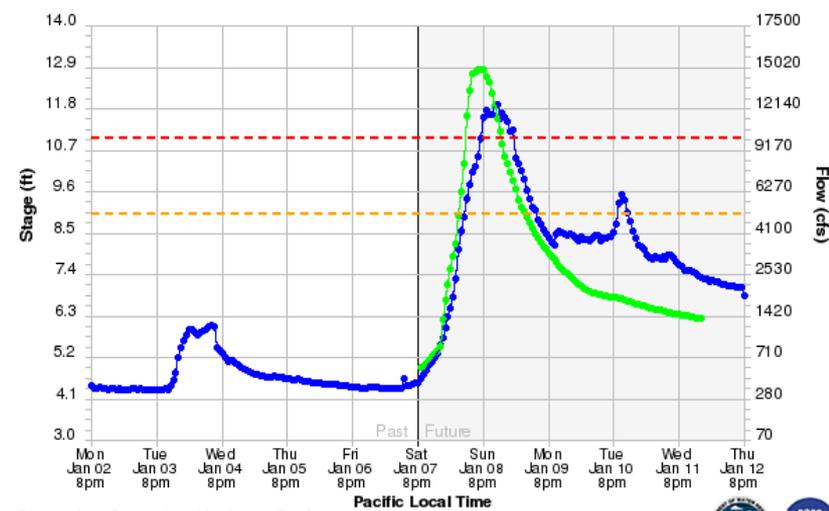
# January 2017

- Atmospheric River Event
  - Rain on Snow
- Back to Back Storms
  - January 9<sup>th</sup> 2017
  - February 10<sup>th</sup> 2017
- Communities Respond
  - Truckee River Flood Management Authority
    - City of Reno
    - City of Sparks
    - Washoe County
  - Douglas County

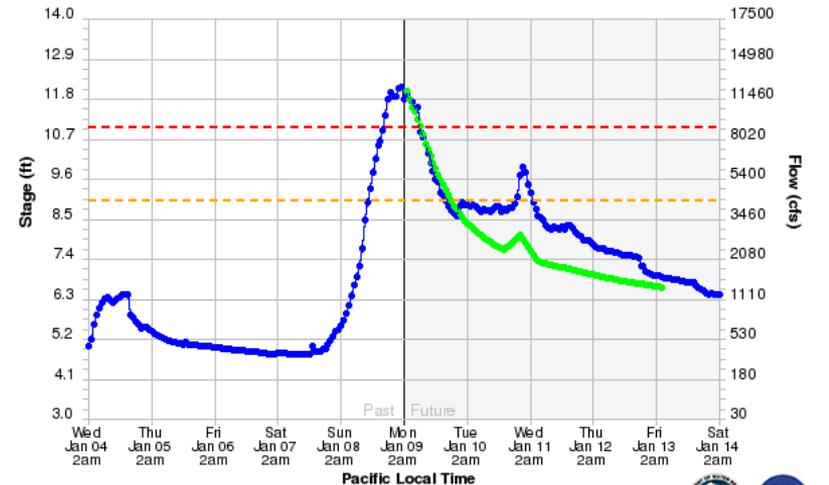


# Truckee NWS Forecast

- Downtown Reno Predictions
  - January 7<sup>th</sup> 8:22 PM – 15,000 cfs – Similar to 2006 event
  - January 8<sup>th</sup> 1:45 PM – 15,000 cfs – Similar to 2006 event
  - January 9<sup>th</sup> 2:28 AM – Peak has passed
  - Final USGS Estimate 12,800 cfs



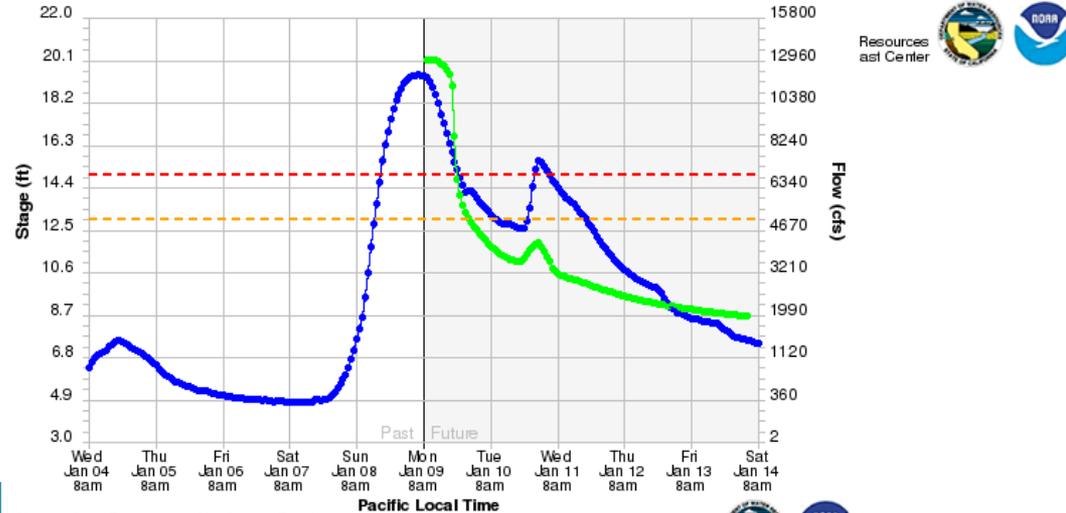
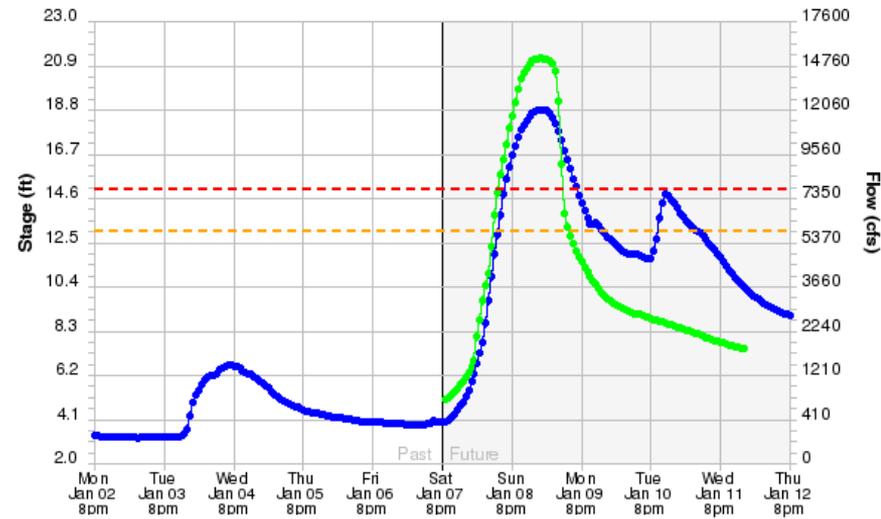
Observed ● Forecast ● Monitor — Flood —  
FCTime: 0422Z ID: TRRN2  
Created: 01/14/2017 at 1:02 AM PST (Source = C) California Department of Water Resources  
NOAA / NWS / California Nevada River Forecast Center



Observed ● Forecast ● Monitor — Flood —  
FCTime: 1028Z ID: TRRN2  
Created: 01/15/2017 at 1:02 AM PST (Source = C) California Department of Water Resources  
NOAA / NWS / California Nevada River Forecast Center

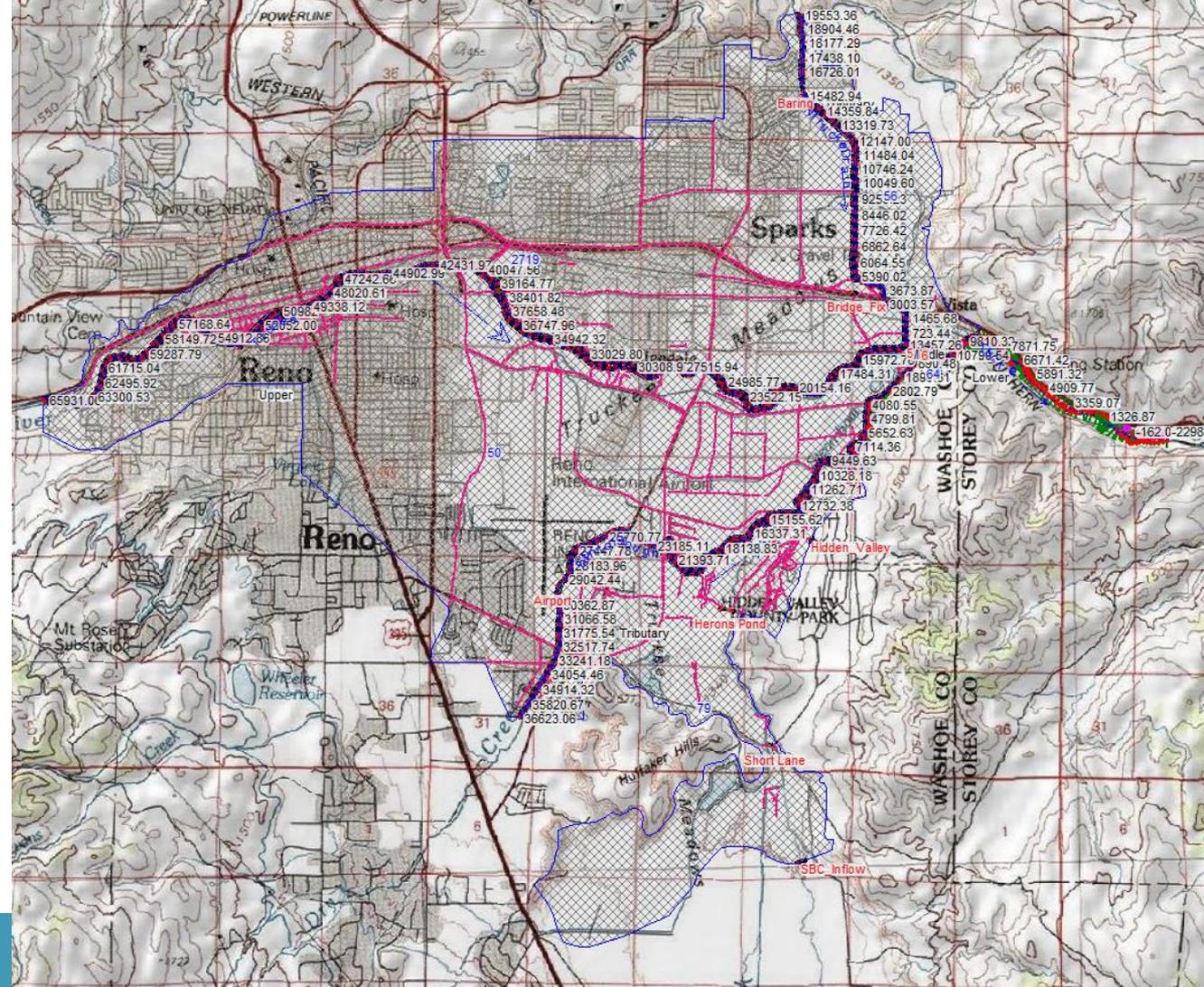
# Truckee NWS Forecast

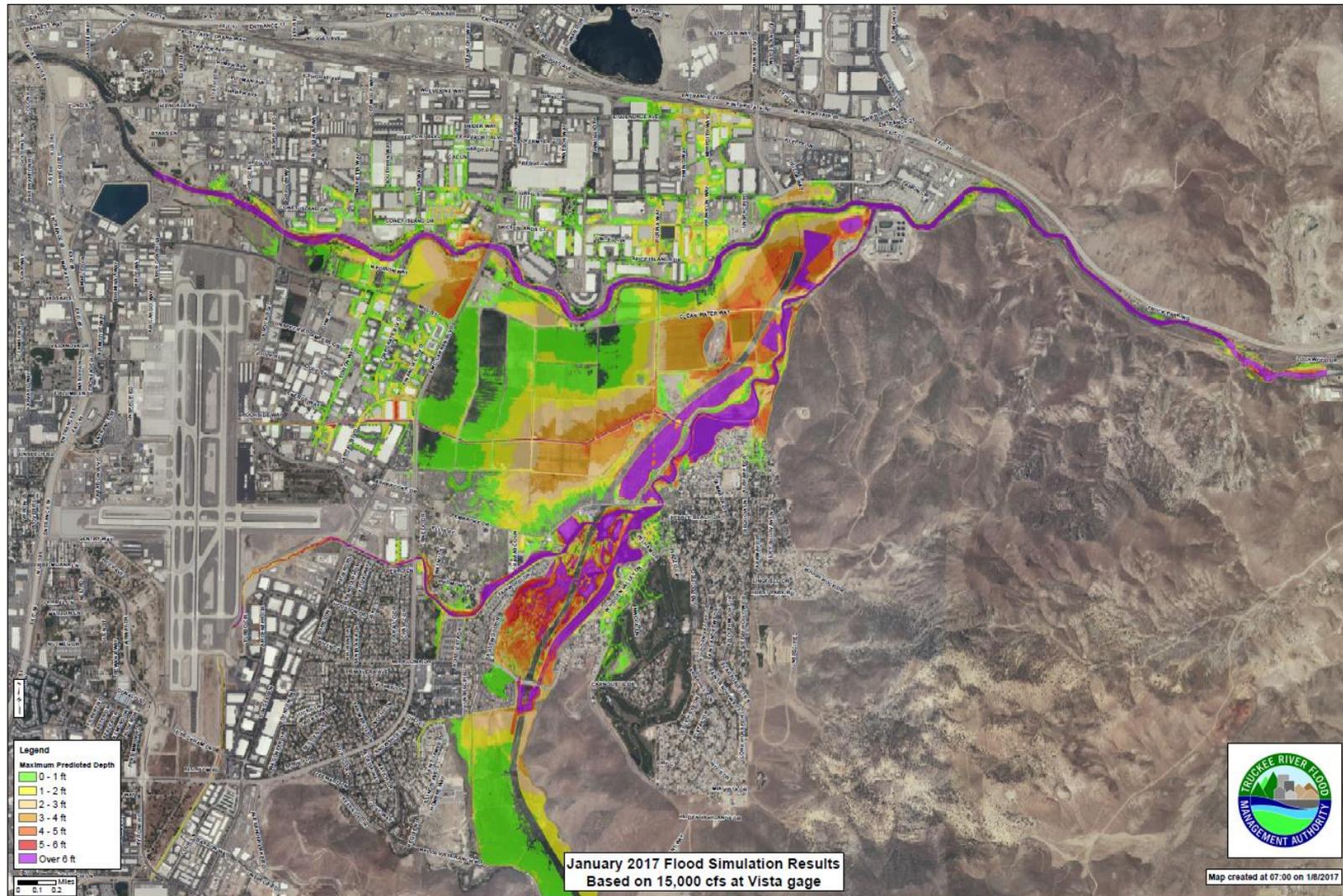
- Truckee Meadows Vista Predictions
  - January 7<sup>th</sup> 8:22 PM – 15,400 cfs – Similar to 2006 event
  - January 8<sup>th</sup> 1:45 PM – 15,400 cfs – Similar to 2006 event
  - January 9<sup>th</sup> 8:26 AM – 13,000 cfs – NWS Estimate. Peak has passed
  - USGS Estimate 11,800 cfs.



# Modeling the Event

- Truckee River Flood Management Authority
  - Truckee River Flood Project
  - Ongoing regional model
  - HEC-RAS 1D/2D combined model
  - Truckee Downtown Flow 15,600 cfs
  - Truckee Vista Flows 15,000 cfs





**Legend**  
Maximum Predicted Depth

0 - 1 ft
1 - 2 ft
2 - 3 ft
3 - 4 ft
4 - 5 ft
5 - 6 ft
Over 6 ft

0 0.1 0.2 Miles

**January 2017 Flood Simulation Results**  
Based on 15,000 cfs at Vista gage

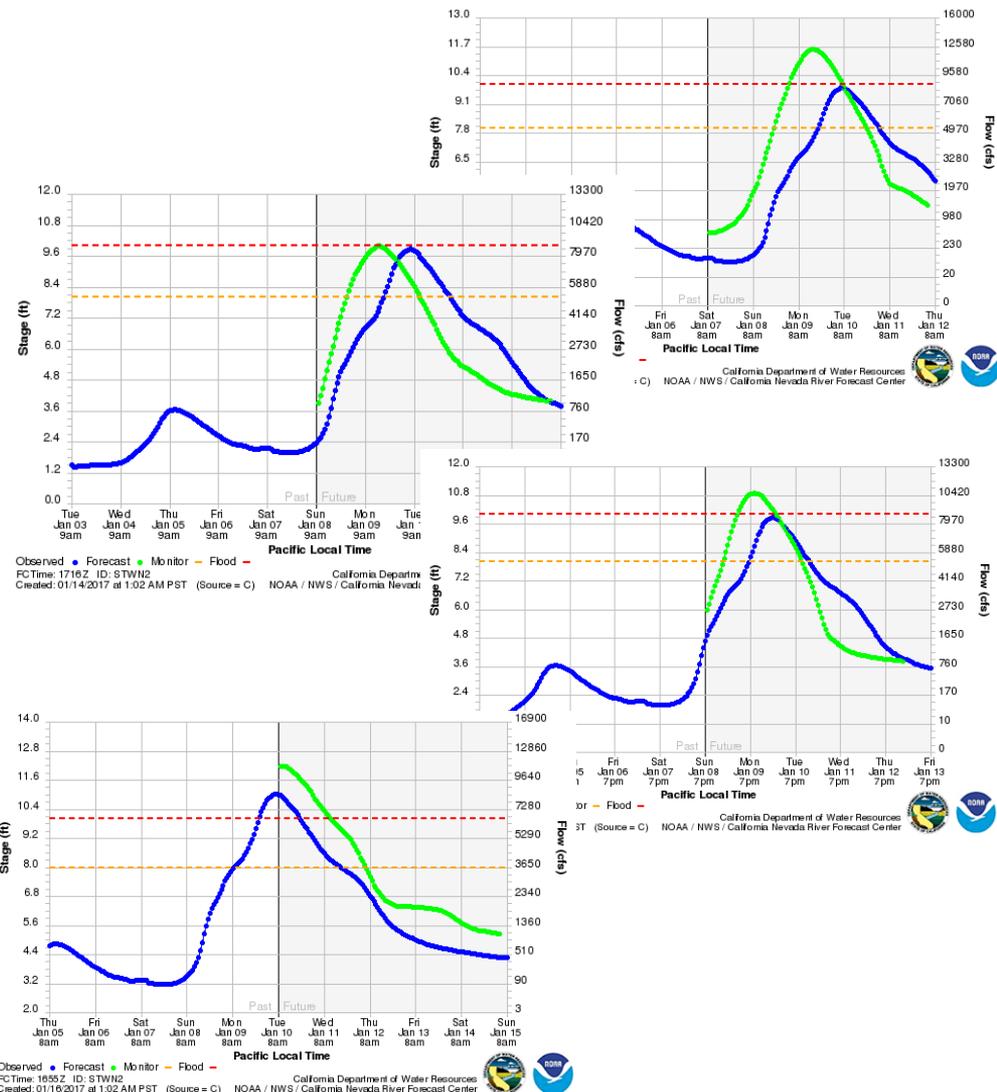


Map created at 07:00 on 1/8/2017

# Carson NWS Forecast

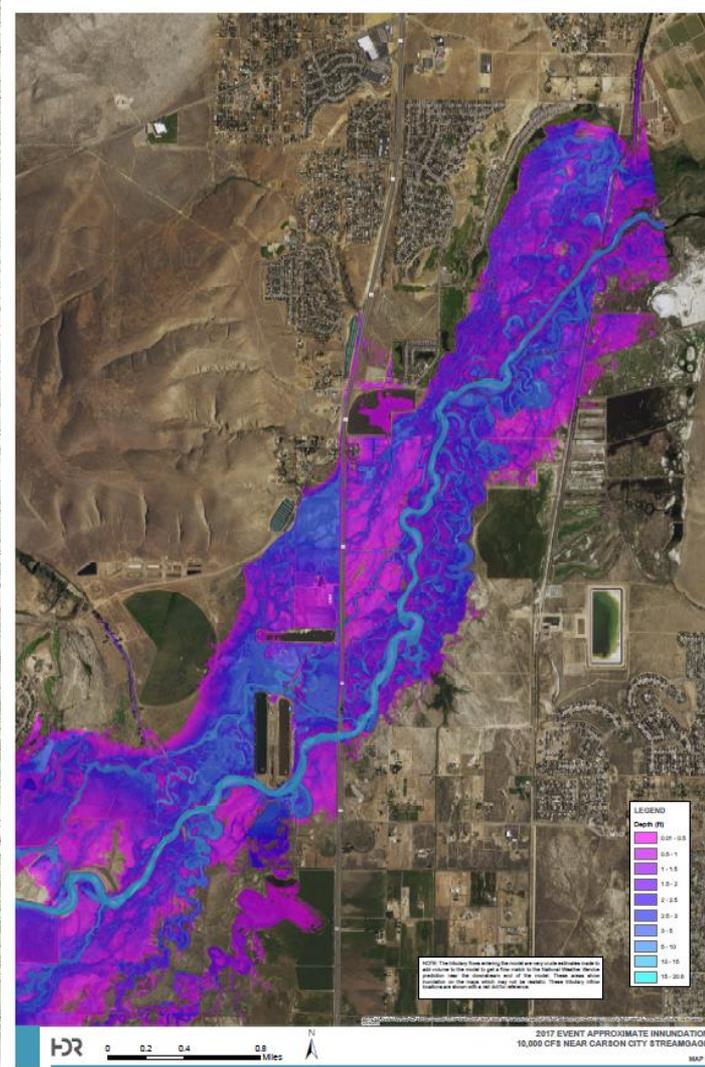
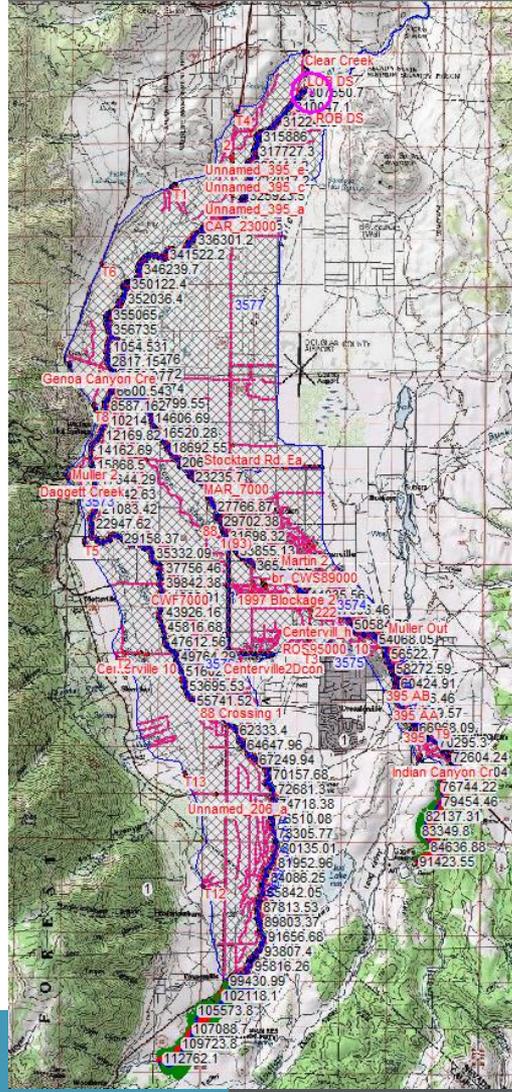
## Carson City Predictions

- January 7<sup>th</sup> 8:52 AM – 12,500 cfs – Similar to 1986 and 2006 events
- January 8<sup>th</sup> 9:16 AM – 8,800 cfs – Just below flood stage
- January 8<sup>th</sup> 7:43 PM – 10,400 cfs – Above flood stage potential for 2006 magnitude event
- January 10<sup>th</sup> 8:55 AM – 8,400 cfs – Just below flood stage
- USGS Estimate 8,370 cfs.
- February 11<sup>th</sup> second event - 10,500 cfs USGS Estimate



# Modeling the Event

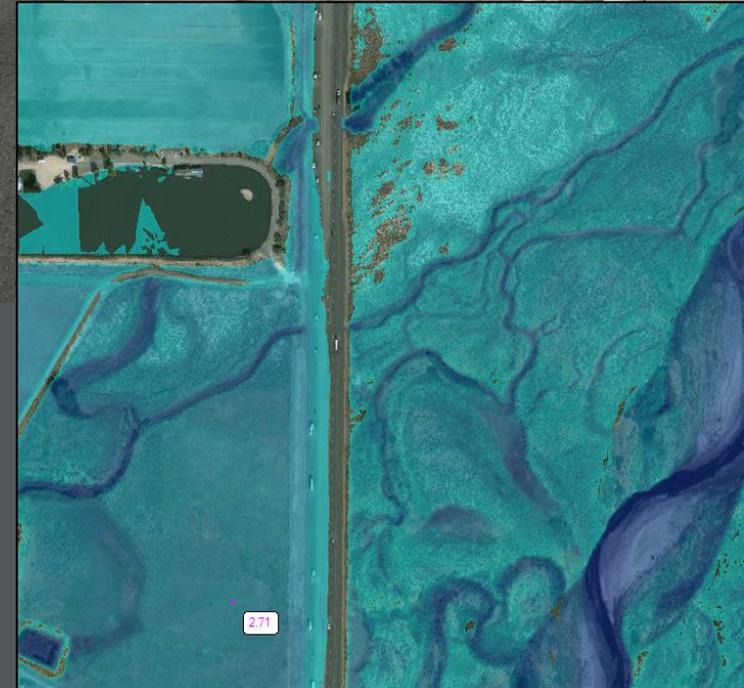
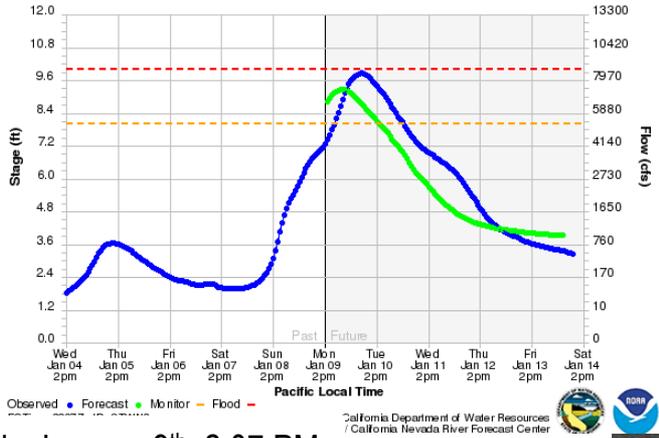
- Carson Water Subconservancy District
  - FEMA Physical Map Revision (PMR)
  - HEC-RAS 1D/2D combined model
  - East Fork Flows  $\approx$  12,000 cfs (Jan 7<sup>th</sup> Prediction)
  - West Fork Flows  $\approx$  1,800 cfs (Jan 7<sup>th</sup> Prediction)
  - Carson City Flows  $\approx$  10,000 cfs



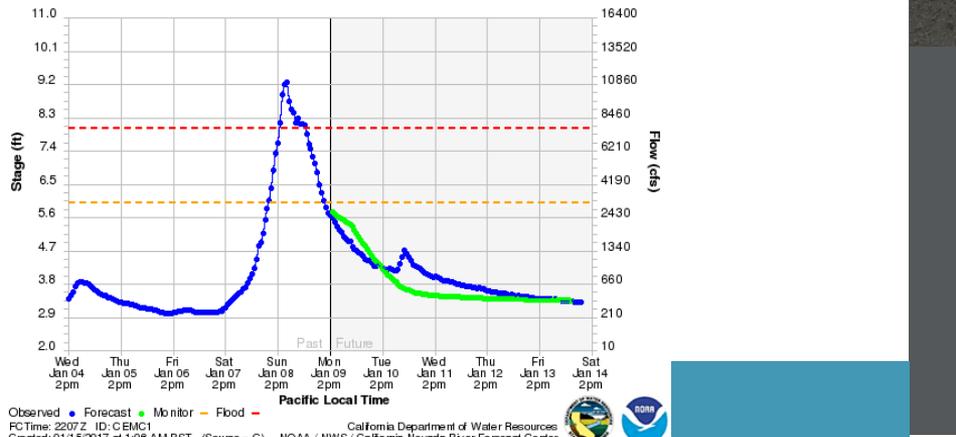
# In the Field

Date & Time: Mon Jan 9 16:12:20 PST 2017  
 Position: +039.05494° / -119.78021°  
 Altitude: 4593ft  
 Datum: WGS-84  
 Azimuth/Bearing: 173° S07E 3076mils (True)  
 Elevation Grade: -017%  
 Horizon Grade: -000%

## Carson City January 9<sup>th</sup> 2:07 PM



## East Fork Markleeville January 9<sup>th</sup> 2:07 PM



# Response

- Flood Maps Distributed to Media in Reno and Douglas County
- Emergency Responders Used Mapping for Road Closures and Sand Bag Efforts
- FIRST Time Flood Mapping Information Available
- Public Access to Information on Sand Bags



# Response

Date & Time: Sun Jan 8 21:40:06 PST 2017  
Position: +039.52451° / -119.81685°  
Altitude: 4452ft  
Datum: WGS-84  
Azimuth/Bearing: 303° N57W 5387mils (True)  
Elevation Grade: -010%  
Horizon Grade: +009%  
Zoom: 1X



Date & Time: Mon Jan 9 16:13:21 PST 2017  
Position: +039.65458° / -119.77894°  
Altitude: 4583ft  
Datum: WGS-84  
Azimuth/Bearing: 332° N28W 5302mils (True)  
Elevation Grade: -018%  
Horizon Grade: +005%  
Zoom: 1X



Date & Time: Tue Jan 10 04:51:30 PST 2017  
Position: 11 N 330422 4227408  
Altitude: 4553ft  
Datum: WGS-84  
Azimuth/Bearing: 337° N28W 5297mils (True)  
Elevation Angle: -05.2°  
Horizon Angle: -01.1°  
Zoom: 1X

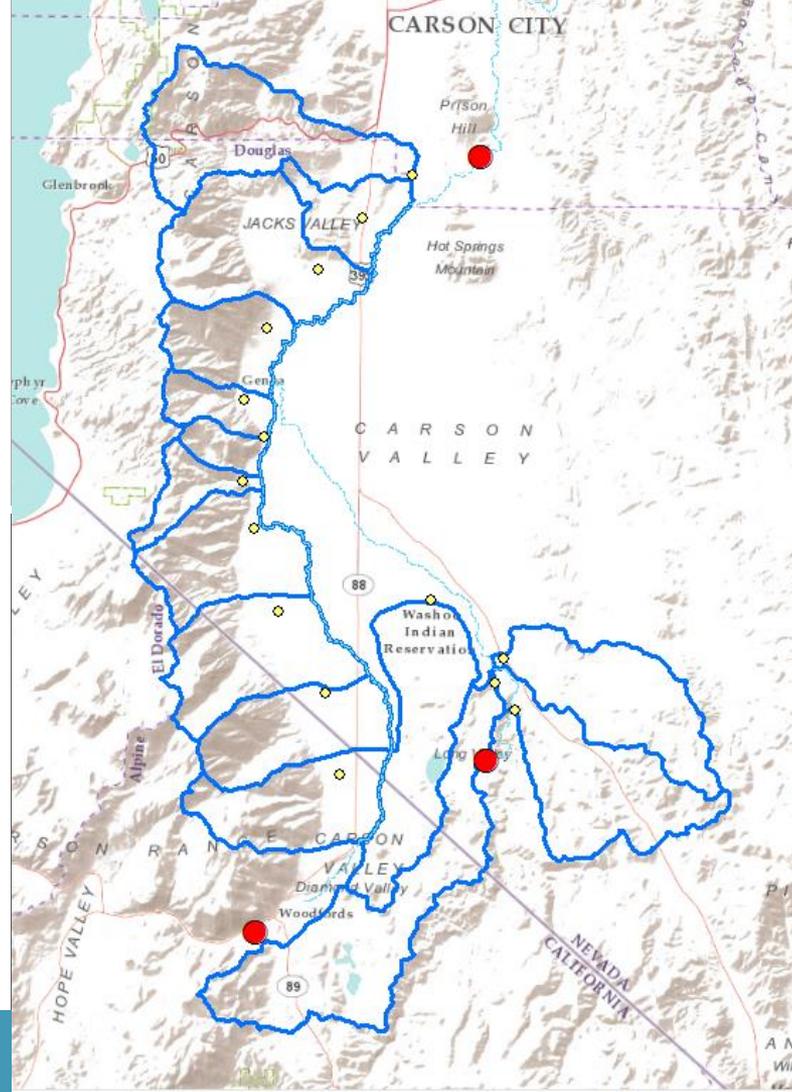


# US 395



# Challenges

- Model Run Time – 5-12 hours
  - NWS forecast updated every 6 hrs
- Limited Forecast Points for Model Inputs
  - Carson = 2 of 17 inputs. Missing 50% of Volume
  - Truckee = 1 of 5 inputs. Missing 15% of Volume
- Timing of Flood Wave Challenging Without Tributary Timing
- Changing Conditions
  - Temperature
  - Precipitation



# Next Steps

- Develop Hydrologic Models to Assess Tributary Timing
- Refine HEC-RAS Models to Take Advantage of Computational Speed Enhancements
- Reduce Model Run Times
- Check Model Performance to HWM and Recorder Hydrograph Data for 2017

