Flood Forecasting in Real Time
Using Modern Hydrodynamic Tools and Collaborative Science

- Mitch Blum PE, CFM - HDR Engineering Inc.
- Tim Bardsley - National Weather Service
Outline

- Hydrodynamic Tools
  - HEC-RAS 5.0
- Historic Flood Events
- 2017 Event
  - National Weather Service Forecast Center
- Truckee River
  - Truckee River Flood Management Authority
- Carson River
  - Carson Water Subconservancy District
  - Douglas County, NV
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 2018

- 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
HEC-RAS 5.0.5

- 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
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

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

- Atmospheric River Event
  - Rain on Snow

- Back to Back Storms
  - January 9th 2017
  - February 10th 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 7th 8:22 PM – 15,000 cfs – Similar to 2006 event
  - January 8th 1:45 PM – 15,000 cfs – Similar to 2006 event
  - January 9th 2:28 AM – Peak has passed
  - Final USGS Estimate 12,800 cfs
Truckee NWS Forecast

- Truckee Meadows Vista Predictions
  - January 7th 8:22 PM – 15,400 cfs – Similar to 2006 event
  - January 8th 1:45 PM – 15,400 cfs – Similar to 2006 event
  - January 9th 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 $\approx 15,600$ cfs
  - Truckee Vista Flows $\approx 15,000$ cfs
Carson NWS Forecast

- Carson City Predictions
  - January 7th 8:52 AM – 12,500 cfs – Similar to 1986 and 2006 events
  - January 8th 9:16 AM – 8,800 cfs – Just below flood stage
  - January 8th 7:43 PM – 10,400 cfs – Above flood stage potential for 2006 magnitude event
  - January 10th 8:55 AM – 8,400 cfs – Just below flood stage
  - USGS Estimate 8,370 cfs.
- February 11th 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 ≈ 12,000 cfs (Jan 7th Prediction)
  - West Fork Flows ≈ 1,800 cfs (Jan 7th Prediction)
  - Carson City Flows ≈ 10,000 cfs
In the Field

Carson City January 9th 2:07 PM

East Fork Markleeville January 9th 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
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

- Work With NWS for More Refined Forecast Points
- 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