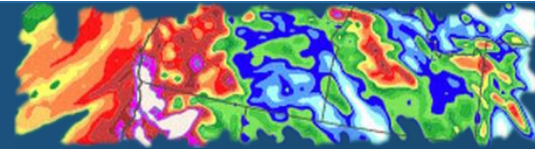


Flood Warning Systems

A Case Study of Frijoles Canyon

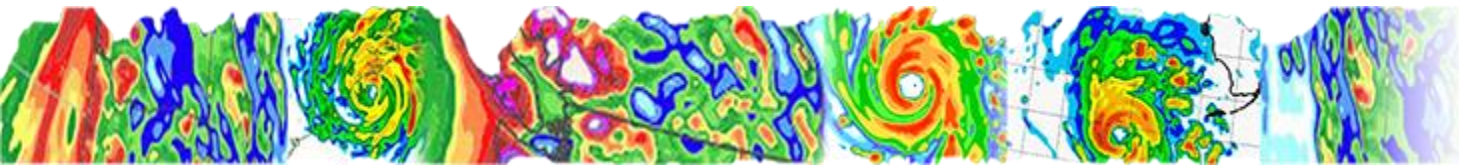


Mike Zucosky
Director of Operations
April 16, 2015



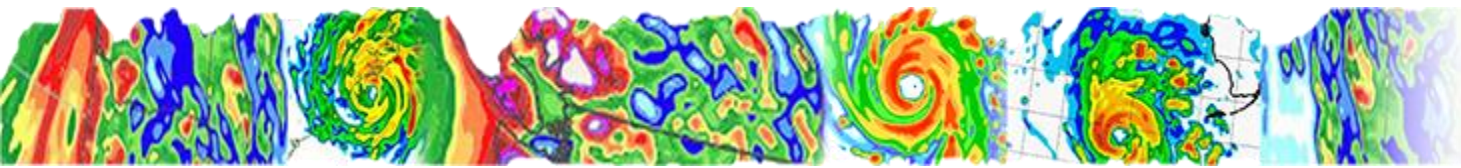
A Case Study of Frijoles Canyon

- The Los Conchas Fire of 2011 left Frijoles Canyon, and the Bandelier National Monument Visitor Center susceptible to flash flooding



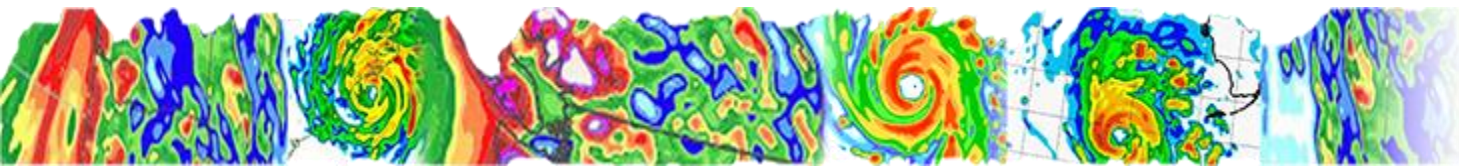
A Case Study of Frijoles Canyon

- Bandelier National Monument, with the help of OneRain, implemented an Early Warning system, with automated alarming which allowed park service personnel to put preventative measures in place to protect the visitor center
 - Early Warning Flood Systems can be vital components in ensuring the safety of people and infrastructure
 - Only effective if the data is timely and accurate

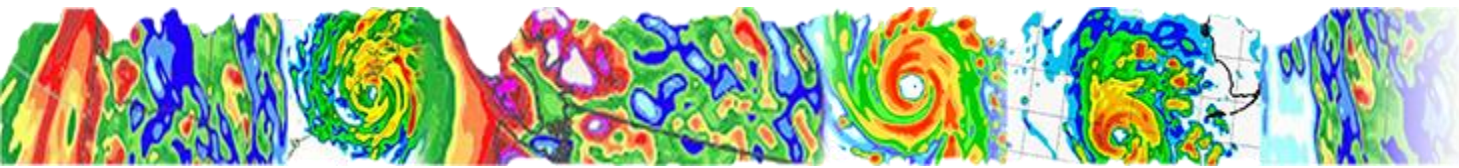


“Experts Measuring and Understanding Water”

- Founded in 1992
- End-to-end solution provider
 - Design of water monitoring networks
 - Software & Data Analysis
 - Field integration solutions (monitoring, telemetry, training, maintenance)
 - Rainfall data (historical, real-time)

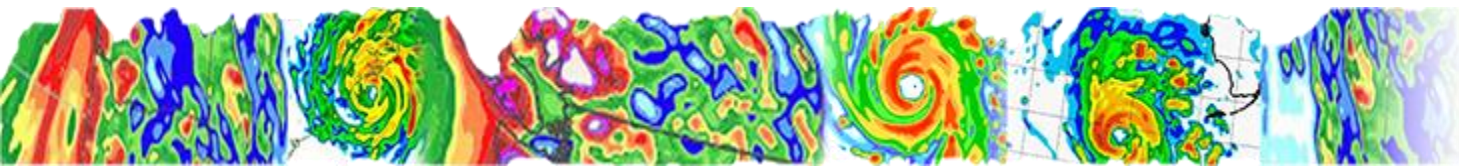


- Hallmarks
 - Verified Data Quality
 - Systems Reliability & Resilience
 - The Right Solution for the Requirement



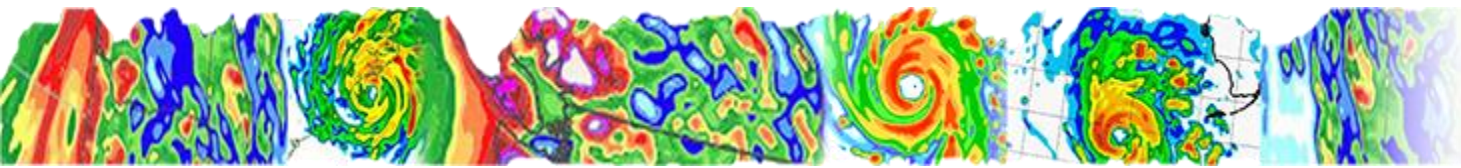
OneRain, Inc.

- Mike Zucosky
 - Director of Operations
 - Electrical Engineer
 - Expertise in designing and implementing flood warning systems, including sensor measurement, telemetry and software development

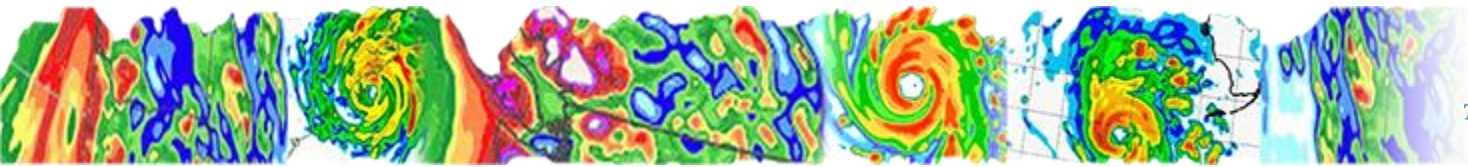
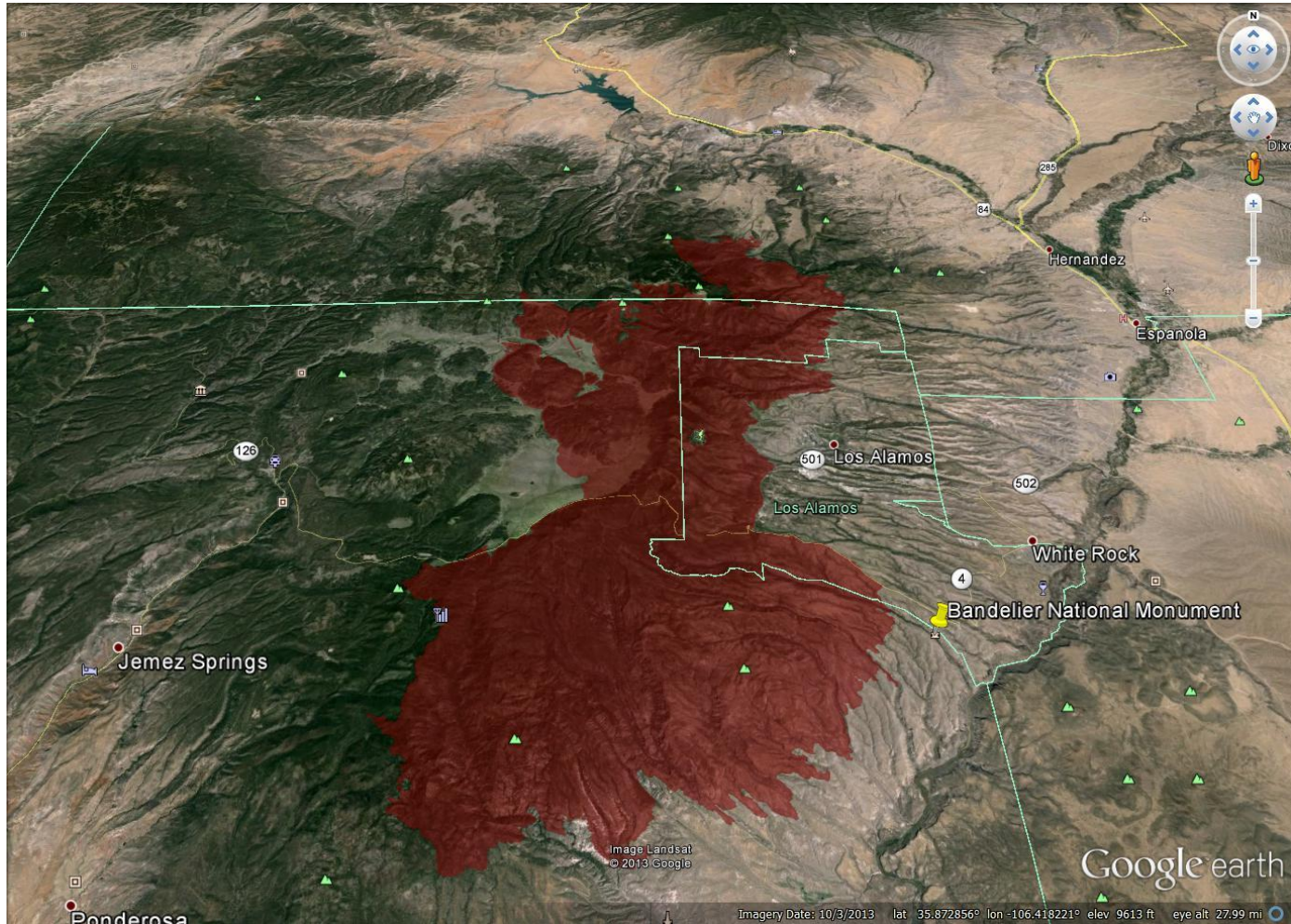


Las Conchas Fire

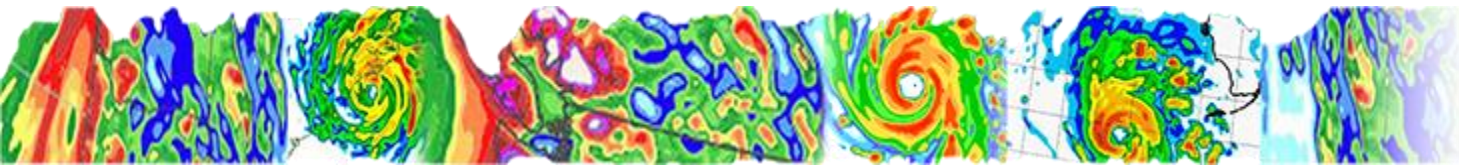
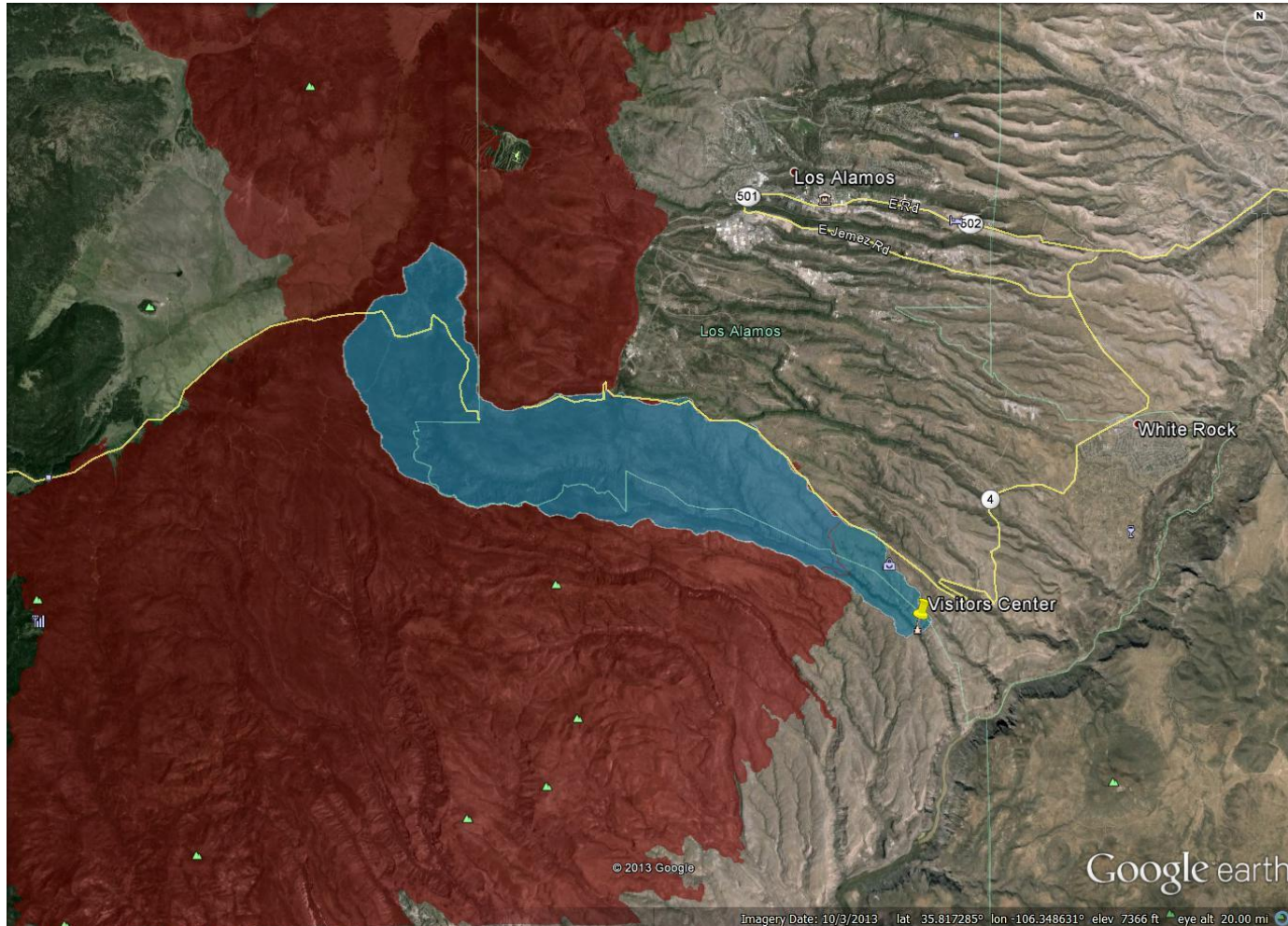
- June 26th, 2011
 - Largest fire in New Mexico state history (at the time) erupted in the Bandelier National Monument
 - 156,000 acres burned²
 - Estimates of 11,000+ acres burned in the Frijoles Canyon watershed¹
 - Over 75% of the Frijoles Canyon watershed was impacted



Las Conchas Fire



Las Conchas Fire – Frijoles Canyon Watershed



Frijoles Canyon

- Flash Flooding is a major concern after any fire
- Frijoles Canyon: high, steep barren walls
 - Increases the magnitude of flooding
 - Decreases response times
 - Small concentrated rains can lead to major flooding

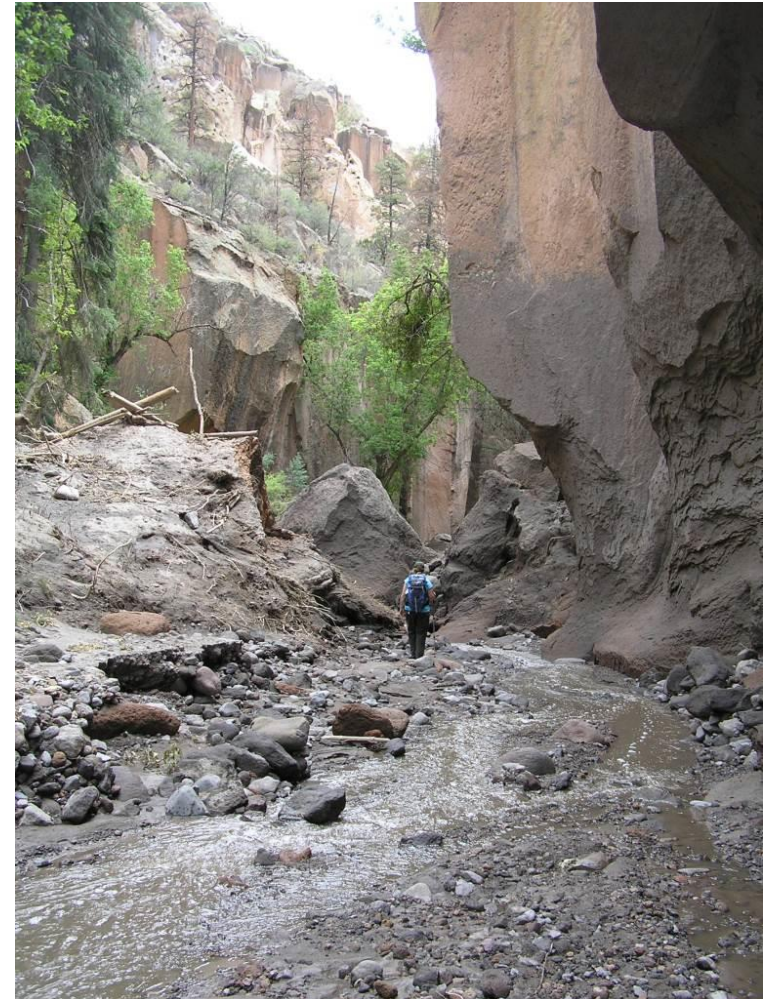
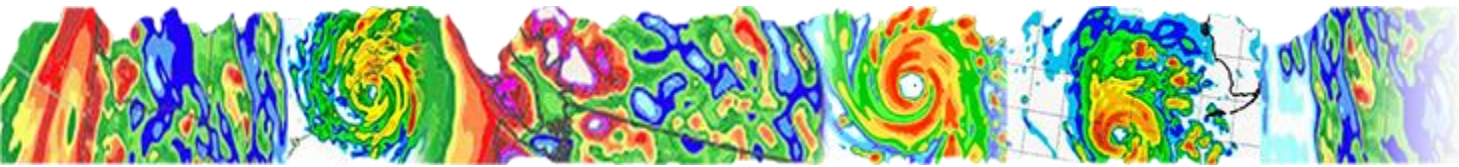


Photo courtesy of USGS

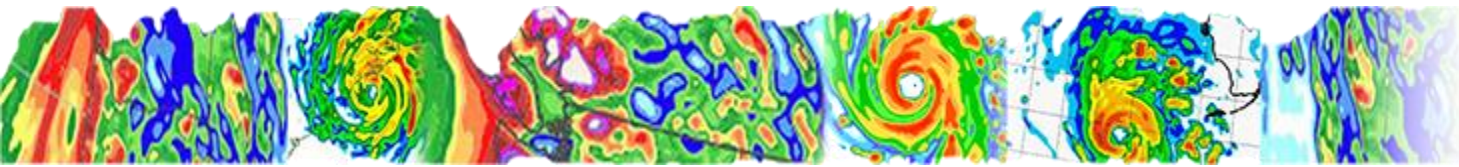


Bandelier National Monument Visitor Center

- Bandelier National Monument Visitor Center sits near the mouth of the Frijoles Canyon

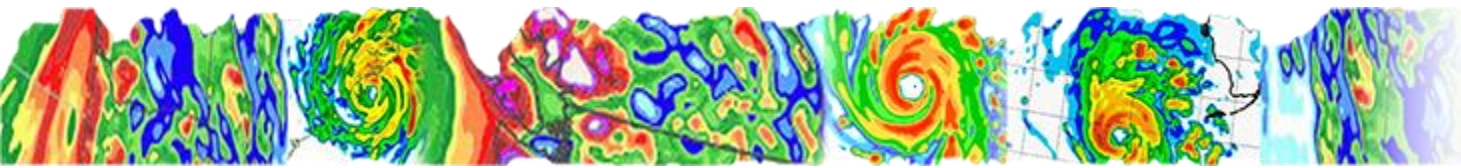


- How can we protect visitors, the visitor center and surrounding area without limiting access?



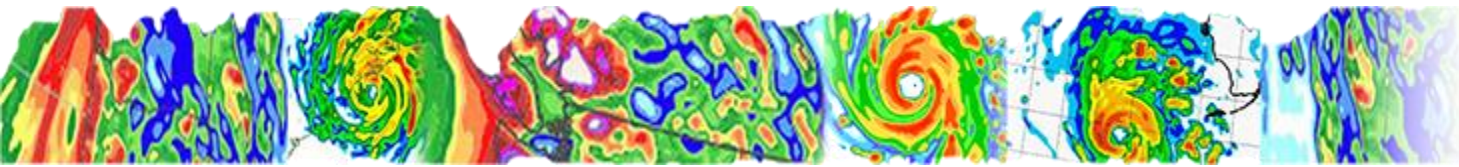
Partners in Protecting Bandelier National Monument

- Post Fire, multiple agencies including the USACE and USGS worked with the National Park Service to mitigate risks to visitors (New Mexico Silver Jackets)



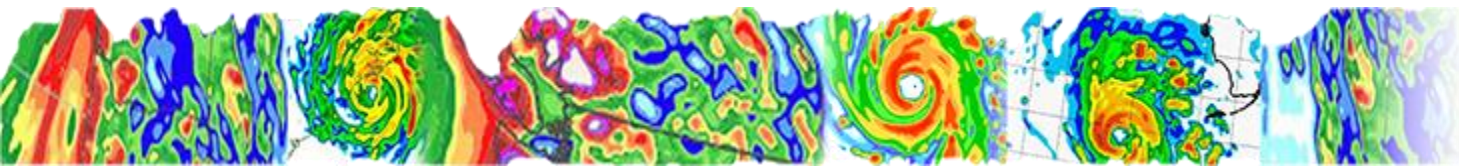
Partners in Protecting Bandelier National Monument

- Jersey barriers and over 14,000 sand bags
- Water repellant material was placed over the outside walls of the historic CCC building
- Bridges were removed from Frijoles Creek
- Early Warning Flood System was designed and installed after a flood in August of 2011



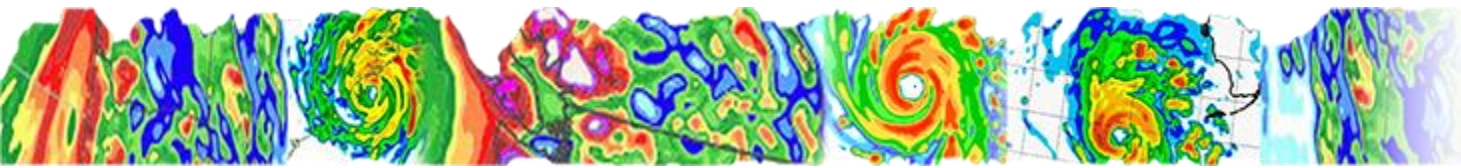
Flood Warning System

- Three tiered approach
 1. National Weather Service Radar for initial warning of possible flooding
 2. Rain Gauge data
 3. Stage gauge data



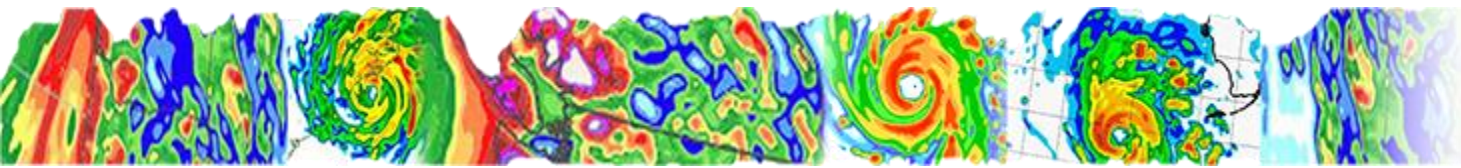
Flood Warning System

- Requirements:
 - Real-time rain and stage data
 - Automated alarming and data validation based on precipitation accumulation and water depth readings
 - Remote access to data for multiple agencies



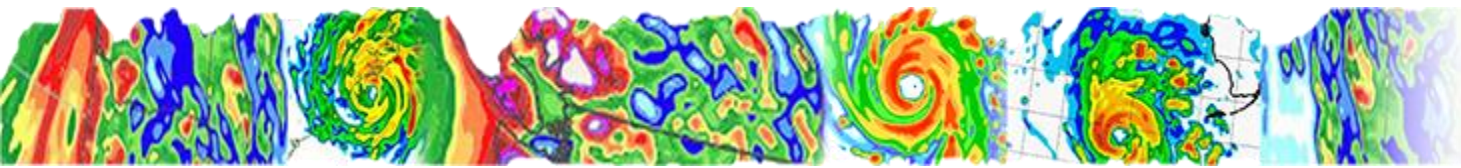
Flood Warning System

- 2 Rain Gauges and 1 Stream Gauge installed in the upper portion of the Frijoles Canyon
 - Too remote for a traditional VFH or Spread Spectrum solution; no cellular reception
 - For real-time data with guaranteed delivery, a private satellite network was selected



Flood Warning System

- All data transmitted to OneRain's Contrail Web
 - Provide password protected access to data via the Cloud for all agencies
 - Automated alarming
 - Data archiving and visualization

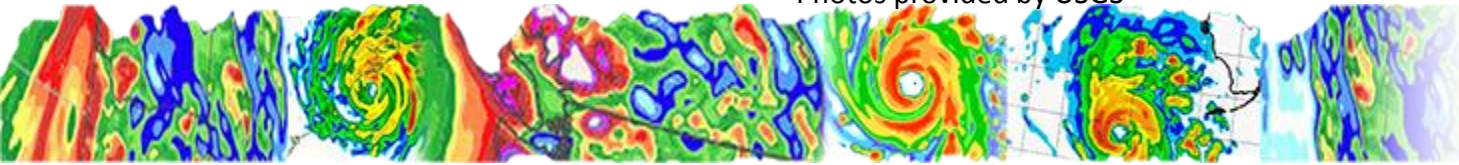


Flood Warning System

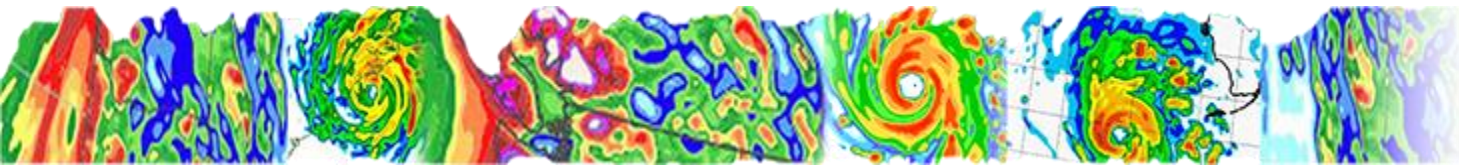
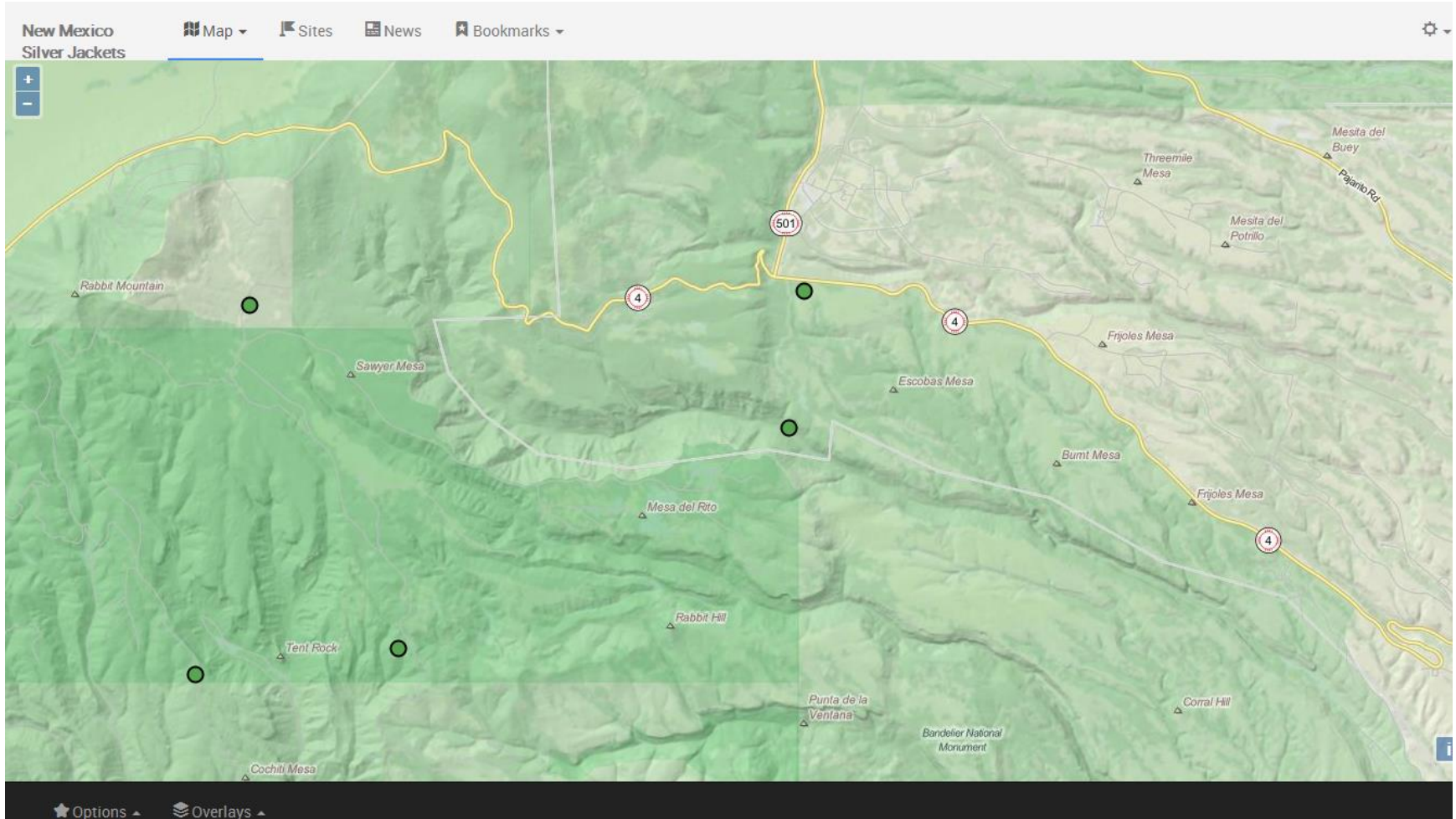
- Electronics, telemetry equipment, sensors and software were provided by OneRain and installed by the USGS



Photos provided by USGS

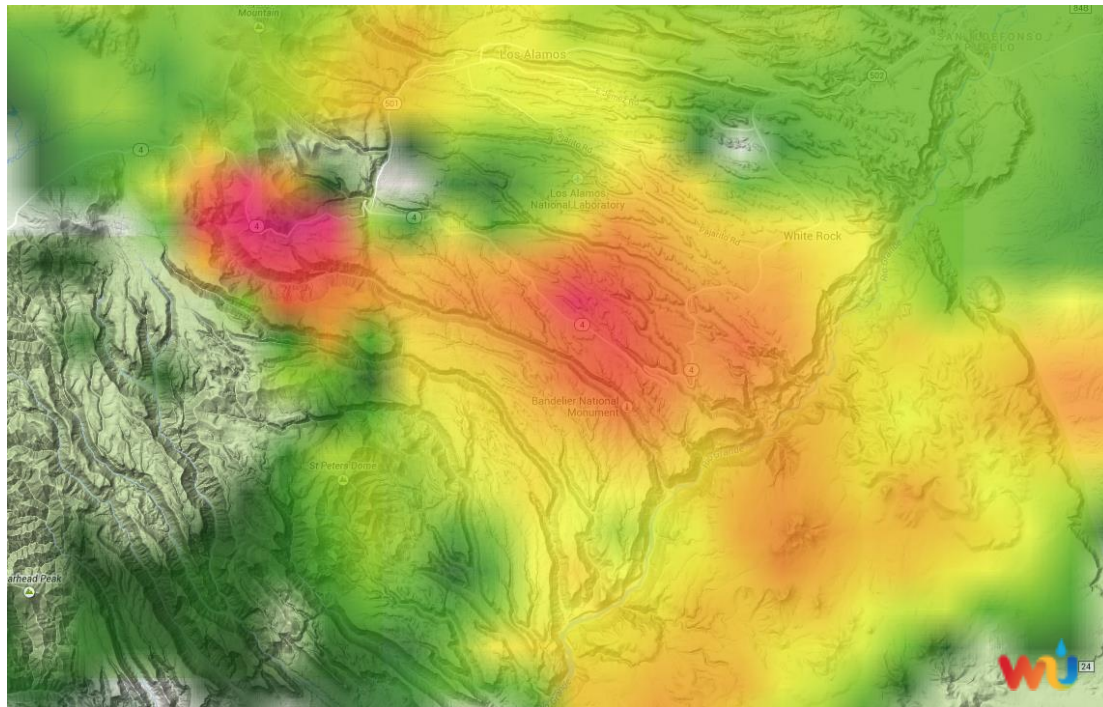


Flood Warning System

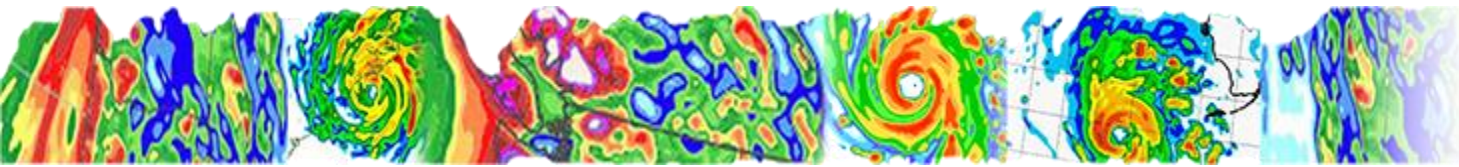


Flooding Event

- July 25th – 26th, 2013
 - Rains in the Frijoles begin at 11:06 PM MDT
 - Short event, but intense rainfall started at 11:23 PM MDT

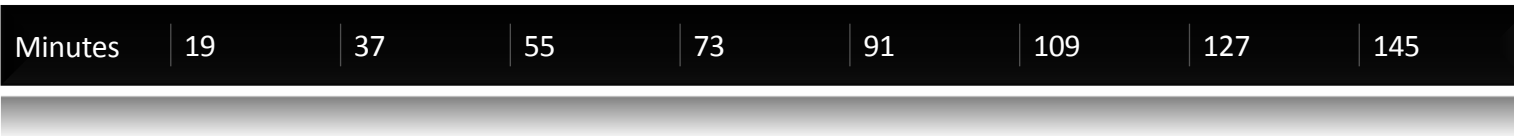


Radar Reflectivity from Jul 25, 2013 23:25 MDT
Image from Weather Underground



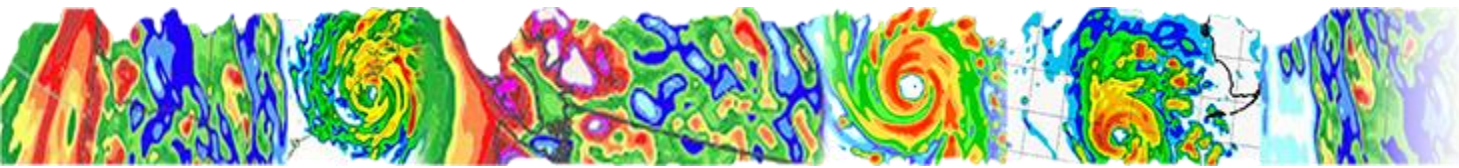
Flooding Event Timeline

- Timeline based on minutes from the first rainfall
 - First rainfall occurs at 23:06:00 MDT



Ponderosa C.G. Rainfall 0 – 33 Minutes

Dome Road Rainfall 17 – 51 Minutes



Flooding Event Timeline

▶ **Ponderosa C.G Rainfall Alarms** 24 Minutes

▶ **Dome Road Rainfall Alarms** 29 Minutes

Minutes

19

37

55

73

91

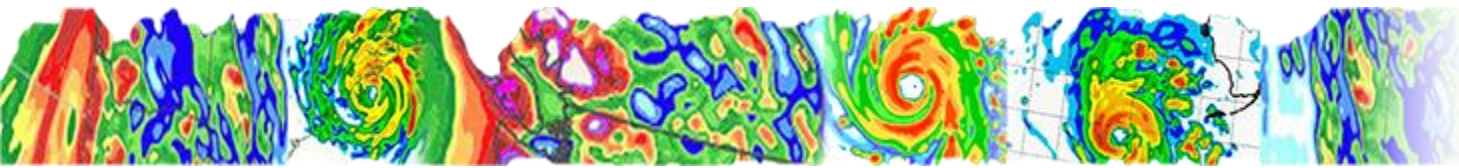
109

127

145

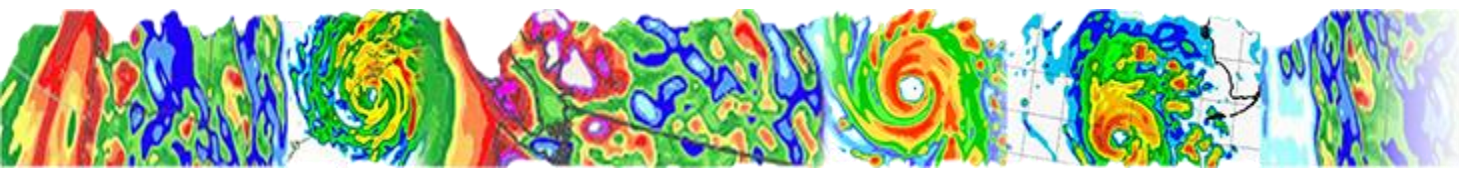
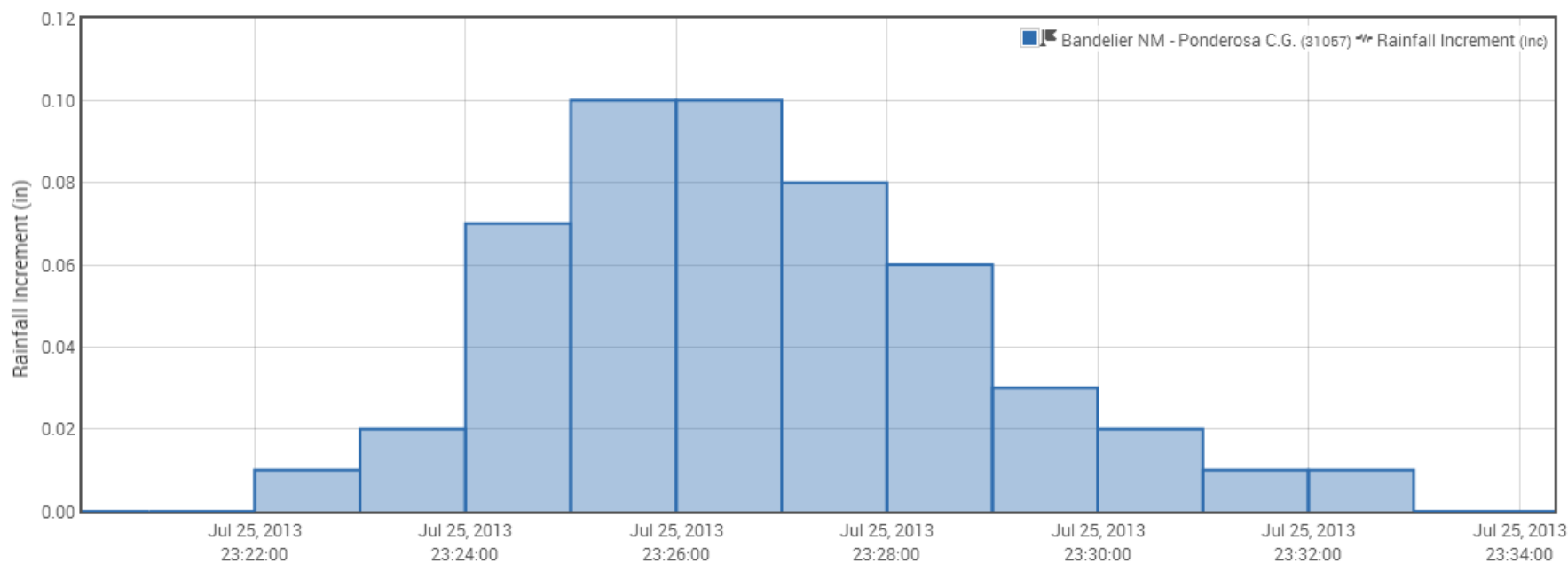
Ponderosa C.G. Rainfall 0 – 33 Minutes

Dome Road Rainfall 17 – 51 Minutes



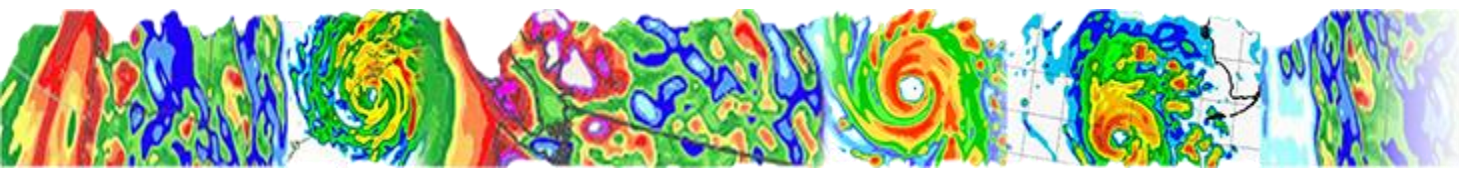
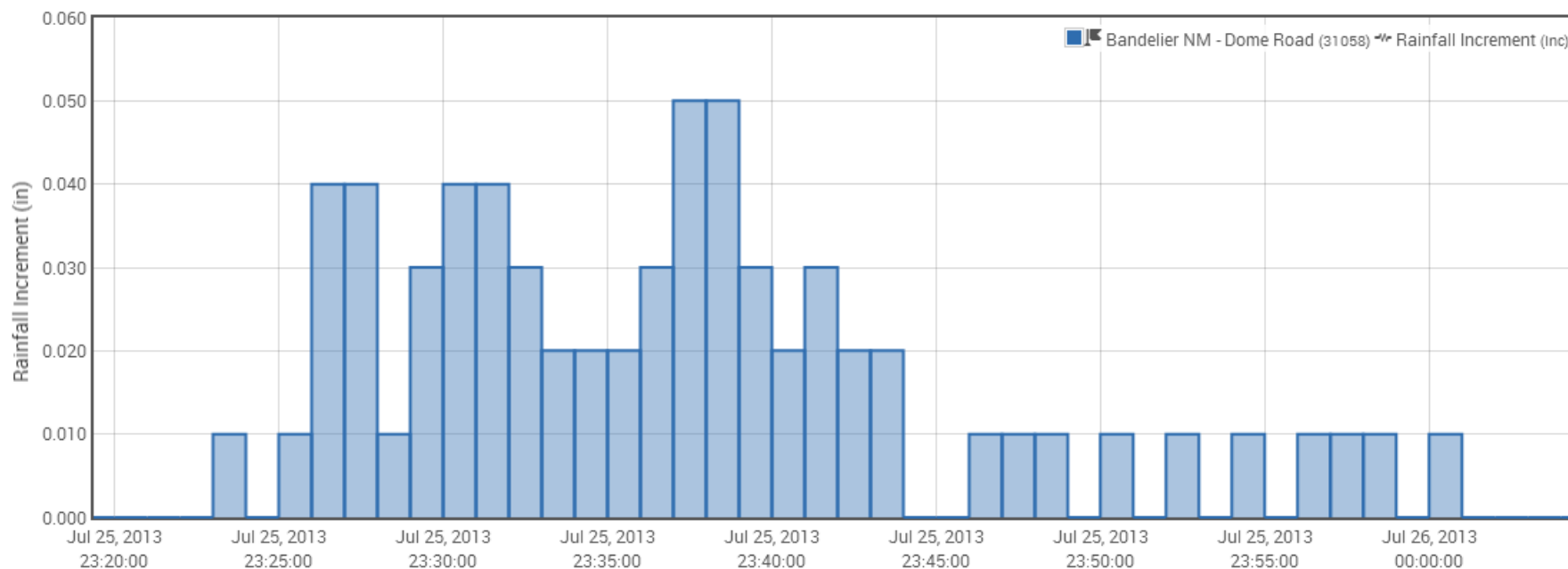
Flooding Event

- Ponderosa Campground
 - 0.50-inches in 11 minutes
 - 1-minute grouping of rainfall data:

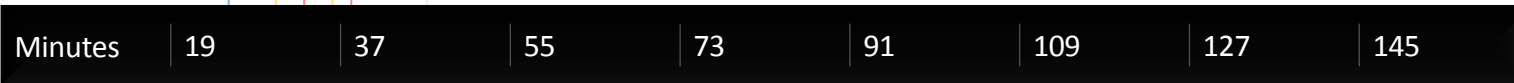
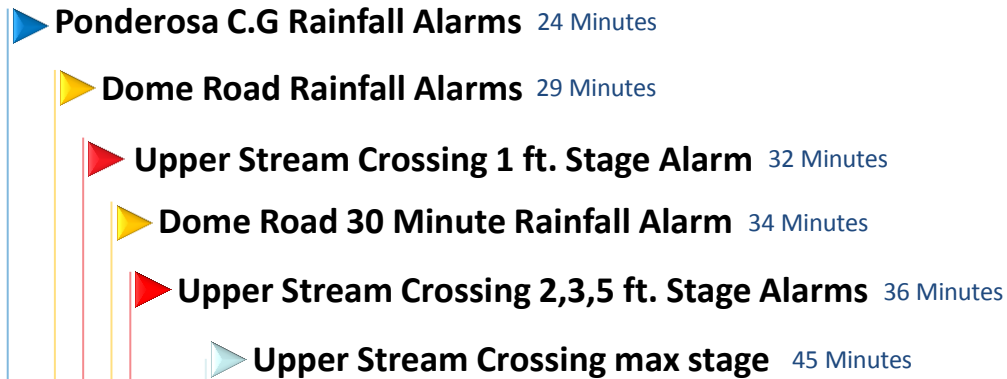


Flooding Event

- Dome Road
 - 0.65-inches in 36 minutes
 - 1-minute grouping of rainfall data:

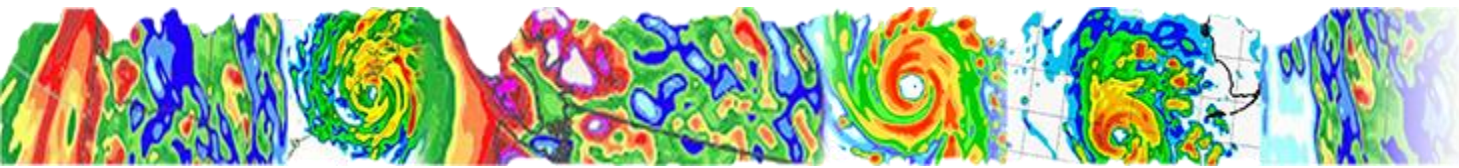


Flooding Event Timeline



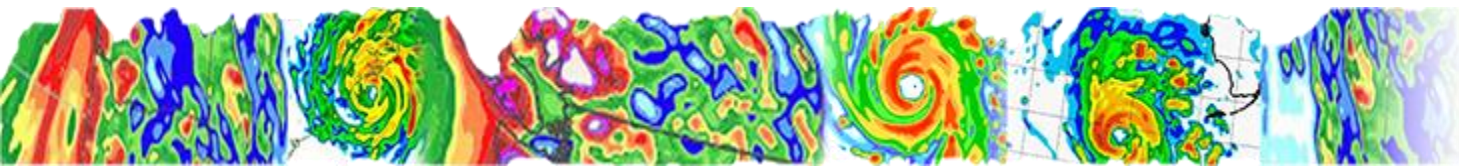
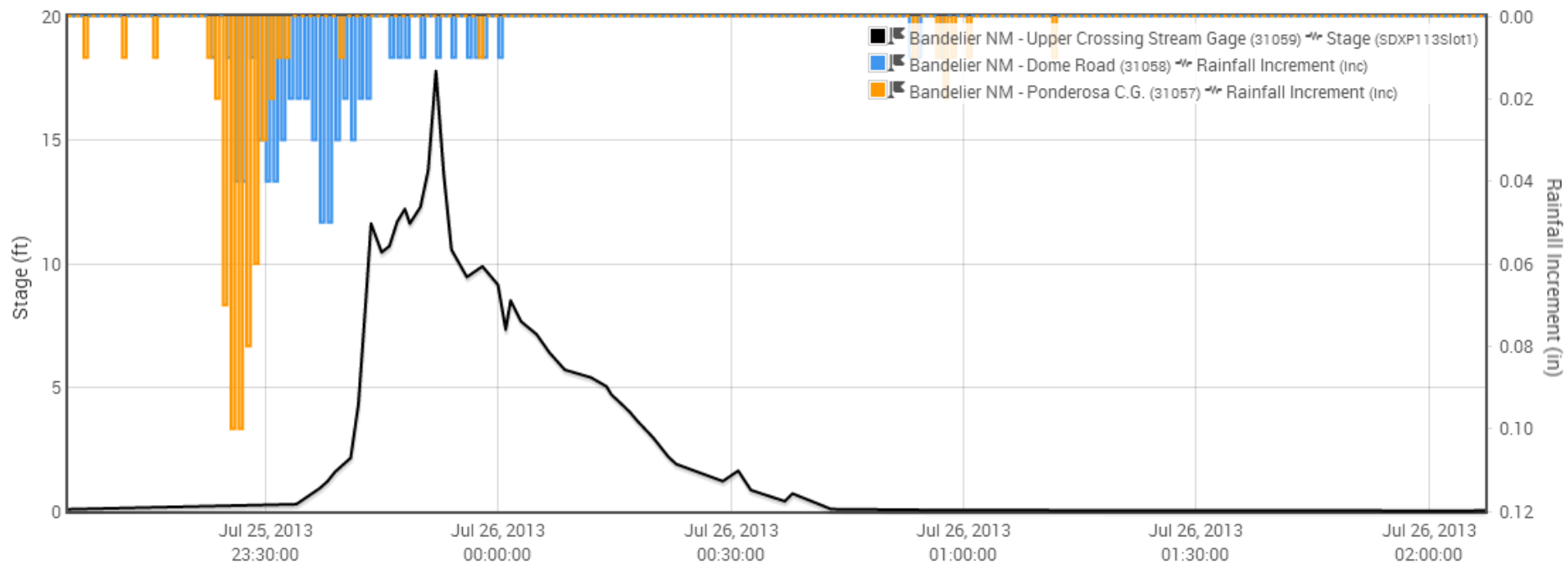
Ponderosa C.G. Rainfall 0 – 33 Minutes

Dome Road Rainfall 17 – 51 Minutes



Flooding Event

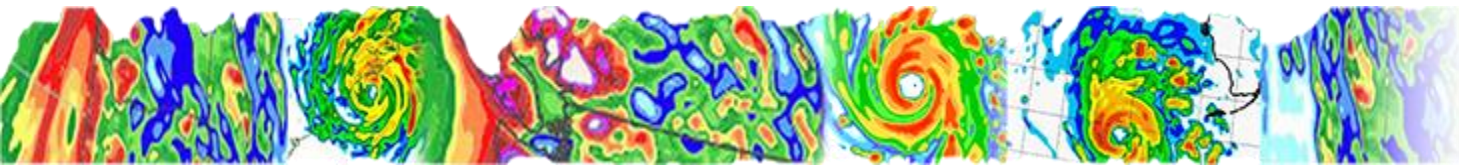
- Upper Crossing Stream Gauge
 - 36 minutes after rain began, stream began to rise
 - Max. stage height: 17.78 feet



Flooding Event



Photo and Annotation provided by Anne Tillery, USGS

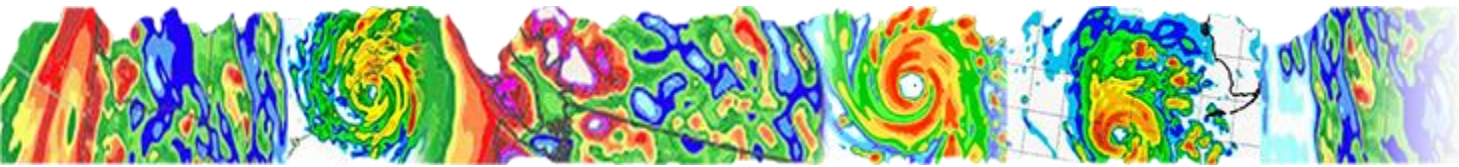


Flooding Event

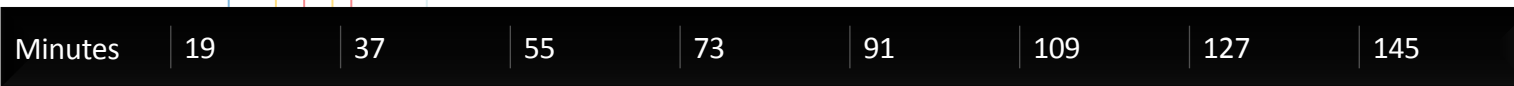
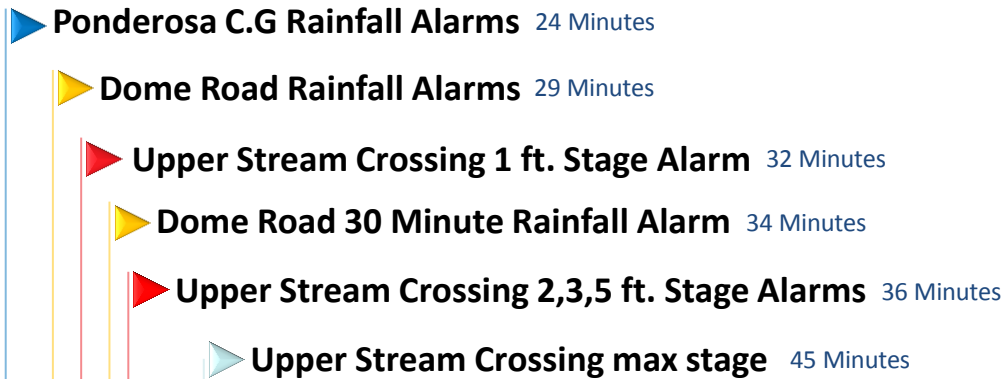
- Automated Alarms were received by Park employees
 - Had approximately 110 minutes to get out of bed, drive to the visitor center, move vehicles and close the flood gate
 - Max stage hit the visitor center 15 minutes after the flood gate had been closed!



Photo courtesy of USGS



Flooding Event Timeline

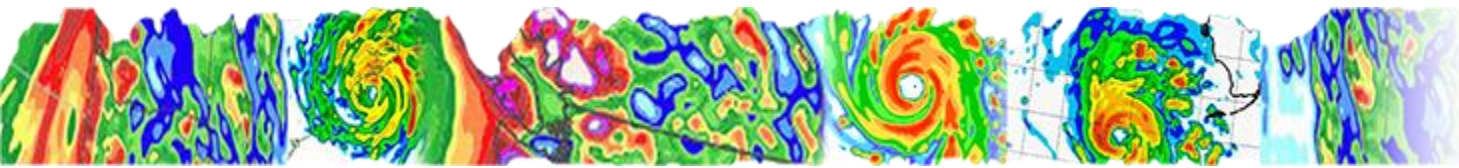


Ponderosa C.G. Rainfall 0 – 33 Minutes

Dome Road Rainfall 17 – 51 Minutes

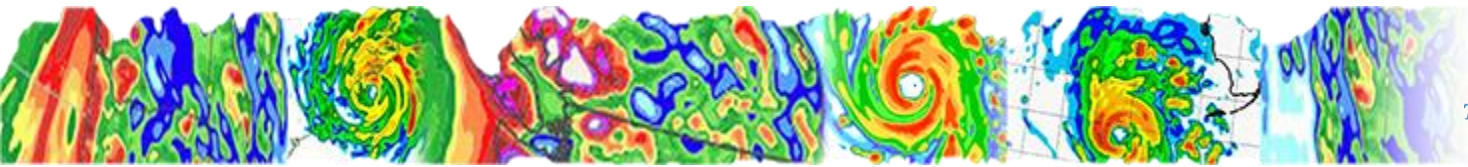
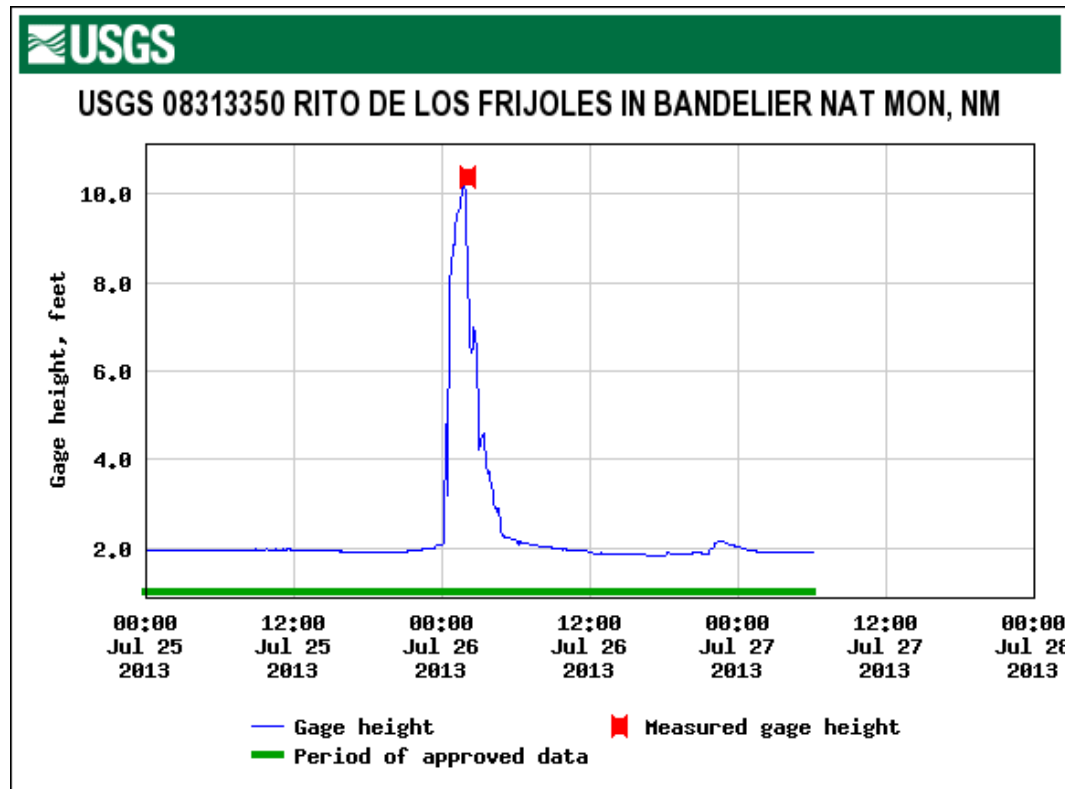
Downstream Peak Stage
164 Minutes

Flood Gate Closure
144 Minutes



Flooding Event

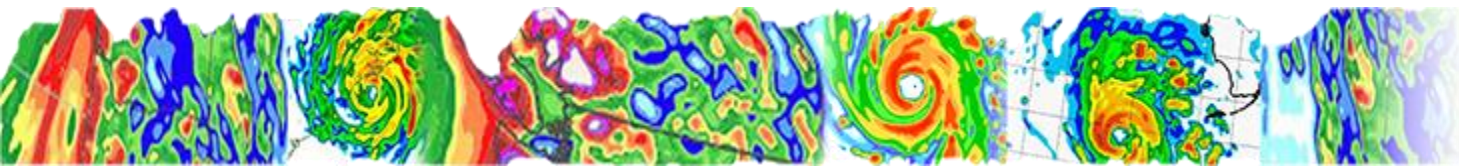
- USGS Stream Gauge
 - Downstream of Visitor Center



Flooding Event



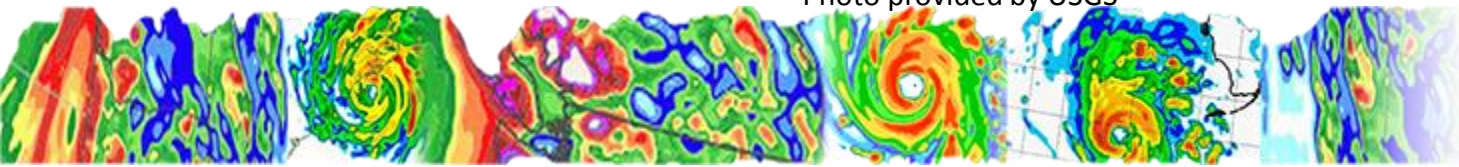
Photo courtesy of USGS



Flooding Event

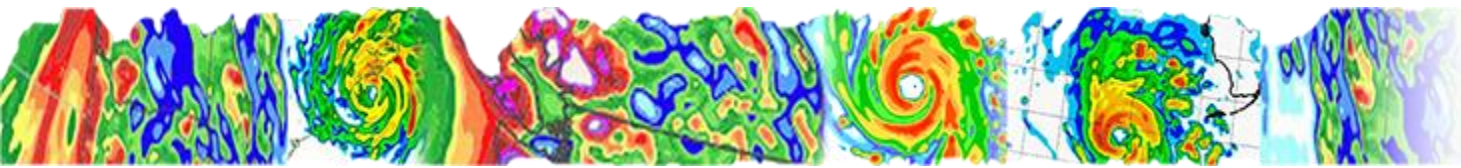


Photo provided by USGS



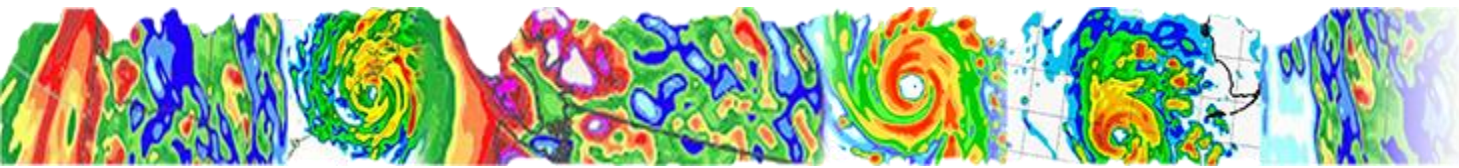
Frijoles Canyon Flood Bandelier National Monument

August 21, 2011



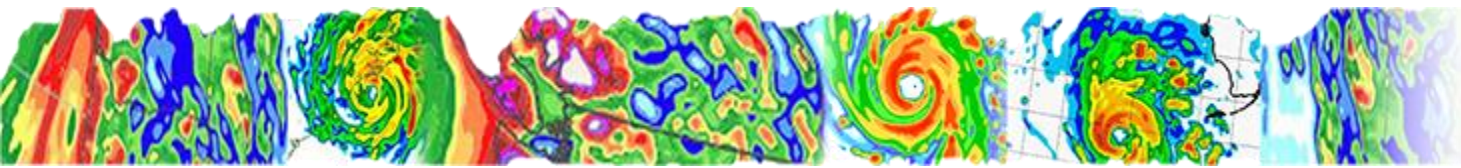
A Case Study of Frijoles Canyon

- Why was this project successful?
 - Co-operation among multiple agencies and private enterprise to provide the best solutions for this particular situation
 - Timely, accurate data with automated alarming
 - Action plans were in place and followed...the rangers knew exactly what to do

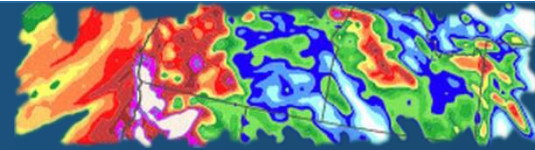


A Case Study of Frijoles Canyon

- Flash flooding is still a major concern for Frijoles Canyon
 - System is still in place, and is currently being upgraded for future reliability and enhanced timeliness of data



Thank you!



Special thanks to Anne Tillery, USGS and Scott Bores, OneRain, Inc.

Questions?

