

# **Trip Report for Weather Forecast Office Tucson, Arizona – Colorado Basin River Forecast Center Hydrology Trip for the Week of December 4<sup>th</sup>, 2006**

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## **Purpose**

Allow Colorado Basin River Forecast Center (CBRFC) staff the opportunity to conduct customer outreach, present to WFO staff, become familiar with WFO river forecast points, and jointly evaluate WFO hydrologic forecast challenges.

## **Customer Meetings**

- U.S. Geological Survey (USGS)
- Arizona Geological Survey (AZGS)
- Pinal County Public Works Department
- Bureau of Indian Affairs (BIA), San Carlos District
- City of Duncan

## **NWS Participants**

- Mike Schaffner (Monday – Thursday)
- Bill Reed (Monday – Thursday)
- Michelle Schmidt (Monday)
- Tom Zickus (Wednesday)

## **Quick Summary of Sites Visited**

- River Forecast Point Reach (2)
- Guidance Forecast Point Reach (4)
- Local Forecast Point Reach (1)
- Water Supply Forecast Point (1)
- High Hazard Dam (1)

## **Accomplishments**

### **Monday:**

- CBRFC and WFO management team discussed services provided during recent flood episodes.
- CBRFC presented on RFC operations to WFO and USGS staff.
- CBRFC and WFO staff discussed with USGS coordination, data timeliness, and rating table updates during flood situations.

**Tuesday:**

- Discussed debris flow potential from burned portions of Brins and Florida Burn Areas with AZGS. Ann Youberg represented AZGS.
- Aravaipa Creek near Mammoth (ARVA3) guidance forecast point. Surveyed flood damage of August 1, 2006. Visited USGS gage. Evaluated flood stages. Accompanied by Elise Moore of Pinal County Public Works.
- San Pedro River below Aravaipa Creek (SPAA3). Meet with residents flooded on August 1, 2006. Recruited residents as new SKYWARN spotters. Accompanied by Elise Moore of Pinal County Public Works.
- Gila River at Kelvin (GLKA3) river forecast point. Evaluated flooded structures, in Kearny, from August 1, 2006 event. Visited USGS gage. Viewed proximity of structures in Riverside to Gila River.
- Gila River below Coolidge Dam (CLDA3 and GCDA3) local forecast point. Evaluated flood potential of occupied structures closest to the Gila River in Winkelman.
- Evaluated drought conditions at water supply forecast point for San Carlos Reservoir.

**Wednesday:**

- Held meeting with Clark Richins, BIA San Carlos natural resources chief, on NWS services.
- Visited flooded parkland, in San Carlos, from August 1, 2006 flood.
- Evaluated spillway at Elgo Dam.
- Evaluated flood stage for San Carlos River near Peridot (SCNA3) guidance forecast point.
- Meeting with Albert Walker, new city manager of Duncan, on NWS services and flood concerns.
- Evaluated dike repairs in Duncan with respect to request by Greenlee County to raise flood stage to prior values.
- Evaluated flood concerns along lower Bonita Creek (BNMA3) guidance forecast point.

**Thursday:**

- Estimated cross-sectional discharge along the San Pedro River at Benson (no gage).

**Observations and Field Notes****Monday:****Presentation/USGS Meeting:**

Michelle Schmidt, CBRFC Hydrologist in Charge, presented on river forecast operations to the NWS and USGS Tucson field staff. The use of USGS data including rating tables was highlighted. CBRFC expressed the need for expedited updating of ratings during flood events. The modification of ratings for low flow conditions was explained by the USGS and how this might impact river forecasting during the switch to higher flow events was discussed. The question of if the USGS can rank their ratings according to confidence was posed by the NWS. The USGS reported that they are in the process of converting additional gages to high transmission rate DCPs. All parties felt that this was a productive meeting and allowed each agency to better appreciate how their data and products are utilized. The USGS welcomed further discussions and meetings with CBRFC regarding rating and data issues. CBRFC proposed sending their data and calibration focal points down to meet with the USGS.

## **Tuesday:**

### **Brins Fire Debris Flow Meeting:**

Ann Youberg (AZGS) discussed her recent findings on the Brins Fire burn area located above Sedona in Oak Creek Canyon. Tom Zickus (WFO Phoenix Senior Service Hydrologist) requested this meeting. Portions of the Brins Fire that received the heaviest monsoon rainfall triggered the greatest density of debris flows. Multiple structures below the Brins Fire were noted. Impacts due to debris flows or flooding from tributaries of Oak Creek seem to be of greatest concern. Localized flooding of Oak Creek just below the fire might also be possible. Flooding of Oak Creek further downstream in the Sedona area is unlikely due to significant channel capacity. Debris flows originating from the Florida Fire burn area was also discussed. The terrain around both the Brins and Florida Fires were debris flow prone before the fires. Ann has requested that we hold a meeting/conference call on the debris flow hazard warning system in Arizona in early 2007.

### **Aravaipa Creek near Mammoth (ARVA3):**

Aravaipa Creek drains an area of 537 square miles. Much the drainage area is roadless and uninhabited. Several ranches and farms exist upstream of the USGS gage in Aravaipa Canyon as do several in Klondyke. The BLM will allow hikers/backpackers, on a permit basis, into the canyon's wilderness area each day. The recognition of prior flood events in Aravaipa Canyon and the potential to flood the San Pedro River below Aravaipa Creek prompted the establishment of ARVA3 as a guidance forecast point in June 2006. Elise Moore, Pinal County Flood Control, joined us at the turn-off for Aravaipa Canyon. High water marks, road damage, and home damage were viewed. The USGS gage was visited.

Flooding occurred in Aravaipa Canyon on July 29<sup>th</sup> and August 1<sup>st</sup>, 2006. CBRFC forecasted a peak of 29.0 feet / 18,000 cfs on July 29, 2006. A flood warning was issued for Aravaipa Creek and points downstream on the San Pedro – Gila River system. The actual peak was 16.09 feet (crest-stage gages). This exceeded bankfull stage, but was 9.0 feet shy of flood stage (or about 6,000 cfs below flood flow based on the USGS rating in effect at the time of the event). At the time, no reports of damage had been received. Pinal County reported later that the Aravaipa Creek Road had been

damaged upstream of the USGS gage in several spots. This resulted in hikers not being able to gain access to trailhead located at the upper reaches of the canyon the following day. If the road had in fact been left usable, additional lives could have potentially been in harms way on August 1<sup>st</sup>.

August 1<sup>st</sup> witnessed 1.0 to 2.0 radar-indicated rainfall totals throughout eastern Pinal and western Graham County. Aravaipa Creek had exceeded bankfull stage at 5:45 AM. A small stream advisory was issued as a result of the rainfall and creek rise. The advisory was allowed to expire at 8:00 AM since the rain had moved off to the east and no reports of flooding were received. The USGS gage had been damaged during this event. CBRFC did not forecast a rise to flood stage for this event.

The USGS conducted a survey about 0.50 miles downstream of the gage to estimate the peak flow which corresponds to a stage height of 19.33 (crest stage gage height). Provisional USGS HEC-RAS simulations place the peak flow between 27,000 and 30,000 cfs converging on 29,500 cfs. From visual inspection, a value in this range seems reasonable.

The flood of record is pegged at 70,000 cfs by the USGS for October 1983. This peak flow has been called into question. At the time, the discharge estimate was rated poor due to alluvial and channel cross-section uncertainties. Long-time residents reported that water was 1 to 2 feet lower in 1983 than on August 1<sup>st</sup>. Furthermore, a peak flow of 26,500 cfs was recalculated by Roberts in a 1987 University of Arizona, Department of Geosciences, master's thesis. Roberts developed a synthetic rating table that paleo-deposits were compared to. Only one deposit exceeded the peak flow of 1983. This was an undated silt deposit with a peak discharge assigned to it of 34,300 cfs. Roberts considers this to be the maximum paleoflood preserved within his study reach of Aravaipa Canyon. Roberts incorporated historical floods outside of the USGS period of record to produce an adjusted 100-year discharge of 35,000 cfs. Roberts (using Malvick, 1980) placed the maximum expected flood at 90,000 cfs.

Our tour visited two sections of the Aravaipa Creek Road. One section was 1.5 miles upstream of the gage and another was just downstream (about 0.25 miles) of the gage. The upstream section is impacted at lower flows (as on July 29<sup>th</sup>) while the lower section is impacted at higher flows (as on August 1<sup>st</sup>). The lower road section is exacerbated by a fish dam located 0.25 miles downstream. It was proposed to set minor flood stage at the flow at which the upper canyon road would be impacted.

About a dozen structures were destroyed or sustained damage. Several buildings were viewed where foundations or frames only remain. Bank erosion destroyed acres of farmland about 1.0 mile upstream from the gage.

Flood forecasting in Aravaipa Creek is a challenge due to the lack of rain gages. The USGS maintains a rain gage at their stream gage and a SKYWARN spotter was recruited in Klondyke. No gages exist in or near the headwaters. The NWS has provided a letter of support to Pinal County in their efforts to secure fiscal year 2007 Automated Flood Warning System (AFWS) grant funds to establish ALERT stream and rain gages upstream in Aravaipa Canyon.

Preliminary flood stages for Aravaipa Canyon based on our findings are:

Bankfull Stage	14.00 feet
Flood Stage	15.00 feet
Flood of July 29, 2006	16.09 feet

Moderate Flood Stage	17.00 feet
Major Flood Stage	18.00 feet
Flood of August 1, 2006	19.33 feet

### **San Pedro River below Aravaipa Creek (SPAA3) at Dudleyville:**

The lower San Pedro River has been flooded in the past from either the flow within the mainstem San Pedro River itself, Aravaipa Creek contribution alone, or both combined. During July 29<sup>th</sup> and August 1<sup>st</sup>, the San Pedro River was running below 5,000 cfs. As a result, Aravaipa Creek was by far the main contributor to downstream flooding.

Pinal County arranged a tour of a residence and property on the west side of Cholla Road in Dudleyville. The residence visited is situated the closest to the San Pedro River. They have experienced flooding historically in both 1983 and 1993. On July 29<sup>th</sup>, the San Pedro River ran through their property, but did not impact the residence. One August 1<sup>st</sup>, water was three feet up on the side of their elevated residence. These long-time residents reported that this was the worst that they had ever seen flooding at their property. In addition to residence, barn, and outbuilding damage, livestock (several dozen sheep and several horses) were lost. The residents also reported that the state highway bridge over Aravaipa Creek had been overtopped on the morning of August 1<sup>st</sup>. USGS reports that water was just lapping up onto the bridge, but was not free flowing over it. The residents have agreed to become SKYWARN spotters and provide rainfall and river conditions.

### **Gila River at Kelvin (GLKA3):**

After flooding both Aravaipa Creek and the San Pedro River at Dudleyville, the flood peak continued downstream and impacted the upper portion of the river forecast reach for the Gila River at Kelvin. The USGS rating table in effect at the time recorded a peak flow of 20,500 cfs which corresponds to a stage of 22.4 feet or 1.4 foot above flood stage of 21.0 feet. Zero flow at the site is about 2.0 feet. Three structures were flooded in Kearny located 6.5 miles upstream of Kelvin. One structure was utilized as a Laundromat and two others appeared unoccupied. Water was about 3 feet deep on the side of each structure. A drive through Riverside confirmed that structures would be impacted from Gila River at stages not all that much higher than reached on August 1<sup>st</sup>. It appeared that Riverside Road would be flooded at about 26 foot stage as opposed to 28 foot stage currently in damage table. At low flows, it was observed that about one third of flow was bypassing the USGS gage.

### **Gila River below Coolidge Dam (CLDA3 and GCDA3):**

A brief stop was made in Winkelman to view several occupied structures closest to the Gila River. Concern has been expressed that Winkelman is no longer impacted by flood waters due to buy-outs after the floods of 1983 and 1993. A structure used for tires/basic auto repair as well as several mobile homes located closest to the river on the right bank were indeed in the floodplain. In addition, a historic arch footbridge and city parkland are also located in the floodplain. All of the above would likely be impacted between minor and moderate flood flow (10,000 – 35,000 cfs).

**San Carlos Reservoir (CLDA3):**

San Carlos Reservoir is a CBRFC water supply point. The USGS reported 31.5 percent capacity at the time. Vegetation and landscape surrounding the reservoir looked stressed. While the area received above normal rainfall over the previous monsoon season, rainfall has been below normal since the middle of September 2006.

**Wednesday:****BIA San Carlos District Meeting:**

Tom Zickus (WFO Phoenix SSH) joined us at San Carlos to meet with Clark Richins (Natural Resources Officer). The town of San Carlos is in the CWA of WFO Phoenix and the HSA of WFO Tucson. We discussed flooding on August 1<sup>st</sup> in San Carlos. Their primary concern was debris caught in Elgo Dam. Elgo Dam is a high hazard dam located 3 miles upstream along the mainstem San Carlos River. The rain gage data-void over the headwaters of the San Carlos River was also discussed. Clark mentioned that two gages were going in the vicinity of the dam. Funding was coming from BIA high hazard dam program. The gage houses were already installed. Equipment is slated for 2007 calendar year. Mike Schaffner said he would take an action item to obtain access to this data. No gages were planned for the headwaters of the basin.

**San Carlos Ball-fields:**

The first stop was ball-fields flooded on August 1<sup>st</sup>. Several feet of water inundated the fields and water approached one occupied structure located to the northwest of the fields. Flood flow for this event was about 25,000 cfs based at the USGS gage (San Carlos River near Peridot (SCNA3)) located 5 miles downstream. SNCA3 is a guidance forecast point. The forecast point was established after the August 1<sup>st</sup> flood. CBRFC forecasts will likely remain poor for this site unless QPE can be dramatically improved over the upper half of the basin.

It was observed that water would have to rise several more feet before it would impact large sections of San Carlos (other than the above mentioned occupied structure). Based on the wide nature of the channel, this would likely approach 60,000 cfs (which about equals the 100-year flow calculated by J.E. Fuller Hydrology and Geomorphology of Phoenix, AZ).

**Elgo Dam:**

Elgo Dam is one of several high hazard dams on the San Carlos Apache Nation. It is located a mere 3 miles upstream of the town of San Carlos on the San Carlos River. Our journey to the dam involved fording the San Carlos River about a mile and a half upstream of the town. This presents a problem with accessing the dam during times of high flow.

Elgo Dam (along with nearby Tufa Stone Dam on a tributary of the San Carlos River below Elgo Dam) has an Emergency Action Plan (EAP). The EAP included input from Weather Forecast Offices Tucson and Phoenix. Elgo Dam is an earthen dam with a capacity of 6,000 acre feet. The reservoir behind Elgo Dam contains water year round and is used for recreation. A fair amount of vegetation has grown on and near the dam. Elgo Dam contains a concrete spillway that spills in an uncontrolled manner. Unlike

previous visits to the dam, the author noticed that there is a fair amount of debris and vegetation at the outlet of the dam. At low flows, this does not impede flow through the spillway.

On August 1<sup>st</sup>, water was reported one-half to two-thirds of the way to spillway capacity. Crews were stationed at the dam to monitor the situation. Of particular concern was the build-up of large debris including logs just upstream of the spillway. There was concern that these would block the spillway. Luckily, the large debris passed the spillway with no problem.

Due to the high hazard nature of the dam and the fact that an event would give little lead time to the town of San Carlos, it was proposed to make the major flood stage equal to the flow corresponding to the maximum spillway capacity. The Elgo and Tufa Stone Dams EAP (2003) and the Tufa Stone and Elgo Dam Inundation Study (1995) assume 30,000 cfs as the maximum spillway capacity and also the approximate 100-year inflow at Elgo Dam).

Tom Zickus departed for Phoenix after our visit to Elgo Dam.

### **Gila River at Duncan (DUUA3):**

The majority of the city of Duncan is located on the left bank of the Gila River and situated quite low with respect to the river. An earthen dike structure (levee) is present to protect the city from river rises. Historically, Duncan has flooded when the levee was breached in one or more locations. It is also possible to have flooding in Duncan due to excessive flow from area washes (e.g. Railroad Wash) impacting a portion of downtown Duncan.

Low flow conditions generally persisted, throughout the 2006 monsoon season, along the Gila River at Duncan until July 29<sup>th</sup>. The Gila River basin upstream of Duncan started getting increased precipitation around the 27<sup>th</sup> of July. This caused the Gila River to rise to around 1,000 cfs by the 1<sup>st</sup> of August. Flow continued to increase and reached a maximum of about 4,590 cfs (corresponding to a gage height of 12.74 feet) on August 23<sup>rd</sup>. These flows did not approach any critical stages. Flows corresponding to bankfull stage and flood stage, in effect in early August 2006, were about 10,000 and 20,000 cfs respectively. In response to concerns raised by the county of erosion and undermining of the dike across from Duncan High School, a flash flood watch was issued for possible levee failure on August 23, 2006. It should be noted that this is the same section of levee that breached during the floods of February 2005.

In coordination with the county, flood stages were lowered. It was agreed that flood stages would remain lowered until the levee section had been improved. Below is a table with old and new flood stages:

	Stages in Effect on August 23, 2006	Discharge (cfs)	Stages in Effect on August 24, 2006	Discharge (cfs)
Bankfull	18.0	15000	14.0	6600
Minor Flood	20.0	20200	15.0	8170
Moderate Flood	22.0	29200	20.0	20200

Major Flood	24.0	45700	24.0	45700
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Inspection of the repaired levee section observations:

- Levee section is located on an outside bend of the Gila River where the highest velocities and erosion rates take place
- Levee dimensions (both height and width) are less than those of levee both down and upstream
- Gila River face of levee has already begun to sluff (i.e. soil slip)

Based upon our observations, it is our recommendation that flood stage not be raised till this section of the levee is riprapped.

Flow was estimated by Schaffner and Reed at 140 cfs. USGS flow agreed well at 125 cfs.

**Bonita Creek near Morenci (BNMA3):**

An attempt to drive up lower Bonita Creek to the city of Safford pumping works located downstream of BNMA3 was unsuccessful due to insufficient daylight. Lower Bonita Canyon was accessed via the Gila Box Wilderness area. We crossed many low-water crossings enroute. Bonita Creek is plagued with many such low-water crossings.

**Thursday:**

**San Pedro River at Benson:**

The city of Benson is located half way between the USGS gages near Tombstone (SPTA3) and near Benson (SPBA3). The channel cross-section was evaluated near the Railroad Bridge and RV Park. The Railroad Bridge capacity was estimated at 100,000 cfs. RV Park on left bank would likely require about 50,000 cfs to impact it from flooding (less from bank erosion).

**Acknowledgments**

I would like to thank CBRFC for supporting outreach and collaborative trips between the RFC and WFO. Bill Reed for his continued support and insight into southeast Arizona’s challenging hydrology. Special thanks for our partners and customers who took the time out of their busy schedules to meet up in their offices and in the field. Your input and participation is key.

**References**

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Roberts, L.K., 1987: Paleohydrologic Reconstruction, Hydraulics, and Frequency-Magnitude Relationships of Flood Events along Aravaipa Creek, Arizona. Masters Thesis, Department of Geosciences, University of Arizona, Tucson, Arizona.

2003: Emergency Action Plan for Elgo and Tufa Stone Dams. Bureau of Reclamation Technical Service Center, Denver, Colorado and Bureau of Indian Affairs, Western Region Office.

### **Action Items**

1. Coordinate with USGS on location of new high transmission rate DCPs.
2. Hold meeting/conference call with AZGS, WFO Tucson, and CBRFC on the debris flow warning system for Arizona.
3. Set new flood stages for Aravaipa Creek near Mammoth (ARVA3).
4. Establish COOP site in Klondyke to support ARVA3 flood forecasting.
5. Establish SKYWARN network within Aravaipa Canyon.
6. Modify damage table for Gila River near Kelvin (GLKA3) for Riverside Road impact stage.
7. Modify damage table for Gila River below Coolidge Dam (CLDA3) for impacts in Winkelman.
8. Work with BIA to allow data access to Elgo Dam gages.
9. Set new moderate and major flood stages for San Carlos River near Peridot (SCNA3).
10. Post trip report on WFO web page.

## Appendix: Field Photos



Image 1: Aravaipa Creek looking downstream towards to southwest. Photo taken about 0.25 miles downstream of USGS gage. This area is impacted by the fish dam located just a short distance further downstream. The photo was taken on top of the right bank at about the same elevation as the Aravaipa Creek Road that got flooded out at this location on August 1, 2006.



Image 2: Aravaipa Creek. Taken from same location as image 1 – just looking upstream. Notice Aravaipa Creek Road and home on left-side of image that were impacted on flood waters on August 1, 2006.



Image 3: Fish dam located about 0.50 miles downstream from USGS gage. One of two fish barriers / dams constructed to keep non-native fish out of upper Aravaipa Creek.



Image 4: Elgo Dam. White line inserted in image above shows approximate level of high water mark on August 1, 2006. Elgo Dam is an earthen high hazard dam situated 3 miles upstream of the city of San Carlos along the San Carlos River.



Image 5: Elgo Dam spillway. Concrete spillway appeared to be in good condition. A mat of vegetation was however covering the outlet of the dam. Water at low flows was not impeded by vegetative mat.



Image 6: Vegetative mat located near outlet for Elgo Dam Spillway. Image taken near spillway looking eastward / upstream.



Image 7: Levee structure on left bank of Gila River at Duncan downstream from USGS gage. Picture taken looking downstream. Farm fields begin immediately beyond levee. Section of levee repaired is narrower and lower in elevation than the remainder of the levee structure. NWS Blazer for scale.



Image 8: Levee structure at Duncan (same section as seen in image 7). Picture taken looking upstream.



Image 9: Farm fields at Duncan taken from top of levee structure seen in prior images looking southward. Duncan high school can be seen as large building in center of image bisected by sunray. Fields, state highway, and fields below high school would all likely be impacted (as in February 2005 flood) if levee was to breach again at this location.



Image 10: San Pedro River at Benson (no gage at site). Flow estimated at 3 to 5 cfs. Channel has significant capacity at both road and railroad bridges seen above. Image taken looking upstream from left bank.