P6.4 AVOIDING DISASTER ACROSS WESTERN COLORADO: THE 2007-08 WINTER SEASON NEAR-RECORD SNOWFALL AND IMPACT OF THE SPRING RUNOFF

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1. Introduction

The Upper Colorado Basin supplies water for a large portion of the population in the southwestern United States. It also provides water for the growing metropolitan areas along the Front Range of the Rocky Mountains, Las Vegas, Phoenix, and Los Angeles. Historically, this region is prone to long-term periods of drought and reduced runoff. Population growth is placing an additional strain on existing water supplies.

An above normal snow season brings both benefits and potential dangers to the people and economies of the arid western United States, including the Upper Colorado Basin. Abundant snowfall bolsters the economies of ski communities. The resulting augmented spring and summer runoff benefits water recreation. Most importantly, this runoff helps to replenish reservoirs which supply water for municipal, agricultural and industrial uses. So, while excessive runoff does pose the threat of flood damage to property and life, especially along unregulated streams, it also sustains life and consumptive water needs in the arid southwestern climate.

This paper will examine the 2007-08 winter season. It will briefly describe the initial long-range seasonal forecast. A brief summary of the near-record snowfall and snowpack, describing several mechanisms which impacted the snowfall distributions will be addressed. Finally, mitigation efforts, as well as fortuitous late spring weather which alleviated runoff impacts, will be detailed.

2. 2007-08 Winter Season

2.1 Seasonal forecast

Preliminary long-range forecasts for the 2007-08 winter season predicted a moderate La Niña event with a weak signal for seasonal precipitation across western Colorado (Figure 1). Local studies conducted by the Grand Junction National Weather Service Forecast Office (WFO GJT) showed evidence of increased probability of higher snowfall across the northern and central mountains in moderate La Niña regimes.

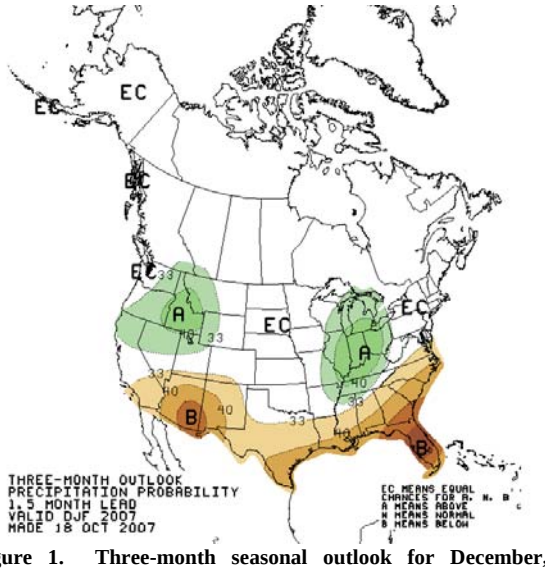

Figure 1. Three-month seasonal outlook for December, January and February issued by the Climate Prediction Center in October 2007.

2.2 Seasonal summary

The 2007-08 winter seasons produced much above normal snowpack for much of western Colorado (Figure 2).

The season was anomalously dry through November. Many ski areas had to delay the start of the season due to lack of snow. However, a strongly progressive pattern began on 30 November, and continued with frequent storms through February.

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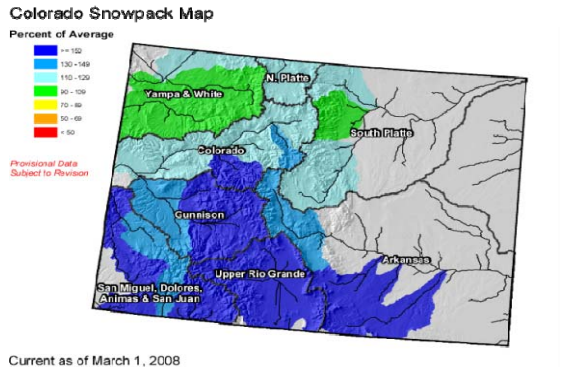

Figure 2. State of Colorado River Basin Snowpack as of March 1, 2008.

By 1 March, several river basins topped 200 percent of normal snow water equivalent. With a few breaks, this progressive pattern continued into early June.

A possible explanation for the more active and progressive pattern was the disruption of the low-level wind fields over the equatorial Pacific due to activity associated with the Madden-Julian Oscillation (MJO). This pattern may have benefited the southern mountains as a higher number of closed lows dropped through the southern Great Basin. Another characteristic of the 2007-08 La Niña season was the lack of a typical dry ridging period which often occurs in the months of January or February.

In addition to the deep closed lows which moved across the southern Great Basin, a persistent pattern of progressive northwest open waves brought heavy snow to the northern and central mountains throughout most of the winter. It is unusual to gain above normal snowpack in both the southern and northern mountains in the same season. Due to the relentless series of storms passing through the region, areas of western Colorado were under hazardous weather highlights (i.e. Winter Storm Warnings, Snow Advisories, etc.) for 70% of the winter season (Figure 3).

Of further concern, heavy snowfall extended down to elevations as low as 2285 m MSL, which adversely impacted wildlife with record-breaking winter kill, and would potentially create flood concerns for the runoff season. Two factors which contributed to the heavier snowfall were cold air damming, and lower density

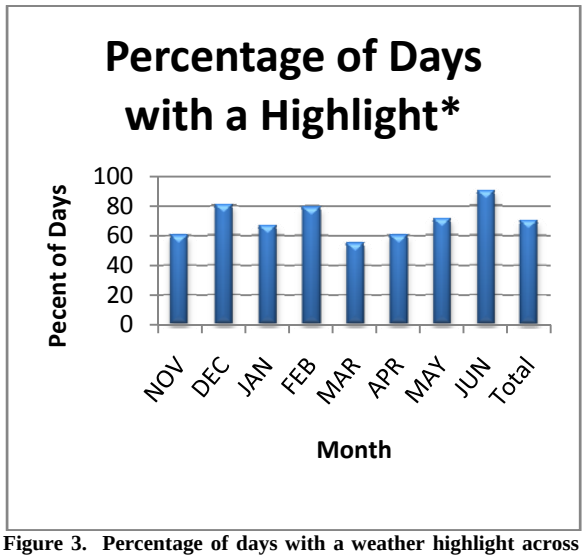

Figure 3. Percentage of days with a weather highlight across western Colorado from November 2007 through June 2008.

snowfall due to colder than normal temperatures (Colton 2008; Borys and Wetzel 1997). An example of this snowfall distribution is seen in Figure 4 a,b,c from the Park Range which shows more normal snowfall at the higher elevation site (Tower Snotel) and record-breaking amounts at the lower two sites.

2.3 Late Spring Weather Pattern

The spring weather pattern slowed excessive snowmelt runoff as the progressive weather pattern continued. This progressive pattern resulted in periods of cooler than normal temperatures with passing storms. Between the storms, the warming temperatures would arrive in 2- to 3-day increments (Figure 5); just enough to start the melting process and bring the rivers to and above bank full. As dangerous flood stages were approached, another storm would enter the region and decrease the snowmelt.

This scenario was repeated through the peak snowmelt months of May and June. The lower elevation snowpack melted first in early and mid May. The mid-level snowpack then melted and ran off during mid and late May, with the high-elevation snow melting in early to mid June.

If seasonably warm and dry conditions occurred early in the snowmelt process, flow levels could have reached catastrophic flood levels at many locations across western Colorado.

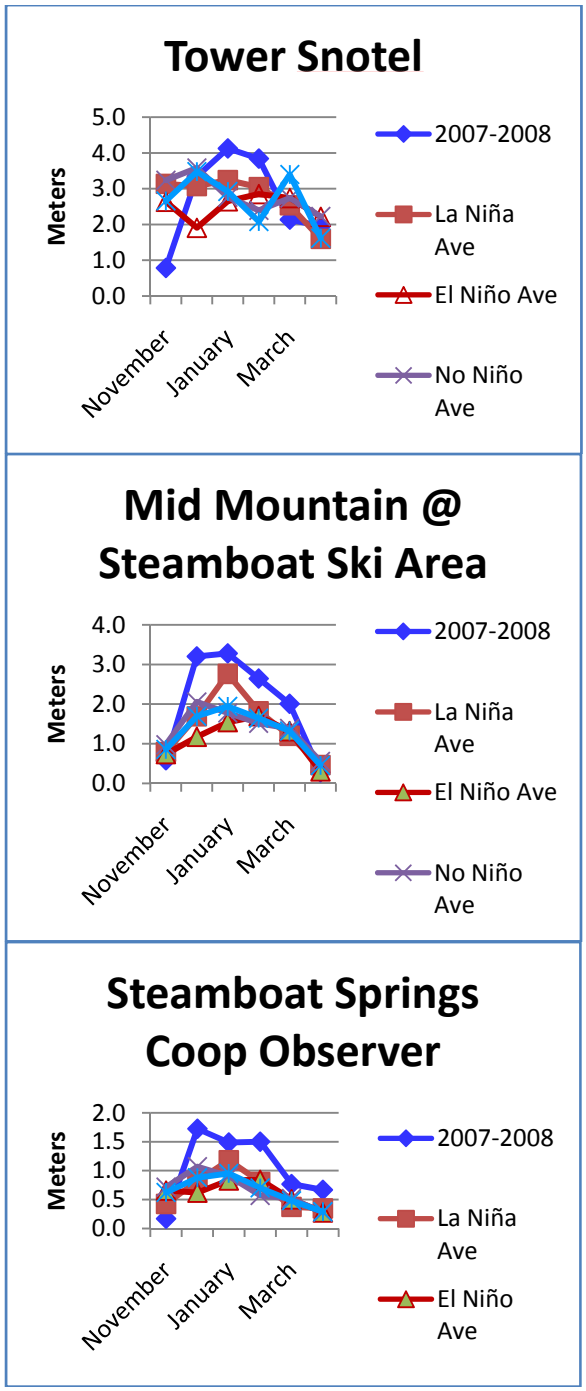

Figure 4 a, b, c. Seasonal snowfall in meters under different climate regimes for the Tower SNOTEL, mid-mountain, and the Steamboat Springs Cooperative Weather Observer reporting sites.

3. Hydrological Impacts

3.1 Snowmelt Flood Planning and Activities

Given the potential of an extreme runoff season, the staff at WFO GJT began educational outreach during the winter.

This advanced education of local media and emergency management teams across the Western Slope allowed WFO GJT staff to reach both those who would benefit and be threatened by flooding.

By starting efforts 4 months in advance, emergency management teams were able to set aside resources and make long-term plans as the runoff season approached.

These outreach efforts will be examined.

Outreach activities can be divided into internal and external efforts. Internally, WFO GJT increased training on hydrologic software systems and reviewed how best to serve our customers and/or partners. The staff changed their work schedule to optimally meet the needs to protect life and property in the community. Externally, WFO GJT regularly coordinated with the Colorado Basin River Forecast Center (CBRFC), the Colorado Division of Water Resources, emergency management officials, and the media. This included regular meetings and conference calls.

This coordinated effort paid off. Early planning and preparation helped mitigate flood risks. Levees were enhanced and strengthened in Grand Junction, Gunnison and other communities around western Colorado. Sand bags were placed around homes and buildings in Routt County and other locations. Informational signs were posted at recreational areas along rivers.

Three fatalities occurred during the runoff season. There was one fatality on the Gunnison River in Gunnison County when a person who was not wearing a personal floatation device (PFD) fell off a raft. A woman riding a horse was lost in Beaver Creek when her horse fell into the fast-moving water. The third death was when a man fell out of his blowup kayak into the Colorado River near Glenwood Springs. It is unclear if the man was wearing a PFD.

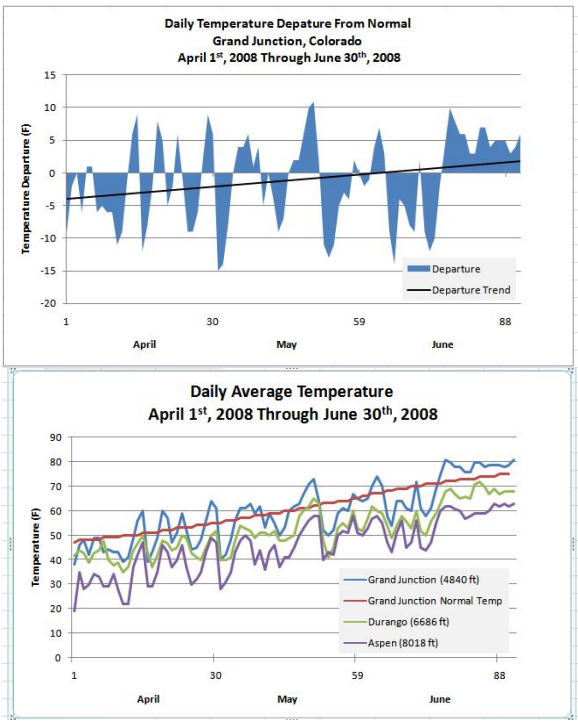

Figure 5. Two temperature graphs representing the steady rise and fall of temperatures across western Colorado. The top graph is of WFO GJT. The bottom graph includes, Grand Junction, Durango and Aspen. All temperatures are in degrees Fahrenheit.

3.2 Impact of River Flooding

WFO GJT issued 7 Flood Warnings, 6 Flood Watches, 33 Flood Advisories, and 6 Areal Flood Advisories during the 2007-08 winter season. In addition, public information statements were issued throughout the snowmelt season to warn people of the potential dangers of fast-moving water and erosion of banks. Thirteen main rivers and creeks went above bankfull stage, including 22 gauge sites. Three of the rivers (four gauge sites) reached or exceeded flood stage.

WFO GJT had river products active from 7 to 10 May and 19 May to 26 June. That is a total of 41 days and 38 consecutive days with active hydrologic products.

4. Conclusions

Heavy winter snowpack leads to significant spring runoff. The 2007-08 winter season produced record-breaking snowfall in many locations across western Colorado. However, the resulting spring runoff season did not produce catastrophic flooding. This was due to cooler-than-normal spring temperatures.

This allowed the snowpack to slowly melt over a longer duration reducing severe flood potential. In addition, lives and property were potentially saved from the minor flooding that did occur due to the aggressive efforts made by the staff of WFO GJT and local and government officials across western Colorado. It was this partnership that raised awareness.

A methodology is now in place to help mitigate loss of life and damage from future runoff flood events.

By using this methodology, major societal impacts can be mitigated, and in some cases, avoided.

5. Acknowledgements

The authors would like to thank the emergency managers of western Colorado and the local media for the outstanding efforts brought forth during the 2008 spring runoff season. Thanks is also extended to the staff of WFO Grand Junction for providing support and allowing the members of this study the extra time needed to work on the research.

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