Intermountain West Climate Summary

by The Western Water Assessment

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November 2008 Climate Summary

Hydrological Conditions — Since mid-September, drought intensity has decreased in southeastern Colorado and southwestern Wyoming, and the Four Corners region (including southeastern Utah and southwestern Colorado) is now in the abnormally dry category of the Drought Monitor.

Temperature — Monthly average temperatures for October 2008 showed positive anomalies of >5ºF above average in a central pocket southeast of Salt Lake City, UT and negative anomalies of <-2ºF below average the central and eastern regions of Wyoming.

Precipitation — Totals ranged between 0 and 3+ inches across the Intermountain West in October 2008. The largest totals were in the eastern half of Colorado, which received over 3 inches.

ENSO —The majority of SST prediction models predict Nino 3.4 SSTs to remain within 0.5°C of average, indicating ENSO neutral conditions will continue through the end of the year.

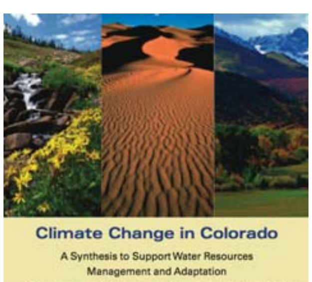
Climate Forecasts — In Dec 2008–Feb 2009, all or parts of the Intermountain West have an increased chance of above average temperatures, and eastern Colorado is included in an area of the central Great Plains with an increased risk of above average precipitation.

We are looking for your input on the Intermountain West Climate Summary (IWCS):

We hope you will help us evaluate the IWCS so that we can improve it for you. The survey is designed to assess the IWCS's usability and relevance to you and/or your organization. By participating in this survey, you will help WWA to improve the quality and content of the IWCS for your benefit. In addition, you will help WWA better understand your needs for climate information in your decision-making.

You can find a link to the survey on the WWA home page: http://wwa.colorado.edu.

Report on Climate Change in Colorado released:



The Colorado Water Conservation Board (CWCB) released a report "Colorado Climate Change: A Synthesis to Support Water Resource Management and Adaptation." Scientists from WWA, University of Colorado, Colorado State Universtiy and NOAA completed the report, which focuses on observed trends and projections of temperature, precipitation, snow and runoff.

We summarize key findings in the Feature Article this month.

Upcoming Conferences:

Utah Water Users Association: Annual Water Summit "Conserving Water – Conserving Energy" on December 2 in Layton, UT. See http://www.utahwaterusers.com for their latest newsletter, and details the annual conference.

In This Issue

On the Web: http://wwa.colorado.edu

Contact Us - To receive an email when a new Summary is available, please email us at: **wwasummary@wwa.colorado.edu.**

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The Intermountain West Climate Summary is published monthly by Western Water Assessment (WWA), a joint project of the University of Colorado Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory, researching water, climate and societal interactions.

Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation

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The Colorado Climate Report is a synthesis of climate change science important for Colorado's water supply. It focuses on observed trends, modeling, and projections of temperature, precipitation, snowmelt, and runoff. The report summarizes Colorado-specific findings from peer-reviewed regional studies, and presents new graphics derived from existing datasets. The following are highlights from the Report.

The scientific evidence is clear: the Earth's climate is warming. Multiple independent measurements confirm widespread warming in the western United States. In Colorado, temperatures have increased by approximately 2ºF between 1977 and 2006 (Figure 1a). Increasing temperatures are affecting the state's water resources.

Temperature & Precipitation

Climate models project Colorado will warm by 2.5ºF by 2025 and 4ºF by 2050, relative to the 1950–99 baseline. Mid-21st century summer temperatures on the Eastern Plains of Colorado are projected to shift westward and upslope, bringing into the Front Range temperature regimes that today occur near the Kansas border (Figure 1b).

Summers are projected to warm more than winters. Projections suggest that typical summer monthly temperatures will be as warm or warmer than the hottest 10% of summers that occurred between 1950 and 1999 (Figure 1c).

Changes in the water cycle will be the delivery mechanism for many impacts of climate change.

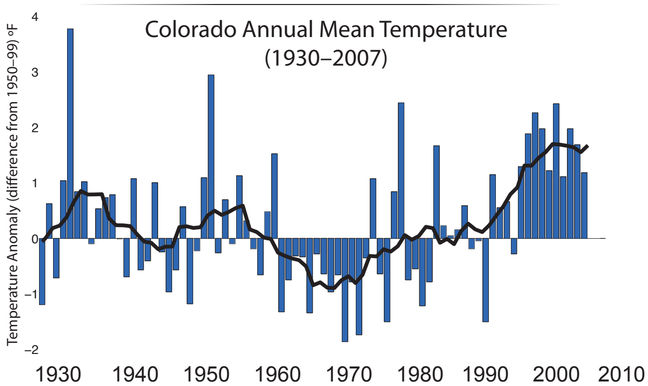


Figure 1a. Annual temperature departures are shown as blue bars relative to a 1950–99 reference period. The 10-year moving average of available data (black curve) highlights low frequency variations in the record. Warm periods occurred in Colorado in the 1930s and 1950s, followed by a cool period in the 1960s and 1970s. Since about 1970, there has been a consistent upward trend in the 10-year average.

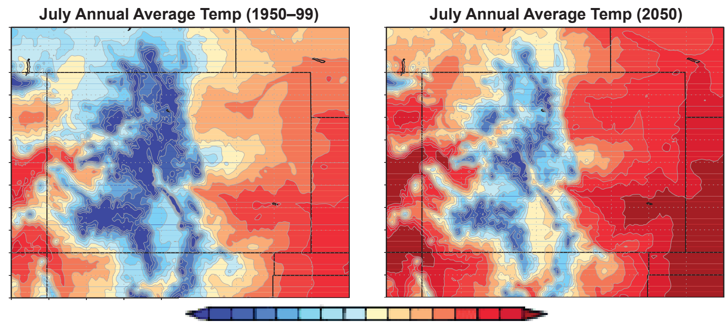


Figure 1b. For July, the temperatures on the Eastern Plains have moved westward and upslope, such that the temperature regime near the western Kansas border has reached the Front Range by 2050.

Changes in the quantity and quality of water may occur due to warming even in the absence of precipitation changes.

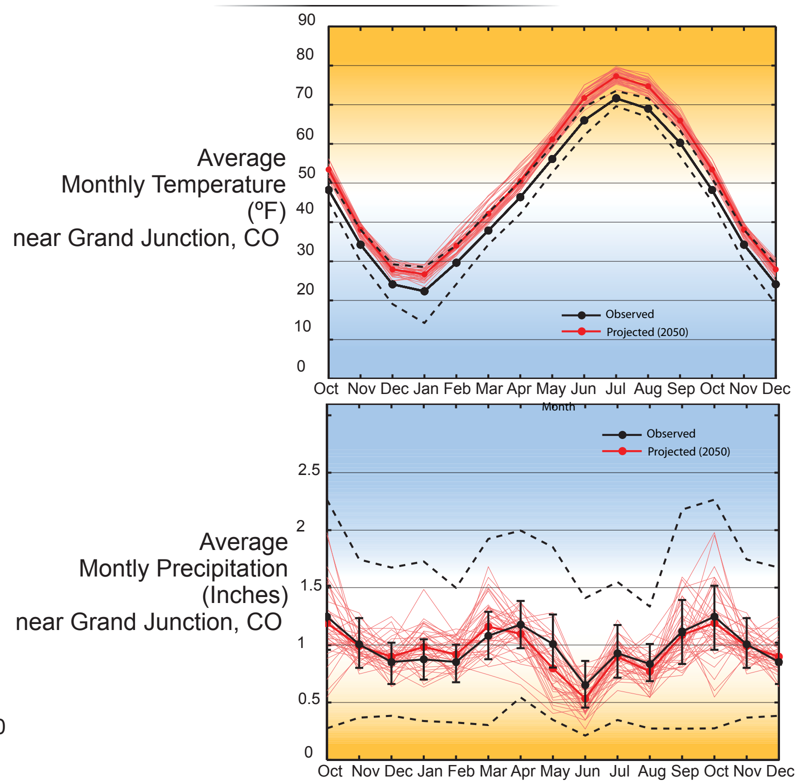


Figure 1c. The monthly average (solid black) and 10th and 90th percentile values (dashed black lines) of temperature (top) and precipitation (bottom) are based on observations (1950–99). Projected monthly climatologies (thin red lines) are from the multi-model ensemble for the 20-year period centered on 2050. Average of the projections is shown as a heavy red line.

No consistent long-term trends in annual precipitation have been detected in all parts of Colorado (Figure 1d). Variability is high, which makes detection of trends difficult. Climate model projections do not agree whether annual mean precipitation will increase or decrease by 2050.

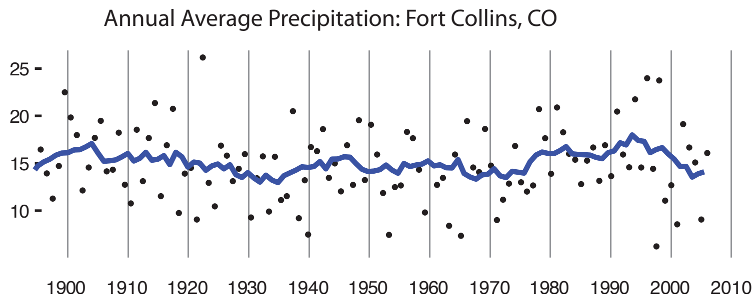


Figure 1d. Water year precipitation (inches) at station in Fort Collins, CO. Overall long-term trends are not detectable here, or at eight other locations (Steamboat Springs, Akron, Grand Junction, Cheyenne Wells, Montrose, Rocky Ford, Trinidad and Lamar) in Colorado. The 10-year moving average is shown to emphasize decadal variations. Data for other locations are shown in the Report.

Snowpack

Most of the reduction in snowpack in the West has occurred below about 8200 ft. However, most of Colorado's snowpack is above this elevation, where winter temperatures remain well below freezing.

Projections show a precipitious decline in lower-elevation (below 8200 ft) snowpack across the West by the mid-21st century. Modest declines are projected (10–20%) for Colorado's high-elevation (above 8200 ft) snowpack (Figure 1e).

Streamflow

Between 1978 and 2004, the spring pulse (the onset of streamflows from melting snow) in Colorado shifted earlier by two weeks. Several studies suggest that shifts in timing and intensity of streamflows are related to warming spring temperatures. The timing of runoff is projected to shift earlier in the spring, and late-summer flows may be reduced.

Recent hydrology projections suggest declining runoff for most of Colorado's river basins in the 21st century. However, the impact of climate change on runoff in the Rio Grande, Platte, and Arkansas Basins has not been studied as extensively as the Colorado River Basin.

For the Upper Colorado River Basin, multi-model average projections suggest decreases in runoff ranging from 6% to 20% by 2050 compared to the 20th century average, although one statistical streamflow model projects a 45% decline by 2050 (Figure 1f).

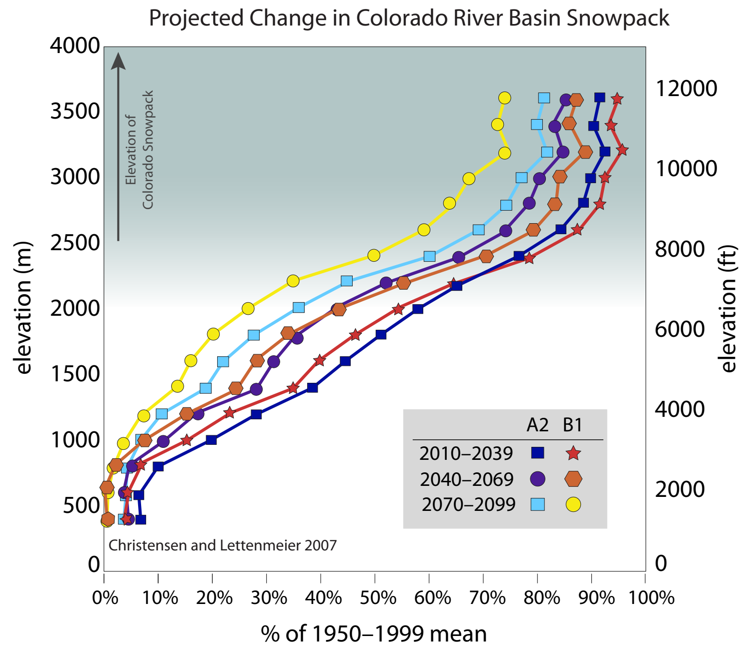


Figure 1e. The data show average snowpack declines throughout the cold season, and are a function of both the snow water equivalent and the amount of time snow is on the ground. The downscaled projections from 11 climate models for the 30-year average centered on 2025, 2055, and 2085 are shown for the B1 and A2 emissions scenarios (see Report for further details). Most of the snowpack in Colorado that feeds the Colorad River lies above 2500 m (8200 ft) in elevation.

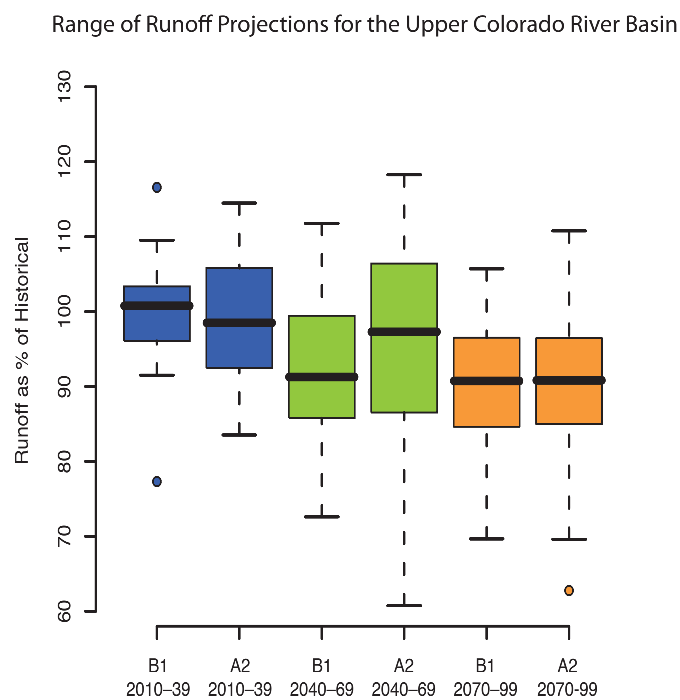


Figure 1f. Box-and-whiskers symbols represent the 5th, 25th, 50th, 75th, and 95th percentiles of the data; outliers are shown by circles. projections are shown for the SRES B1 and A2 emissions scenarios for 30-year averages centered on the years 2025, 2055, and 2085. Changes are relative to 1950–2000 averages. The range of results come from different climate model formulations and from model-simulated climate variability.

A synthesis of the findings in this report suggests a reduction in total water supply by the mid-21st century.

Drought

Throughout the West, less frequent and less severe drought conditions have occurred during the 20th century than revealed in the paleoclimate records over the last 1000 years (Figure 1g).

Precipitation variations are the main driver of drought in Colorado and low Lake Powell inflows, including the drought of 2000–07, and these variations are consistent with the natural variability observed in long-term and paloeoclimate records.

However, warming temeperatures may have increased the severity of droughts and exacerbated drought impacts.

The Report is divided in six sections and includes an Executive Summary, Glossary, List of Resources. An online Appendix will be available soon (http://wwa.colorado.edu). Also included in the Report is an overview of climate models that focuses on how climate projections are developed. This section is intended to provide background for the reader about the the theories behind model development, and the relationship among scenarios, models, and climate projections. Global climate models do not represent the complexity of Colorado's topography. Researchers use techniques such as "downscaling" to study processes that matter to Colorado water resource managers. Several projects are underway to improve regional models.

Reconstructed Streamflow for the Colorado River at Lees Ferry

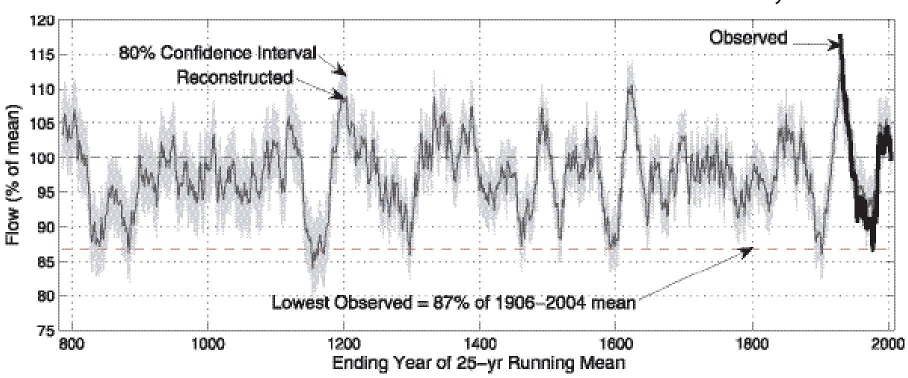


Figure 1g. Reconstructed streamflow (five-year moving average, with 80% confidence interval shown as gray band) compared with observed natural flow (five-year moving average in black). The severity of the 2000–04 drought was probably exceeded at least once in the previous 500 years. (from Meko et al. 2007)

Climate change will affect Colorado's use and distribution of water. Water managers and planners currently face specific challenges that may be further exacerbated by projected climate change.

Issues	Observed and/or Projected Change
Water demands for agriculture and outdoor watering	Increasing temperatures raise evapotranspiration by plants, lower soil moisture, alter growing seasons, and thus increase water demand.
Water supply infrastructure	Changes in snowpack, streamflow timing, and hydrograph evolution may affect reservoir operations including flood control and storage. Changes in the timing and magnitude of runoff may affect functioning of diversion, storage, and conveyance structures.
Legal water systems	Earlier runoff may complicate prior appropriation systems and interstate water compacts, affecting which rights holders receive water and operations plans for reservoirs.
Water quality	Although other factors have a large impact, "water quality is sensitive both to increased water temperatures and changes in patterns of precipitation" (CCSP SAP 4.3, p. 149). For example, changes in the timing and hydrograph may affect sediment load and pollution, impacting human health.
Energy demand and operating costs	Warmer air temperatures may place higher demands on hydropower reservoirs for peaking power. Warmer lake and stream temperatures may affect water use by cooling power plants and in other industries.
Mountain habitats	Increasing temperature and soil moisture changes may shift mountain habitats toward higher elevation.
Interplay among forests, hydrology, wildfires, and pests	Changes in air, water, and soil temperatures may affect the relationships between forests, surface and ground water, wildfire, and insect pests. Water-stressed trees, for example, may be more vulnerable to pests.
Riparian habitats and fisheries	Stream temperatures are expected to increase as the climate warms, which could have direct and indirect effects on aquatic ecosystems (CCSP SAP 4.3), including the spread of in-stream non-native species and diseases to higher elevations, and the potential for non-native plant species to invade riparian areas. Changes in streamflow intensity and timing may also affect riparian ecosystems.
Water- and snow-based recreation	Changes in reservoir storage affect lake and river recreation activities; changes in streamflow intensity and timing will continue to affect rafting directly and trout fishing indirectly. Changes in the character and timing of snowpack and the ratio of snowfall to rainfall will continue to influence winter recreational activities and tourism.

On the Web

- See the full report: http://wwa.colorado.edu
- For more information: email wwa@noaa.gov

Temperature 10/01/08 – 10/31/08

As October marks a transitional month in the Intermountain West, monthly average temperatures for October 2008 were highly variable throughout the region, ranging between about 35 and 60ºF (Figure 2a). The coolest temperatures (<40 ºF) were in the high altitudes in central **Colorado** and northwestern **Wyoming**. The warmest temperatures (55–60 ºF) occurred in the lower elevations in southeastern **Colorado** and southern **Utah**. Average temperatures were most variable across **Utah**, where anomalies ranged from <-3ºF in the west, to >5ºF in a central pocket southeast of Salt Lake City (Figure 2b). Temperatures across most of **Colorado** were close to average, however, small regions experienced negative anomalies (-2ºF), and areas in central **Colorado** were slightly warmer than average (>2ºF). October temperatures were generally below average across **Wyoming** and significant departures from average (<-2ºF) were recorded in both the central and eastern regions of the state.

The majority of record-breaking maximum and minimum temperatures in October were recorded in **Utah**, according to the NWS Salt Lake City, which is consistent with the temperature anomaly pattern (Figure 2b). The month began with warm temperatures across the Intermountain West, with record high maximum and minimum temperatures recorded in **Utah** on October 2 and 3, respectively. Average temperatures then declined, with lowest average temperatures occurring mid-month throughout the region. Record low maximum and low minimum temperatures were recorded from October 12–14 at locations throughout **Utah** and into southwest **Wyoming** (Lander) and western **Colorado** (Grand Junction). Cooler temperatures persisted in southwestern **Colorad**o, where record low temperatures were recorded in Grand Junction and Alamosa on October 23. The last days of the month saw warming across the Intermountain West, with record high maximum and high minimum temperatures across northern **Utah**. For example, temperatures in Zion National Park reached a high of 90ºF, breaking a record of 87ºF set in 1926 for October 26th.

Compared with the pattern of average temperatures from October 2007 (Figure 2c), the data for 2008 (Figure 2b) are more variable across the Intermountain West. Last year, a consistent gradient was evident across the region. Temperatures ranged between approximately 6°F greater than average in western **Colorado** and **Wyoming**, trending toward about 2ºF below average in Western **Utah**. For 2008, the range of anomalies is larger (<-3ºF to >6ºF) and is more spatially variable.

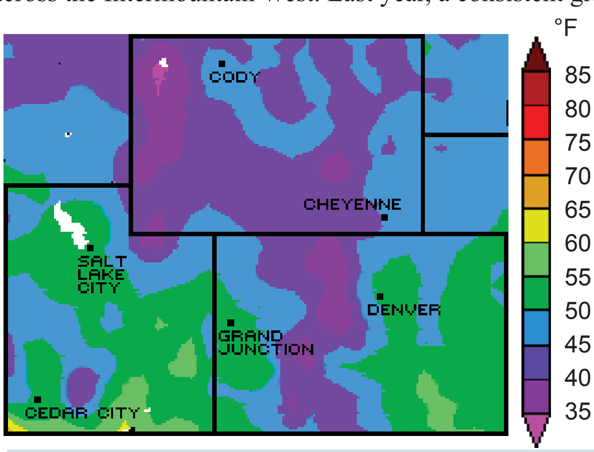


Figure 2a. Average temperature for the month of October 2008 in °F.

Notes

Figures 2a–c are experimental products from the High Plains Regional Climate Center. These data are considered experimental because they utilize the most recent data available, which have been subject to minimal quality control. These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known points to produce continuous categories. Interpolation procedures can cause incorrect values in data-sparse regions. For maps with individual station data, please see web sites listed below. *Average* refers to the arithmetic mean of annual data from 1971–2000. Departure from average temperature is calculated by subtracting current data from the average. The result can be positive or negative.

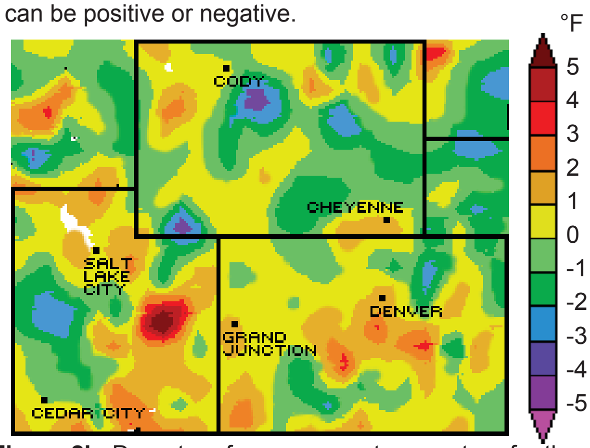


Figure 2b. Departure from average temperature for the month of October 2008 in °F.

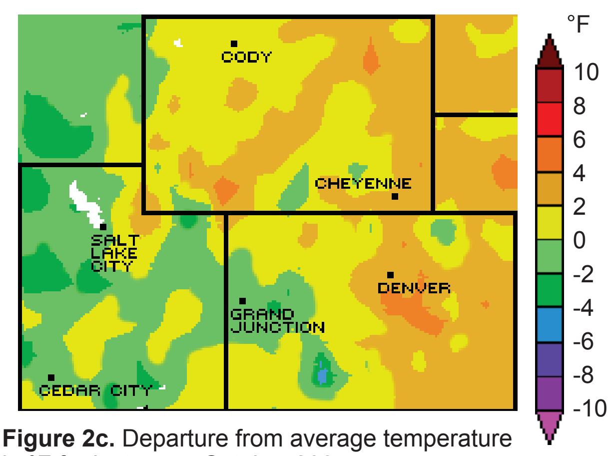


Figure 2c. Departure from average temperature in °F for last year, October 2007.

On the Web

- For maps like Figures 2a–c and maps of other climate variables including individual station data, visit: http://www.hprcc.unl.edu/maps/current/.
- For information on temperature and precipitation trends, visit: http://www.cpc.ncep.noaa.gov/trndtext.htm.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/summary.
- For current discussions about the El Niño Southern Oscillation (ENSO), visit: http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/.
- For current Southwest Forecast discussions, visit: http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html.

Precipitation 10/01/08 – 10/31/08

Precipitation totals ranged between 0 and 3+ inches across the Intermountain West in October 2008 (Figure 3a). The largest totals were in the eastern half of **Colorado**, which received over 3 inches. Throughout southeast **Colorado**, totals exceeded 1 inch. Moving eastward across **Colorado** and into eastern **Utah**, precipitation totals declined to between 0.5 and 1 inches. **Utah** had significant variability in precipitation accumulation, with totals exceeding 1 inch in the northern and central regions of the state. With few exceptions, precipitation amounts between 1 and 3 inches were recorded throughout the western half of **Wyoming**; the eastern portion of the state saw slightly less precipitation (0.5–2 inches).

Record rainfall accumulations were recorded at several locations in and near Salt Lake City and at Capitol Reef National Park, **Utah** on October 5, according to NWS Salt Lake City. No record precipitation events occurred the rest of the month in Utah. The pattern of below average precipitation stretched northeast from **Utah** across the Intermountain West, extending into eastern **Colorado** and tapering off to slightly below (60–80%) to average and above average (80–120%) conditions through **Wyoming**. Of significance are the precipitation totals recorded in western **Colorado**, where accumulations were in excess of 120% of average. This is reflected by changes in the drought severity in the region (see the Drought Monitor on page 8).

See Page 9 for a recap of the 2008 Water Year.

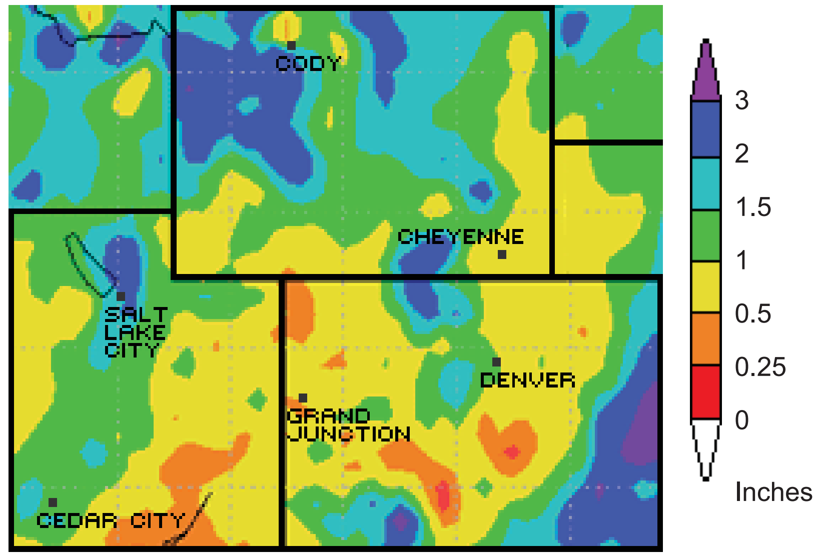


Figure 3a. Total precipitation in inches for the month of October 2008.

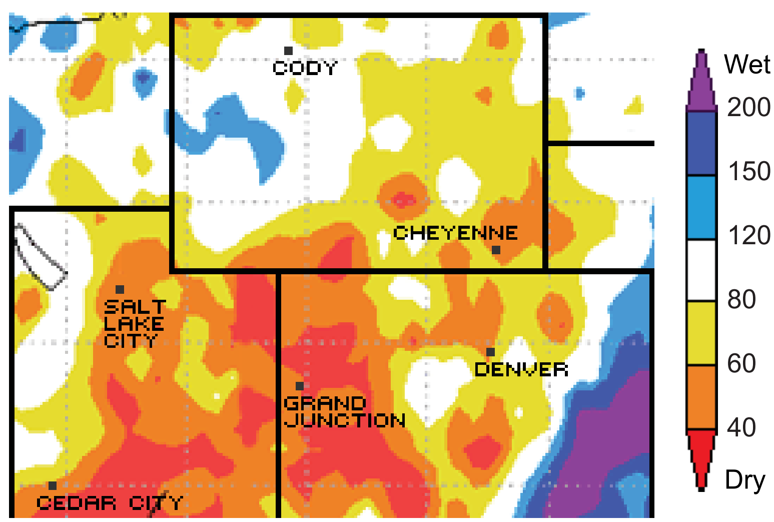


Figure 3b. Percent of average precipitation for the month of October 2008.

Notes

The data in Figs. 3 a-b come from NOAA's Climate Prediction Center. The maps are created and updated daily by NOAA's Earth System Research Laboratory (see website below). These maps are derived by taking measurements at individual meteorological stations and interpolating (estimating) values between known data points to produce continuous categories. Average refers to the arithmetic mean of annual data from 1996–2006. This period of record is only eleven years long because it includes SNOTEL data, which was included in this dataset beginning in 1996. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

On the Web

- For precipitation maps like Figures 3a–b, which are updated daily visit: http://www.cdc.noaa.gov/Drought/.
- For other precipitation maps including individual station data, visit: http://www.hprcc.unl.edu/maps/current/.
- For National Climatic Data Center monthly and weekly precipitation and drought reports for Colorado, Utah, Wyoming, and the whole U. S., visit: http://lwf.ncdc.noaa.gov/oa/climate/research/monitoring.html.
- For a list of weather stations in Colorado, Utah, and Wyoming, visit: http://www.wrcc.dri.edu/index.html.

Regional Standardized Precipitation Index data through 10/31/08

The Standardized Precipitation Index (SPI) is used to monitor moisture supply conditions. The distinguishing traits of this index are that it identifies emerging droughts months sooner than the Palmer Index and that it is computed on various time scales. Three- and 6-month SPIs are useful in short-term agricultural applications. Longer-term SPIs (12 months and longer) are useful in hydrological applications. Although the 3-month SPI shows conditions ranging from very dry (-1.99 to -1.25) to extremely wet (+2.00 to +2.99) throughout the Intermountain West (Figure 4a), the 36-month record indicates conditions at or drier than average (Figure 4b).

The above average October precipitation in eastern **Colorado** contributed to a change to wetter categories in the 3-month SPI (Aug–Oct; Figure 4a) relative to conditions shown in the September IWCS (Jun–Aug). In particular, the far eastern climate division in **Colorado** is in the extremely wet category (+2.00 to +2.99). The opposite situation applies to western half of the state, where below average precipitation put that region in the very dry category (-1.99 to -1.25). Conditions in **Utah** show drying throughout the state in the 3-month SPI compared with the June–August period. The far eastern and western climate divisions in **Utah** are in the very dry category (-1.99 to -1.25) and the central area was categorized as moderately dry (-1.24 to -0.75). For the northeastern corner of **Utah** extending into southern and eastern **Wyoming**, conditions are in the near average category (-0.74 to +0.74). Compared with the June–August period, the whole of Wyoming became wetter, with the exception of the far northwest corner, where conditions changed from the near average to moderately dry category (-1.24 to -0.75).

Despite significant rainfall in western **Colorado** and throughout **Wyoming** in the last several months, the 36-month SPI shows average to very dry conditions in the states' climate regions (Figure 4b). Wyoming underwent a dramatic change in the 36-month SPI compared with the same data from the 9/1/05–8/30/08 period (shown in the September IWCS). The trend toward drier conditions is likely a consequence of relatively persistent high average temperatures in the past several months. Throughout Colorado and eastern **Utah** conditions remain in the near average categories. Far western **Utah** and a large area across southwestern **Wyoming** are the driest in the Intermountain West, where conditions remain in the very dry category (-1.99 to -1.25).

Notes

The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by the NOAA National Climatic Data Center (NCDC) for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought. The Colorado Climate Center describes the SPI as valuable in monitoring both wet and dry periods, and it can be applied to other types of data (e.g. streamflow, reservoir levels, etc.). Near normal SPI means that the total precipitation for the past 12 months is near the long-term average for one year. An index value of -1 indicates moderate drought severity and means that only 15% would be expected to be drier. An index value of -2 means severe drought with only 2.5% of years expected to be drier.

The 3-month SPI uses data for the last three months and represents short-term precipitation patterns (Figure 4a). The 36-month SPI (Figure 4b) compares precipitation patterns for 36 consecutive months with the same 36 consecutive months during all the previous years of available data. The SPI at these time scales reflect long-term precipitation patterns. Figures 4a and b come from the Western Regional Climate Center, which uses data from the NCDC and the NOAA Climate Prediction Center.

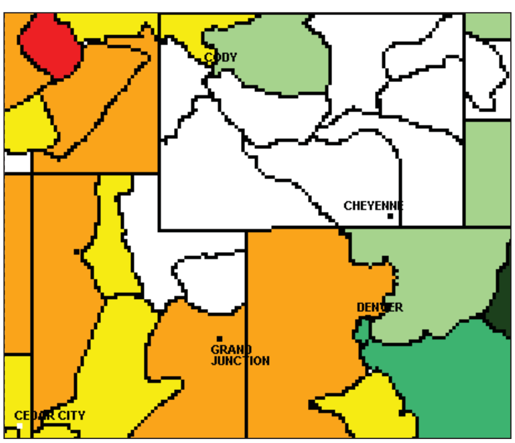


Figure 4a. 3-month Intermountain West regional Standardized Precipitation Index (data from 08/1/08–10/31/08).

+3.00 and above	Exceptionally Wet
+2.00 to +2.99	Extremely Wet
+1.25 to +1.99	Very Wet
+0.75 to +1.24	Moderately Wet
-0.74 to +0.74	Near Normal
-1.24 to -0.75	Moderately Dry
-1.99 to -1.25	Very Dry
-2.99 to -2.00	Extremely Dry
-3.00 and below	Exceptionally Dry

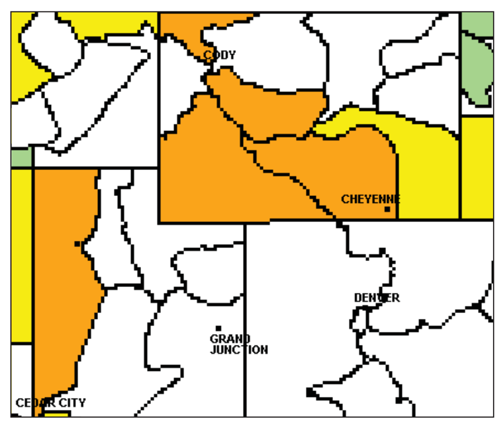


Figure 4b. 36-month Intermountain West regional Standardized Precipitation Index (data from 11/01/05–10/31/08).

On the Web

- For information on the SPI, how it is calculated, and other similar products for the entire country, visit: http://www.wrcc.dri.edu/spi/spi.html.
- For information on past precipitation trends, visit: http://www.hprcc.unl.edu/products/current.html.
- For SPI products directly form the NCDC, visit: http://lwf.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html. These maps use the same data as Figures 4a and b, but the categories are defined slightly differently.

U.S. Drought Monitor conditions as of 11/18/08

The U.S. Drought Monitor shows that the pattern of drought severity in the IMW has changed in parts of the region since the last Intermountain West Climate Summary in September (Figure 5; see inset). While drought intensity decreased in southeastern **Colorado** and southwestern **Wyoming**, it increased in the Four Corners region including southwestern **Colorado** and southeastern **Utah**.

By late September, the precipitation deficits and other indicators in southwestern **Wyoming** no longer supported a drought designation of severe (D2), so the Drought Monitor decreased the drought classification to moderate (D1). In mid-October, moderate to heavy precipitation fell on parts of the southern Plains, including much of eastern **Colorado**. As a result, the area classified as severe drought (D2) intensity near the Oklahoma/Kansas/ **Colorado** borders was reduced to moderate (D1). Finally, in mid-November short-term dryness intensified in the Four Corners region. Consequently, parts of southeastern **Utah**, southwestern **Colorado**, northwestern New Mexico, and northeastern Arizona were classified as abnormally dry (D0).

Utah is the only state in the IMW region that has any reported drought impacts on the Drought Impact Reporter (see On the Web box). As of October 1, Donkey Reservoir SNOTEL site in south-central **Utah** is 76% of normal. This site has recorded below normal precipitation since Oct. 2007. This has the potential to affect agriculture in Wayne County, **Utah** according to the Drought Impact Reporter. On November 3, the governor of **Utah** declared six counties to be agricultural disaster areas and is seeking a federal disaster declaration for the counties because they have lost a third or more of their crops (valued at $28.7 million). The six counties are: Box Elder in northwestern **Utah**, Millard and Sanpete in central **Utah,** and Garfield, Kane, and Piute in south-central **Utah**.

Notes

The U. S. Drought Monitor (Figure 5) is released weekly (every Thursday) and represents data collected through the previous Tuesday. The inset (lower left) shows the western United States from the previous summary's map.

The U. S. Drought Monitor and drought monitor discussion maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies.

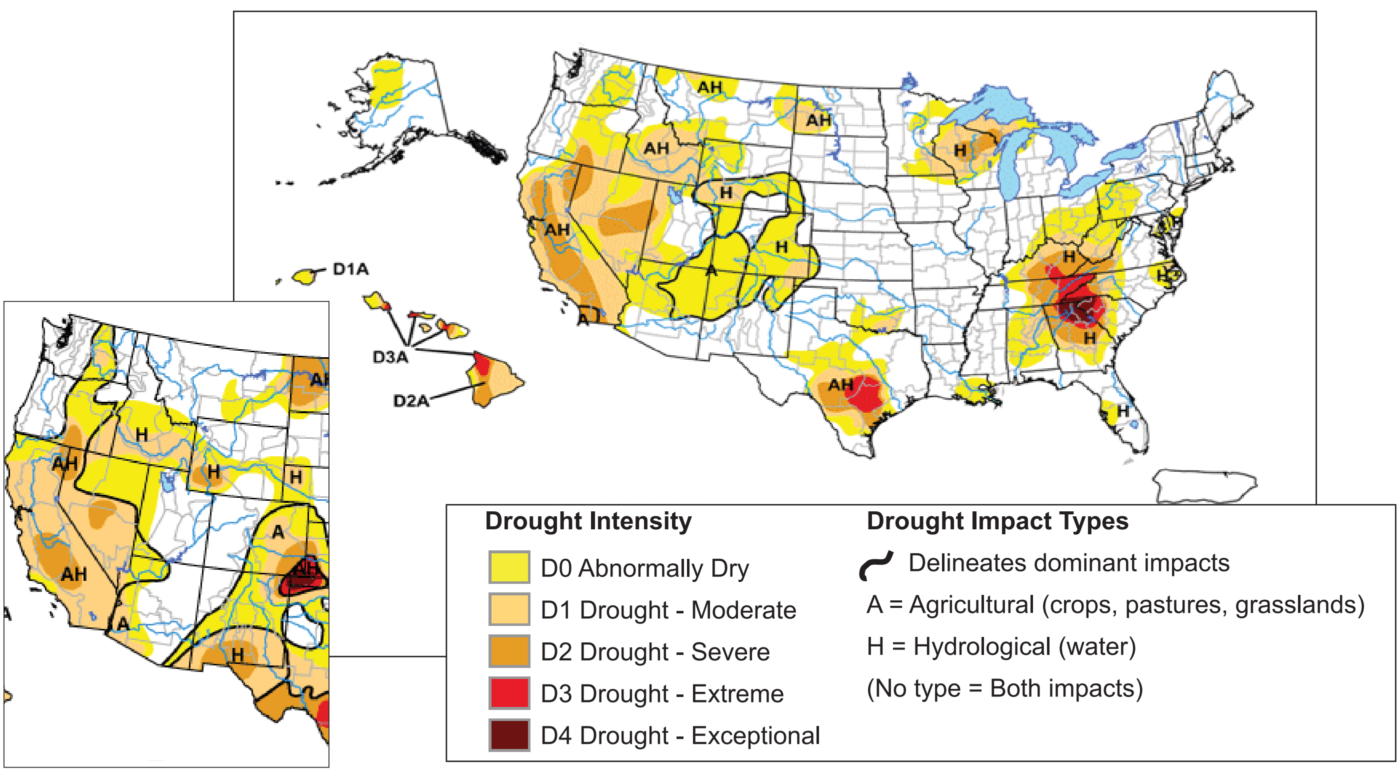


Figure 5. Drought Monitor from November 18, 2008 (full size) and September 16, 2008 (inset, lower left) for comparison.

On the Web

- For the most recent Drought Monitor, released every Thursday, visit: http://www.drought.unl.edu/dm/monitor/html. This site also includes archives of past drought monitors.
- Drought Impact Reporter (National Drought Mitigation Center): http://droughtreporter.unl.edu/.
- NIDIS Drought Portal: http://www.drought.gov.

2008 Water Year in Review

During the 2008 water year (WY2008), from October 1, 2007 through September 30, 2008, widespread drought was mitigated in the western U.S., including most of **Utah**, and drought conditions continued in the Mid-West and High Plains, including eastern **Colorado**. In this page, we take you through WY2008 focusing on how drought status changed and evolved in the Intermountain West (IMW) based on precipitation throughout the year.

At the beginning of WY2008, the Drought Monitor indicated drought across all of **Utah** most of **Wyoming**, and the northeast corner of **Colorado** (Figure 6a). Drought status ranged from the lowest intensity (D0-abnormally dry) in northeastern **Colorado** and south-central **Wyoming** to the highest intensity (D2-severe with pockets of D3-extreme) in western **Utah** and western **Wyoming**. Storms in late November in the western U.S. helped decrease the pockets of D3 drought in western **Wyoming** to D2, but below average precipitation on the Plains brought eastern **Colorado** into D0 drought by mid December.

December, January, and February brought above average precipitation to most of **Utah**, western **Colorado**, and southern **Wyoming**. However, eastern **Colorado** continued to have below average precipitation. By the beginning of March, southern **Utah** was no longer classified in drought. These precipitation systems did not bring sufficient precipitation to eastern **Colorado**, a trend that continued through March and April because of below average

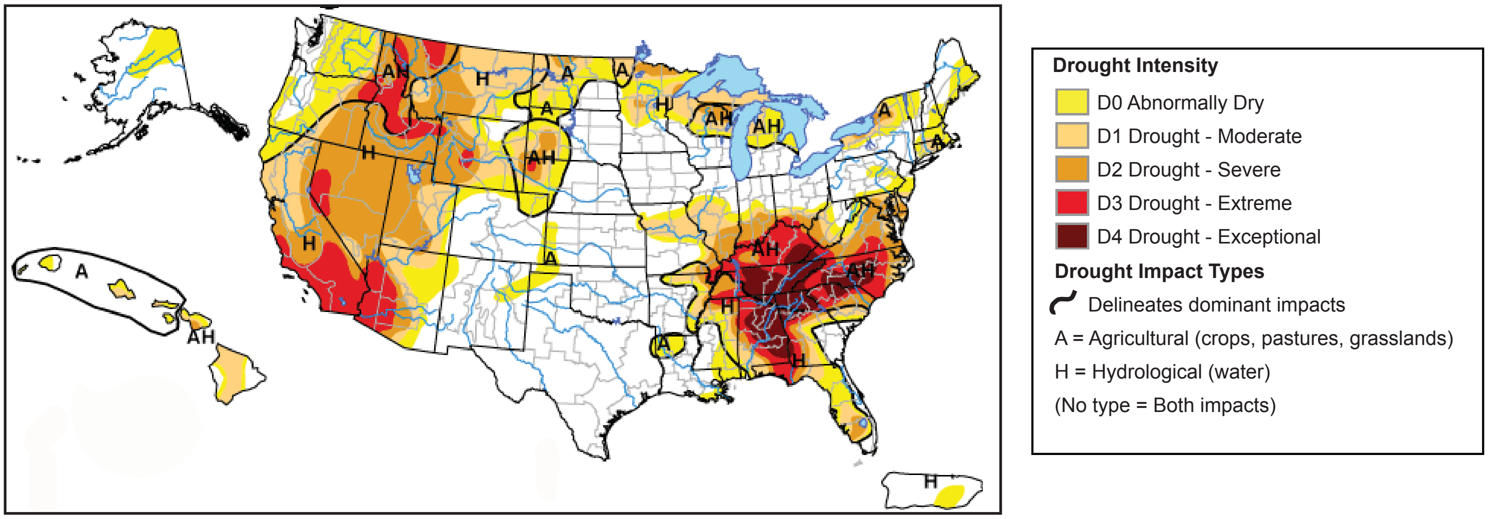


Figure 6a: Drought Monitor from October 2, 2007, the start of the 2008 water year. This shows drought across all of Utah most of Wyoming, and the northeast corner of Colorado.

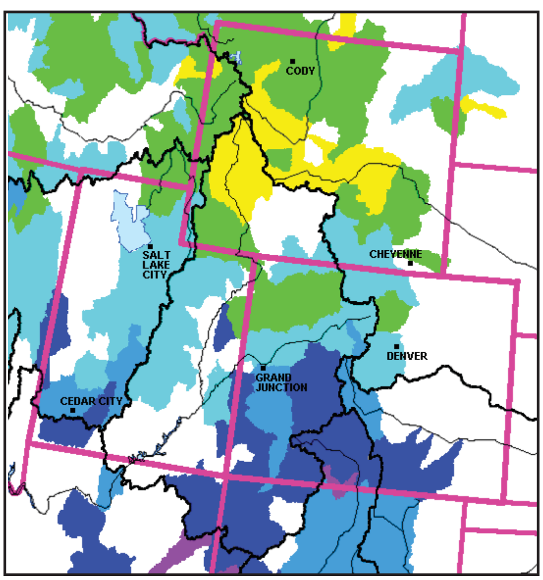


Figure 6b: Intermountain West snowpack as of March 1, 2008 showing that most of the region has near to above average snowpack, with the exception of central Wyoming that has basins at 70–89% of average.

Reservoir	Current Storage (KAF)	Total Capacity (KAF)	% Full	% of Average
Colorado				
Dillon Reservoir	257.7	254.0	101%	103%
Turquiose Lake	99.9	129.4	77%	85%
Lake Granby	444.7	539.7	82%	106%
Blue Mesa Res.	725.9	829.5	88%	104%
Pueblo	232.4	354.0	66%	145%
Utah				
Strawberry Res.	966.7	1,106.5	87%	136%
Utah Lake	815	870.9	94%	93%
Bear Lake	407.4	1302.0	31%	42%
Lake Powell	15150.5	24322.0	62%	76%
Wyoming				
Fontenelle Res.	337.4	344.8	98%	125%
Flaming Gorge Res.	3028.9	3749.0	81%	94%
Seminoe Res.	661.0	1017.2	65%	95%
Boysen Res.	662.6	741.6	89%	108%
Buffalo Bill Res.	616.0	644.1	96%	127%

KAF = Thousands of Acre Feet

Figure 6c: Status of several large reservoirs in the Intermountain West as of July 1, 2008. The storage in eleven out of fourteen are 90% of average or more.

precipitation across the whole IMW region. However, the above average precipitation throughout most of the region in the early winter led to near to above average snowpack by March 1 (Figure 6b), which carried through to April 1, despite below average precipitation in April in **Utah** and **Colorado**. This snowpack led to above average streamflows through out the spring, and to near or above average reservoir levels by July (Figure 6c).

Several changes in drought intensity occurred between April and June; these were reflected in the Drought Monitor in June (Figure 6d). In April, the Drought Monitor team used the latest snowpack and streamflow reports to downgrade drought status in northern **Utah** from D1 to no drought. In May, while below average precipitation continued in most of the IMW region, northern **Wyoming** received above average precipitation. This contributed to a decrease in drought intensity from D0 to no drought in northwestern **Wyoming**. Finally, below average precipitation continued in eastern **Colorado**, and by June the drought intensity ranged from D3 to D0. Some relief came to the area in mid-August when above average precipitation fell on the Plains and drought status in the southeast corner of **Colorado** was downgraded from D3 to D2. Nevertheless, all of eastern **Colorado** remained in drought.

As of September 30, the last day of WY2008, eastern **Colorado**, western and central **Wyoming**, and a small part of eastern **Utah** are in drought status in the Drought Monitor, but for the most part the drought intensity is lower than it was at the start of WY2008 (Figure 6e). However, while drought intensity decreased in **Utah** and **Wyoming**, it increased in eastern **Colorado**, where the agricultural sector suffered large economic losses due to the intense drought throughout the summer months.

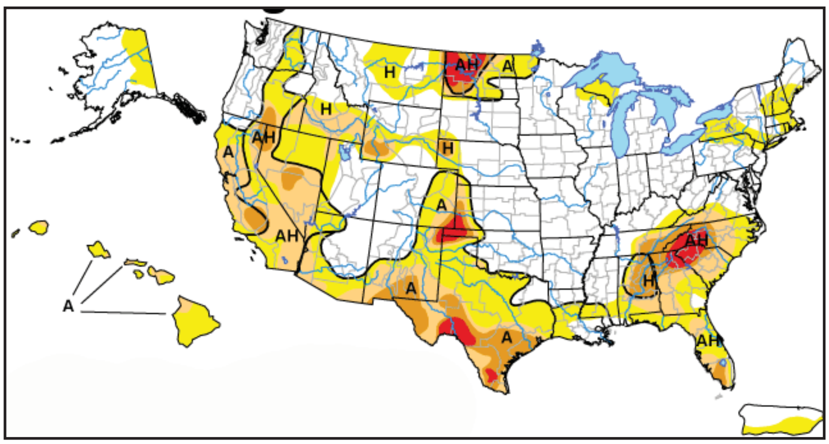


Figure 6d: Drought Monitor from June 10, 2008 showing how drought intensity decreased in Utah and Wyoming, but increased in Eastern Colorado since the start of the water year in October 2007.

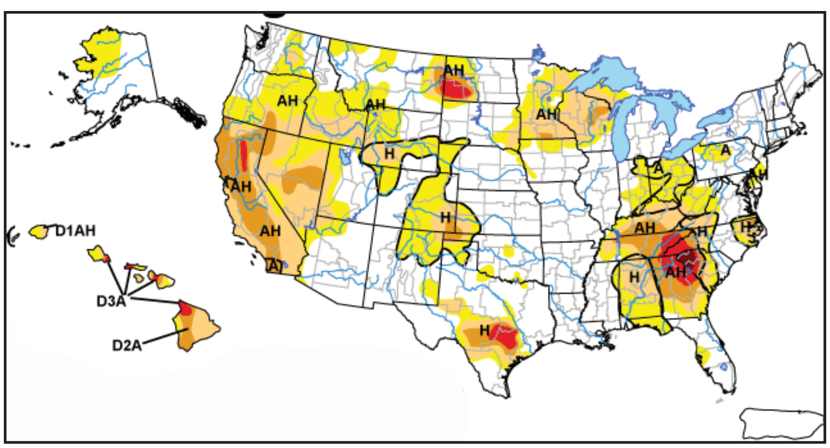


Figure 6e: Drought Monitor from September 30, 2008, the last day of the 2008 water year. Precipitation during the year mitigated widespread drought in the western U.S., including most of Utah, and prolonged the drought in the Mid-West and High Plains, including eastern Colorado.

On the Web

- For the most recent Drought Monitor and Drought Monitor Discussion (Figures 6a,d,e), released every Thursday, visit: http://www.drought.unl.edu/dm/monitor/html. This site also includes archives of past drought monitors.
- For snowpack maps from the Natural Resources Conservation Service visit (Figure 6b): http://www.wcc.nrcs.usda.gov/snowcourse/snomap.html.
- Individual reservoir information including management agency, operations, and storage content (Figure 6c), visit the WWA website at: http://wwa.colorado.edu/products/forecasts_and_outlooks/intermountain_west_climate_summary/links.html, and click on individual links.

Colorado Water Availability

The current water supply status is shaped by winter snowpack, reservoir storage, temperature, and precipitation as we move into the main snow accumulation season. As of November 3, SWE values were below average across most of Colorado (<75% of average; Figure 7). Only three SNOTEL locations along the Continental Divide reported above average conditions (100 – 200% of average). However, it is still very early in the snow accumulation season and a few inches of additional snow can make a big difference in the percent of average. Colorado should expect dry conditions early in the winter (at least through the end of December) due to lingering effects of the La Niña event earlier in the year, according to Klaus Wolter's Colorado (and Interior Southwest) Forecast Discussion (http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html).

Reservoir storage across the state is near or above average. Denver Water is reporting system reservoir storage at 87% capacity. According to the USBR Draft Annual Operating Plan for the Colorado River Reservoirs, Blue Mesa is expected to fill in 2009 under the most probable inflow scenarios (50% exceedence). These inflow scenarios were developed by the NWS Colorado River Basin Forecast Center, using the Ensemble Streamflow Prediction (ESP) Model. At this time of year, the ESP model accounts for antecedent streamflows and current soil moisture levels with the Sacramento Soil Moisture Accounting Model, which uses continuous soil moisture accounting.

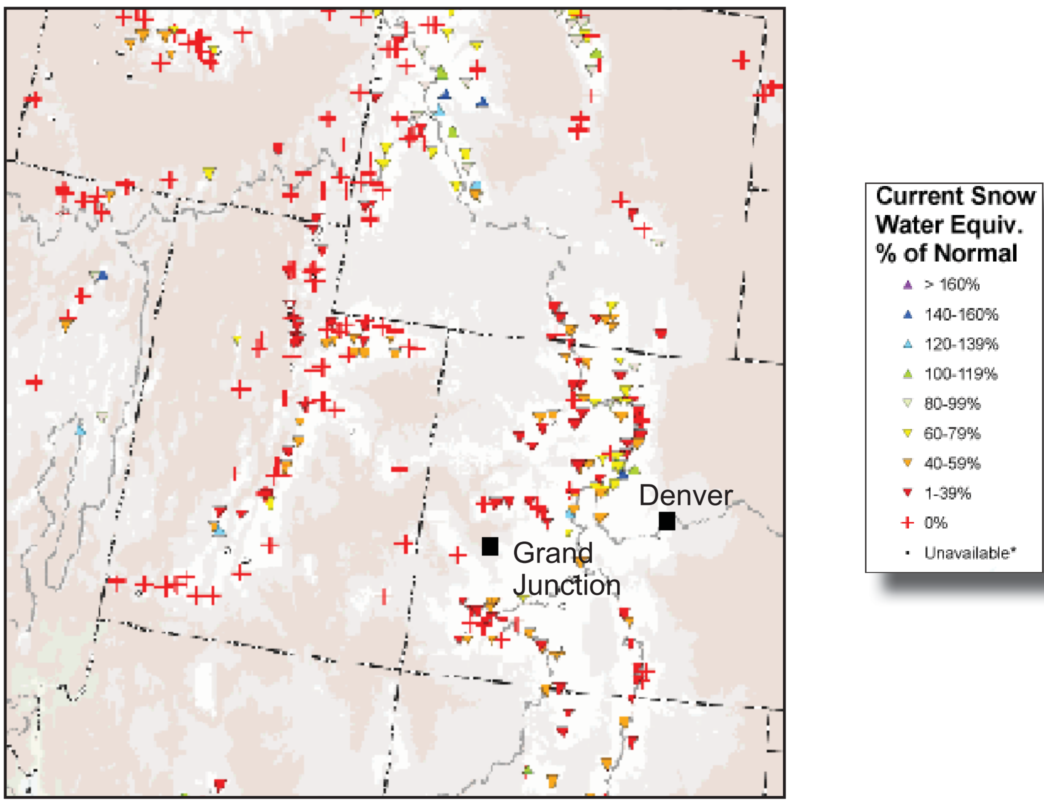


Figure 7. Current snow water equivalent (SWE) as a percent of average for SNOTEL sites in Colorado as of November 3, 2008, (NRCS).

On the Web

- For current maps of SWE as a percent of average as shown in Figure 7 visit: http://www.wcc.nrcs.usda.gov/gis/snow.html
- For current streamflow information from USGS visit: http://water.usgs.gov/waterwatch/.
- For current soil moisture calculations from the Univ of Washington visit: http://www.hydro.washington.edu/forecast/monitor/.
  -For current soil moisture estimates, select "VIC~CPC" in the "Current Conditions" under "Soil Moisture".
  -For changes in soil moisture, select either 1 wk (shown on this page), 2 wk or 1 mo in the "Recent Changes" row, "Soil Moisture" column
- The Colorado SWSI along with more data about current water supply conditions for the state can be found at: http://www.co.nrcs.usda.gov/snow/fcst/watershed/current/monthly/maps_graphs/index.html.
- The Colorado Water Availability Task Force information, including agenda & minutes of meetings is available at: http://cwcb.state.co.us/Conservation/DroughtPlanning/WaterAvailabilityTaskForce/MeetingAgendasPresentations
- The Asipinall status summary is updated at the first of each month and is available at http://www.usbr.gov/uc/.

Wyoming Water Availability

The current water supply status is shaped by winter snowpack, reservoir storage, temperature, and precipitation as we move into the main snow accumulation season. As of November 3, SWE values were below average across most of the state (<75% of average), with several locations along the Continental Divide reporting above average conditions (100 – 200% of average; Figure 8). However, it is still very early in the snow accumulation season and a few inches of additional snow can make a big difference in the percent of average.

According to the Wyoming Association of Rural Water Systems, heavy snowfall in the 2008 water year allowed for above average inflows into the Alcova, Glendo, Seminoe, and Pathfinder Reservoirs in the North Platte Basin. However, drought during the previous eight years means that the reservoirs are still not full. The North Platte Basin captured 84% of average storage for the 2008 water year, but still is only at 43% capacity.

The Fontenelle Reservoir filled in 2008 and bypass releases, which are common for Fontenelle, were necessary in order to safely route spring runoff, according to the USBR Draft Annual Operating Plan for the Colorado River Reservoirs. A similar situation is expected this year with the most probable April - July inflow projection for the Fontenelle being 766,000 af or 89% of average. Due to this high projection, it is very likely that the Fontenelle Reservoir will fill during the 2009 water year and storage will be lowered by April 1 to anticipate spring inflows. These inflow scenarios were developed by the NWS Colorado River Basin Forecast Center, using the Ensemble Streamflow Prediction (ESP) Model. At this time of year, the ESP model accounts for antecedent streamflows and current soil moisture levels with the Sacramento Soil Moisture Accounting Model, which uses continuous soil moisture accounting.

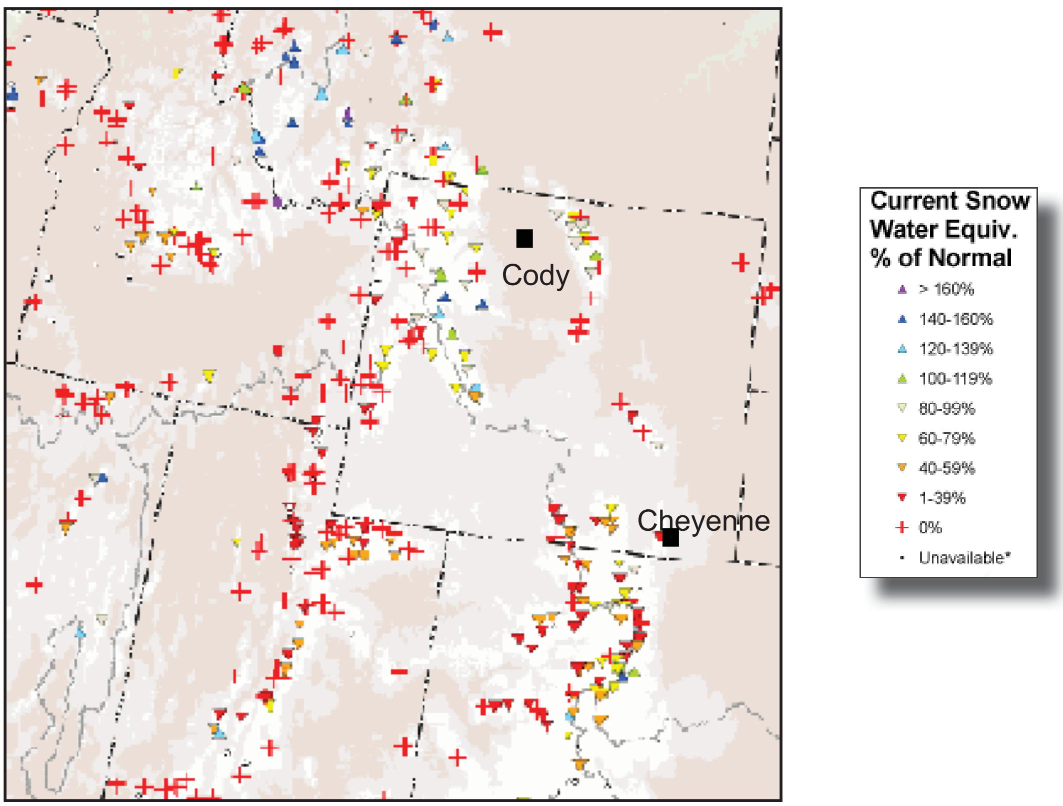


Figure 8. Current snow water equivalent (SWE) as a percent of average for SNOTEL sites in Wyoming as of November 3, 2008, (NRCS).

On the Web

- For current maps of SWE as a percent of average as shown in Figure 8 visit: http://www.wcc.nrcs.usda.gov/gis/snow.html
- For current streamflow information from USGS visit: http://water.usgs.gov/waterwatch/.
- For current soil moisture calculations from the Univ of Washington visit: http://www.hydro.washington.edu/forecast /monitor/.
  - -For current soil moisture estimates, select "VIC~CPC" in the "Current Conditions" under "Soil Moisture".
  - -For changes in soil moisture, select either 1 wk (shown on this page), 2 wk or 1 mo in the "Recent Changes" row, "Soil Moisture" column.
- The Flaming Gorge and Fontenelle status summary are updated at the first of each month and are available at http://www.usbr.gov/uc/.
- Wyoming Water Resource Data system's drought page is located at: http://www.wrds.uwyo.edu/wrds/wsc/dtf/drought.html

Utah Water Availability

The current water supply status is shaped by winter snowpack, reservoir storage, temperature, and precipitation as we move into the main snow accumulation season. As of November 3, SWE values were below average (<75% of average) across the entire state, with one exception in southwest Utah that was near average (100–124% of average; Figure 9). A majority of the SNOTEL stations reported conditions of 0–24% of average. However, it is still very early in the snow accumulation season and a few inches of additional snow can make a big difference in the percent of average. Utah should expect dry conditions early in the winter (at least through the end of December) due to lingering effects of the La Niña event we had earlier in the year, according to Klaus Wolter's Colorado (and Interior Southwest) Forecast Discussion, (http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/index.html)

Reservoir storage in Lake Powell increased significantly during the 2008 water year, according to the USBR Draft Annual Operating Plan for the Colorado River Reservoirs. At the start of the 2008 water year, Lake Powell was at 49% of capacity and by the end of the 2008 water year, it was at 60% of capacity. Inflows during the 2008 water year were 102% of average. Under the most probable scenarios for the 2009 water year, the Equalization Tier of the Interim Guidelines will govern release and the storage volume of Lake Powell will increase to 62% of capacity by the end of the 2009 water year. These inflow scenarios were developed by the NWS Colorado River Basin Forecast Center, using the Ensemble Streamflow Prediction (ESP) Model. At this time of year, the ESP model accounts for antecedent streamflows and current soil moisture levels with the Sacramento Soil Moisture Accounting Model, which uses continuous soil moisture accounting.

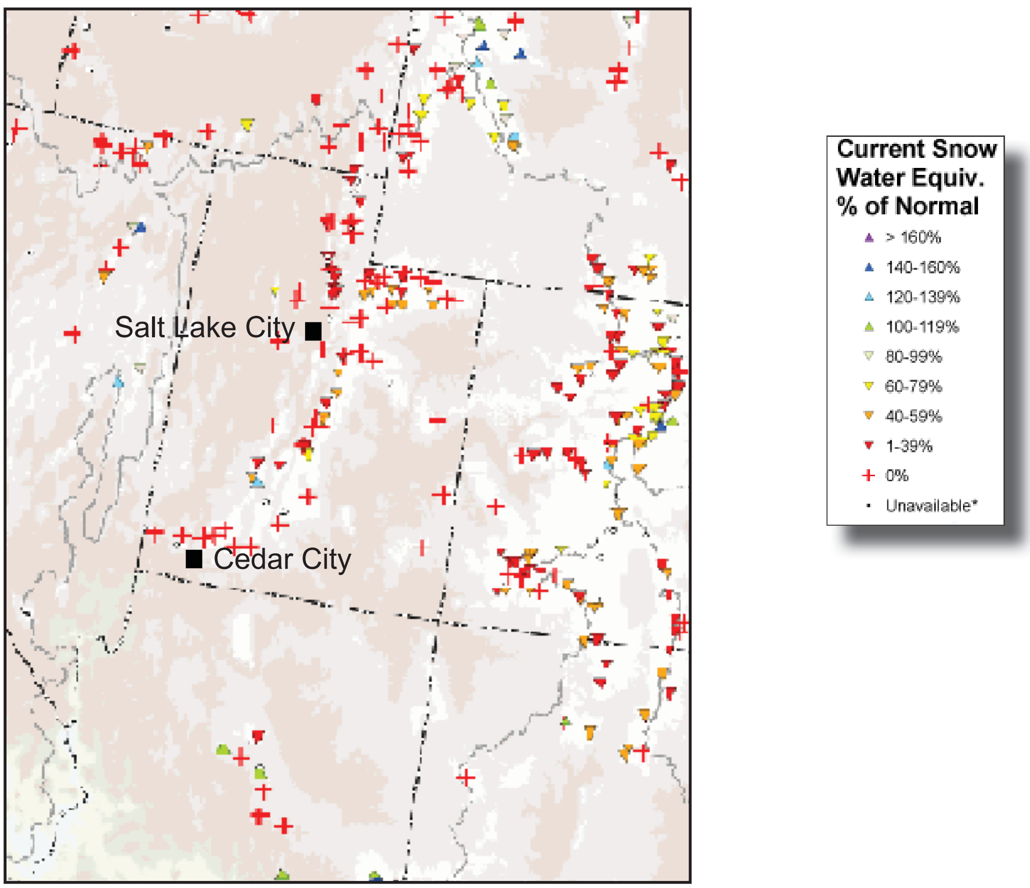


Figure 9. Current snow water equivalent (SWE) as a percent of average for SNOTEL sites in Utah as of November 3, 2008, (NRCS).

On the Web

- For current maps of SWE as a percent of average as shown in Figure 9 visit: http://www.wcc.nrcs.usda.gov/gis/snow.html
- For current streamflow information from USGS visit: http://water.usgs.gov/waterwatch/.
- For current soil moisture calculations from the Univ of Washington visit: http://www.hydro.washington.edu/forecast/monitor/.
  -For current soil moisture estimates, select "VIC~CPC" in the "Current Conditions" under "Soil Moisture".
  -For changes in soil moisture, select either 1 wk (shown on this page), 2 wk or 1 mo in the "Recent Changes" row, "Soil Moisture" column
- The Lake Powell Status Summary is updated at the first of each month and is available at http://www.usbr.gov/uc/.

Temperature Outlook December 2008 – April 2009

The latest temperature outlooks for December 2008 from the NOAA Climate Prediction Center indicate a slightly enhanced risk of above average temperatures in much of **Colorado**, southeastern **Wyoming** and much of the Great Plains, and equal chances for above-, near-, or below-average temperatures for the rest of the Intermountain West (Figure 10a). This forecast is largely based on temperature trends in the Western U.S. In the December-February (DJF) and seasons throughout the spring (not all shown) all or parts of the Intermountain West have an increased chance of above average temperatures (Figures 10b and d). However, in January–March 2009 (JFM) season, the forecast is for Equal Chances (EC) in the entire Intermountain West (Figure 10c), The enhanced likelihood of above average temperatures during the upcoming seasons are largely due to recent temperature trends.

According to CPC, with the absence of La Niña and El Niño in the equatorial Pacific Ocean this season, predicting weather patterns on seasonal timescales becomes increasingly challenging. Instead, other climate patterns over the Arctic and North Atlantic regions may play a significant role in influencing U.S. winter weather. "These patterns are only predictable a week or two in advance and could persist for weeks at a time," said Michael Halpert, deputy director, Climate Prediction Center. "Therefore, we expect variability, or substantial changes in temperature and precipitation across much of the country."

The December 2008 precipitation forecast will be updated on November 30th on the CPC web page. Because of the shorter lead-time, the "zero-lead" forecast (i.e. on the last day of the previous month) often has increased skill over the half-month lead forecasts shown here. The Seasonal Temperature Outlooks are updated on the third Thursday of the month, and the next one will be issued on December 18th.

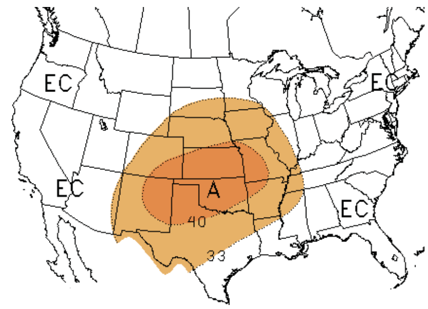


Figure 10a. Long-lead national temperature forecast for December 2008 (released Nov. 20, 2008).

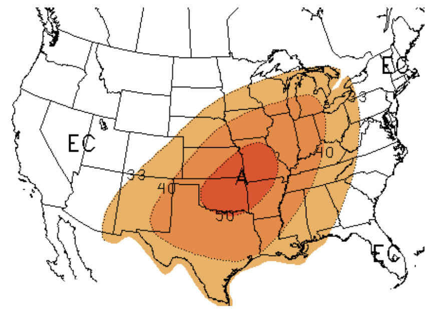


Figure 10b. Long-lead national temperature forecast for December 2008- January 2009 (released Nov. 20, 2008).

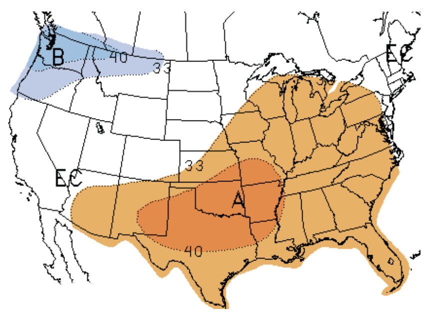


Figure 10c. Long-lead national temperature forecast for January-March 2009 (released Nov. 20, 2008).

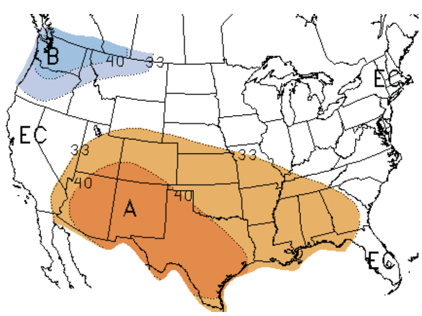


Figure 10d. Long-lead national temperature forecast for February April 2009 (released Nov. 20, 2008).

A = Above
- 60.0–69.9%
- 50.0–59.9%
- 40.0–49.9%
- 33.3–39.9%

B = Below
- 40.0–49.9%
- 33.3–39.9%

EC = Equal Chances

Notes

The CPC seasonal temperature outlooks predict the likelihood (percent chance) of temperatures occurring in the above-average, near-average, and below-average categories. The numbers on the maps do not refer to actual temperature values, but to the probability, in percent, that temperatures will be in one of these three categories. The skill of the temperature outlooks largely comes from the status of ENSO and recent trends. The categories are defined based on the 1971–2000 climate record; each 1- or 3-month period is divided into 3 categories (terciles), indicating the probabilities that the temperature in the period will fall into the upper third of the years (upper tercile), the middle third of the years (middle tercile, or around average), or the lowest third of the years (lower tercile). The forecast map depicts the probability that temperature will be in the above-average (A, orange shading) or below-average (B, blue shading) tercile--with a corresponding decrease in the opposite category. The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high. Equal Chances (EC) represents equal chances or a 33.3% probability for each tercile, indicative of areas where signals are weak or conflicting and the reliability (i.e., 'skill') of the forecast is poor. For a more detailed description, see notes on the precipitation outlook page.

On the Web

- For more information and the most recent forecast images, visit: http://www.cpc.ncep.noaa.gov/products/predictions/90day/. Please note that this website has many graphics and may load slowly on your computer.
- The CPC "discussion for non-technical users" is at: http://www.cpc.noaa.gov/products/predictions/90day/fxus05.html.
- For IRI forecasts, visit: http://iri.columbia.edu/climate/forecast/net_asmt/.
- More information about temperature distributions at specific stations in Colorado, Utah, Wyoming, and across the West can be found at the Western Regional Climate Center, http://www.wrcc.dri.edu/CLIMATEDATA.html.

Precipitation Outlook December 2008 – April 2009

The CPC precipitation outlook for December 2008 (Figure 11a) indicates increased likelihood of above median precipitation for the northern Rockies, including much of **Wyoming**. For December 2008 -February 2009, eastern **Colorado** is included in an area of the central Great Plains with an increased risk of above average precipitation. For the remainder of the winter season, the outlooks show "EC" or equal chances for above-, near-, or below-average precipitation for the interior West. These anomalies are derived from the consolidation forecast (CON, see feature article in the June 2008 Summary). EC indicates that no skillful information on precipitation is available.

With the absence of La Niña and El Niño in the equatorial Pacific Ocean this season, predicting weather patterns on seasonal timescales becomes increasingly challenging. Instead, other climate patterns over the Arctic and North Atlantic regions may play a significant role in influencing U.S. winter weather. "These patterns are only predictable a week or two in advance and could persist for weeks at a time," said Michael Halpert, deputy director of CPC. "Therefore, we expect variability, or substantial changes in temperature and precipitation across much of the country."

The December 2008 precipitation forecast will be updated on November 30th on the CPC web page. Because of the shorter lead-time, the "zero-lead" forecast (i.e. on the last day of the previous month) often has increased skill over the half-month lead forecasts shown here. The Seasonal Outlooks are updated on the third Thursday of the month, and the next one will be issued on December 18th.

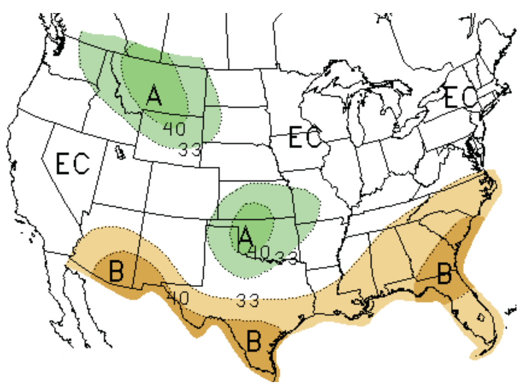


Figure 11a. Long-lead national precipitation forecast for December (released November 20, 2008).

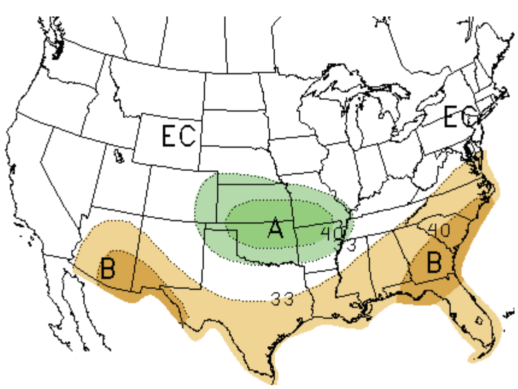


Figure 11b. Long-lead national precipitation forecast for December 2008 – February 2009 (released November 20, 2008).

Notes

The seasonal precipitation outlooks predict the likelihood (percent chance) of precipitation occurring in the above-average, near-average, and below-average categories. The numbers on the maps do not refer to actual precipitation values, but to the probability in percent that precipitation will be in one of these three categories. The categories are defined based on the 1971–2000 climate record; each 1- or 3-month period is divided into 3 categories (terciles), indicating the probabilities that the precipitation in the period will fall into the upper third of the years (upper tercile), the middle third of the years (middle tercile, or around average), or the lowest third of the years (lower tercile), each with a 33.3% chance of occurring. The middle tercile is considered the near-average (or normal) precipitation range. The forecast indicates the likelihood of the precipitation occurring in the below-average (B, brown shading) or above-average (A, green shading) --with a corresponding decrease in the opposite category, The near-average category is preserved at 33.3% likelihood, unless the anomaly forecast probability is very high.

Thus, areas with dark brown shading indicate a 40.0–50.0% chance of below-average, a 33.3% chance of near-average, and a 16.7–26.6% chance of above-average precipitation. Light brown shading displays a 33.3–39.9% chance of below-average, a 33.3% chance of near-average, and a 26.7–33.3% chance of above-average precipitation and so on. Equal Chances (EC) represents equal chances or a 33.3% probability for each tercile, indicative of areas where signals are weak or conflicting and the reliability (i.e., 'skill') of the forecast is poor. "N" indicates an increased chance of near-average conditions, but is not forecast very often.

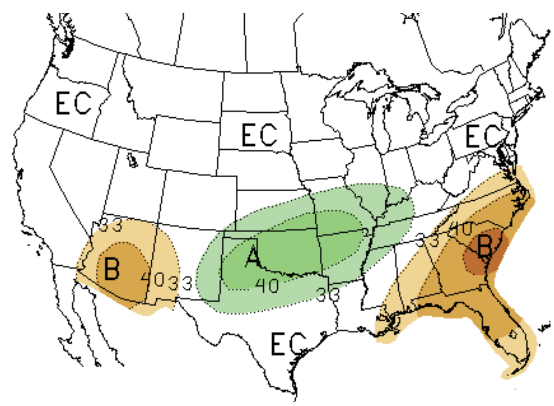
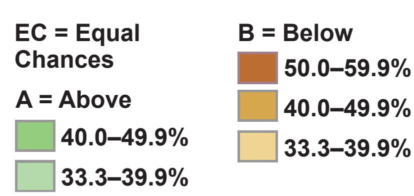


Figure 11c. Long-lead national precipitation forecast for January – March 2009 (Released November 20, 2008).



Seasonal Drought Outlook through February 2009

According to the U.S. Drought Monitor (page 8), hydrologic drought conditions have persisted since earlier in the summer across a swath of central **Wyoming**, most of **Colorado** east of the Continental Divide, and along the western border of **Utah**. Readers interested in the next 5 and 6-10 days can consult the "Looking Ahead" section of each week's DM for near-term drought outlook conditions. The U.S. Seasonal Drought Outlook (DO) builds on the DM categories to project how these drought areas might change or where new drought areas might develop. The DO issued November 20th, projects that drought is likely to persist in southwestern **Wyoming**, and projects some improvement in southeastern **Colorado** and western **Utah** over the next three months. These projections indicate at least a one-category change in drought status.

The DO provides the following basis for the area of some improvement in southeastern **Colorado**: "the official December-February outlook favors above-normal precipitation following a dry end to November." The confidence in this outlook for the High Plains is "High." For Great Basin part of **Utah**, some improvement is expected because this is a relatively wet and cold time of year, especially in the higher elevations where accumulating mountain snowpack provides hydrologic recharge. With an Equal Chances (EC) outlook in this area, climatology dictates a forecast for some improvement. Farther east, winter is one of the drier times of year in southwestern **Wyoming**, and again with an EC outlook favoring neither dryness or wetness for the next few months, climatological considerations imply persisting drought.

There are no new areas of drought development elsewhere in the Interior West indicated in this DO. The next Seasonal Drought Outlook will be issued in two weeks, on December 4th.

Notes

The Seasonal Drought Outlook (DO) depicts general, large-scale trends from that date through the end of the forecast period (3 to 3.5 months, depending on the date of issue). The delineated areas in the DO (Figure 12) are defined subjectively based on expert assessment of numerous indicators described above, including outputs of short- and long-term forecasting models. Areas of continuing drought are schematically approximated from the Drought Monitor (D1 to D4). For weekly drought updates, see the latest Drought Monitor text on the website (updated weekly) see: http://www.drought.unl.edu/dm/monitor.html. NOTE: The green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.

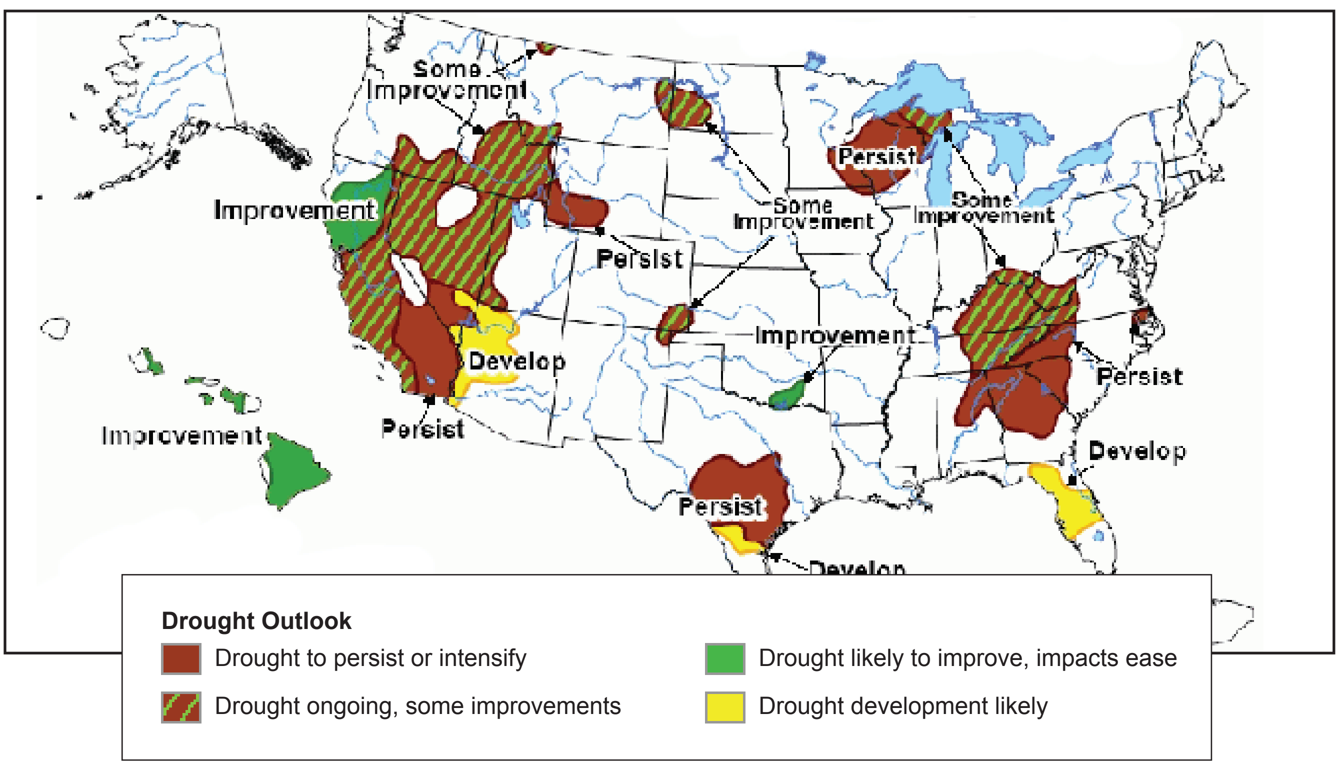


Figure 12. Seasonal Drought Outlook for November 20, 2008–February 2009.

On the Web

- For more drought information, visit: http://www.drought.noaa.gov/.
- Forecasts of drought termination probabilities can be found at: http://www.ncdc.noaa.gov/oa/climate/research/drought/current.html.

El Niño Status and Forecast

The equatorial Pacific has been in ENSO neutral conditions from June through early November 2008, following the 2007/8 La Nina event, according to NOAA and its partner the International Research Institute for Climate and Society (IRI). The atmospheric winds and convection patterns exhibited a high degree of week-to-week variability across the tropical Pacific during October in response to the Madden-Julian Oscillation (MJO, see the May 2008 IWCS Feature Article). However, overall, the ocean-atmosphere system remains consistent with ENSO-neutral conditions (Figure 13a).

The majority of SST prediction models predict Nino 3.4 SSTs to remain slightly below normal through early 2009, but to remain within 0.5°C of normal, indicating ENSO neutral conditions will continue. MJO activity is expected to remain weak so no significant predictable impacts are expected at this time from either ENSO or the MJO. The dynamical and statistical model forecasts issued in November 2008 are largely in agreement regarding ENSO-neutral conditions throughout the forecast period (Figure 13b). Based on current atmospheric and oceanic conditions, recent trends, and model forecasts, ENSO-neutral conditions are expected to continue through the spring of 2009. While the model spread continues to include the possibility of an El Niño, the decrease in subsurface and surface temperatures makes this outcome unlikely during the next several months. There is a somewhat greater probability of La Niña returning. Based on model forecasts and current observations of the ocean surface and subsurface, there is an estimated 85% probability of ENSO-neutral conditions persisting during the current November-January season, with the probability of La Nina and El Nino being 13% and 2%, respectively. For March–May 2009, the estimated probability of La Niña conditions increases to 20%, and El Niño to 10%.

Notes

Two NOAA graphics in Figure 13a show observed SST (upper) and SST anomalies (lower) in the Pacific Ocean, averaged over a recent 7-day period. Data are from satellite observations and the NOAA TAO array of 70 moored buoys spread out over the Pacific Ocean, centered on the equator. The buoys measure temperature, currents, and winds and transmit data in real-time. NOAA uses these observations to predict short-term (a few months to one year) climate variations.

Figure 13b shows forecasts for SST forecasts in the Niño 3.4 region for nine overlapping 3-month periods. "Niño 3.4" refers to the region of the equatorial central Pacific from 120°W to 170°W and 5°N to 5°S, which is used as an SST-based index for defining ENSO. Abbreviations represent groups of three months (e.g. SON = Sept–Nov). The expected skills of the models, based on historical performance, vary among the models, and skill generally decreases with lead-time. Forecast skill also varies over the year because of seasonal differences in predictability of SSTs, e.g., forecasts made between June and December are generally better than those made between February and May (the spring predictability "barrier"). Differences among model forecasts in Figure 13b reflect differences in model design, which in turn reflect uncertainty in the forecast of the possible future SST scenarios.

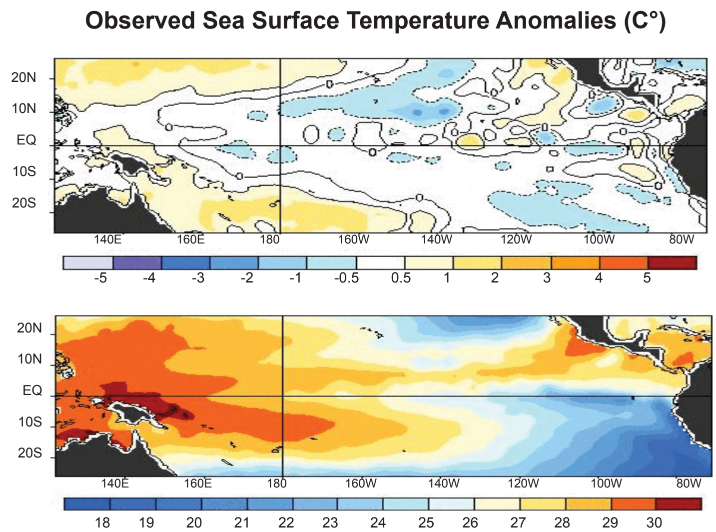


Figure 13a. Observed SST (upper) and the observed SST anomalies (lower) in the Pacific Ocean. The Niño 3.4 region encompasses the area between 120°W–170°W and 5°N–5°S. The graphics represent the 7-day average centered on November 12, 2008.

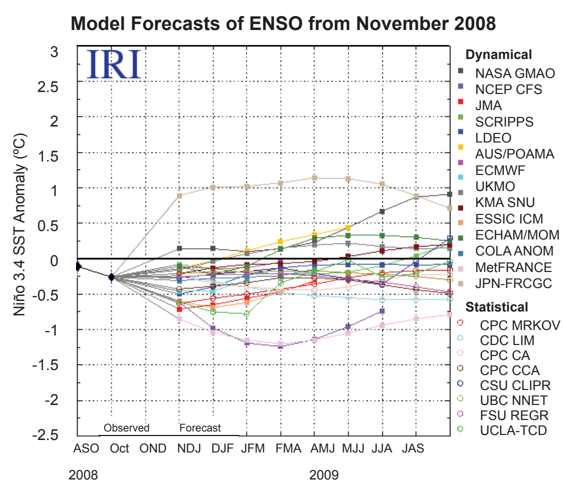


Figure 13b. Forecasts made by dynamical and statistical models for sea surface temperatures (SST) in the Niño 3.4 region for nine overlapping 3-month periods from November 2008–September 2009 (released November 20, 2008). Forecast graphic is from the International Research Institute (IRI) for Climate and Society.

On the Web

- For a technical discussion of current El Niño conditions, visit the ENSO Diagnostic Discussion, a collaborative effort of the several parts of NOAA, including the research labs, the IRI, and other institutions funded by NOAA: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ (updated on the second Thursday of the month).
- For updated graphics of SST and SST anomalies like figure 13a, visit this site and click on "Weekly SST Anomalies": http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml#current.
- For more information about El Niño, including the most recent forecasts (Figure 13b), visit: http://portal.iri.columbia.edu/climate/ENSO/. The "forecast plume" showing multiple model projections is updated on the third Thursday of the month.
- The Multivariate ENSO Index is available at: http://www.cdc.noaa.gov/people/klaus.wolter/MEI/.

Low Flow Related Impacts in the Upper Colorado River Basin

By Donna Woudenberg, National Drought Mitigation Center NWS Advanced Hydrologic Prediction Service

The National Weather Service's Advanced Hydrologic Prediction Service (AHPS) currently provides forecast information related to flooding and flooding impacts on rivers throughout the United States (Figure a; see On the Web box). The web page provides current observations and forecasts of river stages and potential impacts associated with different flood stages for over 4,000 gauge sites across the U.S.

Historically, this website has only provided flood impacts, but not impacts of low flows. However, lack of water in a stream or river may also have negative consequences. This is particularly true in the arid and semi-arid western U.S. Water shortages can affect many segments of society including industry, agriculture, energy, recreation, environment, and government. Therefore, a similar system for low flow/stage forecasting is being created for several river basins, including the Upper Colorado River Basin.

Through a new collaborative effort among NWS, the NDMC, and water users and managers, the current AHPS river forecasting system will be enhanced to forecast low river level warnings for many stations, and to include information on current and potential future impacts of low flows on a variety of sectors. Impacts information is collected from agencies at federal, state, and local levels and from other stakeholders. The Upper Colorado River Basin is the sixth U.S. river basin to be targeted in this effort, including the North Platte River basin in Wyoming and northern Colorado. There are plans to provide nationwide low-flow forecast coverage.

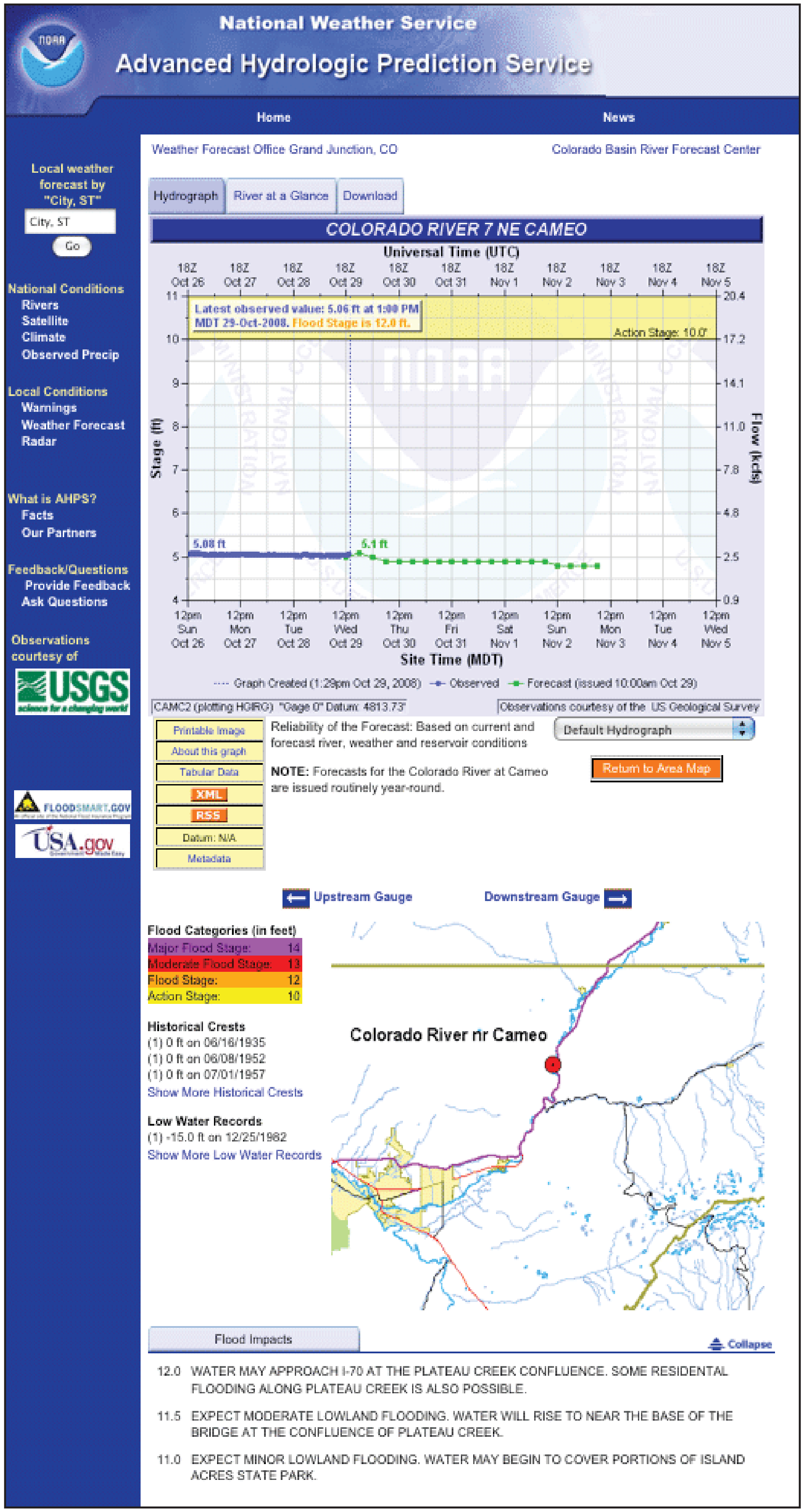


Figure 14a: NOAA-NWS Advanced Hydrologic Prediction Service website, showing the observed and forecasted streamflows for the Colorado River near Cameo, CO. Below the map, one can see the impacts associated with different flood stages. This project seeks to add impacts from low flows for 164 gauge location sin the Upper Colorado River Basin.

Potential Low-flow Impacts
Impacts can be categorized within three major sectors: economic, environmental, and social.

Economic impacts include losses to agricultural and livestock producers, businesses and industries, the energy sector and water suppliers.

- *Agricultural producers*: restrictions on irrigation water supplies, more expensive irrigation water, need for new or supplemental water sources, water rights shut off – this may result in lower production and the cascading effect of higher food prices.
- *Livestock producers*: need for new or supplemental water sources or a need to decrease herd size.
- *Fishery producers*: damage to fish habitat or loss of fish and other aquatic organisms.
- *Businesses and industries:* rafting and fishing outfits may have decreased business, the transportation industry may face impaired navigability, hydroelectric and water cooled power plants may experience a decrease in production, and water suppliers may need to provide new or supplemental water.

Fort Laramie Forecast Point, Wyoming

Flow (cfs)	Stage (ft)	Impacts	Timing/Other Considerations	Information Sources
40		Irrigation releases for crops become sporadic; some fields may not receive full allotment of water	Late summer	Brian Artery, District Manager, Platte County Conservation District
20		Recreation opportunities very limited, boat ramps at Greyrocks Reservoir are likely to be inaccessible	Late summer	
10		Irrigation releases cease; crops will require alternative irrigation water supply		
10		Conditions are not favorable for aquatic life; fish and other aquatic organisms begin to die		
10		Conditions are not favorable for livestock and wildlife water, livestock producers must implement alternative livestock water supply		

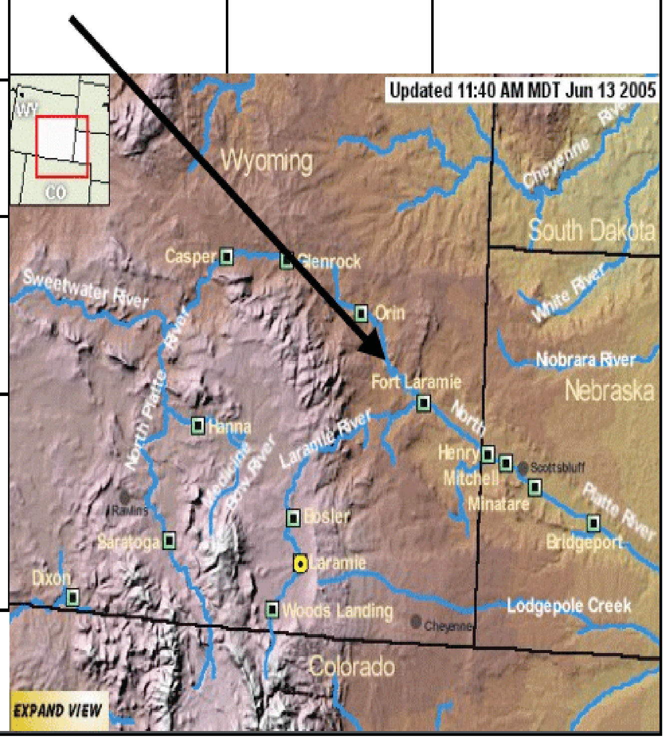


Figure 14b: Impacts associated with low flows for the Fort Laramie forecast point in the North Platte River Basin in Wyoming. This is an example of the type of information Dr. Woudenberg is seeking from water users in the Upper Colorado River Basin.

Environmental impacts include reductions in surface and groundwater quantity and quality and resultant damage to animal species and plant communities.

- *Animals/fish communities*: habitat is reduced and/or degraded and food sources and drinking water are reduced, potentially leading to increased mortality rates from lack of food and/or water, disease, or increased vulnerability to predation. Endangered species may be especially vulnerable.
- *Plant communities*: loss of biodiversity and diminished aesthetics.

Social impacts include health risks, conflicts over water, increased inequity and public dissatisfaction.

- *Health-related impacts:* increased pollutant concentrations in drinking water and reduced fire fighting capability.
- *Water user conflicts*: local, state, regional, national, and international levels may see increased competition for water supplies.
- *Water providers may have to find alternate sources*, which may lead to losses of cultural sites, public dissatisfaction with government response, or perceptions of inequity (based on socioeconomic status, ethnicity, age, gender, or seniority) in receipt of water supplies or relief.

We Need Your Help!

To assist in collecting information for the project, the National Weather Service has partnered with the National Drought Mitigation Center. The NDMC will collect information from local experts on potential impacts associated with low river levels near each of 164 selected AHPS sites in the Upper Colorado River Basin (see On the Web Box). Figure 14b shows an example of the low-flow impacts associated with the Fort Laramie streamflow forecast point in the North Platte River Basin, an earlier project. The NDMC needs information from you about the following:

- **What are the typical impacts of low river levels?**
- **At what stages/flows do these impacts occur?**
- **Is there a specific time of year when the impacts will occur?**
- **Are there any other considerations that should be noted?**

These responses will be organized into a database for incorporation into the current AHPS system. It is expected that this work will provide valuable advance information for government and public sectors to help them better prepare for and respond to water shortages in the future. You can find a form to submit low flow impacts for specific gauges in the Upper Colorado River Basin on the WWA website at: http://wwa.colorado.edu/forecasts_and_outlooks/Nov2008_focus.html.

On the Web

- For additional information about specific gauges in the Upper Colorado River Basin and to download a form to submit low flow impacts, see http://wwa.colorado.edu/forecasts_and_outlooks/Nov2008_focus.html. For further information, please contact:Donna Woudenberg, Ph.D, NDMC, (402) 472-8287, dwoudenberg2@unl.edu
- For more information on the National Drought Mitigation Center, please see: http://drought.unl.edu
- For more information on the NOAA/NWS Advanced Hydrologic Prediction Service (AHPS), please see: http://www.weather.gov/ah

  –From this site, you can choose the “River Observations” tab or the “River Forecast” tab on the top of the map. Click on a region of the country to zoom in, then click on a gauge to see the observations, forecast and impacts related to each gauge location.