Upper Missouri River Basin
June 2012 Calendar Year Runoff Forecast
June 1, 2012

U.S. Army Corps of Engineers, Northwestern Division
Missouri River Basin Water Management
Omaha, NE

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

The long-range runoff forecast is presented as the Calendar Year Runoff Forecast. This forecast is developed shortly after the beginning of each calendar year and is updated at the beginning of each month to show the actual runoff for historic months of that year and the updated forecast for the remaining months of the year. This forecast presents monthly inflows in million acre-feet (MAF) from five incremental drainage areas, as defined by the individual System projects, plus the incremental drainage area between Gavins Point Dam and Sioux City. Due to their close proximity, the Big Bend and Fort Randall drainage areas are combined. Summations are provided for the total Missouri River reach above Gavins Point Dam and for the total Missouri River reach above Sioux City. The Calendar Year Runoff Forecast is used in the Monthly Study simulation model to plan future system regulation in order to meet the authorized project purposes throughout the calendar year.

May 2012 Runoff

May 2012 Missouri River runoff was 3,314 KAF (102% of normal) above Sioux City, and 2,726 KAF (92% of normal) above Gavins Point. In January and February very warm temperatures caused a premature ice breakup on rivers and tributaries, and soil frost thawed earlier than usual allowing more runoff to occur in January and February than would normally occur during a year with normal temperatures. As a result, March runoff did not benefit from the spring thaw. In March, record high temperatures across the upper basin melted the very light plains snowpack early in March. Although May precipitation was above normal in many areas, very dry soil moisture conditions absorbed most rainfall resulting in lower than normal runoff in the upper basin. The exceptions were the Fort Peck and Gavins Point reaches where abundant rainfall caused above normal runoff.

2012 Calendar Year Forecast Synopsis

The June 1 runoff forecast above Sioux City, IA is **22.2 MAF** (89% of normal) and **19.6 MAF** (86% of normal) above Gavins Point Dam. This is an increase from the May 1 forecast due to much higher than normal rainfall in the Gavins Point Dam to Sioux City reach. Due to the amount of variability in precipitation that can occur over the next 7 months, the range of expected inflow is quite large and ranges from the 26.9 MAF upper basic forecast to the 18.4 MAF lower basic forecast. The upper and lower basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions. The upper and lower basic forecasts are used in long-term

regulation planning models to "bracket" the range of expected runoff given much wetter or drier conditions, respectively. Given that 7 months are being forecasted for this June 1 forecast (5 months observed/7 months forecast), the range of greater than normal (upper basic) and lower than normal (lower basic) runoff is attributed to all 6 reaches for all 7 months. The result is a large range or "bracket" for each reach, and thus, for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

ENSO (La Niña)

La Niña dissipated during April 2012 with the weakening of below-average sea surface temperatures in the equatorial Pacific and the continuation of above-average sea surface temperatures in the eastern Pacific. The official CPC forecast states that current and evolving conditions, combined with model forecasts suggest that La Niña is unlikely to re-develop later in 2012, with models predicting ENSO-neutral conditions to continue from April through August. During ENSO-neutral conditions, there is not a strong climate signature that would suggest if weather in the Missouri River basin will be wetter or drier than normal and warmer or cooler than normal.

Precipitation

The June Climate Prediction Center (CPC) precipitation outlook called for equal chances of precipitation in all of the upper Missouri River basin above Sioux City except for Montana and North Dakota. Actual precipitation during May 2012 was over 200% of normal in north-central Montana and greater than 300% in localized areas, while in the mountains of Montana, precipitation varied from about 50 to 125% of normal (Figure 1). Precipitation in Wyoming was predominantly less than 75% of normal. Precipitation in the Dakotas and Nebraska ranged from less than 50% of normal to greater than 300%. The greater than 300% of normal rainfall in southwest-Minnesota/northwest-Iowa was produced by moderate to heavy rain that occurred from May 23-28 in the eastern Dakotas and southwestern Minnesota. Resultant end-of-month rainfall totals are shown in Figure 2. Even with much of the upper basin receiving above normal precipitation, runoff in May was below normal due to the lack of plains snowpack, warmer than normal temperatures during the winter and early spring and much drier than normal soil conditions

Over the 90-day period (March-April-May) shown in Figure 3, greater than normal precipitation in the areas of the Missouri River basin has occurred primarily as a result of above normal April and May rainfall in these same areas. The northern half of Montana has received greater than 200% of normal precipitation since March 1, 2012, while precipitation accumulations in the eastern Dakotas and the lower basin below Sioux City now ranges from normal to above normal with widely scattered areas of below normal precipitation.

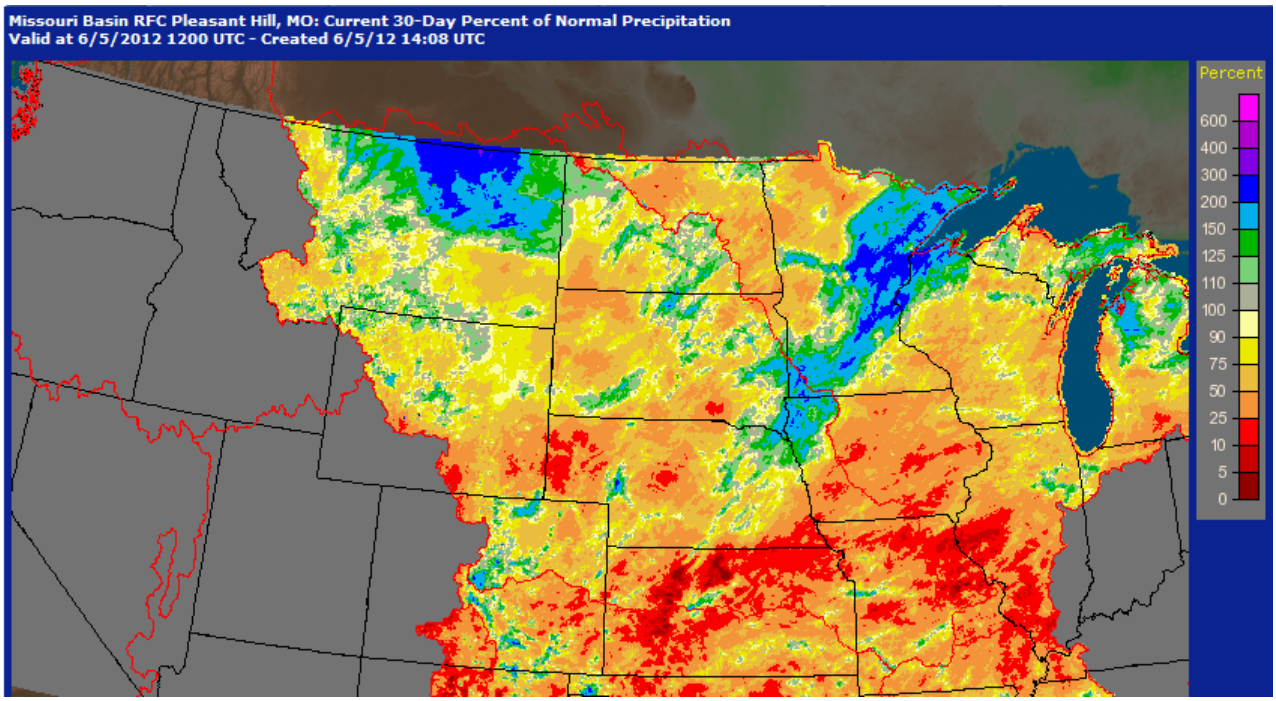


Figure 1. May 2012 Percent of Normal Precipitation. Source: National Weather Service.

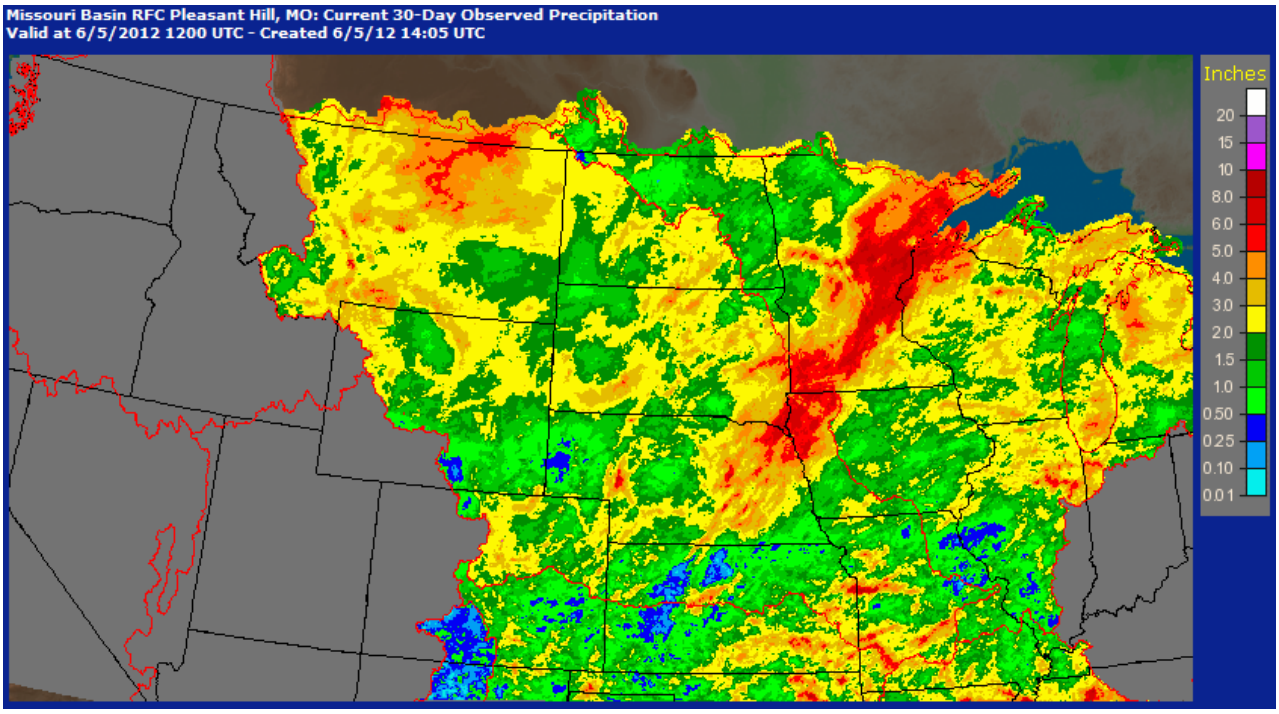


Figure 2. May 2012 Accumulated Precipitation (inches). Source: National Weather Service.

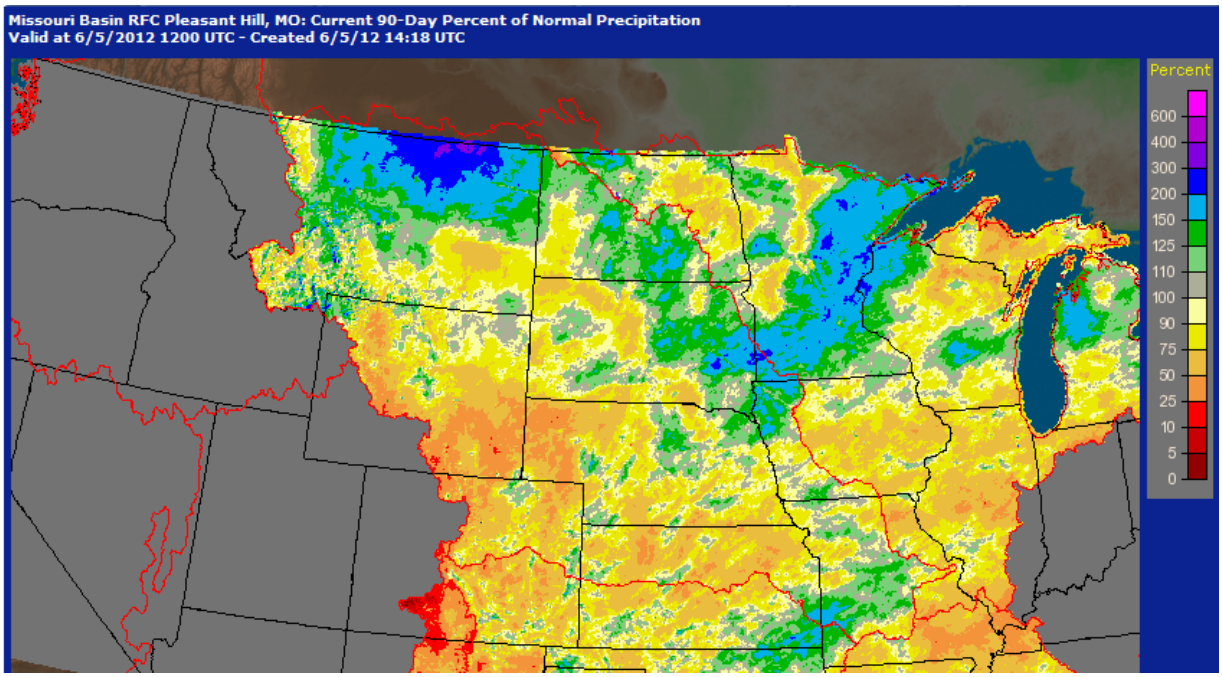


Figure 3. March-April-May 2012 Percent of Normal Precipitation. Source: National Weather Service.

Please refer to the January, February, March, April, and May Calendar Year Forecast narratives for information on the amounts of precipitation that occurred in previous months as well as a comparison to 2011 precipitation amounts in the Missouri River basin.

Temperature

The June (CPC) temperature outlook called for an increased probability for above normal temperatures across most of the Missouri River basin with the exception of Montana and western North Dakota. The June-July-August temperature forecast is essentially equal chances of above normal, below normal, and normal temperatures throughout the basin.

Average temperatures throughout the Missouri River basin were well above normal in May 2012 (Figure 4), except for Montana and western North Dakota which were slightly below normal. These warm temperatures have been a major driving factor that has dried surface soils and reduced the overall upper basin runoff volume to below normal.

Ninety-day (90-day) temperature departures ending on May 30, 2012 are shown in Figure 5. During the time period from March 1, 2012 to May 30, 2012, average daily temperatures ranged from 1 to 6 degrees F above normal in the mountain regions of the upper Missouri River basin, and 3 to 8 degrees F above normal in the plains region of the upper Missouri River basin.

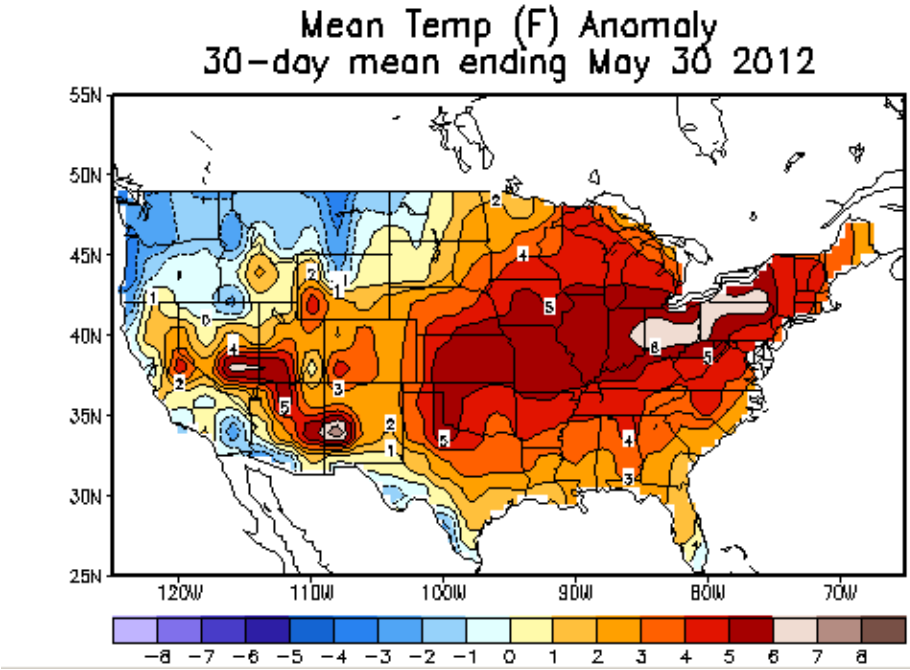


Figure 4. 30-day temperature anomaly (deg F) ending 30 May 2012.

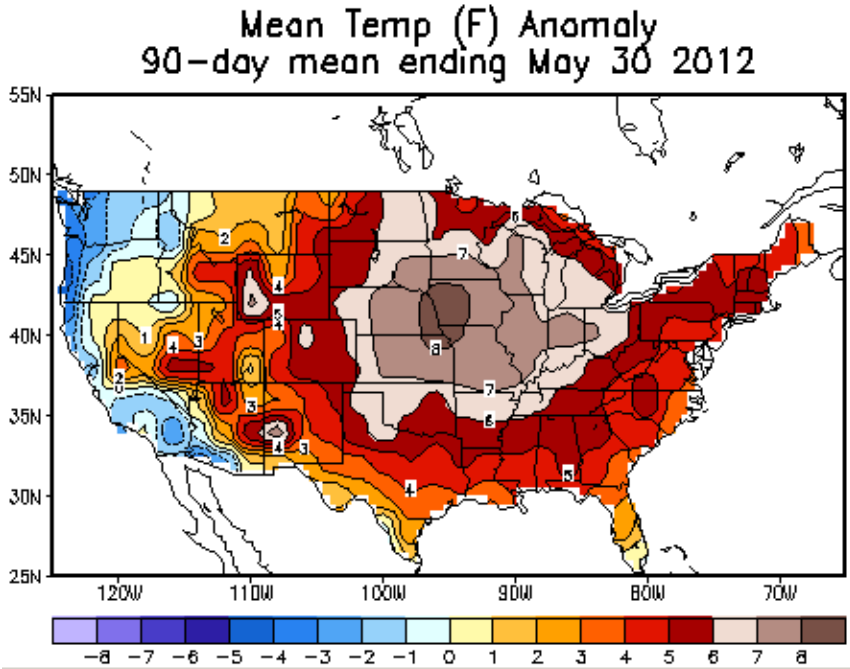


Figure 5. 90-day temperature anomaly (deg F) ending 30 Apr 2012.

Soil Moisture Conditions

Two independent assessments of soil moisture are provided below which include the CPC soil moisture percentile ranking (Figure 6) and the Variable Infiltration Capacity (VIC) soil moisture percentile ranking (Figure 8). The CPC soil moisture percentile ranking (Figure 6) continues to show below normal soil moisture in northeast Nebraska, northwest Iowa and southeast South Dakota. Additional areas of below normal soil moisture include eastern Wyoming, northwest Nebraska and southwest South Dakota. The CPC map also shows wet to very wet soils in the northern Rocky Mountains with percentile rankings ranging from the 70 to 99th percentile. These conditions have developed due to earlier than normal mountain snowpack and precipitation. The VIC model (Figure 7) shows the same dry areas in South Dakota, Nebraska and Iowa with additional areas of below normal soil moisture in North Dakota, and northern and southern Wyoming. The VIC model does not show the wet soils in western Montana to the same aerial extent as the CPC soil moisture map; however, it does show isolated areas of very wet soils greater than the 98th percentile ranking in central and western Montana, and the upper Yellowstone River basin. In summary, the two soil moisture assessments indicate wetter than normal conditions and in some cases much wetter than normal soil in Montana and the Yellowstone headwaters in Wyoming, and drier than normal soil conditions in the plains.

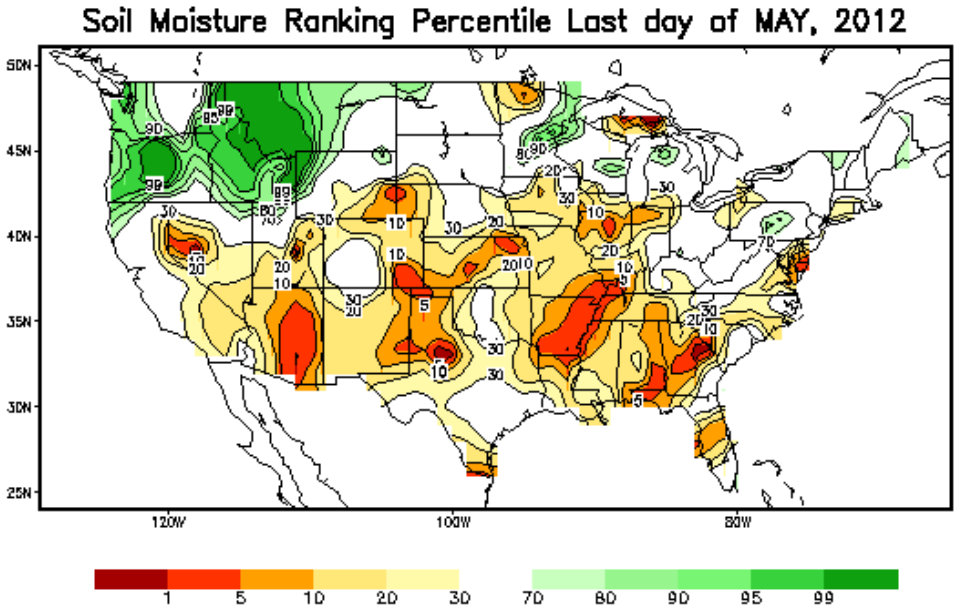


Figure 6. Calculated Soil Moisture Ranking Percentile on the last day of May 2012. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

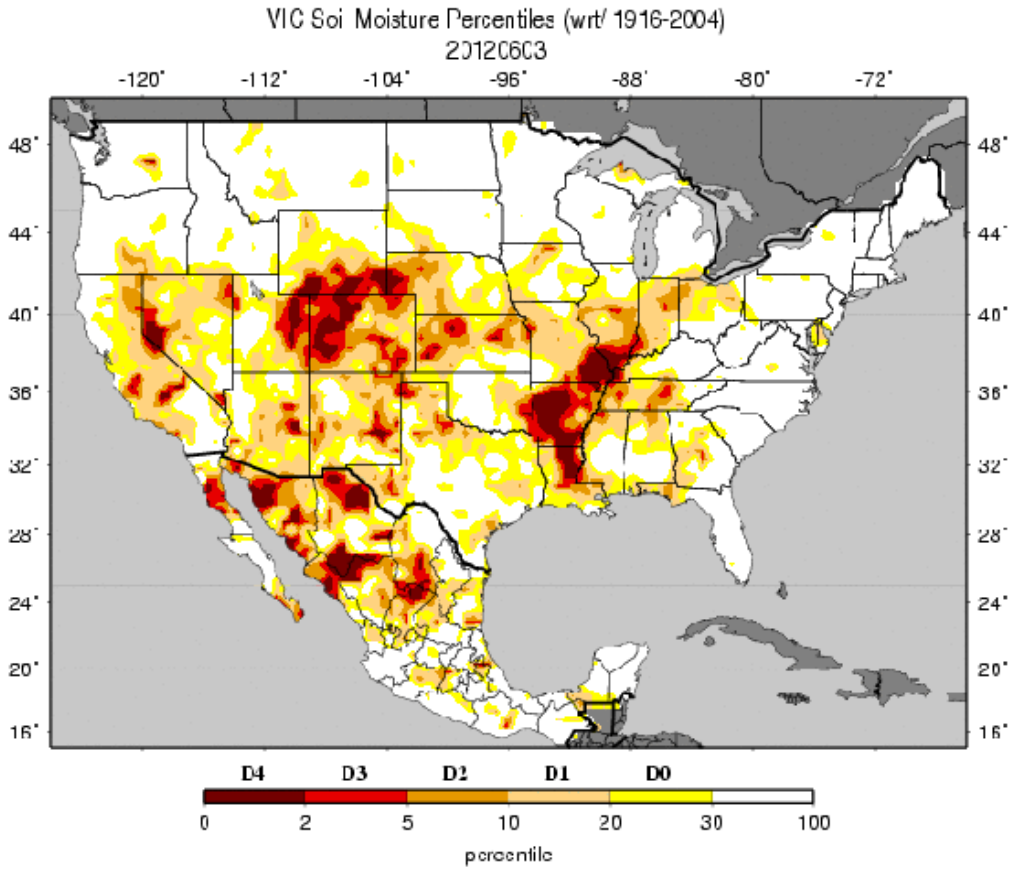


Figure 7. VIC modeled soil moisture percentiles as of May 31, 2012. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. Historically, about 25% of annual runoff occurs in March and April due to both melting snowpack and rainfall runoff; however, runoff occurs in March and April whether or not there is any plains snow to melt. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May-June-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month runoff period, about 50% of the annual runoff enters the mainstem system as a result of mountain snowmelt and rainfall runoff. Greater than average mountain snow accumulations are usually associated with greater than average May-June-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years.

The average mountain snow accumulation in the basin above Fort Peck Dam peaked on April 9, 2012 at 97% of the normal peak mountain snow accumulation that would normally occur on April 15. The peak SWE on April 9, 2012 was 17.4 inches compared to an average peak of 18.0 inches. The average mountain snow accumulation in the reach from Fort Peck Dam to Garrison Dam peaked on March 22, 2012 at 88% of the normal peak that would normally occur on April 15. The peak SWE on March 22, 2012 was 13.8 inches compared to an average peak of 15.6 inches. As of June 1, 2012, mountain snowpack continued to decline in both the Fort Peck and Garrison subbasins. Earlier than normal peak accumulations usually indicate that May-June-July mountain runoff due to snowmelt may be below average unless influenced by much greater than normal rainfall. In addition, earlier than normal peak accumulations cause the peak runoff discharge rate to occur earlier than normal in the runoff season

Table 1. 2012 mountain snowpack accumulation as a percent of normal.

Date	Above Fort Peck	Fort Peck to Garrison
January 1, 2012	79%	96%
February 1, 2012	87%	96%
March 1, 2012	94%	105%
April 1, 2012	97%	86%
Peak Accumulation as a % of the Normal April 15 Peak Accumulation	97% on April 9, 2012	88% on March 22, 2012
May 1, 2012*	72%	66%
June 1, 2012*	37%	35%

* Percent of normal April 15 Peak

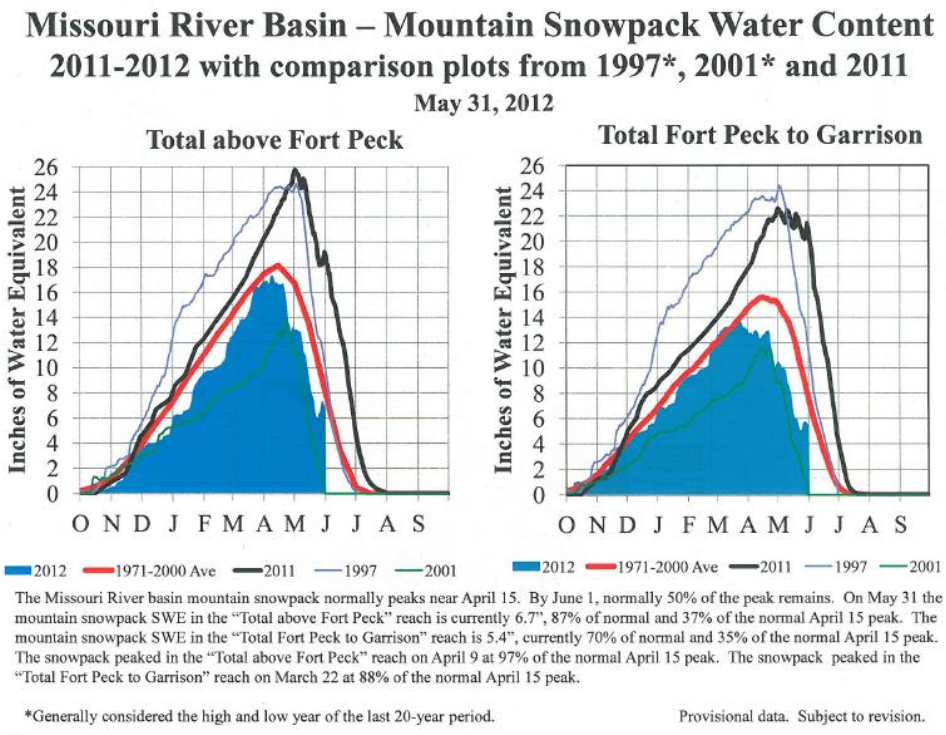


Figure 9. Mountain snowpack water content compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management. The shaded blue area indicates 2012 mountain SWE amounts. The bold black line indicates 2011 mountain SWE amounts.

Drought Analysis

According to the National Drought Mitigation Center (NDMC), Abnormally Dry (D0) conditions cover a region over southeastern Montana, eastern Wyoming, the western Dakotas and western Nebraska. Moderate Drought (D1) conditions are impacting an area within this region (see Figure 10). The NDMC drought outlook (Figure 11) which extends through August 31, 2012 is forecasting improvement in western South Dakotas and northwest Iowa, with some improvement in western Nebraska.

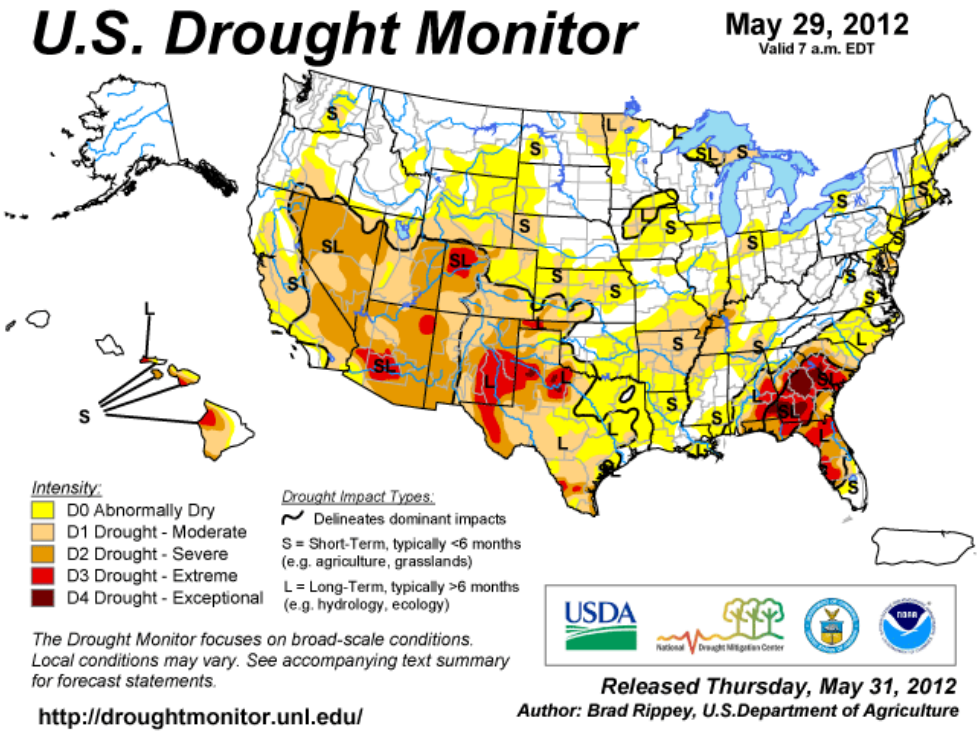


Figure 60. National Drought Mitigation Center U.S. Drought Monitors for May 1, 2012.

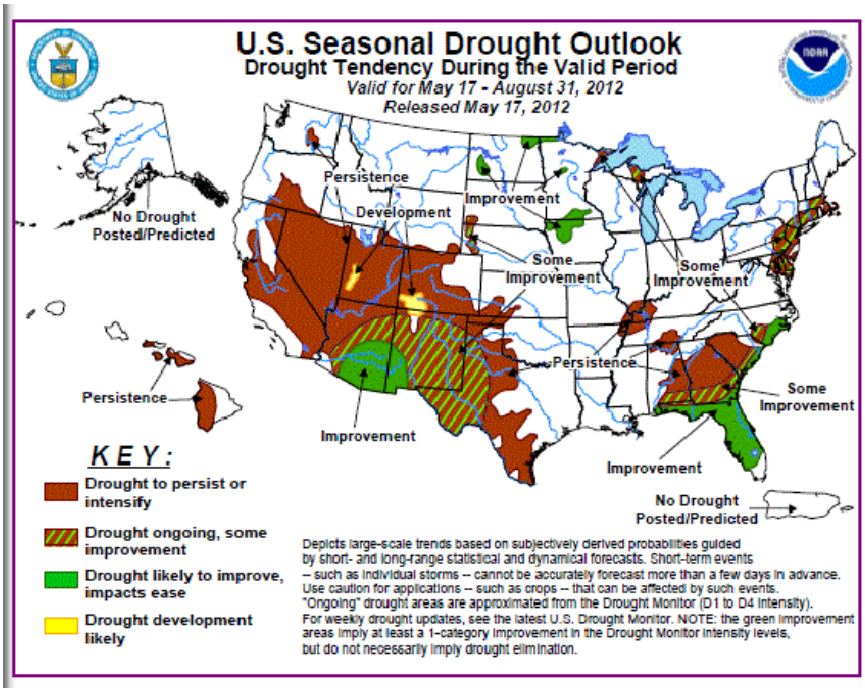


Figure 7. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook for 3 May to 31 July 2012.

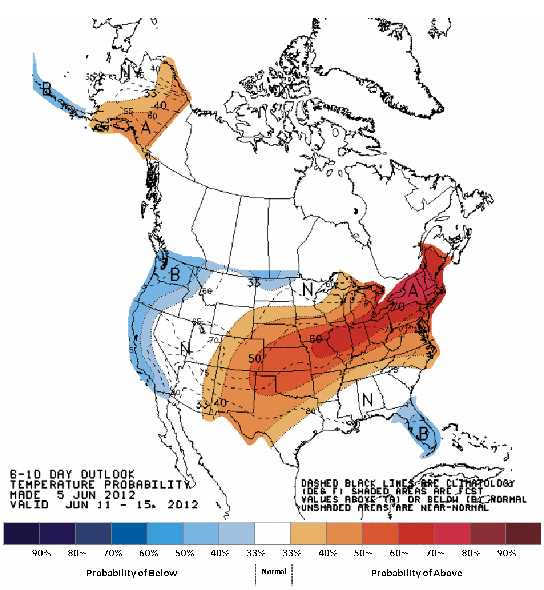
Climate Outlook

La Niña dissipated during April 2012 with the weakening of below-average sea surface temperatures in the equatorial Pacific and the continuation of above-average sea surface temperatures in the eastern Pacific. The official CPC forecast states that current and evolving conditions combined with model forecasts suggest that La Niña is unlikely to re-develop later in 2012, with models predicting ENSO-neutral conditions continuing through August. During ENSO-neutral conditions, there is not a strong climate signature that would suggest if weather in the Missouri River basin will be wetter or drier than normal and warmer or cooler than normal.

The 6-10 Day (Figure 13) and 8-14 Day (Figure 14) Outlooks indicate that temperatures are very likely to be above normal in the northern Rocky Mountains and northern Plains through May 15. With regard to precipitation, there will be increased probabilities for below normal precipitation in the northern Rockies while there are increased probabilities for above normal precipitation in the central Plains and Midwest through May 11. During the 8-14 day period ending May 15, the precipitation probability is forecast to be below normal over a larger expanse of the northern Plains, with equal chances across Wyoming and Nebraska.

For temperature the May outlook (Figure 15) indicates equal chances for above, below and normal temperatures in Montana and North Dakota, while there are increased chances for above normal temperatures throughout the remainder of the Missouri River Basin. For precipitation (Figure 15) the May outlook indicates equal chances for above, below and normal precipitation in all areas of the basin with the exception of an increased likelihood of below normal precipitation in Wyoming and southwest Montana. The 3-month or May-June-July outlooks (Figure 16) call for increased chances of below normal temperatures in Montana, western North Dakota and northern Wyoming, with Equal Chances for the remainder of the upper basin. Precipitation chances favor below normal precipitation in Montana and Wyoming, while there are Equal Chances in the remainder of the basin.

Longer term CPC outlooks indicate there is an increased probability for above normal temperatures especially in the fall and winter in the western U.S. affecting the Rocky Mountains and bordering high plains regions (Figure 17 & 18). There are equal chances for precipitation throughout most of the basin with the exception of western Montana in August-September-October 2012 (Figure 17). In November-December-January, there is an equal chance for above, below and normal precipitation (Figure 18).



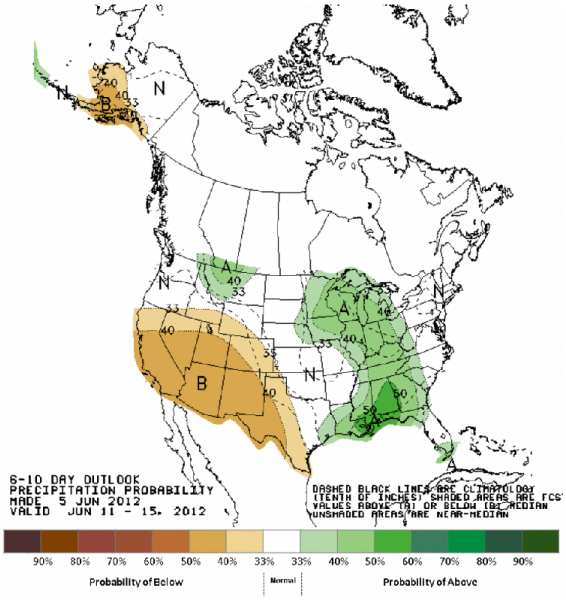
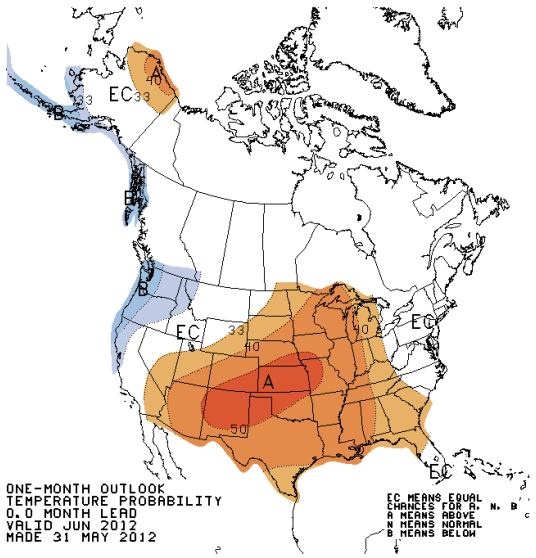


Figure 8. CPC 6-10 day temperature and precipitation outlooks.



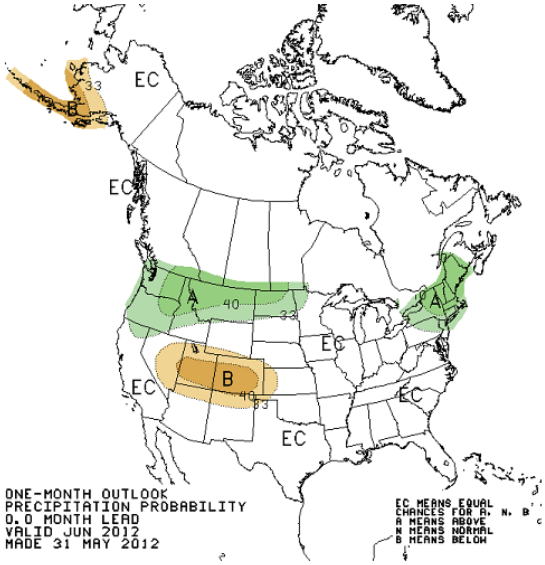


Figure 9. CPC June 2012 temperature and precipitation outlooks.

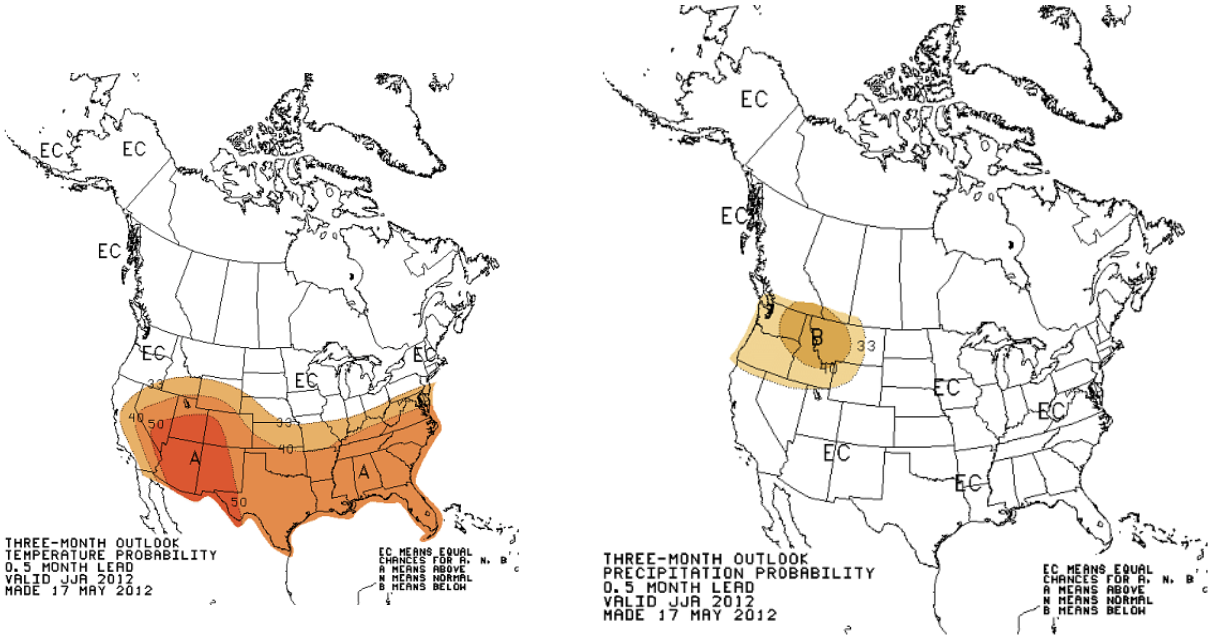


Figure 15. CPC June-July-August 2012 temperature and precipitation outlook.

June 2012 Calendar Year Runoff Forecast

As stated earlier in this report the June 1 runoff forecast above Sioux City, IA is **22.6 MAF** (89% of normal) and **19.6 MAF** (86% of normal) above Gavins Point Dam. This is a slight increase from the May 1 forecast due to higher than normal runoff in May between Gavins Point Dam and Sioux City. Actual May 2012 Missouri River runoff was 3.3 MAF (102% of normal) above Sioux City, and 2.7 MAF (92% of normal) above Gavins Point. The end of May calendar year accumulation above Sioux City is 92% of normal or 10.0 MAF. Due to the amount of variability in precipitation that can occur over the next 7 months, the range of expected inflow is quite large and ranges from the 26.9 MAF upper basic forecast to the 18.4 MAF lower basic forecast.

June-July-August

During the May-June-July period, the mainstem system normally receives 50% of its annual runoff as a result of mountain snowmelt and spring and summer precipitation. This is the most active period for precipitation in the Missouri River basin, so runoff can vary significantly as a result of the above or below normal rainfall. The significance of accurately forecasting the May-June-July runoff for the Fort Peck and Garrison reaches is based on the fact that, historically, an average of 9.2 MAF of runoff occurs during these 3 months into these 2 projects. That is 37% of the total average annual runoff into the system.

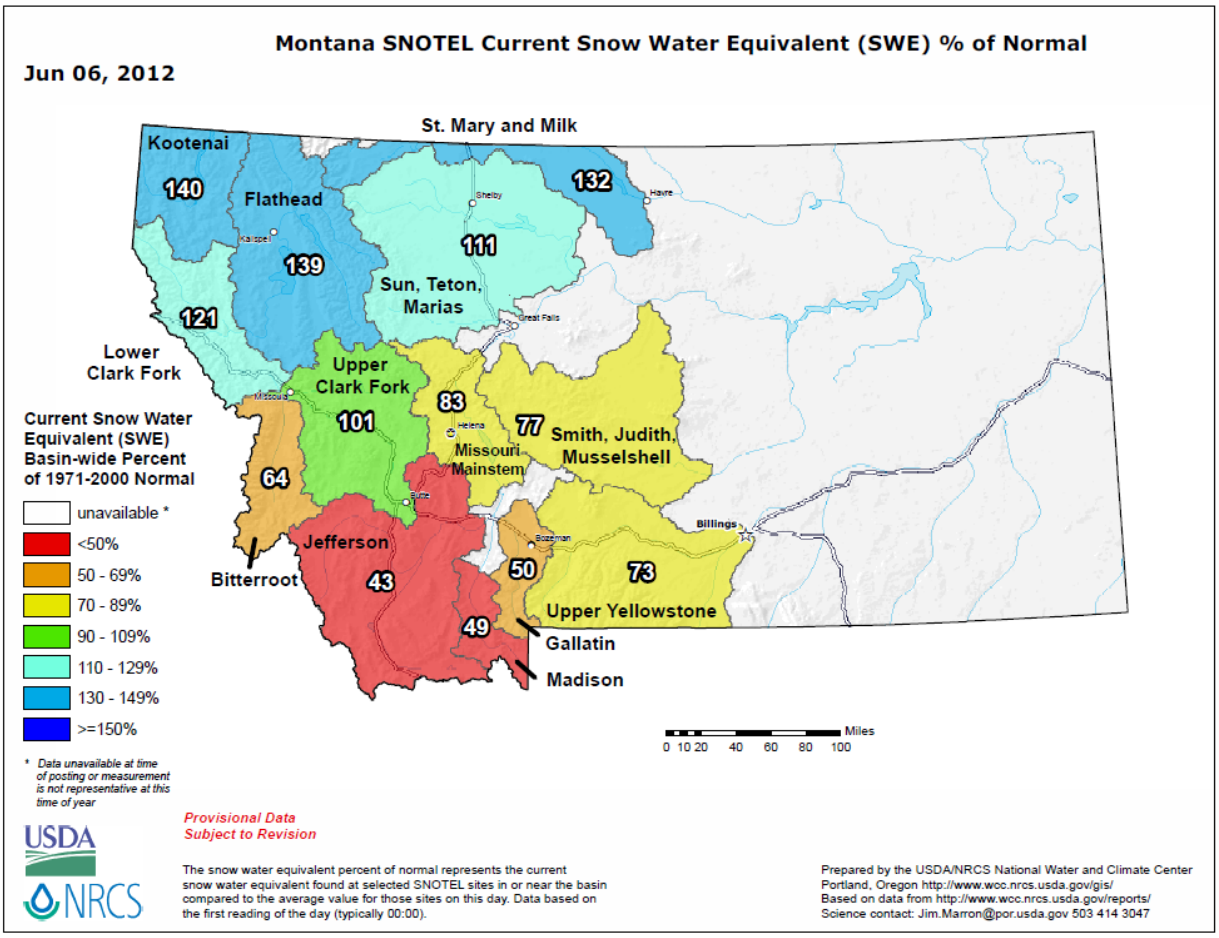
For this 3-month period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack, precipitation, and temperature to runoff. Existing mountain snowpack peaked at 97% of normal in the reach above Fort Peck on April 9 and 88% of normal in the reach between Fort Peck and Garrison on March 22. Since then, mountain snowpack has been steadily melting, and on June 1, it was 87% of the normal June 1 level above Fort Peck, and it was 70% of the normal June 1 level in the Fort Peck to Garrison reach. Soil moisture conditions in the mountain basins are above normal due to early season snowmelt. The chance for precipitation is forecast to be below normal through July and there is a greater probability for below normal temperatures. As a result runoff is forecast to be 3219 kaf (92% of normal) above Fort Peck and 4413 kaf (78% of normal) from Fort Peck to Garrison. Since mountain snowpack peaked much earlier than normal, the peak of the mountain snowmelt runoff is forecast to occur earlier than normal, placing some additional water in May.

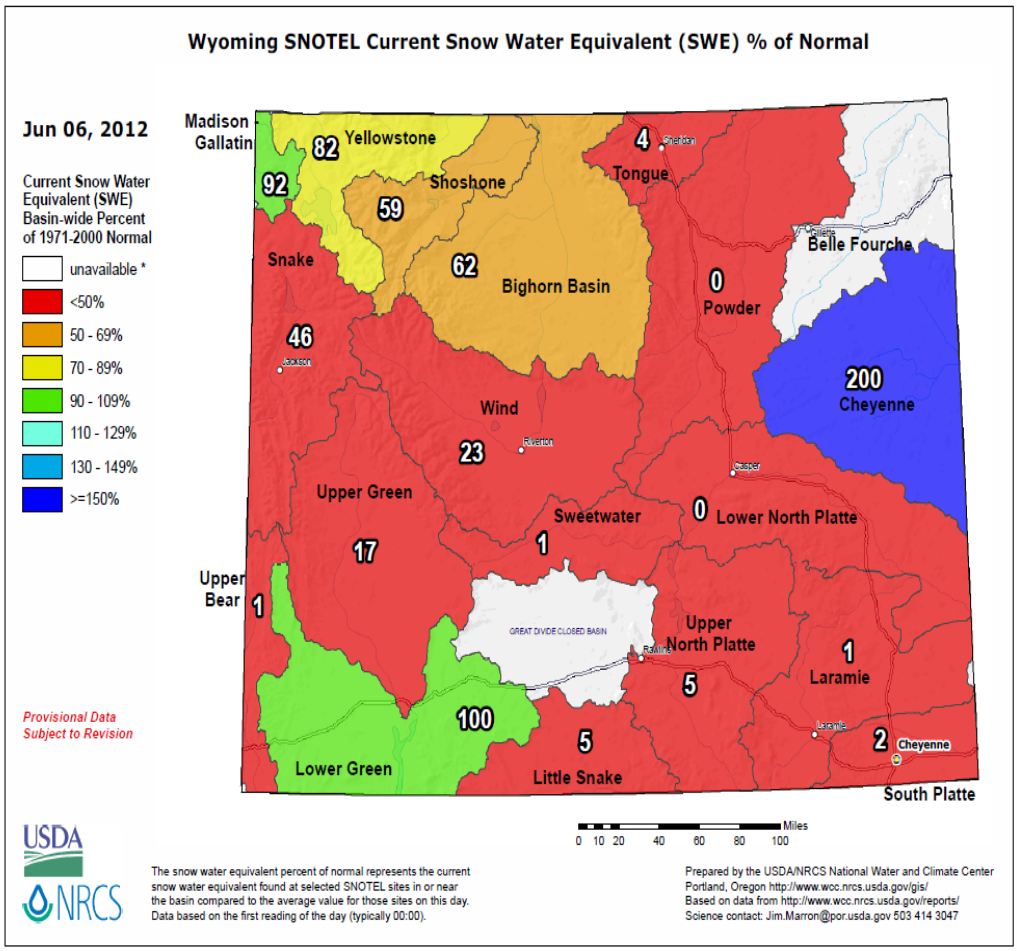
Following below-normal runoff in March and April, runoff in June and July is also expected to be below normal in the Oahe, Fort Randall, and Gavins Point reaches. Above average runoff is expected for June in the Sioux City reach. Drought conditions as defined by the National Drought Mitigation Center continue to impact the Dakotas, Wyoming, and Nebraska.

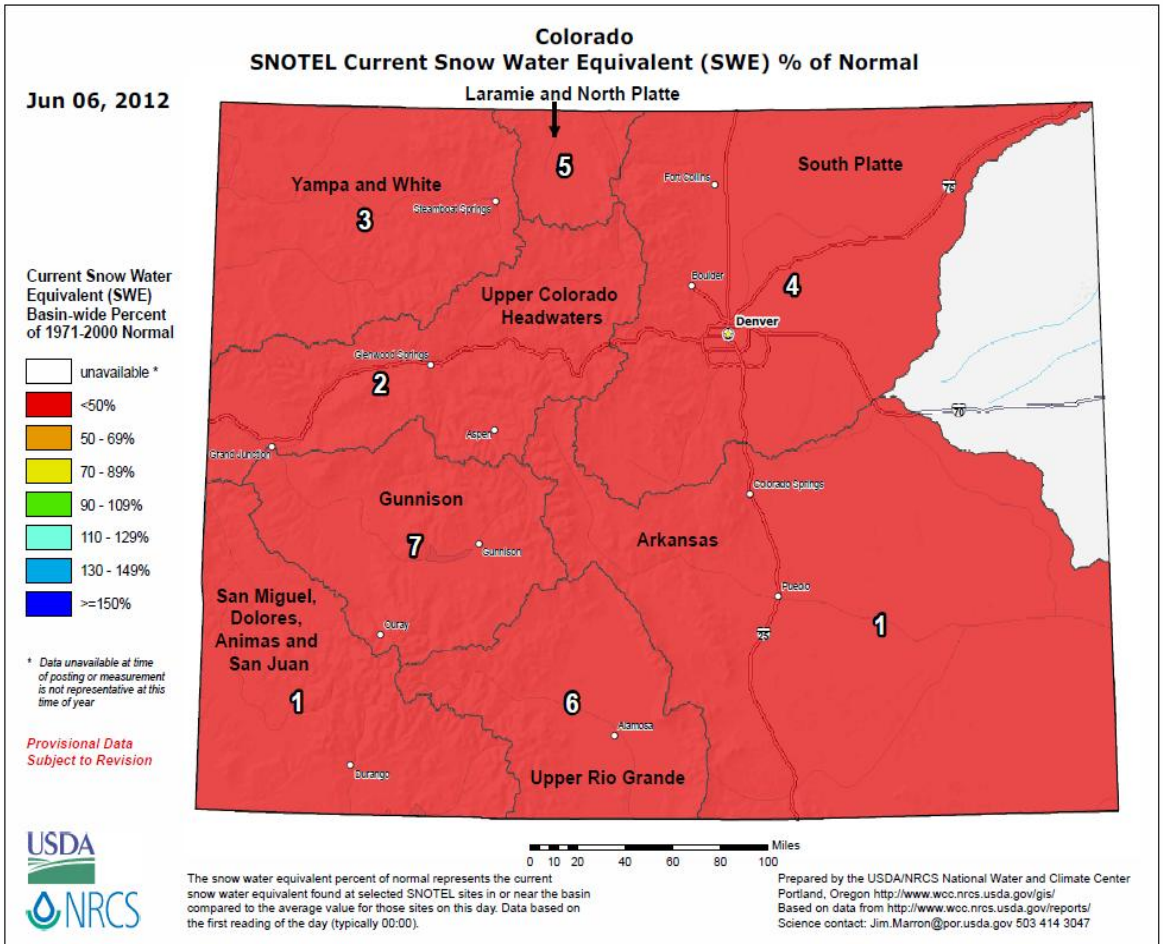
August through December

During the August through December period, runoff is forecast to be slightly below normal in all reaches from above Fort Peck to Gavins Point, primarily due to the increased chances for above normal temperatures during the fall. As the year progresses and the August through December precipitation and temperature outlooks are updated with more detail, these values may change.

Additional Figures




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Jun 06, 2012
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1971-2000 Normal
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison Gallatin
82
Yellowstone
92
Shoshone
59
4
Tongue
Sheridan
Snake
62
Bighorn Basin
Belle Fourche
Gillette
0
Powder
46
Jackson
200
Cheyenne
Wind
23
Riverton
Casper
Upper Green
Sweetwater
0
Lower North Platte
17
1
Upper Bear
1
GREAT DIVIDE CLOSED BASIN
Upper North Platte
Rawlins
1
Laramie
5
100
5
Laramie
2
Cheyenne
Lower Green
Little Snake
South Platte
Miles
0 10 20 40 60 80 100
USDA
NRCS
The snow water equivalent percent of normal represents the current snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).
Prepared by the USDA/NRCS National Water and Climate Center
Portland, Oregon http://www.wcc.nrcs.usda.gov/gis/
Based on data from http://www.wcc.nrcs.usda.gov/reports/
Science contact: Jim.Marron@por.usda.gov 503 414 3047


Colorado
SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Jun 06, 2012
Laramie and North Platte
5
Yampa and White
3
Steamboat Springs
Fort Collins
South Platte
Boulder
4
Upper Colorado Headwaters
Denver
Glenwood Springs
2
Aspen
Grand Junction
Colorado Springs
Gunnison
7
Gunnison
Arkansas
Pueblo
San Miguel, Dolores, Animas and San Juan
Ouray
1
1
6
Alamosa
Durango
Upper Rio Grande
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1971-2000 Normal
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
* Data unavailable at time of posting or measurement is not representative at this time of year
Provisional Data Subject to Revision
0 10 20 40 60 80 100
Miles
The snow water equivalent percent of normal represents the current snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).
Prepared by the USDA/NRCS National Water and Climate Center
Portland, Oregon http://www.wcc.nrcs.usda.gov/gis/
Based on data from http://www.wcc.nrcs.usda.gov/reports/
Science contact: Jim.Marron@por.usda.gov 503 414 3047

NRCS Water Supply Outlook (June not available)