Upper Missouri River Basin
January 2014 Calendar Year Runoff Forecast
January 6, 2014

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.

2013 Calendar Year Runoff

December 2013 Missouri River runoff was 0.7 MAF (94% of normal) above Sioux City, and 0.6 MAF (90% of normal) above Gavins Point. The (preliminary, with no holdouts) calendar year 2013 runoff summation above Sioux City, IA was **25.1 MAF** (99% of average), while above Gavins Point it was **22.7 MAF** (99% of average). These preliminary runoff numbers will be finalized within the first few months of 2014.

2014 Calendar Year Forecast Synopsis

The January 1 forecast for the 2014 Missouri River runoff above Sioux City, IA is 26.1 MAF (104% of normal). Runoff above Gavins Point Dam is forecast to be 23.9 MAF (104% of normal). Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 36.0 MAF upper basic forecast to the 17.4 MAF lower basic forecast. 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 12 months are being forecasted for this January 1 forecast (0 months observed/12 months forecast), the range of wetter than normal (upper basic) and lower than normal (lower basic) is attributed to all 6

reaches for all 12 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 Nina)

ENSO-neutral conditions continue in the equatorial Pacific, and equatorial sea surface temperatures are near average across most of the Pacific Ocean. ENSO-neutral conditions are favored in the Northern Hemisphere through the summer of 2014, where there are indicators for increasing chance of El Nino by summer. Therefore, there is not a strong indication of future temperature and precipitation conditions in the Missouri River basin based on ENSO conditions.

Drought Analysis

According to the National Drought Mitigation Center (Figure 1), drought conditions on December 31, 2013 have greatly improved since last year at this time (Figure 2). Montana, North and South Dakota are out of any drought category with the exception of southwest Montana. The majority of Nebraska, Kansas, and Iowa have improved the past year to "Abnormally Dry to Severe Drought" conditions. The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions that are currently impacting central Nebraska and western Kansas will persist through winter and early spring 2014 with limited change in drought category. Further information about long-range climate factors that may impact drought conditions are discussed later in the climate outlook section.

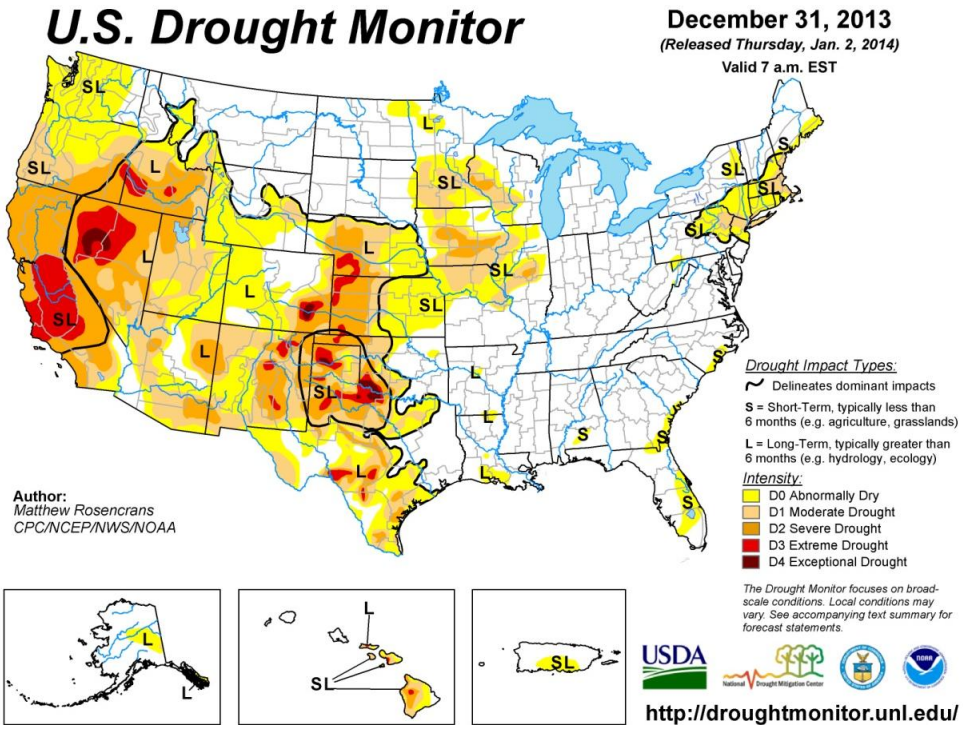


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for December 31, 2013.

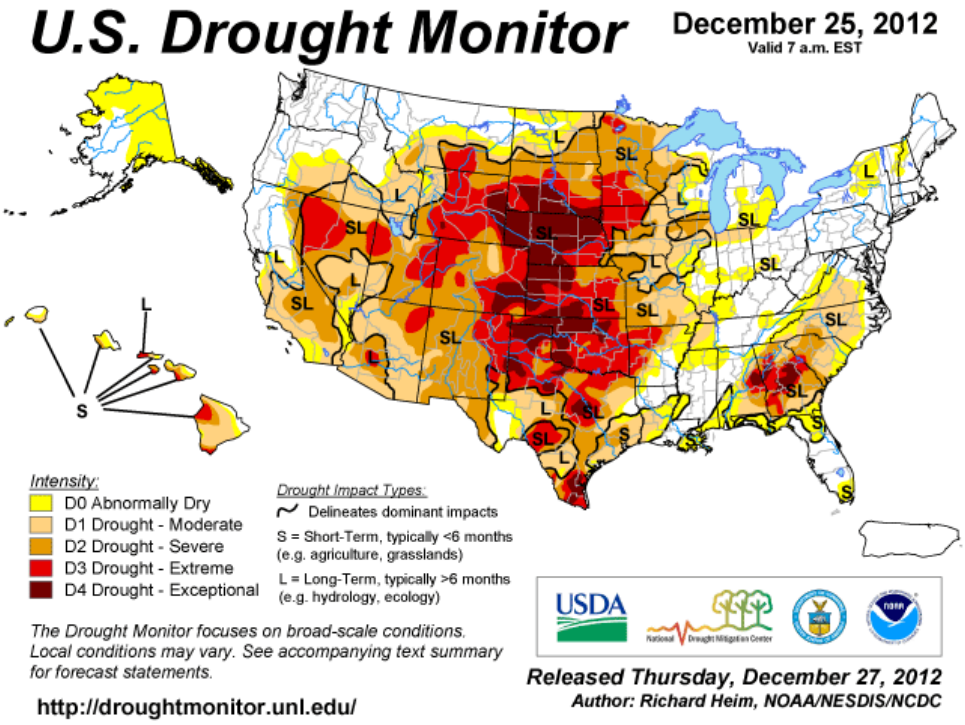


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for December 25, 2012.

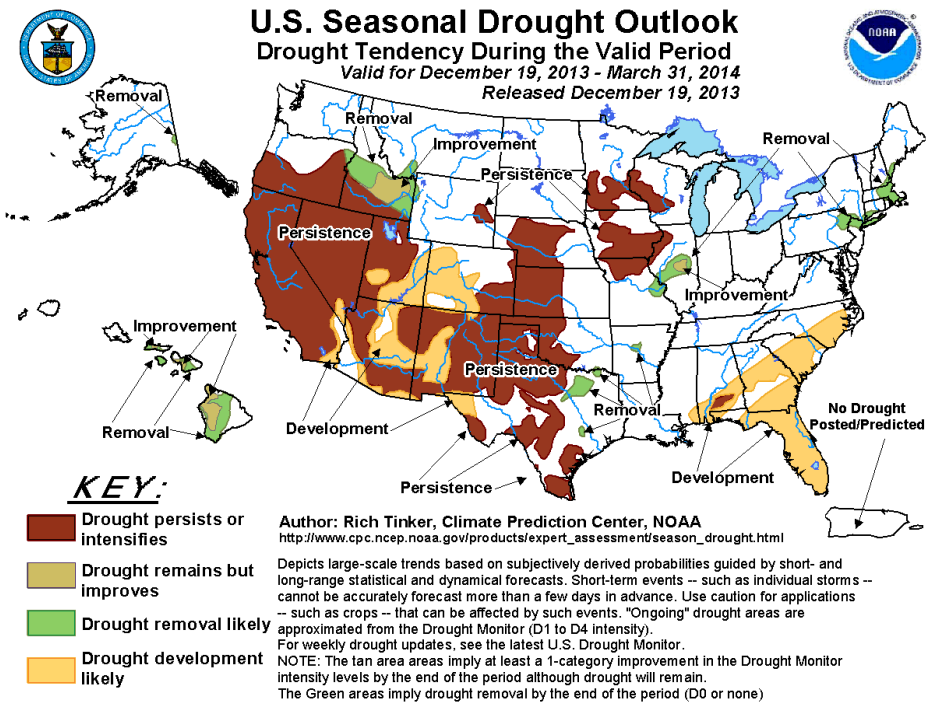


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation as a percent of normal during the month of December is shown in Figure 4. While December precipitation generally has limited impact on December runoff since it generally falls as snow and does not result in immediate runoff, it was above normal in many parts of Montana and the Dakotas, while in Wyoming, Nebraska and Iowa, it was mostly below normal except for a few regions. Precipitation in Montana was greater than 200% of normal across the Rocky Mountain front, in northern and northeast Montana with some areas receiving up to 400% of normal. Similar amounts occurred in southern North Dakota and across South Dakota. West-Central South Dakota received over 400% of normal precipitation in December. Some areas received much less than normal precipitation in December including Nebraska, Iowa, Kansas, and Missouri where precipitation was as little as 10% of normal.

Accumulated precipitation over the 90-day period ending on December 31, 2013, is shown in Figure 5. Precipitation was well below normal in Nebraska, Iowa, Kansas, and Missouri. Most of this area received less than 50% of normal precipitation over the past three months, with some accumulations ranging from 10 to 25% of normal. In contrast, large portions of Montana, South and North Dakota received greater than 200% of normal precipitation. Accumulations in excess of 600% of normal have occurred in portions of these states.

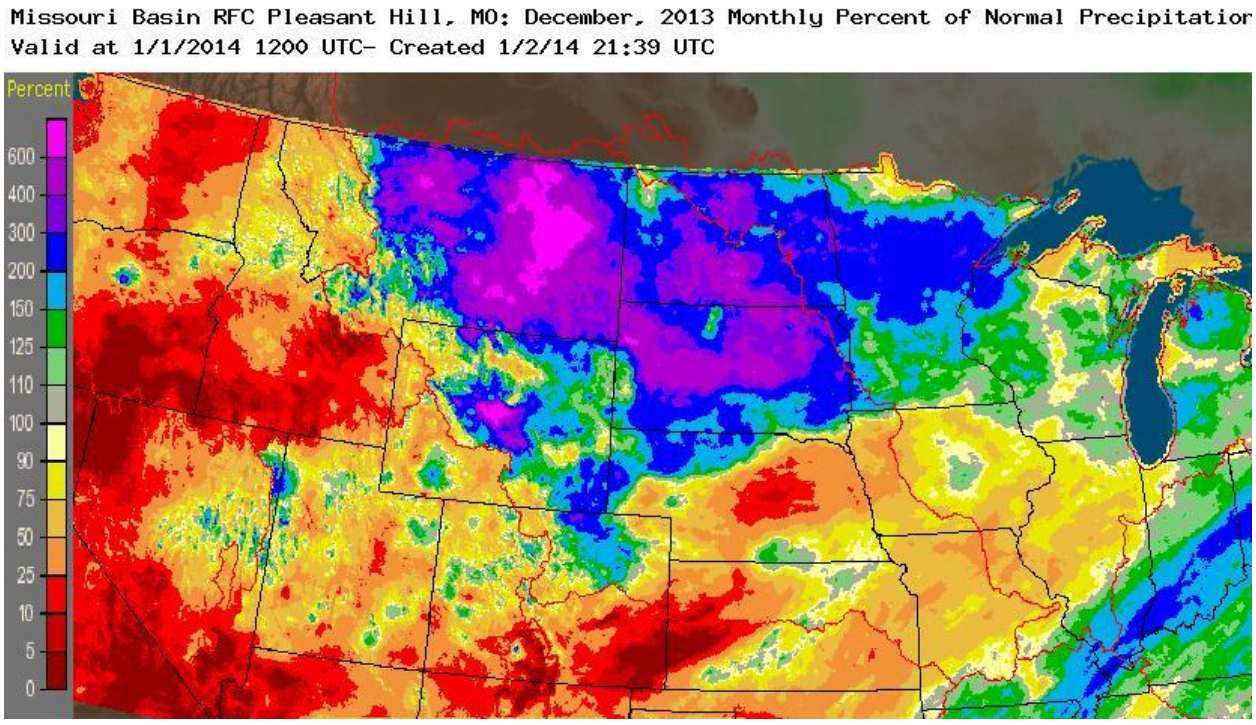


Figure 4. December 2013 Percent of Normal Precipitation.

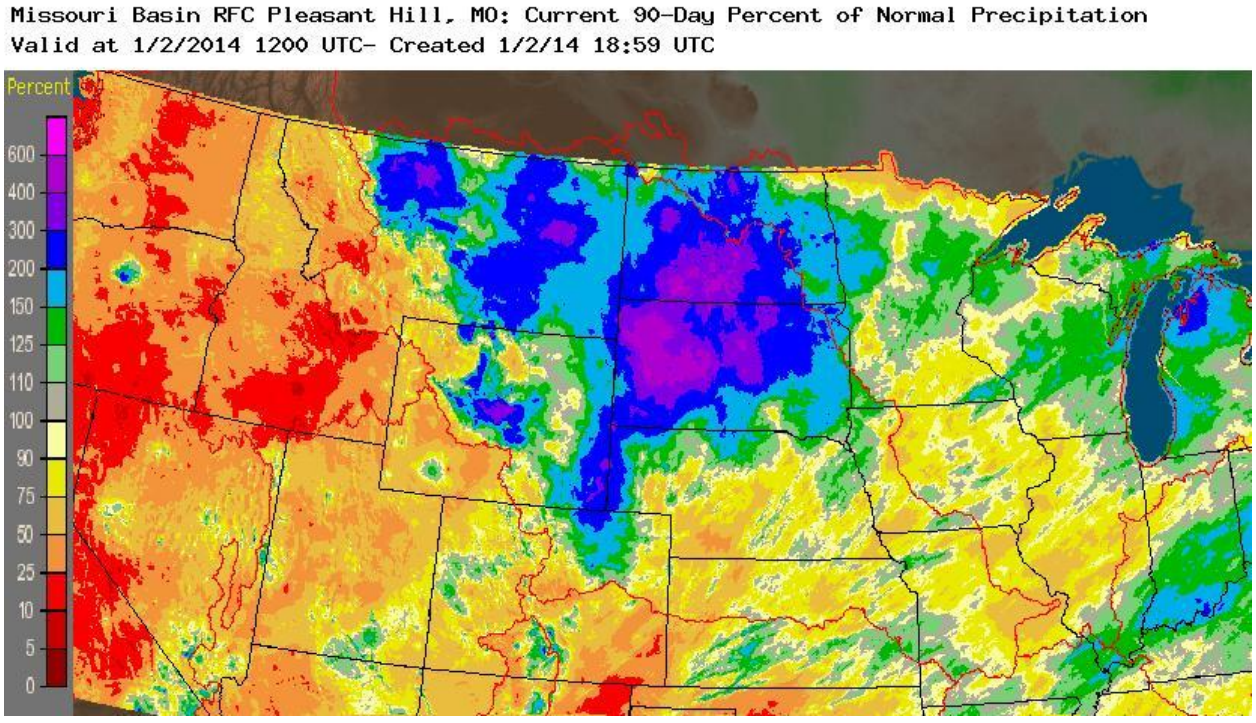


Figure 5. 90-day Percent of Normal Precipitation ending on December 31, 2013.

Temperature

Average temperatures throughout the basin above Sioux City, IA during the month of December 2013 were well-below normal, with broad areas in South and North Dakota 9 degrees below normal (Figure 6).

Ninety-day (90-day) temperature departures ending on December 31, 2013 are shown in Figure 7. The map in this figure indicates that temperatures in the majority of the basin were 1 to 4 degrees below normal.

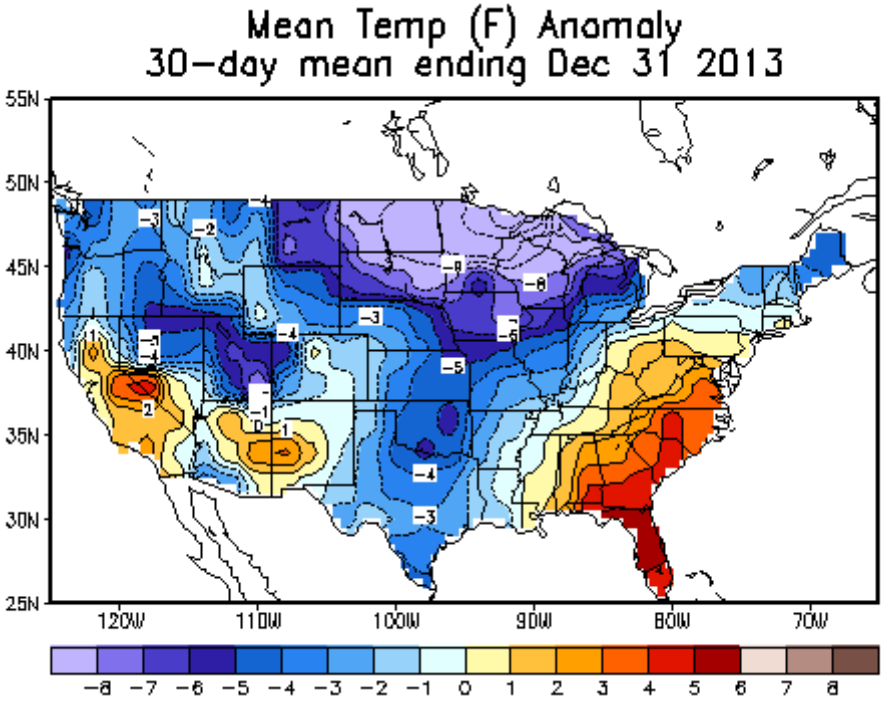


Figure 6. 30-day temperature anomaly (deg F) ending 31 Dec 2013.

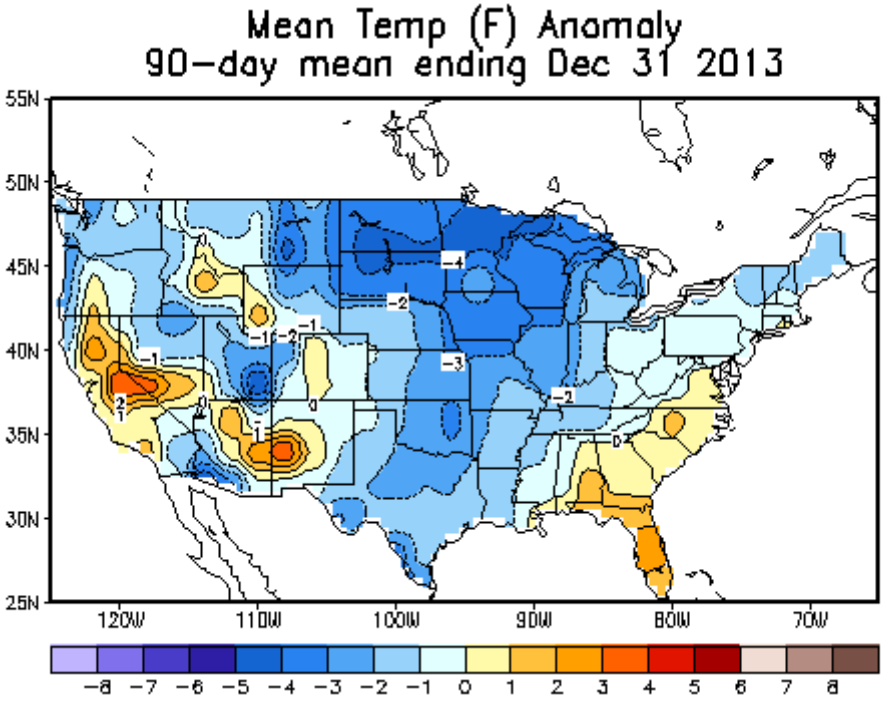


Figure 7. 90-day temperature anomaly (deg F) ending 31 Dec 2013.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Three estimates of soil moisture are presented in this report. Figure 8 shows the Climate Prediction Center's calculated soil moisture ranking percentiles on January 1, 2014. Figure 9 shows the Variable Infiltration Capacity model soil moisture percentiles on January 1, 2014. Figure 10 shows the NOAA NLDAS Drought Monitor soil moisture percentiles on December 30, 2013.

All three soil moisture estimates depict very wet soil moisture conditions throughout the upper Missouri River basin in Montana and western portions of North and South Dakota. CPC soil moisture conditions in these areas rank from the 75th to the 95st percentile. Soil moisture conditions in Nebraska, eastern Colorado, Kansas, and Missouri are fairly normal, while Iowa have very dry soil moisture conditions. As an indicator of future monthly runoff, soil moisture conditions suggest runoff will be above normal in the upper portion of the basin and below average in the lower portion of the basin.

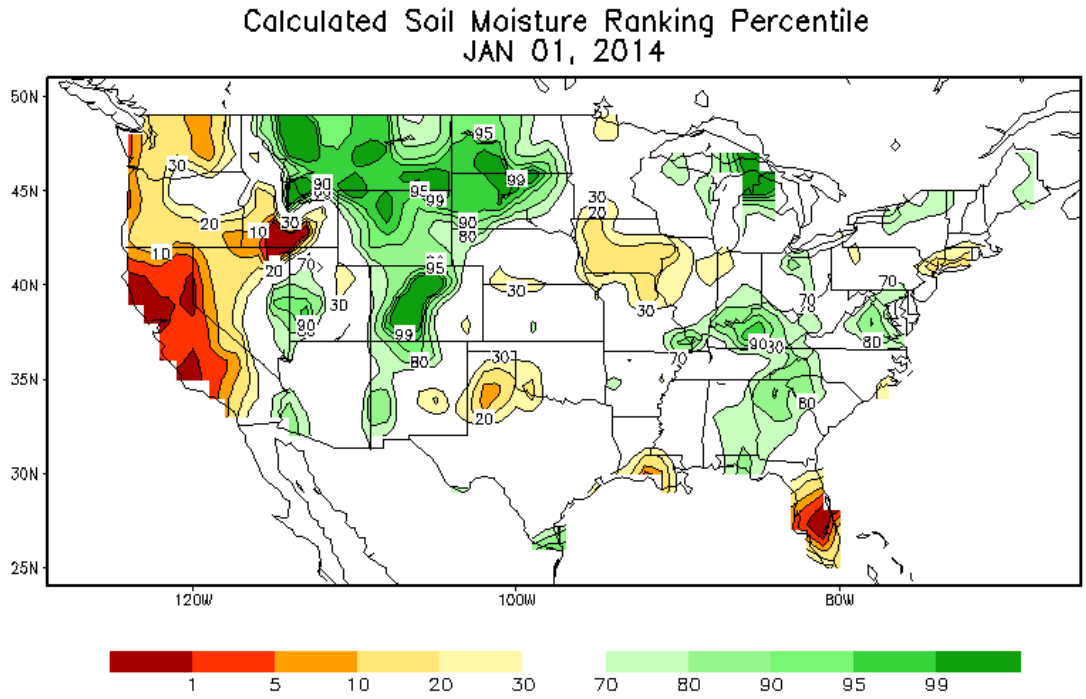


Figure 8. Calculated Soil Moisture Ranking Percentile on January 1, 2014. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

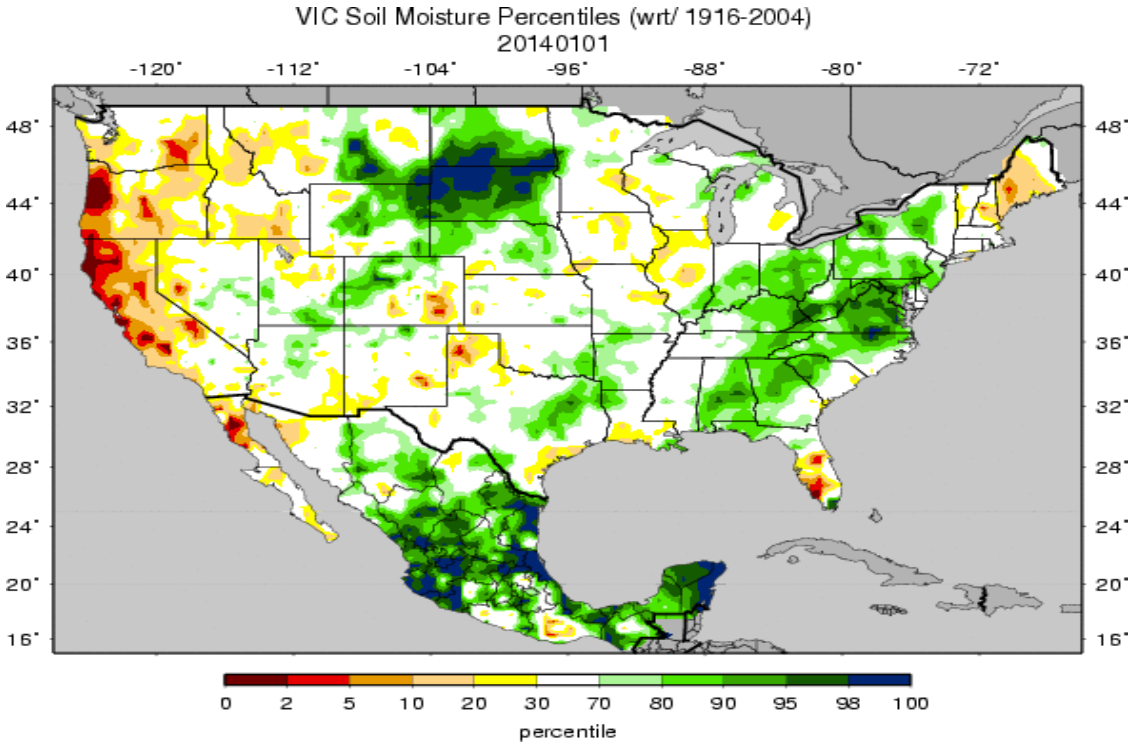


Figure 9. VIC modeled soil moisture percentiles as of January 1, 2014. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

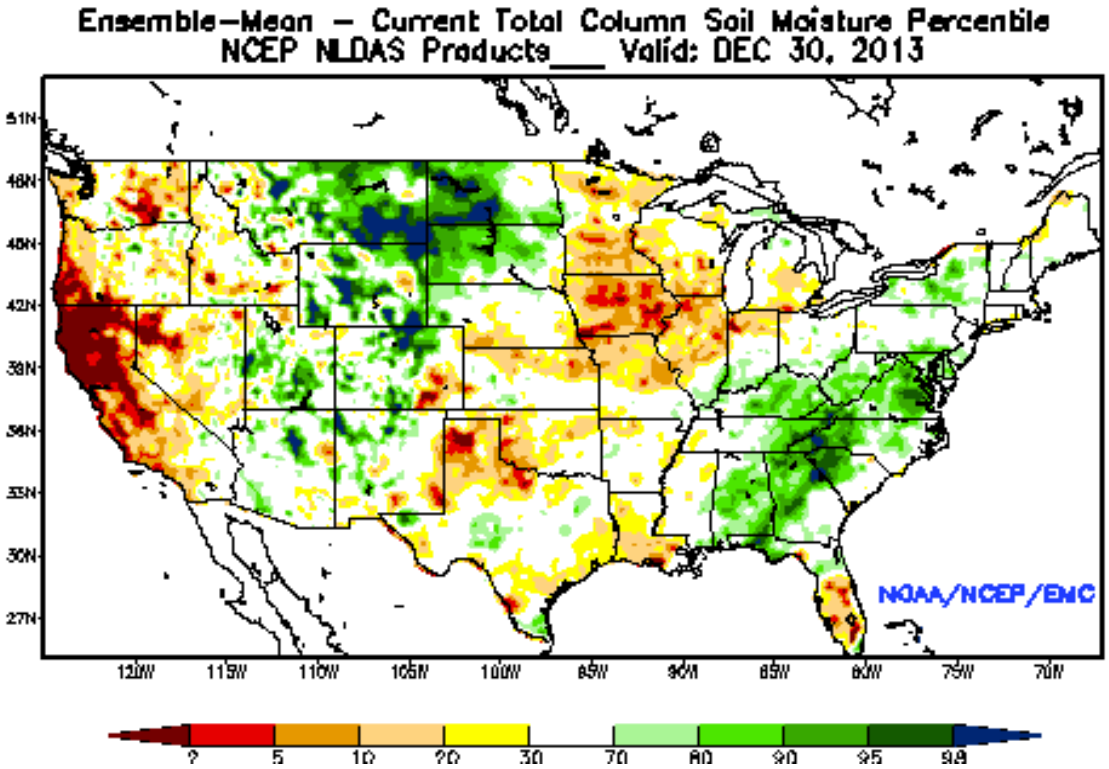


Figure 10. Total Column Soil Moisture Percentile as of December 30, 2013. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The CPC calculated soil moisture anomaly for the contiguous U.S. on January 1, 2014 is shown in Figure 11. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 40 mm (1.6 inches). Some areas in North Dakota, South Dakota and Montana have anomalies greater than 80 mm (3.2 inches) of moisture .

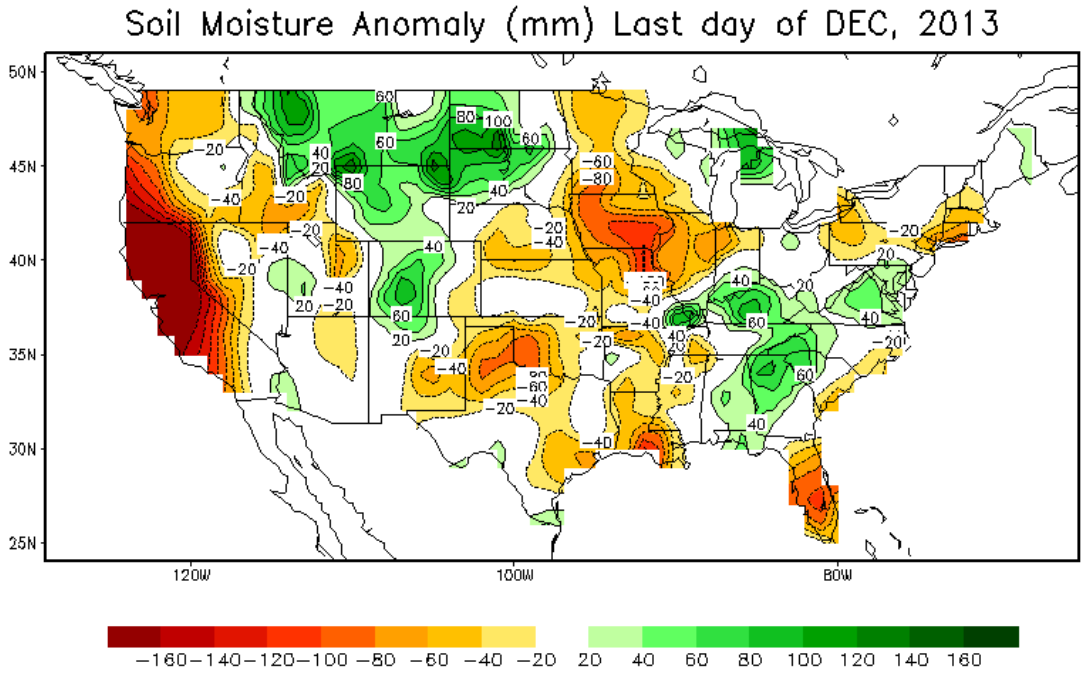


Figure 11. Calculated Soil Moisture Anomaly (mm) on December 31, 2013. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

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. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Determining exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

Based on the National Operational Hydrologic Remote Sensing Center (NOHRSC) assessment (Figure 12) as of January 1, 2014 most plains snow water equivalent (SWE) amounts ranged from trace to 2-inch amounts throughout the upper Missouri River basin. Amounts ranging from 1 to 2 inches covered a majority of eastern Montana, North Dakota, and less than half of South Dakota. Amounts less than 1 inch covered all remaining plains areas of the basin.

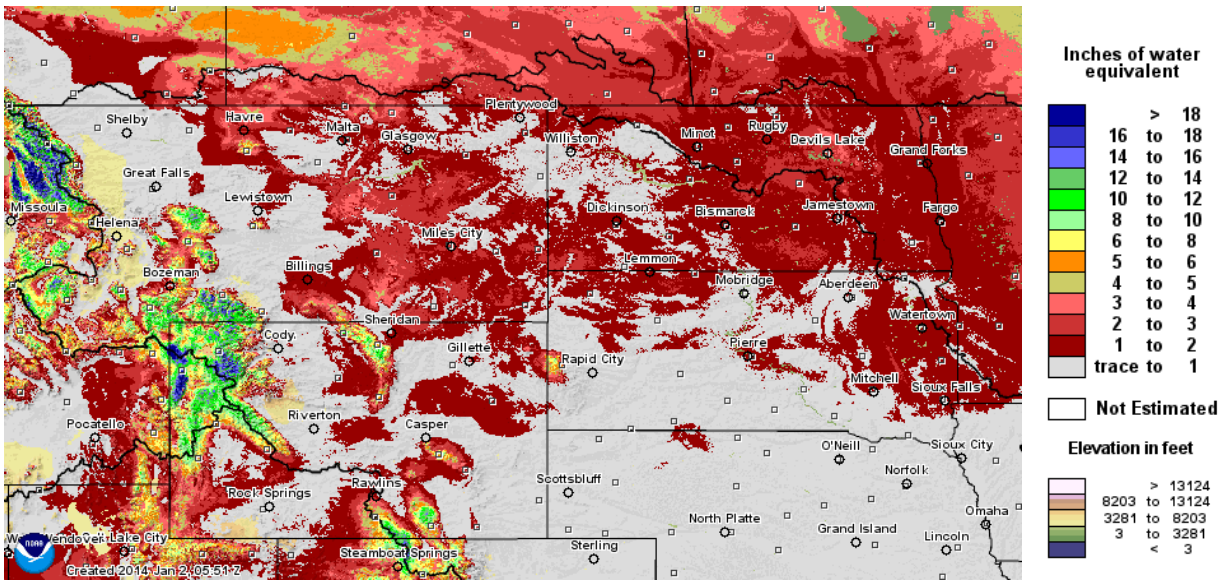


Figure 12. January 1, 2014, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Using the MRBWM snowpack classification method, plains snowpack as of January 1, 2014, was classified as Light across the upper Missouri River basin in all reservoir reaches except the Fort Peck to Garrison reach (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0 to 1 inch of SWE in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins and 0 to 2 inches in the Gavins Point to Sioux City reach. Snowpack was classified as Light-Moderate in the Fort Peck to Garrison reach with a SWE ranging from 1 to 3 inches of SWE.

Table 1. January 1, 2012 plains snowpack classification for runoff forecasting.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Light (0 – 1 inch SWE)
Fort Peck to Garrison	Light-Moderate (1 – 3 inch SWE)
Garrison to Oahe	Light (0 – 1 inch SWE)
Oahe to Fort Randall	Light (0 – 1 inch SWE)
Fort Randall to Gavins Point	Light (0 – 1 inch SWE)
Gavins Point to Sioux City	Light (0 – 2 inch SWE)

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July 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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would

expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions.

As of January 1, 2014, the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 7.9 inches, which is 110% of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 7.2 inches, which is 113% of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by January 1, 44% of the peak snow accumulation has occurred in the mountains. In comparison, January 1, 2013 mountain snowpack was 7.2 inches in the Fort Peck subbasin and 5.9 inches in the Fort Peck to Garrison subbasin.

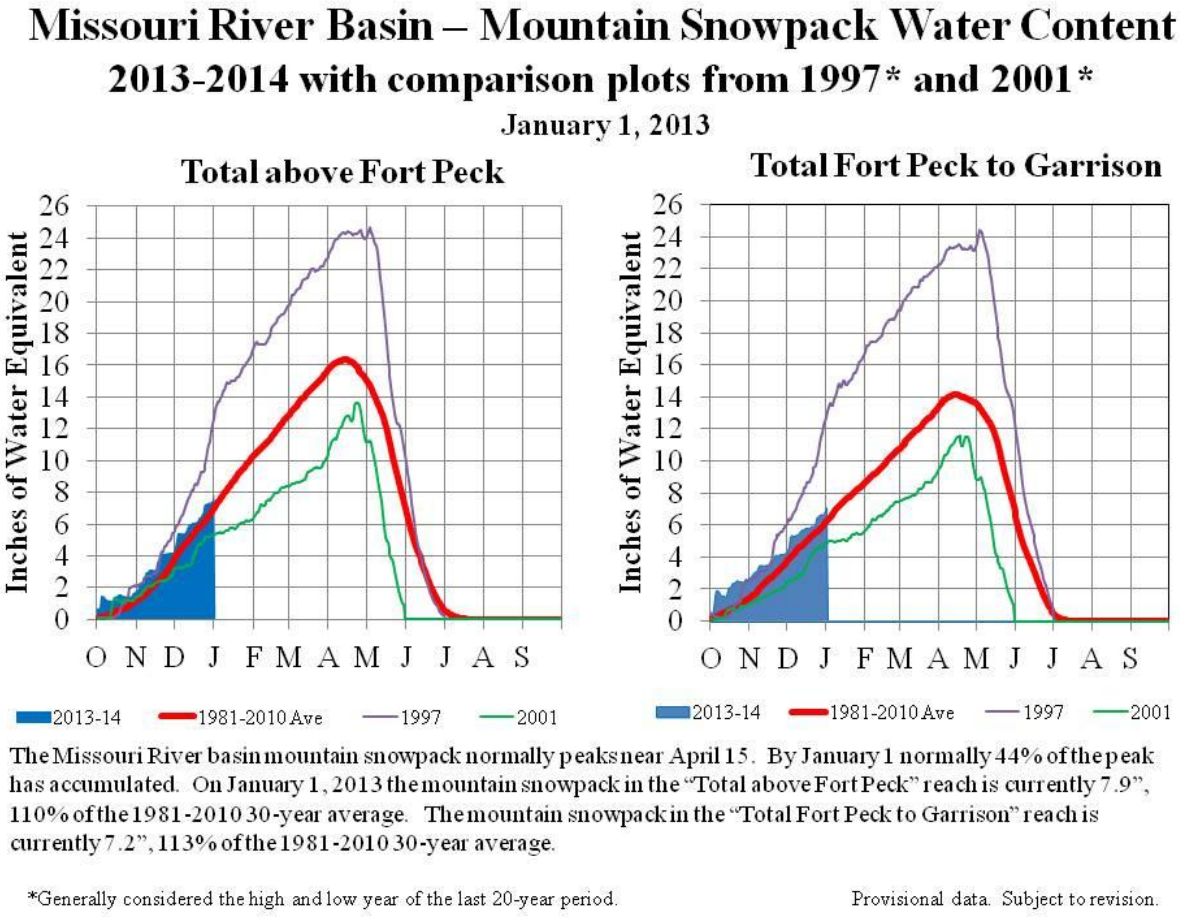


Figure 13. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

The El Nino Southern Oscillation is currently in a neutral phase, which is expected to persist into the summer of 2014. During a neutral phase, there is not a strong indicator of winter weather conditions usually associated with El Nino/La Nina.

The Climate Prediction Center's January outlook (Figure 13) is indicating colder than normal conditions for Montana, North and South Dakota, and Iowa, all other areas of the basin show equal chances for above, below or normal temperatures. With regard to precipitation, there are above normal chances for above normal precipitation in Montana and equal chances for above, below or normal precipitation in all other areas.

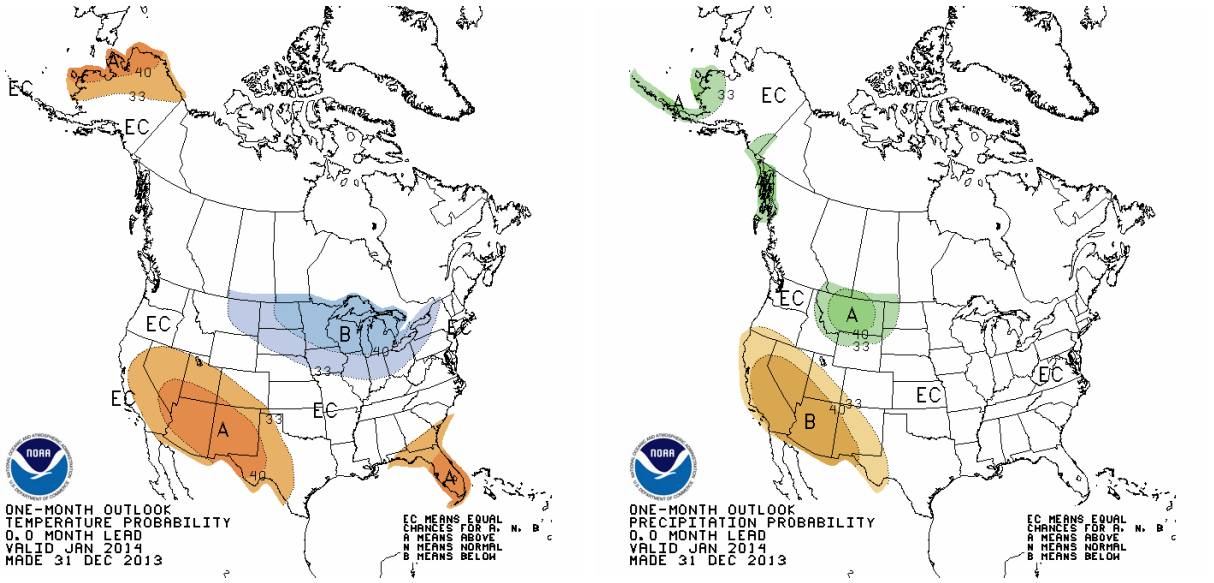


Figure 13. CPC January 2014 temperature and precipitation outlooks.

The three-month climate outlook ending in March 2014 (Figure 14) indicates cooler than normal temperatures in Montana and North Dakota, with equal chances for all other areas. In terms of precipitation, there are equal chances for all portions of the basin. Looking further into 2014, the CPC's climate outlook for April-June (Figure 15) is indicating an increased probability for below normal temperatures in northern Montana and western North Dakota, and equal chances for above, below or normal temperatures in the remainder of the basin. In terms of precipitation, there are equal chances for above, below or normal precipitation throughout the upper Missouri River basin.

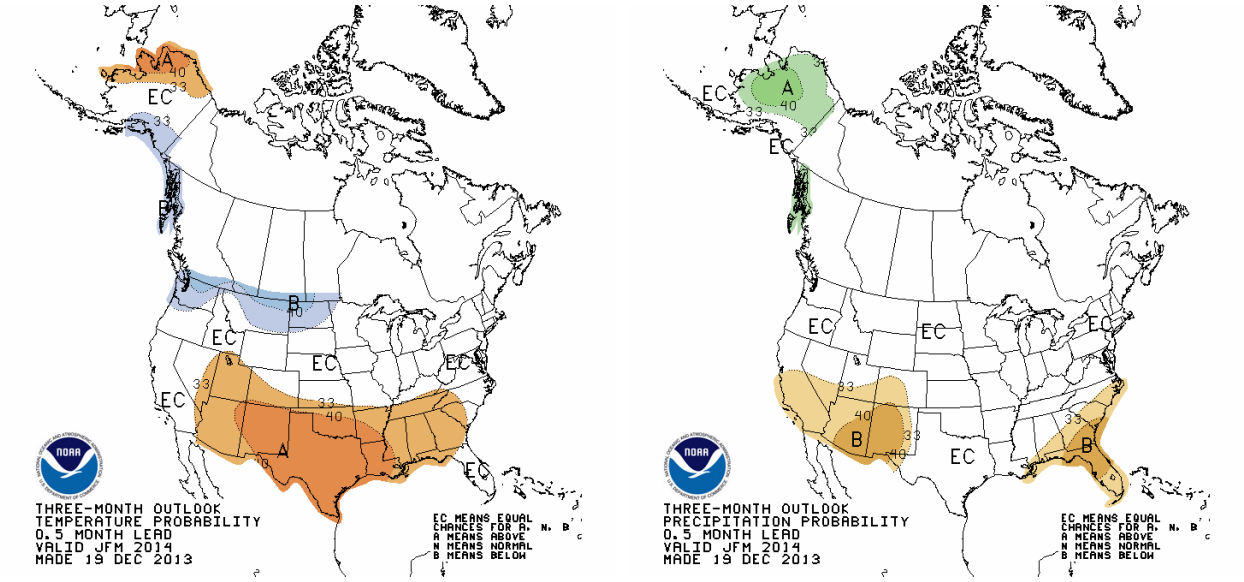


Figure 14. CPC January-February-March 2014 temperature and precipitation outlook.

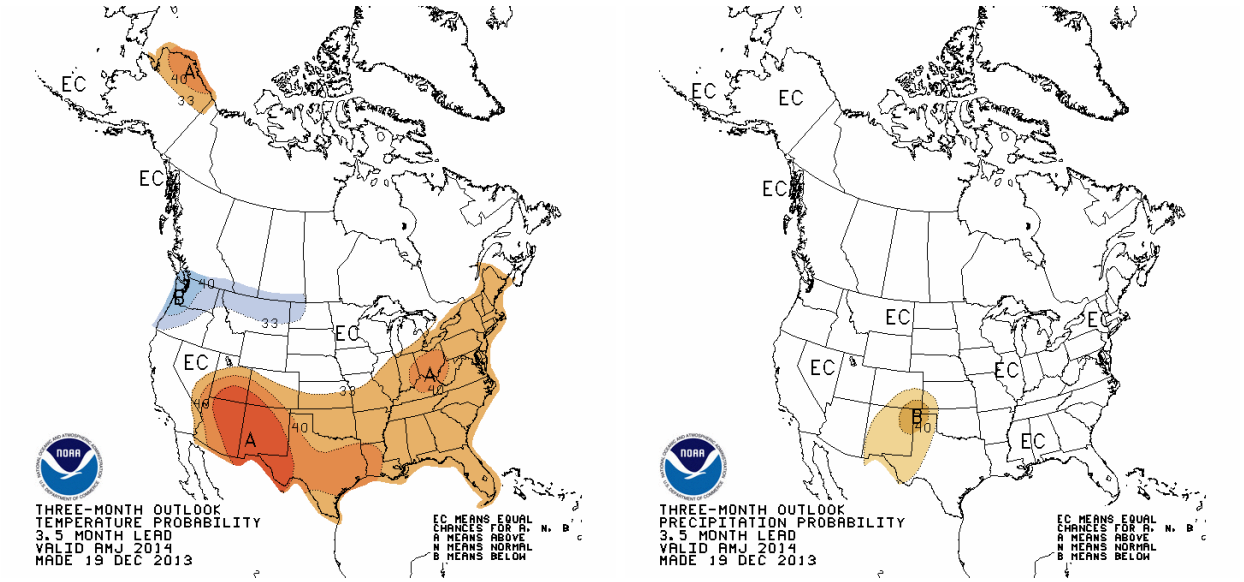


Figure 15. CPC April-May-June 2014 temperature and precipitation outlook.

Climate outlooks for July-September 2013 and October – December 2013 are provided in Figures 16 and 17. The CPC is indicating an increased probability for above normal temperatures in central Montana, Wyoming, and Colorado through September. The precipitation outlook indicates equal chances for above, below and normal precipitation for all of the Missouri River basin. Finally, in the October through December outlook, the CPC is indicating above-normal temperatures for all of the basin and equal chances for above, below and normal precipitation.

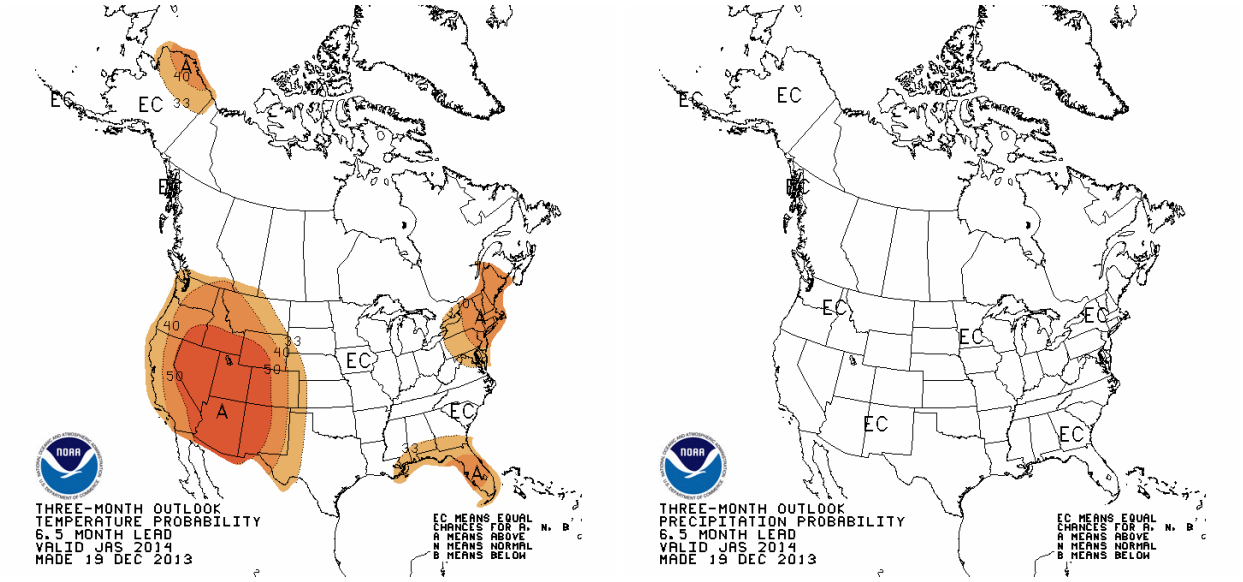


Figure 16. July-August-September 2014 temperature and precipitation outlook.

.

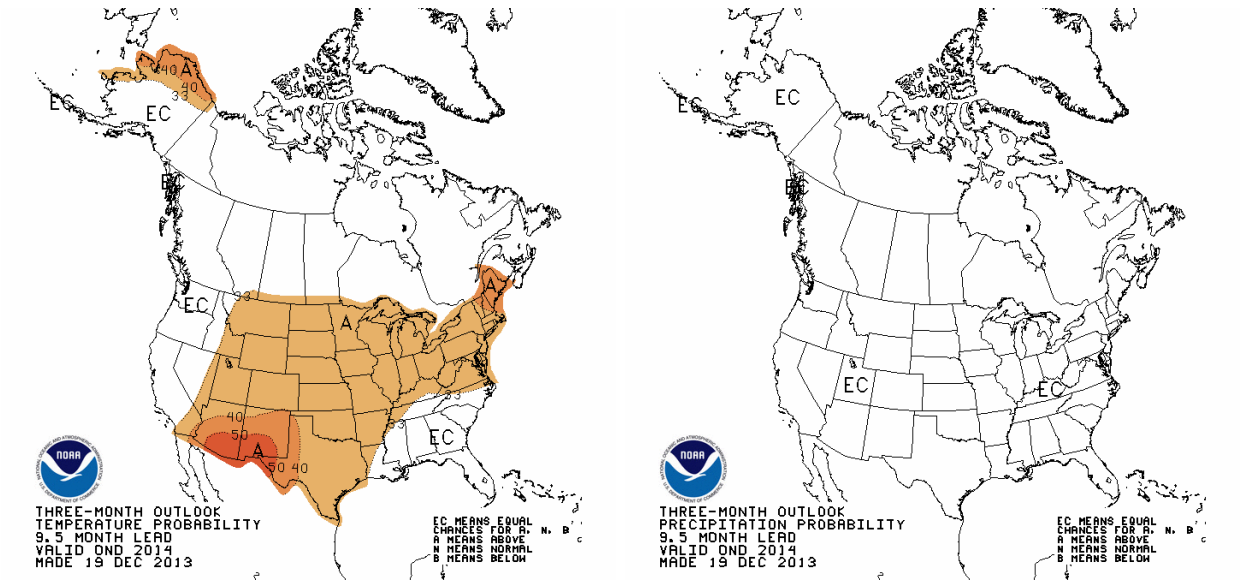


Figure 17. CPC October-November-December 2014 temperature and precipitation outlook.

January 2014 Calendar Year Runoff Forecast

The calendar year runoff forecast is 26.1 MAF (104% of average) above Sioux City and 23.9 MAF (104% of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 36.0 MAF upper basic forecast to the 17.4 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. It should be

noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

Factors taken into consideration while preparing the 2013 forecast include: continuing drought conditions in the upper Missouri River basin, soil moisture content, antecedent precipitation, antecedent temperature conditions, plains snowpack, mountain snowpack, and the CPC's monthly and seasonal temperature and precipitation outlooks.

January-February

Runoff in Dec 2013 was 94% of normal because of colder than normal temperatures slowing runoff due to ice formation.

January and February runoff is expected to be below normal due to the colder conditions that have recently frozen up any available water. February runoff volumes are higher than January because there is an inherent chance that some snowmelt runoff will occur near the end of February with intermittent warm periods.

March-April

Plains snowpack is a significant factor influencing the volume of runoff in March and April; however, snow and rainfall precipitation during this time period are also very important factors that need consideration. Furthermore, antecedent accumulated precipitation and antecedent soil moisture conditions have a significant influence on March-April runoff.

Plains snowpack is Light in the Fort Peck and Oahe reaches, while it is considered Light-Moderate in the Garrison reach. The Plains Snowpack Category Runoff forecast method was used to initially estimate March-April runoff, then these values were adjusted for localized soil moisture and recent runoff conditions. Due to much wetter soil moisture conditions in Fort Peck, Garrison, and Oahe reaches, above normal runoff is forecast in these reaches in March-April. Below normal runoff is forecast in the Fort Randall, Gavin's Point and Sioux City reaches.

The CPC's climate outlook indicates colder than normal temperatures from January – March in the Fort Peck and Garrison subbasins with equal chances for above, below and normal precipitation in the entire basin. Therefore March and April runoff are forecast to be 110 and 118% of average into Fort Peck, 138 and 128% of average into Garrison, and 109 and 107% of average into Oahe. The climate outlook is less favorable for runoff in the other reservoir reaches, therefore March-April runoff is forecast to be slightly less into Fort Randall, Gavins Point and Sioux City.

May-June-July

During the May-June-July period, the mainstem system 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.

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 to runoff. Using the January 1, 2014 mountain snowpack (110% of average in the reach above Fort Peck and 113% of average in the reach between Fort Peck and Garrison) and the CPC 3-month outlooks of spring precipitation and temperatures, the May-June-July runoff is forecast to be 103% of average in the Fort Peck and Garrison reaches.

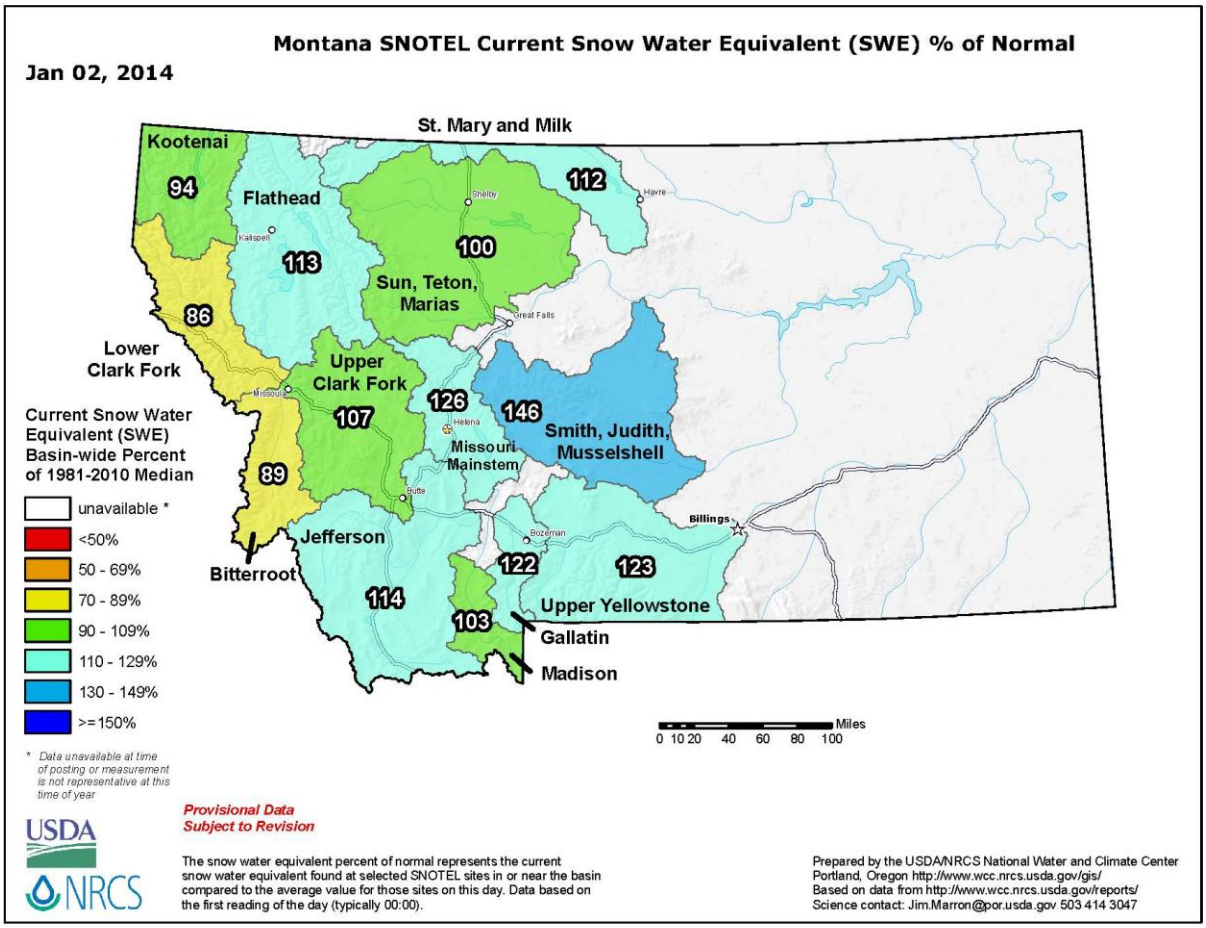
The significance of accurately forecasting the May-June-July runoff for the Fort Peck and Garrison reaches is based on the fact that, historically, an average of 9.2 MAF of runoff occurs during these 3 months into these 2 projects. That is 37% of the total annual runoff into the system.

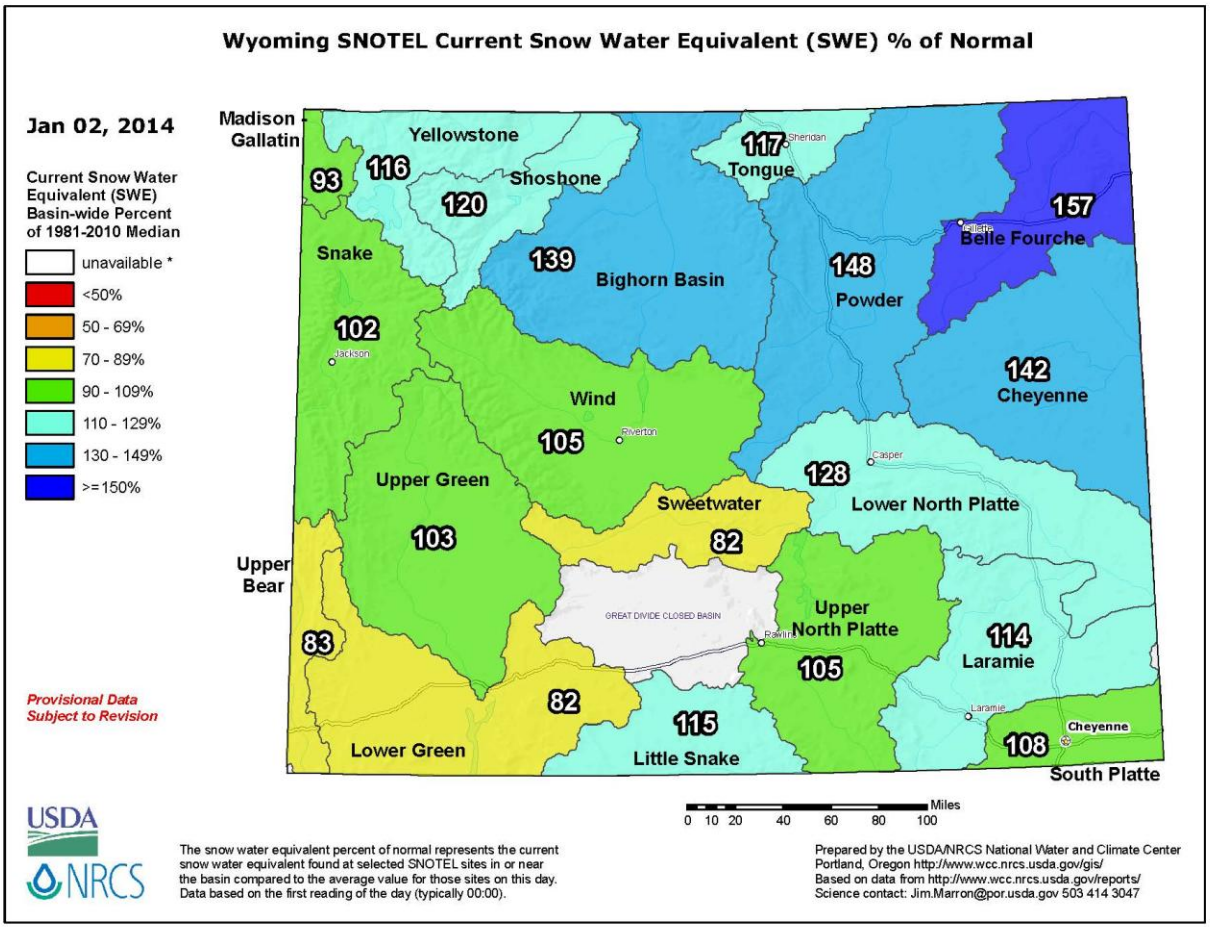
Based on NOAA climate projections and relatively average soil moisture conditions, runoff in the Oahe, Fort Randall and Gavins Point reaches is forecast to be normal.

August through December

For the latter half of 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the basin and equal chances for above, below and normal precipitation. Consequently runoff for all reaches are forecasted to be essentially normal.

Additional Figures and Information




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Jan 02, 2014
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison Gallatin
Yellowstone
93
116
120
Shoshone
117
Tongue
Sheridan
157
Belle Fourche
Snake
139
Bighorn Basin
148
Powder
102
Jackson
142
Cheyenne
Wind
105
Riverton
Casper
128
Lower North Platte
Upper Green
103
Sweetwater
82
Upper Bear
GREAT DIVIDE CLOSED BASIN
Upper North Platte
Rawlins
83
105
114
Laramie
82
115
Little Snake
Laramie
Cheyenne
108
South Platte
Lower Green
0 10 20 40 60 80 100 Miles
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

USDA NRCS National Water & Climate Center

*** - DATA CURRENT AS OF: January 07, 2014 12:11:49 PM**

- Based on January 01, 2014 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	94	97	114	102	86	74	97
	APR-SEP	109	97	130	118	101	89	112
St. Mary R at Int'l Boundary (2)	APR-JUL	405	93	525	455	360	290	435
	APR-SEP	470	93	590	520	420	350	505
Lima Reservoir Inflow (2)	APR-JUL	57	70	99	74	40	15.0	82
	APR-SEP	60	67	107	79	41	12.7	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	68	67	167	108	28	-15.0	101
	APR-SEP	85	71	193	128	41	-4.0	120
Jefferson R nr Three Forks (2)	APR-JUL	720	97	1180	905	535	260	740
	APR-SEP	795	99	1310	1000	590	285	800
Hebgen Reservoir Inflow (2)	APR-JUL	345	93	455	390	300	235	370
	APR-SEP	435	93	570	490	385	305	470
Ennis Reservoir Inflow (2)	APR-JUL	575	92	730	640	510	420	625
	APR-SEP	710	92	890	785	635	525	775
Missouri R at Toston (2)	APR-JUL	1760	98	2530	2070	1450	995	1790
	APR-SEP	2040	99	2930	2400	1680	1150	2070
Smith R bl Eagle Ck (2)	APR-JUL	142	134	197	164	120	87	106
	APR-SEP	161	139	225	187	135	97	116
Gibson Reservoir Inflow (2)	APR-JUL	330	84	450	380	280	210	395
	APR-SEP	365	83	490	415	315	240	440
Marias R nr Shelby (2)	APR-JUL	330	96	530	410	250	132	345
	APR-SEP	340	94	545	425	255	135	360
Milk R at Western Crossing	MAR-SEP	28	87		44	18.4	9.3	33
Milk R at Eastern Crossing	MAR-SEP	60	75		82	40	21	82

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	56	95	66	60	52	46	59
	APR-SEP	72	97	84	77	67	59	74
Wind R ab Bull Lake Ck (2)	APR-JUL	500	110	660	565	435	340	455
	APR-SEP	540	110	720	615	465	360	490
Bull Lake Ck nr Lenore	APR-JUL	146	105	180	160	132	112	139
	APR-SEP	178	105	220	195	161	135	169
Boysen Reservoir Inflow (2)	APR-JUL	665	109	1050	820	510	285	610
	APR-SEP	740	111	1170	915	565	310	665
Greybull R nr Meeteetse	APR-JUL	157	120	193	172	143	121	131
	APR-SEP	215	121	260	230	195	167	177
Shell Ck nr Shell	APR-JUL	59	107	74	65	53	44	55
	APR-SEP	71	108	87	78	64	55	66
Bighorn R at Kane (2)	APR-JUL	975	116	1440	1160	785	510	840
	APR-SEP	1060	117	1580	1270	855	550	905
NF Shoshone R at Wapiti	APR-JUL	485	105	585	525	445	385	460
	APR-SEP	545	106	645	585	500	440	515
SF Shoshone R nr Valley	APR-JUL	230	107	280	250	210	181	215
	APR-SEP	265	108	320	285	240	210	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	710	105	870	775	645	550	675
	APR-SEP	785	105	955	855	720	620	745
Bighorn R nr St. Xavier (2)	APR-JUL	1550	112	2130	1790	1320	980	1380
	APR-SEP	1670	114	2320	1940	1410	1030	1460
Little Bighorn R nr Hardin	APR-JUL	101	103	153	122	80	49	98

	APR-SEP	114	103	171	137	91	58	111
Tongue R nr Dayton (2)	APR-JUL	90	105	124	104	76	56	86
	APR-SEP	103	105	140	118	88	67	98
Tongue River Reservoir Inflow (2)	APR-JUL	200	104	315	245	156	89	193
	APR-SEP	225	105	345	275	178	108	215
NF Powder R nr Hazelton	APR-JUL	11.8	130	15.1	13.1	10.5	8.5	9.1
	APR-SEP	12.8	129	16.2	14.2	11.5	9.4	9.9
Powder R at Moorhead	APR-JUL	225	127	340	270	179	110	177
	APR-SEP	250	128	370	300	200	129	196
Powder R nr Locate	APR-JUL	255	128	395	315	199	115	199
	APR-SEP	285	130	435	345	225	133	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAR-JUL	10.4	168	15.1	12.3	8.5	5.7	6.2
	APR-JUL	9.0	173	14.4	11.0	7.2	4.9	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	43	172	66	52	34	20	25
	APR-JUL	39	177	70	50	29	17.2	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	APR-JUL	230	102	350	280	181	110	225
	APR-SEP	255	102	385	310	200	123	250
Encampment R nr Encampment	APR-JUL	130	101	187	153	107	73	129
	APR-SEP	139	101	199	163	115	79	138
Rock Ck nr Arlington	APR-JUL	56	114	74	63	49	38	49
	APR-SEP	59	113	78	67	51	40	52
Seminoe Reservoir Inflow (2)	APR-JUL	710	99	1130	880	540	295	715
	APR-SEP	765	99	1210	945	585	320	770
Sweetwater R nr Alcova	APR-JUL	33	56	69	48	18.3	7.5	59
	APR-SEP	37	58	76	53	21	7.8	64
La Prele Ck ab La Prele Reservoir	APR-JUL	19.2	96	38	27	11.8	0.75	19.9
	APR-SEP	19.5	98	38	27	12.0	0.90	19.9
North Platte R-Alcova to Orin Gain	APR-JUL	57	112	192	112	2.5	-78	51
	APR-SEP	20	100	158	76	-36	-118	20
North Platte R bl Glendo Res (2)	APR-JUL	800	98	1060	905	695	535	820
	APR-SEP	820	96	1100	935	710	545	850
North Platte R bl Guernsey Res (2)	APR-JUL	815	99	1140	950	680	485	820
	APR-SEP	850	100	1190	990	710	510	850
Laramie R nr Woods	APR-JUL	113	98	150	128	98	76	115
	APR-SEP	125	99	165	141	108	84	126
Little Laramie R nr Filmore	APR-JUL	56	110	77	64	48	35	51
	APR-SEP	60	109	83	69	51	37	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.
Milk forecasts provided by Alberta, medians are for the 1980-2008 period, there is no max (90%), the 30% column is 25% exceedance, and the 70% column is 75% exceedance.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
February 2014 Calendar Year Runoff Forecast
February 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The February 1, 2014 calendar year forecast for the Missouri River Basin above Sioux City, IA is 26.7 MAF (106% of normal). Runoff above Gavins Point Dam is forecast to be 24.3 MAF (106% of normal). The increase since the January forecast is due to greater than forecast January runoff, an increased precipitation probability in February, and slight increases in the May-July runoff forecast. Runoff is typically slowed during winter months as rivers freeze over and cause temporary reductions to inflows in the reservoir system. Warmer than normal temperatures in Montana, Wyoming, North Dakota and South Dakota contributed to above normal January runoff.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 11 months, the range of expected inflow is quite large and ranges from the 36.4 MAF upper basic forecast to the 18.2 MAF lower basic forecast. 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 11 months are being forecasted for this February 1 forecast (1 month observed/11 months forecast), the range of wetter than normal (upper basic) and lower than normal (lower basic) is attributed to all 6 reaches for all 11 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 Nina)

ENSO-neutral conditions continue in the equatorial Pacific, and equatorial sea surface temperatures are near average across most of the Pacific Ocean. ENSO-neutral conditions are expected to continue into the Northern Hemisphere through the summer of 2014. Therefore, there is not a strong indication of future temperature and precipitation conditions in the Missouri River basin based on ENSO conditions.

Drought Analysis

According to the National Drought Mitigation Center (Figure 1), drought conditions on January 28, 2014 have greatly improved since last year at this time (Figure 2). Montana, North and South Dakota are out of any drought category with the exception of southwest Montana. The majority of Nebraska, Kansas, and Iowa have improved the past year to "Abnormally Dry to Severe Drought" conditions. The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions that are currently impacting central Nebraska and western Kansas will persist through winter and early spring 2014 with limited change in drought category. Further information about long-range climate factors that may impact drought conditions are discussed later in the climate outlook section.

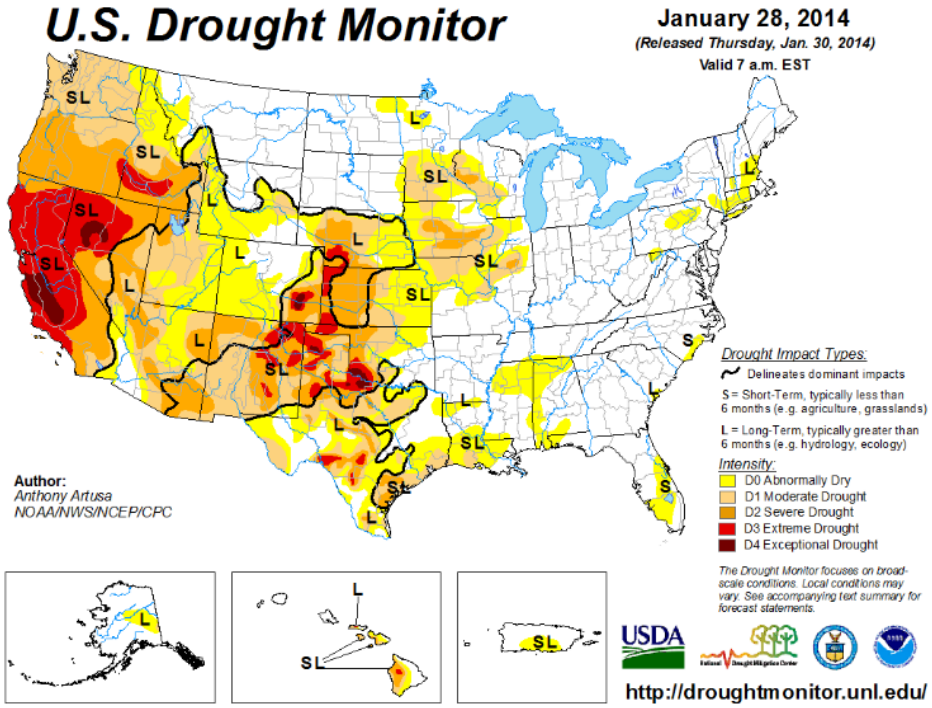


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for January 28, 2014.

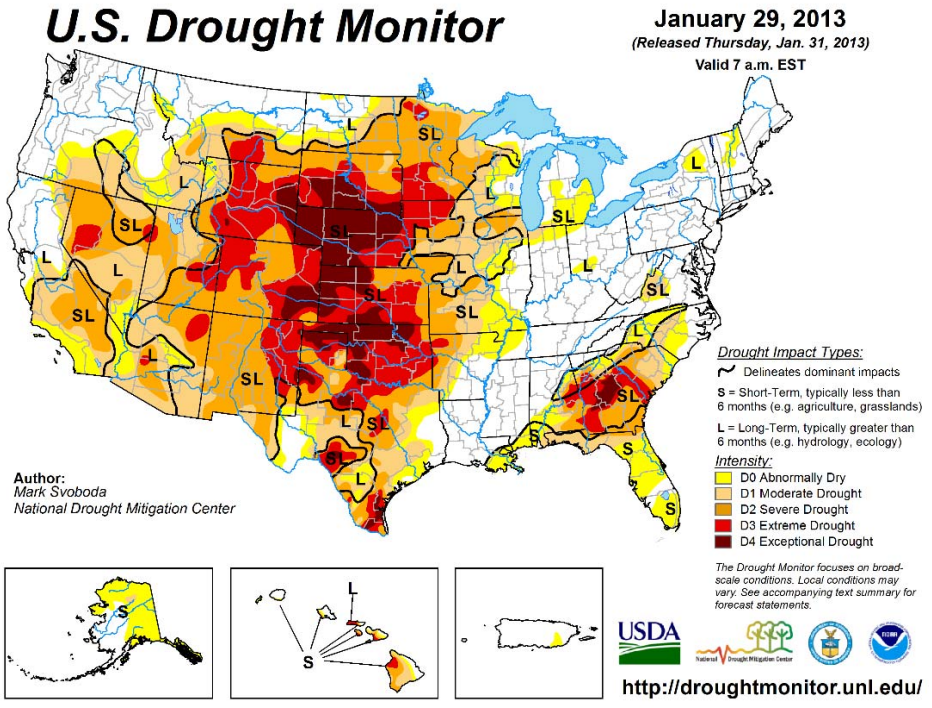


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for January 29, 2013.

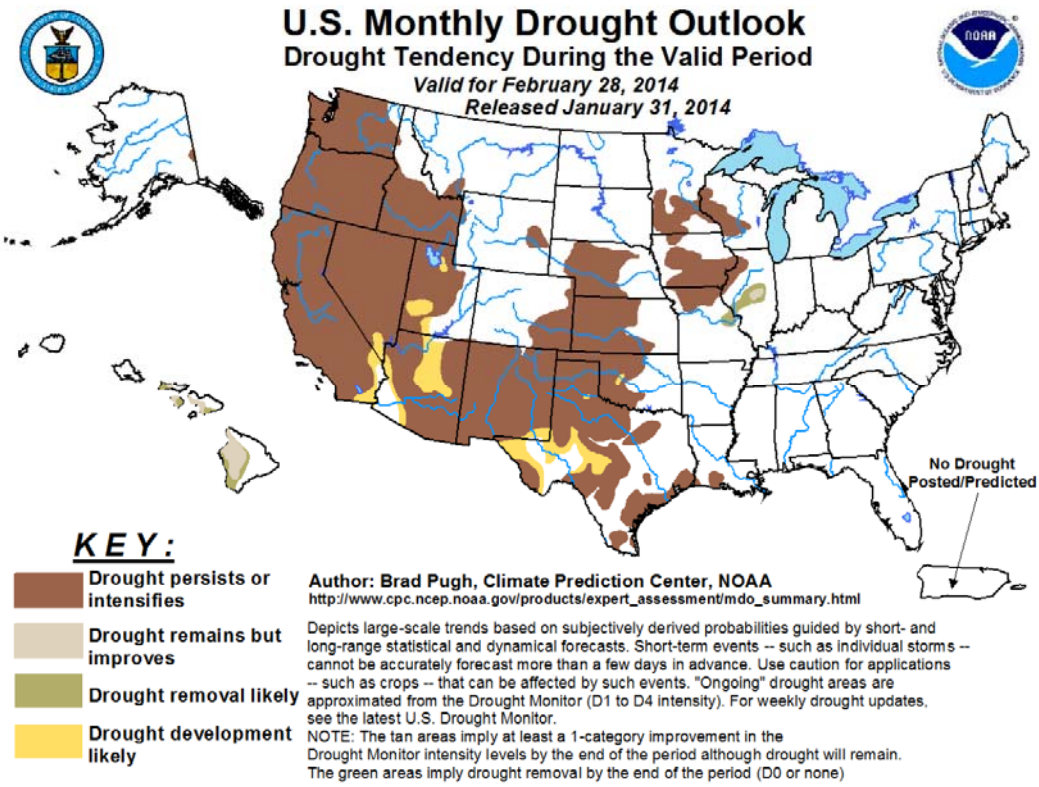


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation as a percent of normal during the month of January is shown in Figure 4. This map was created by the High Plains Regional Climate Center. Precipitation accumulations within the upper Missouri River Basin varied by region with above normal accumulations occurring in western and southern Montana, northern and central Wyoming, and central North Dakota. Well-below normal accumulations occurred over a large portion of northeast Montana, western North Dakota, South Dakota, Nebraska and Iowa.

Accumulated precipitation over the three-month (November-December-January) period ending on January 31, 2014 is shown in Figure 5. Precipitation has been well-below normal in the lower basin below Sioux City, IA and in a majority of the North Dakota and South Dakota. Montana and Wyoming show a mix of above and below normal precipitation accumulations for the past three months; however, wet conditions with characterized by greater than 150% of normal precipitation have occurred over large areas of Montana and a small portion of western North Dakota.

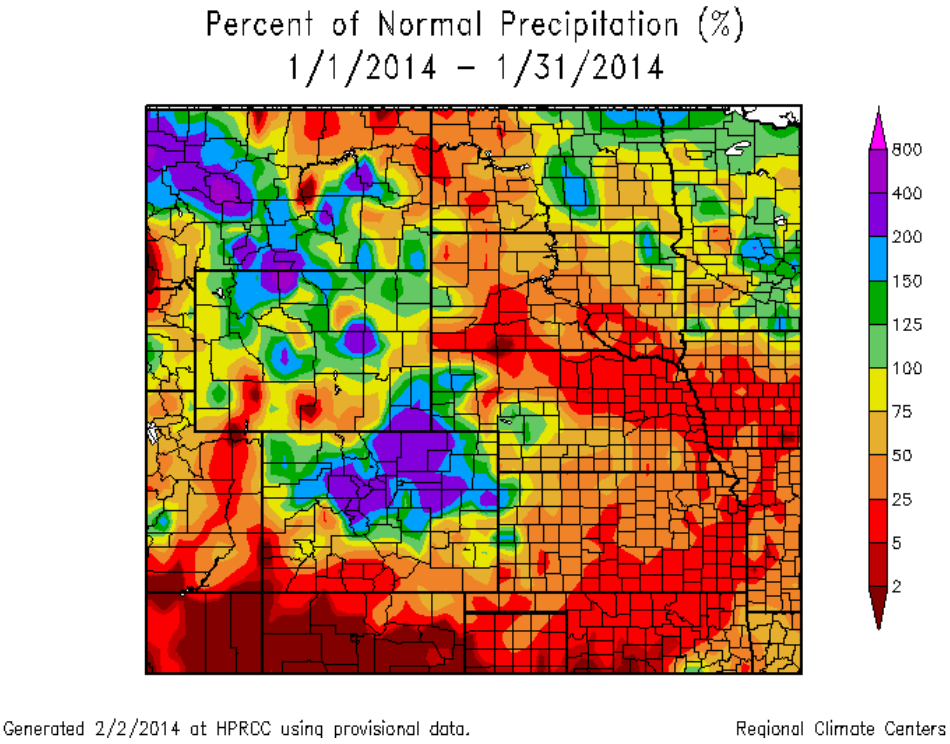


Figure 4. Monthly Percent of Normal Precipitation ending on January 31, 2014.

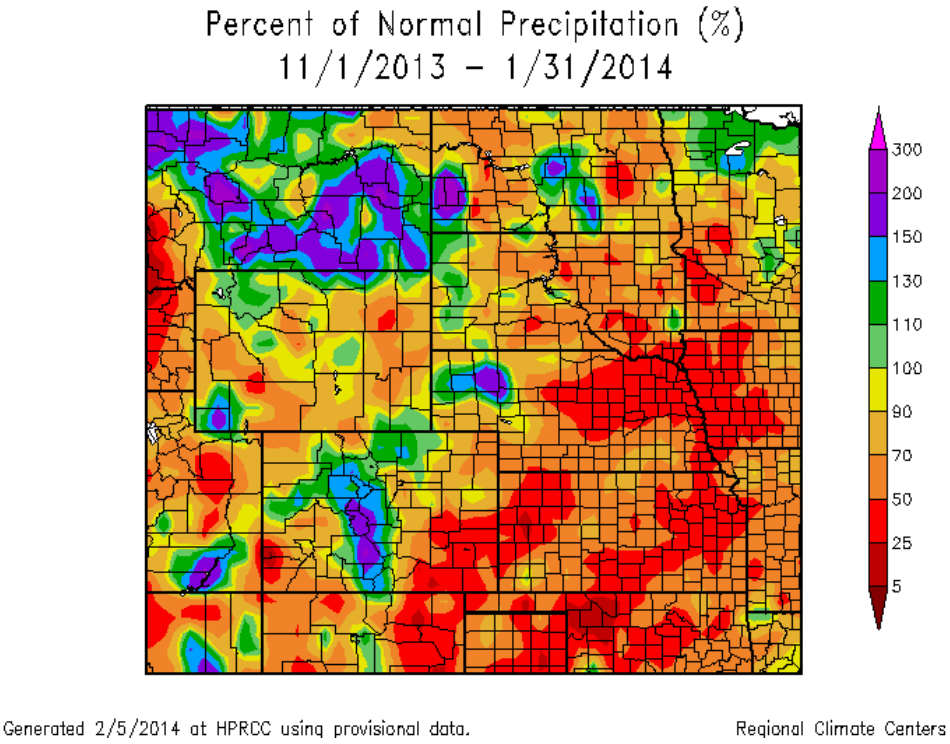


Figure 5. Three-month Percent of Normal Precipitation ending on January 31, 2014.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of January, courtesy of the High Plains Regional Climate Center, is shown in Figure 6. Temperatures in Montana and Wyoming have ranged from 3 to 9 deg F above normal, while in the eastern Dakotas and eastern Nebraska, temperatures have ranged from 0 to 6 deg F below normal. Weather patterns were characterized by fast-moving Alberta clippers that moved through the upper Midwest causing short and very cold temperature outbreaks accompanied by very high winds. In addition very warm temperatures occurred in eastern parts of the basin at times. The warm temperatures in northern and western regions have limited plains snow formation, while in contrast cold temperatures have maintained on-the-ground snow accumulations in the eastern portion of the Basin.

Three-month (November-December-January) temperature departures ending on January 31, 2014 are shown in Figure 7. The three-month map indicates that temperatures have been 0 to 4 deg F colder than normal in a majority of the basin, while temperatures in the mountainous regions of the basin have been 0 to 2 deg F above normal, with some areas up to 4 deg F above normal.

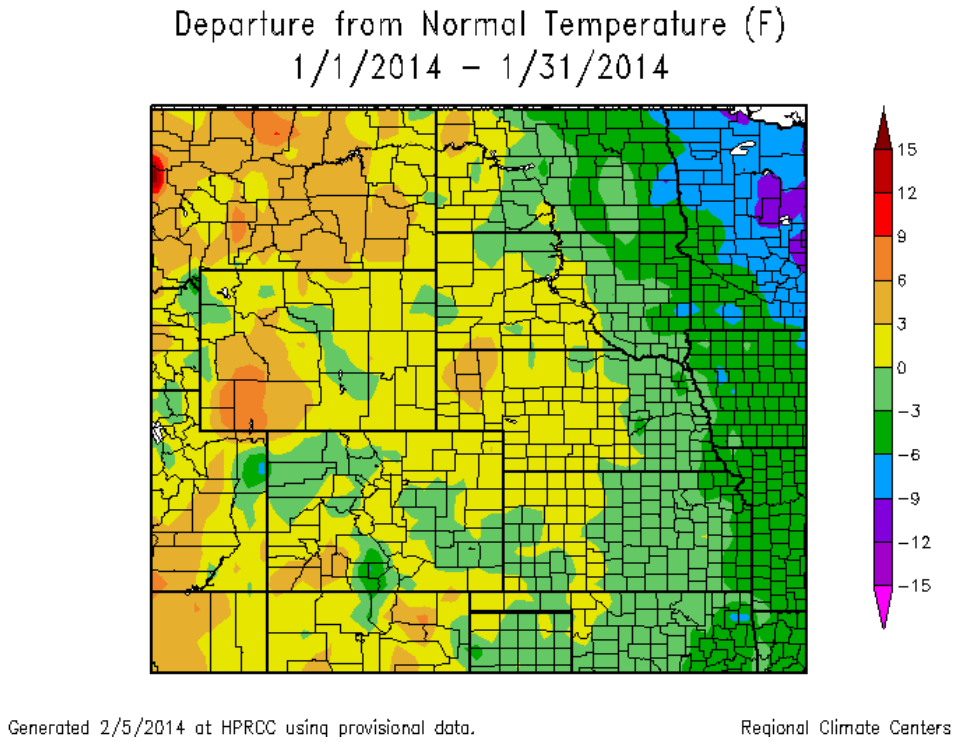


Figure 6. Monthly Departure from Normal Temperature (deg F) ending January 31, 2014.

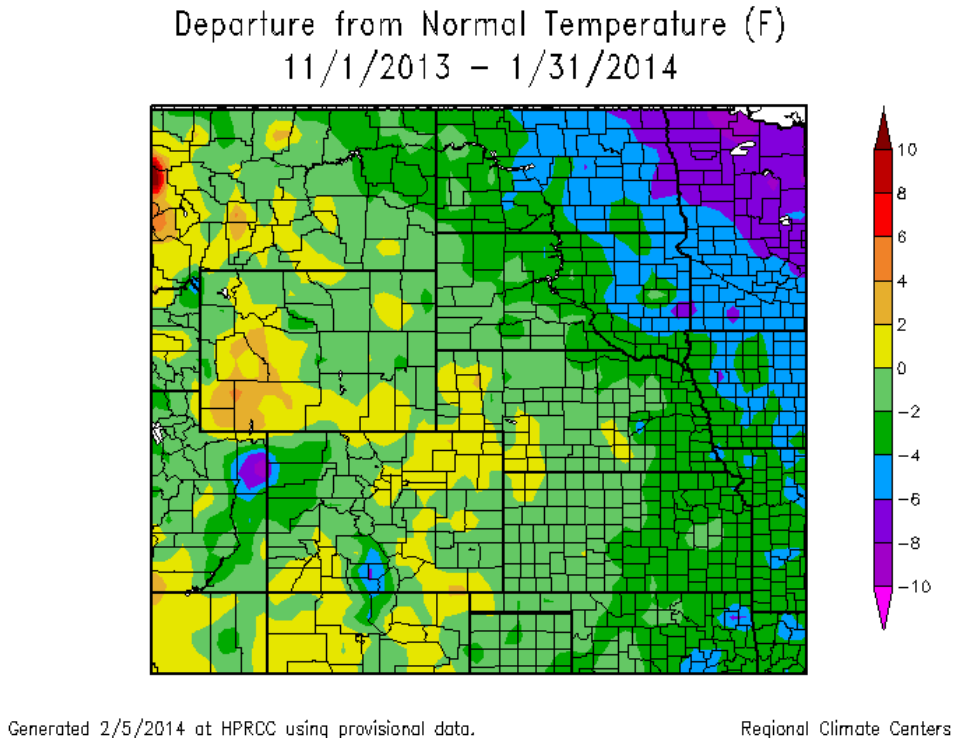


Figure 7. Three-month Departure from Normal Temperature (deg F) ending January 31, 2014.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Three estimates of soil moisture are presented in this report. Figure 8 shows the Climate Prediction Center's calculated soil moisture ranking percentiles on January 31, 2014. Figure 9 shows the Variable Infiltration Capacity model soil moisture percentiles on February 3, 2014. Figure 10 shows the NOAA NLDAS Drought Monitor soil moisture percentiles on January 31, 2014.

All three soil moisture estimates depict very wet soil moisture conditions throughout the upper Missouri River basin in Montana and western portions of North and South Dakota. CPC soil moisture conditions in these areas rank from the 75th to the 95st percentile. Soil moisture conditions in Nebraska, eastern Colorado, Kansas, and Missouri are fairly normal, while Iowa has very dry soil moisture conditions.

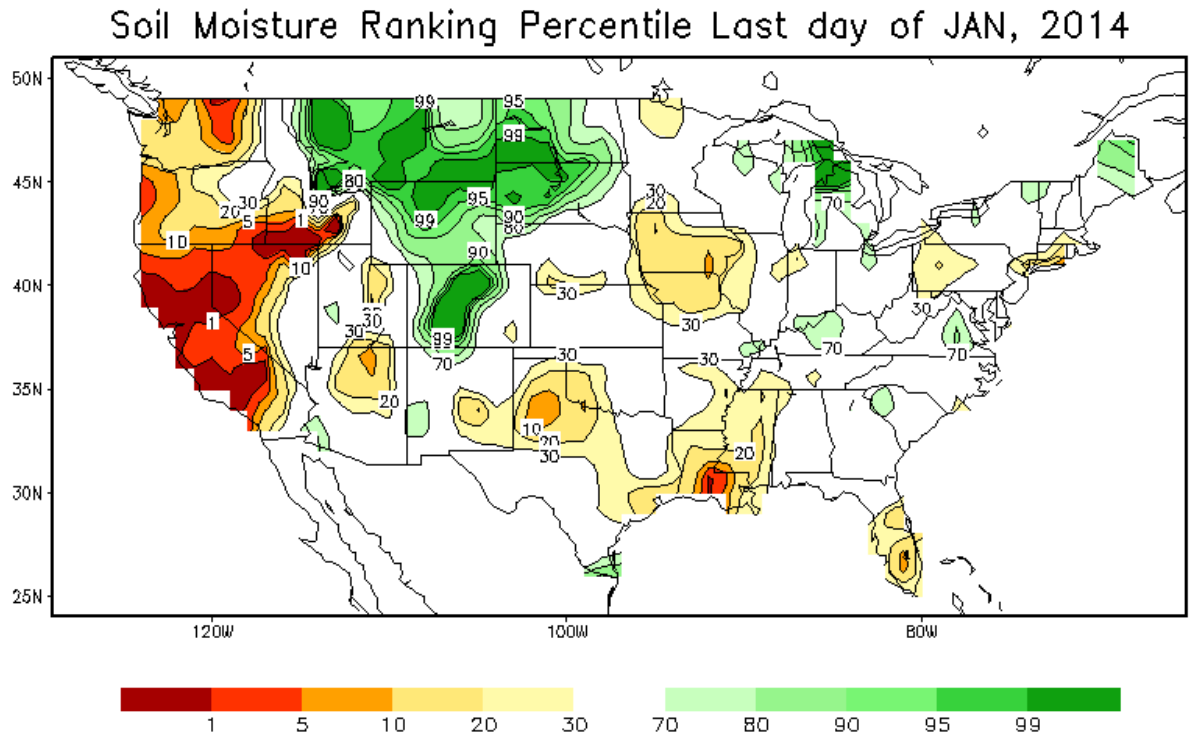


Figure 8. Calculated Soil Moisture Ranking Percentile on January 31, 2014. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

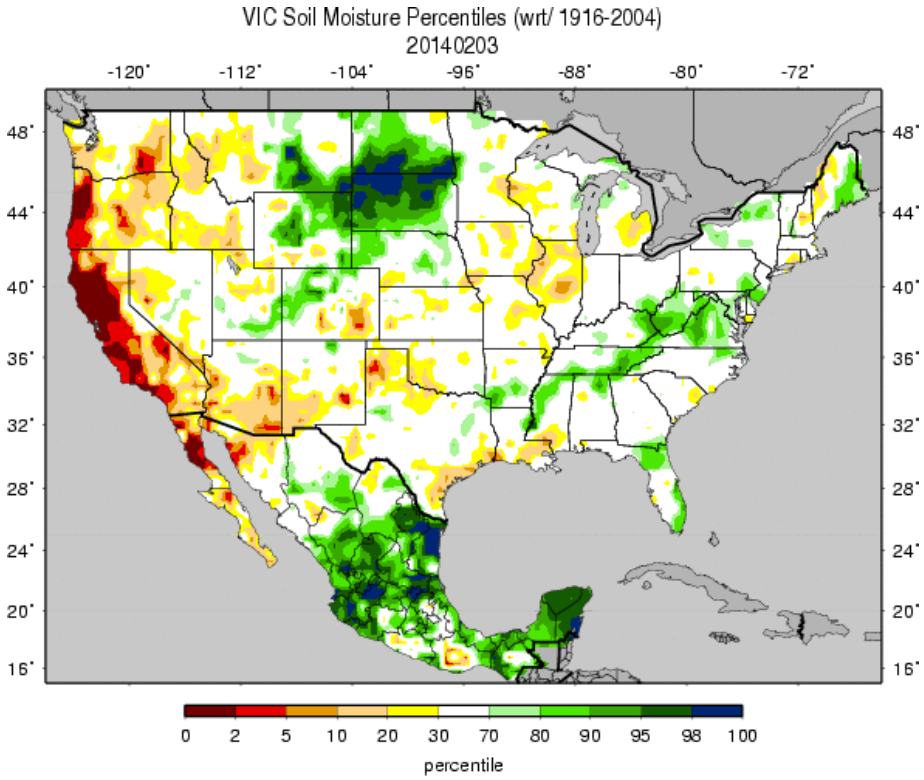


Figure 9. VIC modeled soil moisture percentiles as of February 3, 2014. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

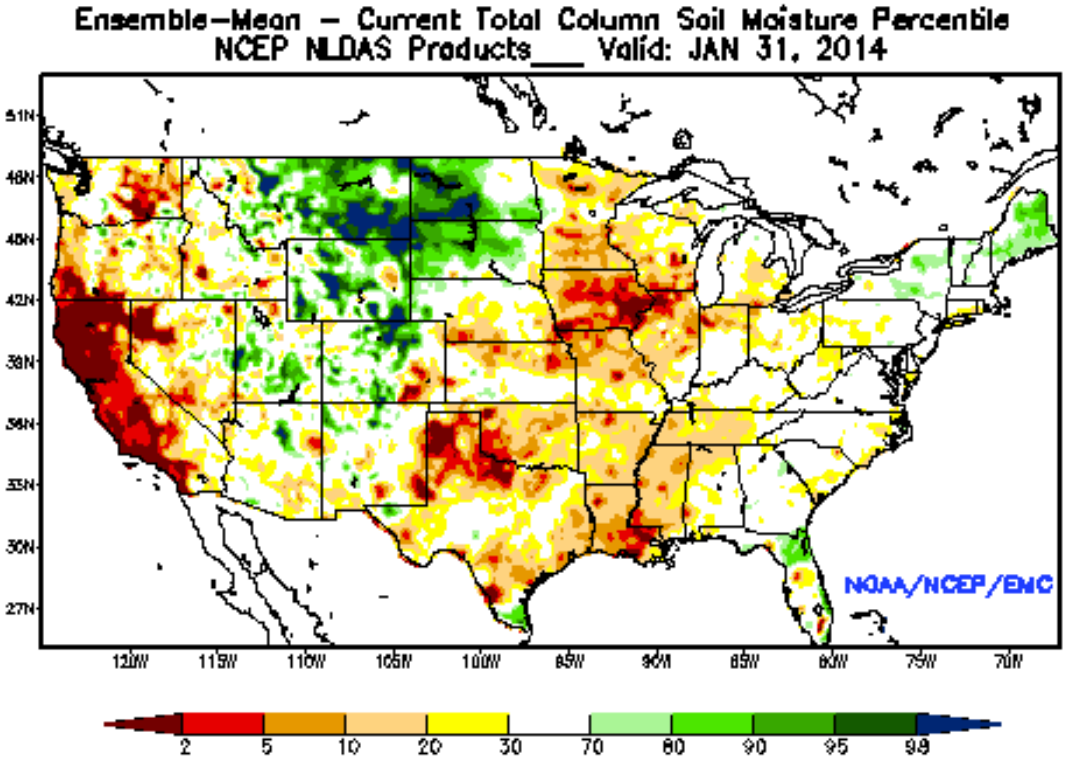


Figure 10. Total Column Soil Moisture Percentile as of January 31, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The CPC calculated soil moisture anomaly for the contiguous U.S. on January 31, 2014 is shown in Figure 11. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 20 mm (0.8 inches). Some areas in North Dakota, South Dakota and Montana have anomalies greater than 80 mm (3.2 inches) of moisture.

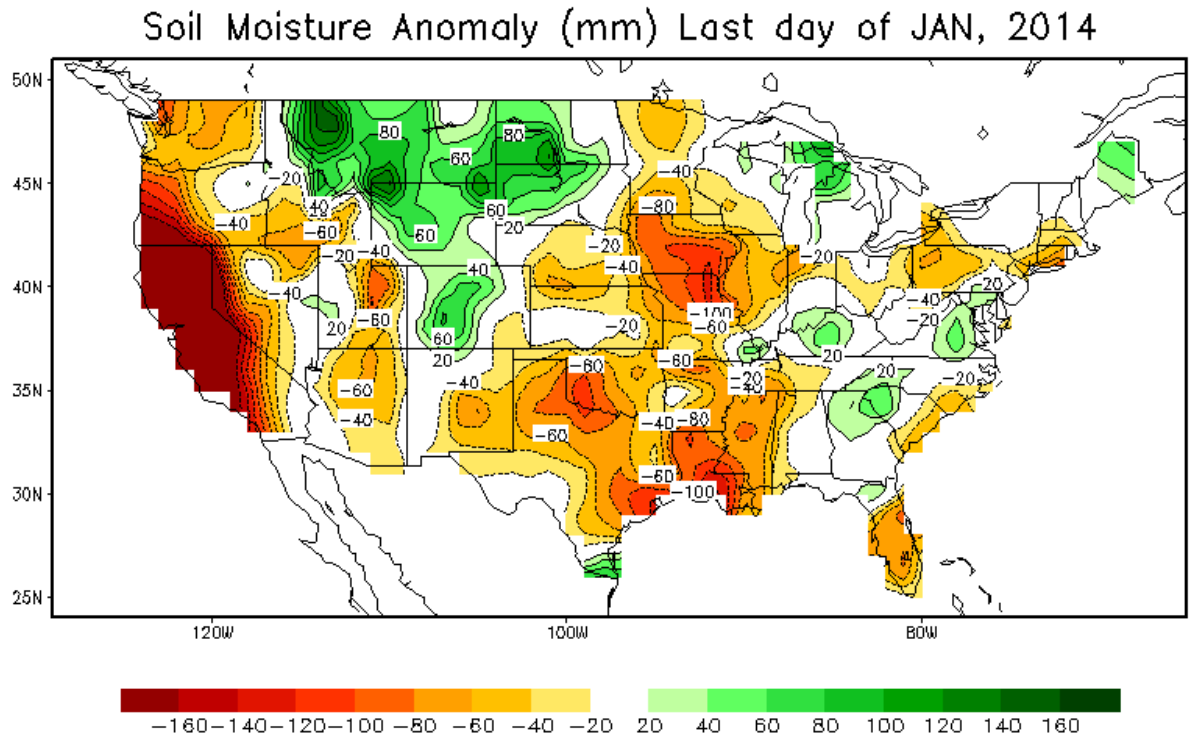


Figure 11. Calculated Soil Moisture Anomaly (mm) on January 31, 2014. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

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. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

Based on the National Operational Hydrologic Remote Sensing Center (NOHRSC) assessment (Figure 12) on February 1, 2014, most plains snow water equivalent (SWE) amounts ranged from trace to 1-inch throughout the upper Missouri River basin. Amounts ranging from 1 to 2 inches were present along the northern and eastern watershed boundary in the upper Basin. Based on the NOHRSC map, a few heavier areas with 3-inch SWE amounts were present in North Dakota and eastern South Dakota.

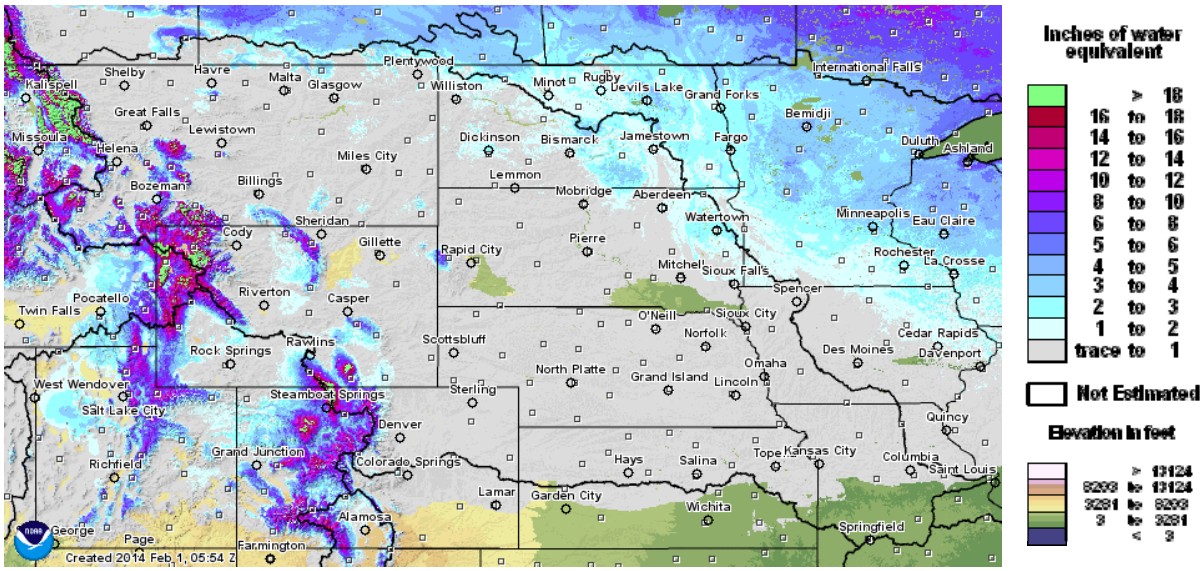


Figure 12. February 1, 2014, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Using the MRBWM snowpack classification method, plains snowpack as of February 1, 2014, was generally classified as Light to slightly less than Light across the upper Missouri River basin (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0 to 1 inch of SWE in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins and 0 to 2 inches in the Gavins Point to Sioux City reach.

Table 1. February 1, 2014 plains snowpack classification for runoff forecasting.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Average-Light (0 – 1 inch SWE)
Fort Peck to Garrison	Light (0 – 2 inch SWE)
Garrison to Oahe	Average-Light (0 – 1 inch SWE)
Oahe to Fort Randall	Average (0 – 0.5 inch SWE)
Fort Randall to Gavins Point	Average (0 – 0.5 inch SWE)
Gavins Point to Sioux City	Light (0 – 2 inch SWE)

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July 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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions.

As of February 1, 2014, the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 11.1 inches, which is 107% of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 9.9 inches, which is 113% of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by February 1, 64% of the peak snow accumulation has occurred in the mountains.

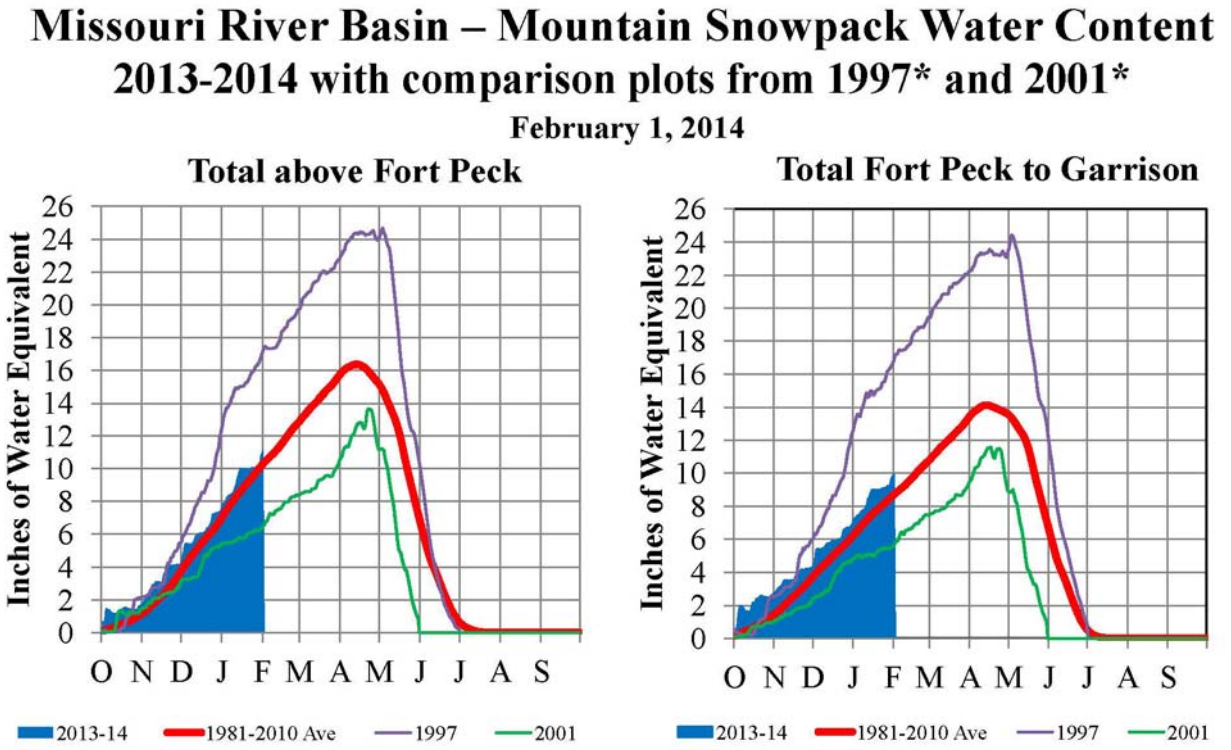


Figure 13. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

The El Nino Southern Oscillation is currently in a neutral phase, which is expected to persist into the summer of 2014. During a neutral phase, there is not a strong indicator of winter weather conditions usually associated with El Nino/La Nina.

The Climate Prediction Center's February outlook (Figure 13) is indicating increased chances for colder than normal conditions in the entire Missouri River Basin. With regard to precipitation, there are increased chances for above normal precipitation in Montana and equal chances for above, below or normal precipitation in all other areas.

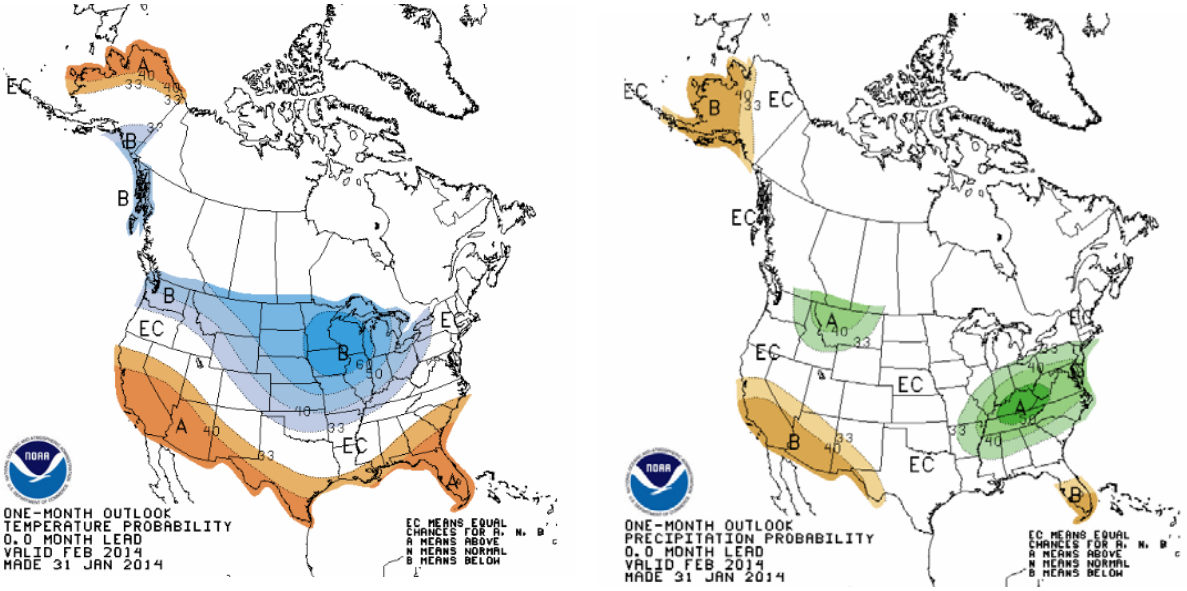


Figure 13. CPC February 2014 temperature and precipitation outlooks.

The three-month climate outlook through April 2014 (Figure 14) indicates increased chances for cooler than normal temperatures in northeast Montana, North Dakota and northern South Dakota, with equal chances in all other areas. In terms of precipitation, there are equal chances for all portions of the basin. Looking further into 2014, the CPC's climate outlook for May-July (Figure 15) is indicating equal chances for above, below and normal temperatures in the upper Basin. There are equal chances for above, below or normal precipitation throughout the upper Basin.

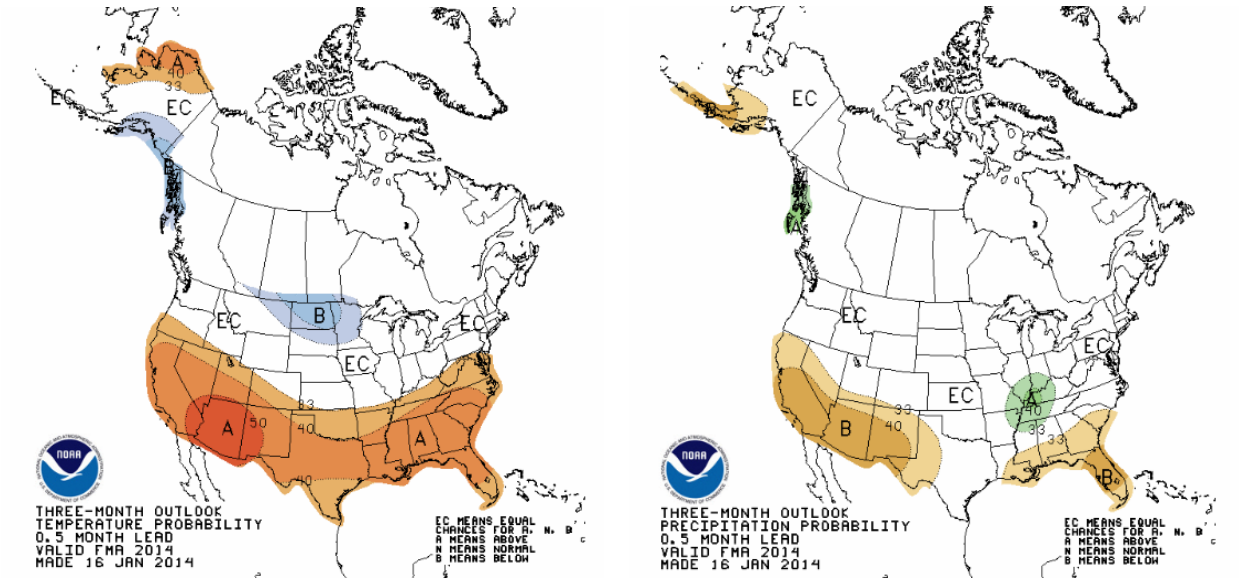


Figure 14. CPC February-March-April 2014 temperature and precipitation outlook.

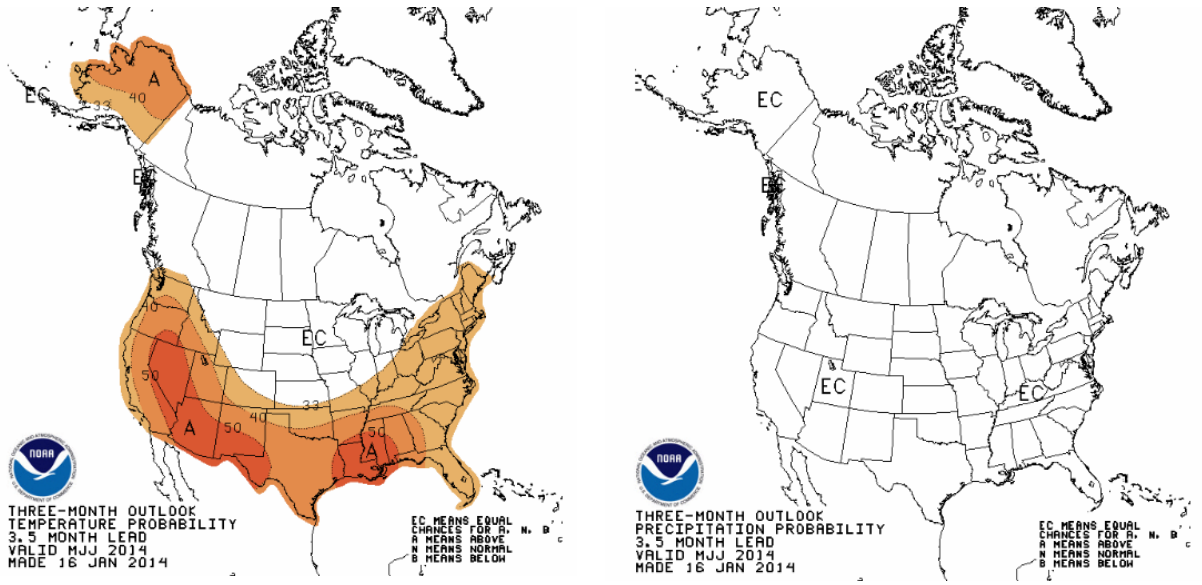


Figure 15. CPC May-June-July 2014 temperature and precipitation outlook.

Climate outlooks for August-October2014 and November 2014 – January 2015 are provided in Figures 16 and 17. The CPC is indicating an increased probability for above normal temperatures in central Montana, Wyoming, and Colorado for August through October. The precipitation outlook indicates equal chances for above, below and normal precipitation for all of the Missouri River basin. Finally, in the November through January outlook, the CPC is indicating equal chances for above, below and normal temperatures for all of the basin and equal chances for above, below and normal precipitation.

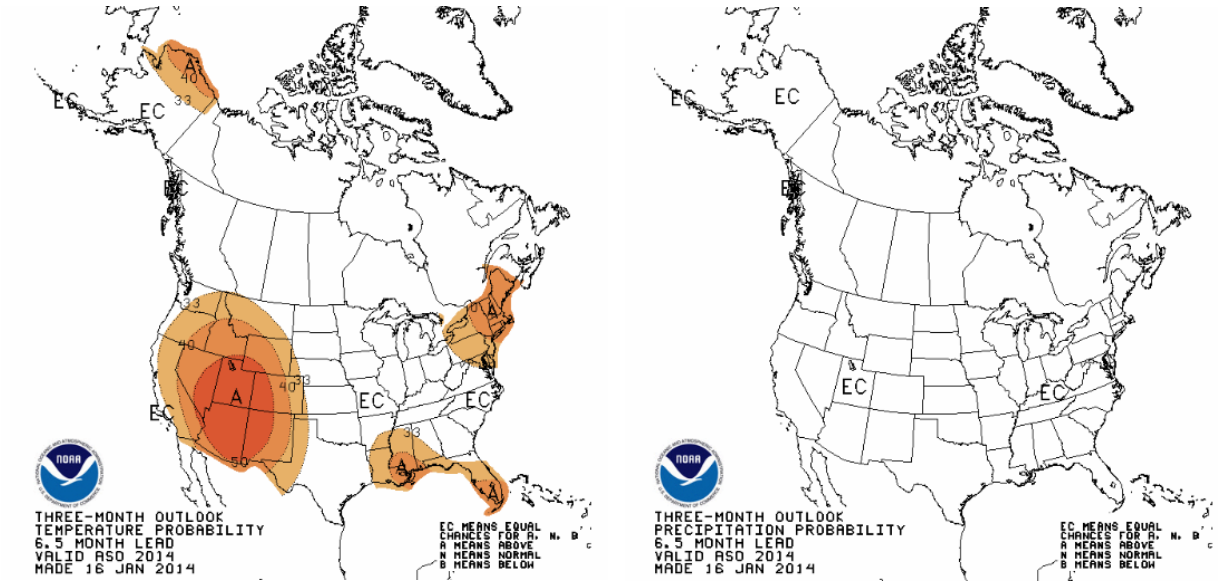


Figure 16. August-September-October 2014 temperature and precipitation outlook.

.

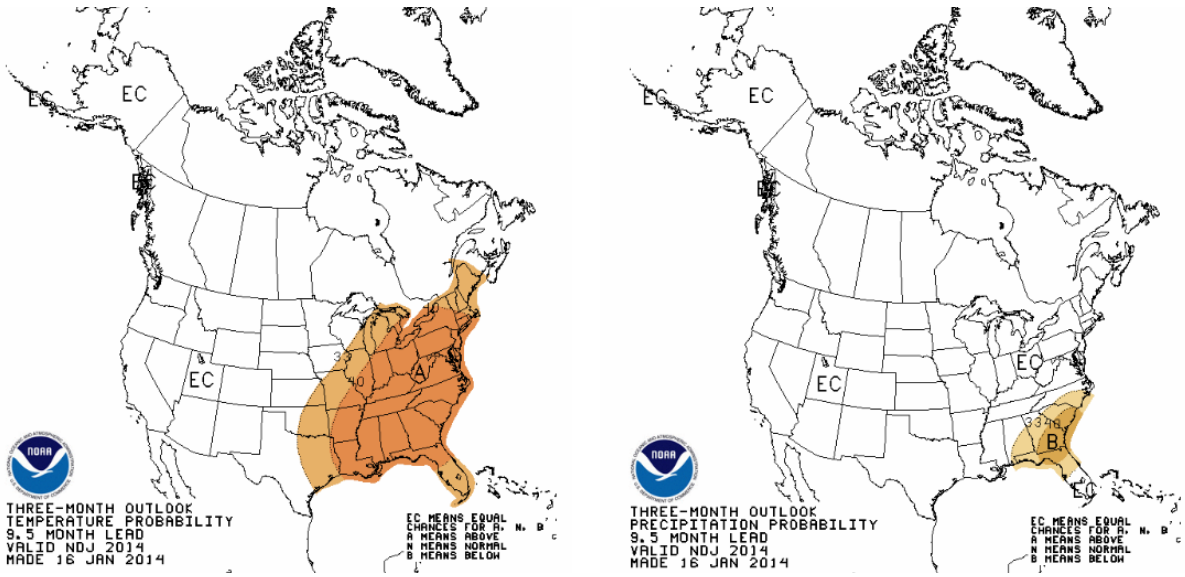


Figure 17. CPC November-December-January 2014-2015 temperature and precipitation outlook.

February 2014 Calendar Year Runoff Forecast

The calendar year runoff forecast is 26.7 MAF (106% of average) above Sioux City and 24.3 MAF (106% of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 11 months, the range of expected inflow is quite large and ranges from the 36.4 MAF upper basic forecast to the 18.2 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. It should be

noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

The increase in the calendar year runoff forecast is due to much higher than normal January runoff (175% of normal), an increased precipitation probability in February, and slight increases in the May-July runoff forecast. Other factors considered in updating the 2014 forecast included soil moisture conditions, plains snowpack, mountain snowpack and the Climate Prediction Center's long range climate outlook.

February

February runoff is expected to be about normal given the 175% of normal runoff in January and the forecast for colder and wetter conditions in the upper basin. Although a forecast for colder conditions could reduce runoff, the chance for wetter conditions neutralizes the loss of runoff due to cold temperatures.

March-April

Plains snowpack is a significant factor influencing the volume of runoff in March and April; however, snow and rainfall precipitation during this time period are also very important factors that need consideration. Furthermore, antecedent accumulated precipitation and antecedent soil moisture conditions have a significant influence on March-April runoff.

The Plains Snowpack Category Runoff forecast method was used to initially estimate March-April runoff, and the values were adjusted for localized soil moisture and recent runoff conditions. Plains snowpack is Light in the Garrison and Sioux City reaches and slightly less, classified as Average-Light, in the Ft. Peck and Oahe reaches. Due to much wetter soil moisture conditions in Fort Peck and Garrison reaches, above normal runoff is forecast in these reaches in March-April. Soil moisture conditions in the Sioux City reach vary from above normal to below normal; however, this reach has maintained its snowpack over the last two months whereas in all other reaches, the snowpack has diminished. Above normal runoff is forecast in the Oahe and Sioux City reaches in March-April. Snowpack is average resulting in a normal runoff forecast level in the Fort Randall and Gavins Point reaches.

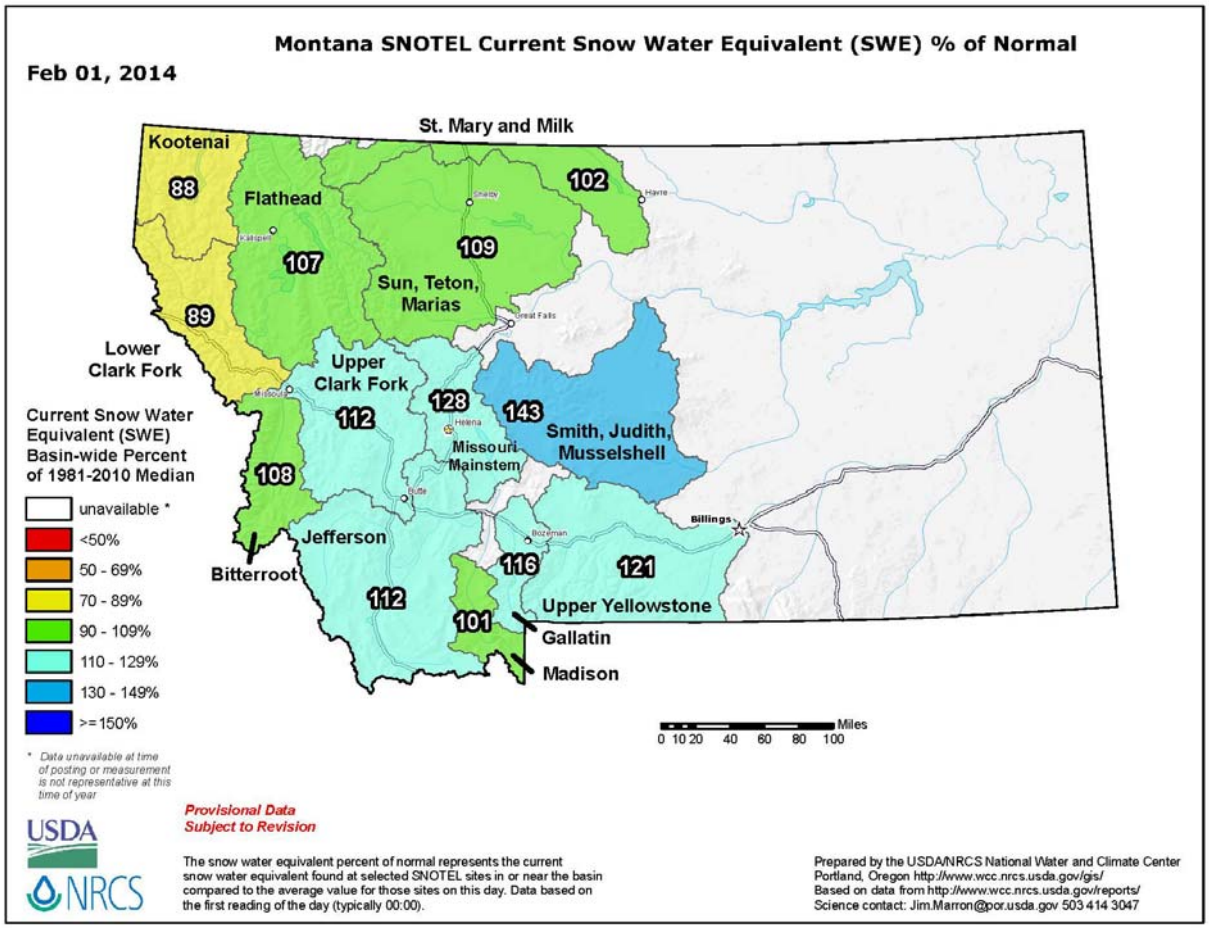
May-June-July

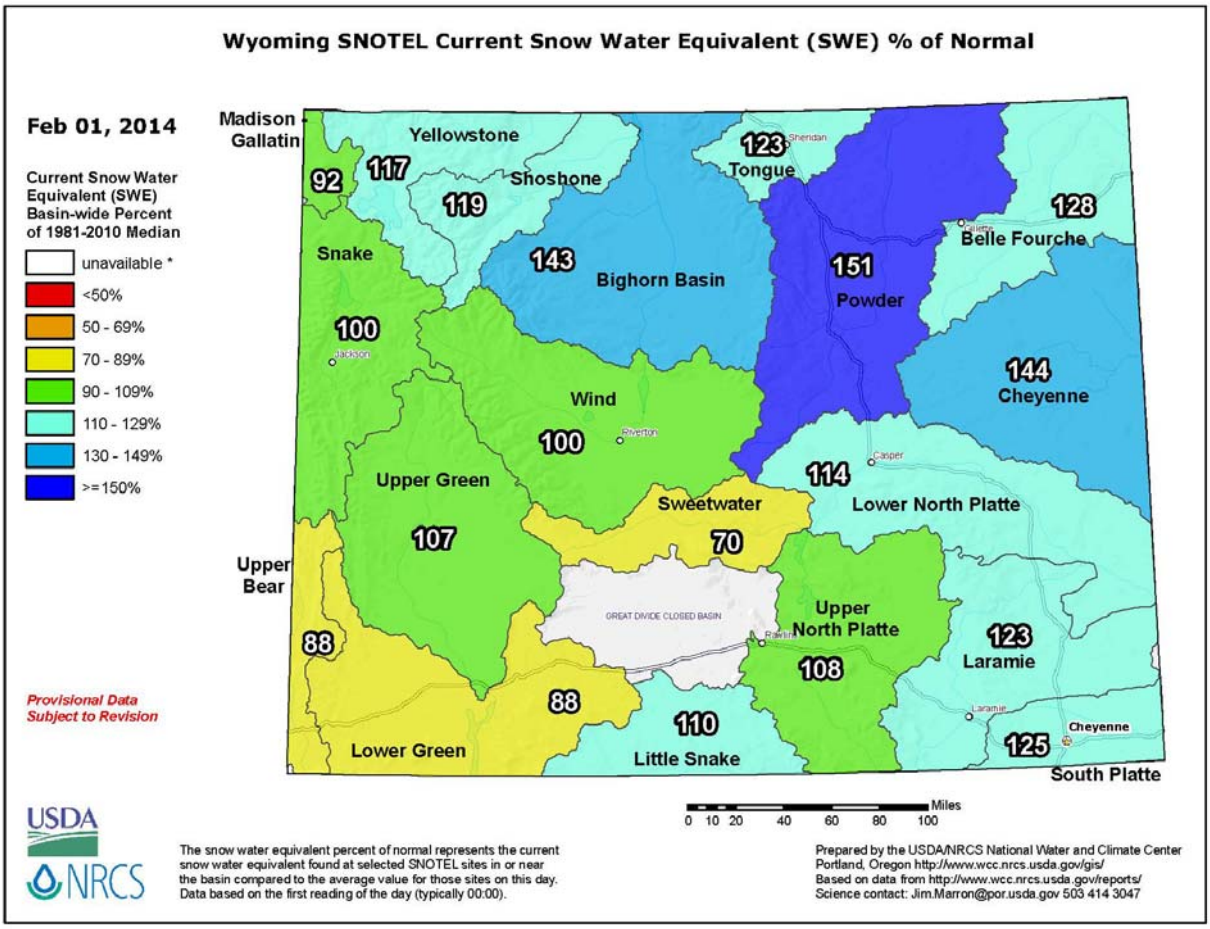
For this three-month period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. Using the February 1, 2014 mountain snowpack (107% of average in the reach above Fort Peck and 113% of average in the reach between Fort Peck and Garrison) and the CPC 3-month outlooks of spring precipitation and temperatures, the May-June-July runoff forecast is 104% of normal runoff above Fort Peck and 106% of normal runoff from Fort Peck to Garrison.

August through December

For the latter half of 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the basin and equal chances for above, below and normal precipitation. Consequently, runoff for all reaches is forecast to be essentially normal, with the exception of slightly less than normal runoff in the Fort Peck and Garrison reaches.

Additional Figures and Information




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Feb 01, 2014
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison Gallatin
Yellowstone
92
117
Shoshone
119
123
Tongue
Sheridan
128
Belle Fourche
Snake
143
Bighorn Basin
151
Powder
100
Jackson
144
Cheyenne
Wind
100
Riverton
Casper
114
Lower North Platte
Upper Green
107
Sweetwater
70
Upper Bear
GREAT DIVIDE CLOSED BASIN
Rawlins
Upper North Platte
108
123
Laramie
88
88
110
Little Snake
Lower Green
Laramie
Cheyenne
125
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

USDA NRCS National Water & Climate Center

** - DATA CURRENT AS OF: February 06, 2014 09:40:16 AM*

- Based on February 01, 2014 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	93	96	108	99	87	78	97
	APR-SEP	107	96	122	113	101	92	112
St. Mary R at Int'l Boundary (2)	APR-JUL	405	93	510	450	365	305	435
	APR-SEP	465	92	565	505	425	365	505
Lima Reservoir Inflow (2)	APR-JUL	48	59	81	61	35	15.1	82
	APR-SEP	49	55	87	65	33	10.6	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	54	53	141	89	18.7	-16.0	101
	APR-SEP	66	55	161	104	28	-4.0	120
Jefferson R nr Three Forks (2)	APR-JUL	705	95	1080	855	550	330	740
	APR-SEP	770	96	1190	940	600	350	800
Hebgen Reservoir Inflow (2)	APR-JUL	325	88	395	355	295	255	370
	APR-SEP	415	88	500	450	380	330	470
Ennis Reservoir Inflow (2)	APR-JUL	500	80	650	560	440	355	625
	APR-SEP	625	81	800	695	555	455	775
Missouri R at Toston (2)	APR-JUL	1680	94	2320	1940	1420	1040	1790
	APR-SEP	1950	94	2710	2260	1640	1190	2070
Smith R bl Eagle Ck (2)	APR-JUL	144	136	197	165	123	91	106
	APR-SEP	163	141	225	188	138	102	116
Gibson Reservoir Inflow (2)	APR-JUL	360	91	455	400	320	265	395
	APR-SEP	395	90	495	435	355	295	440
Marias R nr Shelby (2)	APR-JUL	335	97	515	405	265	156	345
	APR-SEP	345	96	535	420	270	156	360
Milk R at Western Crossing	MAR-SEP	31	95	58	42	20	4.4	33
Milk R at Eastern Crossing	MAR-SEP	67	82	139	96	38	10.0	82

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	57	97	65	60	54	49	59
	APR-SEP	73	99	84	77	69	62	74
Wind R ab Bull Lake Ck (2)	APR-JUL	480	105	615	535	425	345	455
	APR-SEP	515	105	655	570	460	375	490
Bull Lake Ck nr Lenore	APR-JUL	142	102	174	155	129	110	139
	APR-SEP	173	102	215	189	157	132	169
Boysen Reservoir Inflow (2)	APR-JUL	575	94	980	740	410	171	610
	APR-SEP	650	98	1090	825	475	215	665
Greybull R nr Meeteetse	APR-JUL	151	115	186	165	137	116	131
	APR-SEP	205	116	250	225	188	162	177
Shell Ck nr Shell	APR-JUL	58	105	73	64	52	43	55
	APR-SEP	70	106	87	77	63	54	66
Bighorn R at Kane (2)	APR-JUL	890	106	1410	1100	680	370	840
	APR-SEP	985	109	1540	1210	760	430	905
NF Shoshone R at Wapiti	APR-JUL	480	104	565	515	445	395	460
	APR-SEP	535	104	625	575	500	445	515
SF Shoshone R nr Valley	APR-JUL	230	107	270	245	215	188	215
	APR-SEP	265	108	310	285	245	220	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	710	105	850	765	650	570	675
	APR-SEP	785	105	935	845	725	635	745
Bighorn R nr St. Xavier (2)	APR-JUL	1470	107	2080	1720	1220	855	1380
	APR-SEP	1600	110	2270	1870	1320	915	1460
Little Bighorn R nr Hardin	APR-JUL	105	107	153	124	86	57	98
	APR-SEP	118	106	171	140	97	66	111
Tongue R nr Dayton (2)	APR-JUL	91	106	123	104	79	60	86
	APR-SEP	105	107	138	118	91	71	98

Tongue River Reservoir Inflow (2)	APR-JUL	205	106	310	250	162	98	193
	APR-SEP	230	107	345	280	187	120	215
NF Powder R nr Hazelton	APR-JUL	13.1	144	15.6	14.1	12.1	10.6	9.1
	APR-SEP	14.0	141	16.6	15.1	12.9	11.4	9.9
Powder R at Moorhead	APR-JUL	245	138	345	285	205	145	177
	APR-SEP	270	138	375	310	230	167	196
Powder R nr Locate	APR-JUL	280	141	405	330	230	156	199
	APR-SEP	310	141	445	365	255	177	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAR-JUL	10.4	168	14.5	12.1	8.7	6.3	6.2
	APR-JUL	9.0	173	13.5	10.7	7.4	5.4	5.2
Pactola Reservoir Inflow (2)	MAR-JUL	46	184	65	54	38	27	25
	APR-JUL	41	186	67	51	32	21	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	APR-JUL	260	116	375	305	210	142	225
	APR-SEP	285	114	415	335	235	156	250
Encampment R nr Encampment	APR-JUL	136	105	182	155	117	90	129
	APR-SEP	145	105	193	164	126	97	138
Rock Ck nr Arlington	APR-JUL	56	114	73	63	49	39	49
	APR-SEP	59	113	77	66	52	41	52
Seminoe Reservoir Inflow (2)	APR-JUL	765	107	1170	930	600	360	715
	APR-SEP	825	107	1260	1000	645	385	770
Sweetwater R nr Alcova	APR-JUL	24	41	61	39	9.5	5.0	59
	APR-SEP	27	42	66	42	11.2	6.0	64
La Prele Ck ab La Prele Reservoir	APR-JUL	20	101	39	28	12.2	0.80	19.9
	APR-SEP	20	101	40	28	12.4	0.96	19.9
North Platte R-Alcova to Orin Gain	APR-JUL	51	100	189	107	-5.0	-87	51
	APR-SEP	18.0	90	161	76	-40	-118	20
North Platte R bl Glendo Res (2)	APR-JUL	840	102	1100	945	735	575	820
	APR-SEP	870	102	1150	980	760	590	850
North Platte R bl Guernsey Res (2)	APR-JUL	860	105	1190	990	725	530	820
	APR-SEP	890	105	1230	1030	750	550	850
Laramie R nr Woods	APR-JUL	121	105	160	137	105	82	115
	APR-SEP	134	106	176	151	116	91	126
Little Laramie R nr Filmore	APR-JUL	60	118	79	68	52	41	51
	APR-SEP	65	118	86	73	57	44	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
March 2014 Calendar Year Runoff Forecast
March 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The March 1, 2014 calendar year forecast for the Missouri River Basin above Sioux City, IA is 30.6 MAF (121% of normal). Runoff above Gavins Point Dam is forecast to be 28.3 MAF (123% of normal). The increase since the February forecast is due to greater than predicted February runoff and an increase in the March-April runoff forecast due to wet soil conditions, frost depths, and continued above normal precipitation patterns. Also contributing to the increased runoff forecast is a rise in mountain snowpack resulting in increases to the May-July runoff forecast.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 10 months, the range of expected inflow is quite large and ranges from the 41.7 MAF upper basic forecast to the 20.9 MAF lower basic forecast. 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 10 months are being forecasted for this March 1 forecast (2 months observed/10 months forecast), the range of wetter than normal (upper basic) and lower than normal (lower basic) is attributed to all 6 reaches for all 10 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 Nina)

ENSO-neutral conditions continue in the equatorial Pacific, and equatorial sea surface temperatures were below-average in the eastern Pacific Ocean while remaining above average in the western Pacific. ENSO-neutral conditions are expected to continue through the Northern Hemisphere through the spring of 2014, with a 50 percent chance of El Nino developing in the summer or fall 2014. El Nino can increase chances for above normal temperatures and below normal precipitation in the Missouri River Basin during the Northern Hemisphere winter.

Drought Analysis

According to the National Drought Mitigation Center (Figure 1), drought conditions on February 25, 2014 have greatly improved since last year at this time (Figure 2). Montana, North and South Dakota, and northern Wyoming are out of any drought category. The majority of Nebraska, Kansas, and Iowa have improved the past year to "Abnormally Dry to Severe Drought" conditions with "Extreme Drought" conditions isolated to southwest Nebraska and northwest Kansas. The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions that are currently impacting central Nebraska and western Kansas will persist through winter and early spring 2014 with limited change in drought category. Further information about long-range climate factors that may impact drought conditions are discussed later in the climate outlook section.

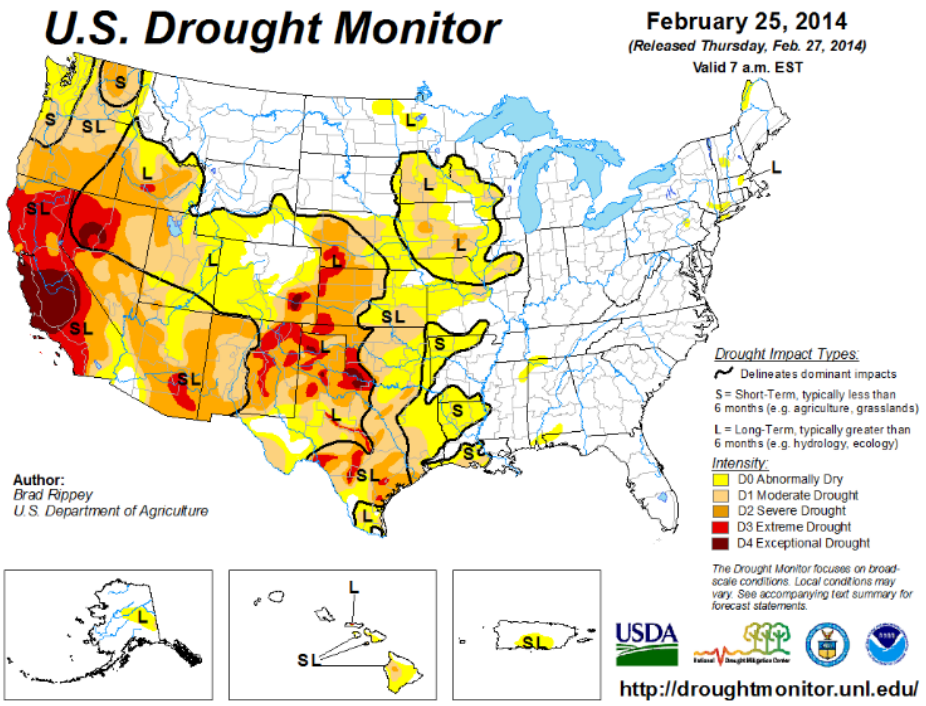


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for February 25, 2014.

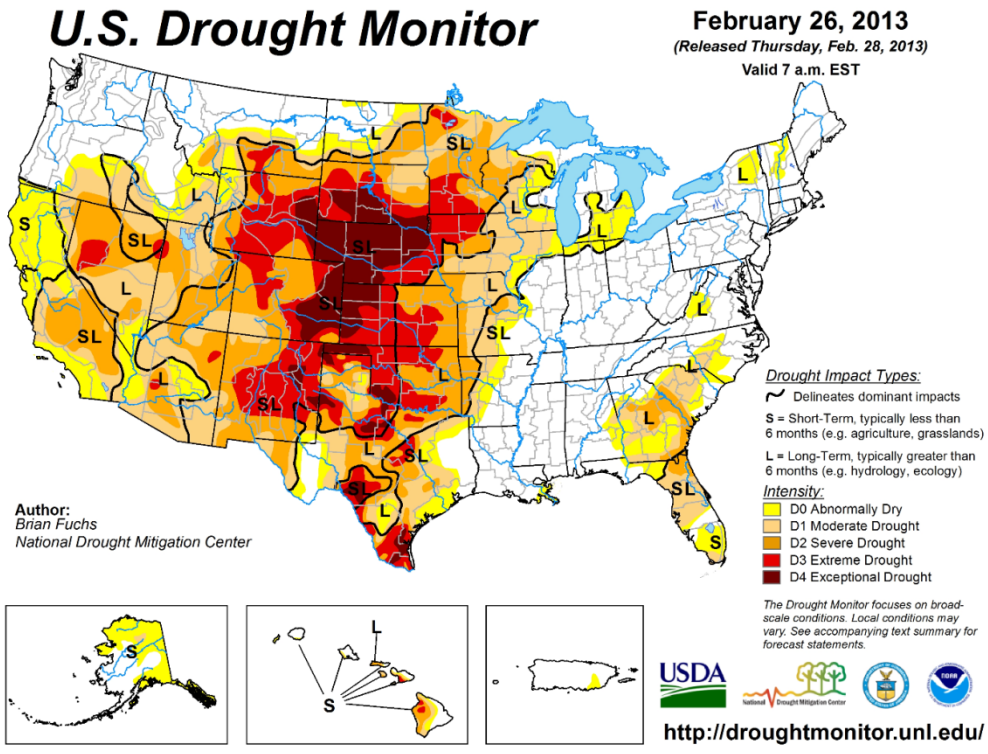


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for February 26, 2013.

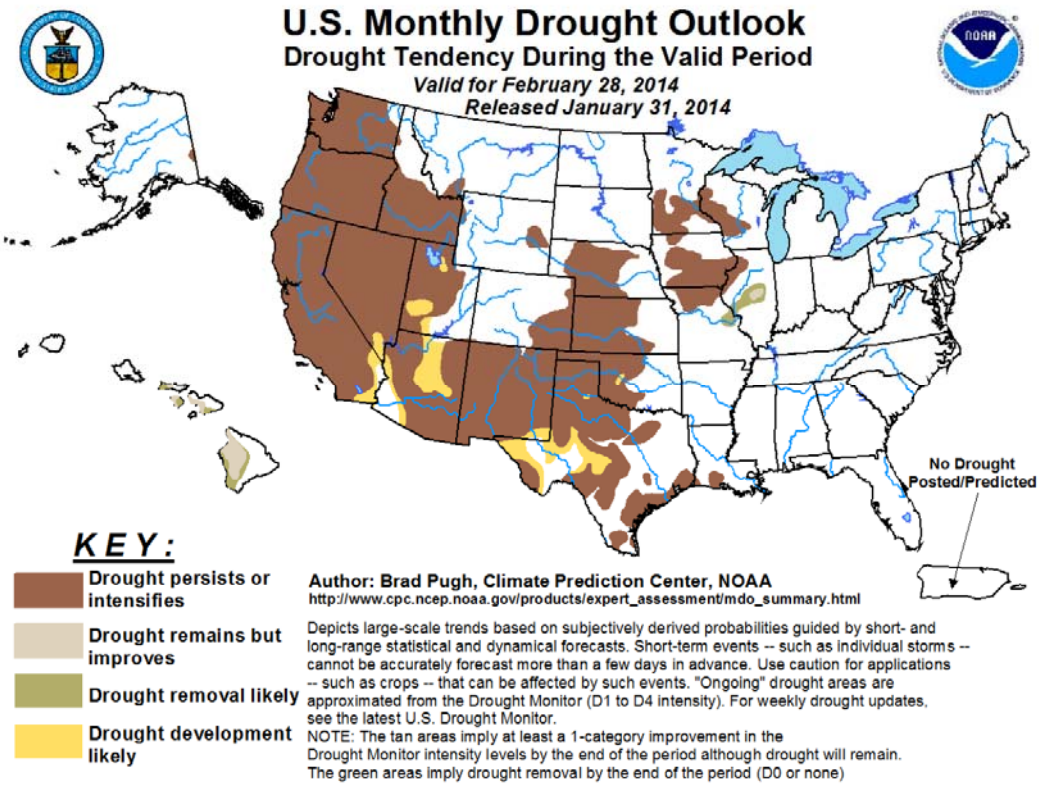


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation as a percent of normal during the month of February is shown in Figure 4. This map was created by the High Plains Regional Climate Center. Below normal precipitation highlighted the Dakotas and Nebraska, with southeastern North Dakota and northeastern South Dakota receiving less than 25% of normal precipitation. Above normal precipitation accumulations occurred in the Rocky Mountains with areas in western Montana and Wyoming up to 400% of normal. Well above normal precipitation occurred to a lesser extent in southeastern Wyoming, northeastern Colorado and western Nebraska along with extreme northeastern Montana.

Accumulated precipitation over the three-month (December-January- February) period ending on February 28, 2014 is shown in Figure 5. Precipitation has been normal to above normal in the upper basin west of the Missouri River. Wet conditions characterized by greater than 150% of normal precipitation have occurred over large areas of Montana and Wyoming, along with isolated areas in North Dakota, northeastern Colorado and western Nebraska. Precipitation has been normal to below normal in eastern South and North Dakota, Nebraska and western Iowa.

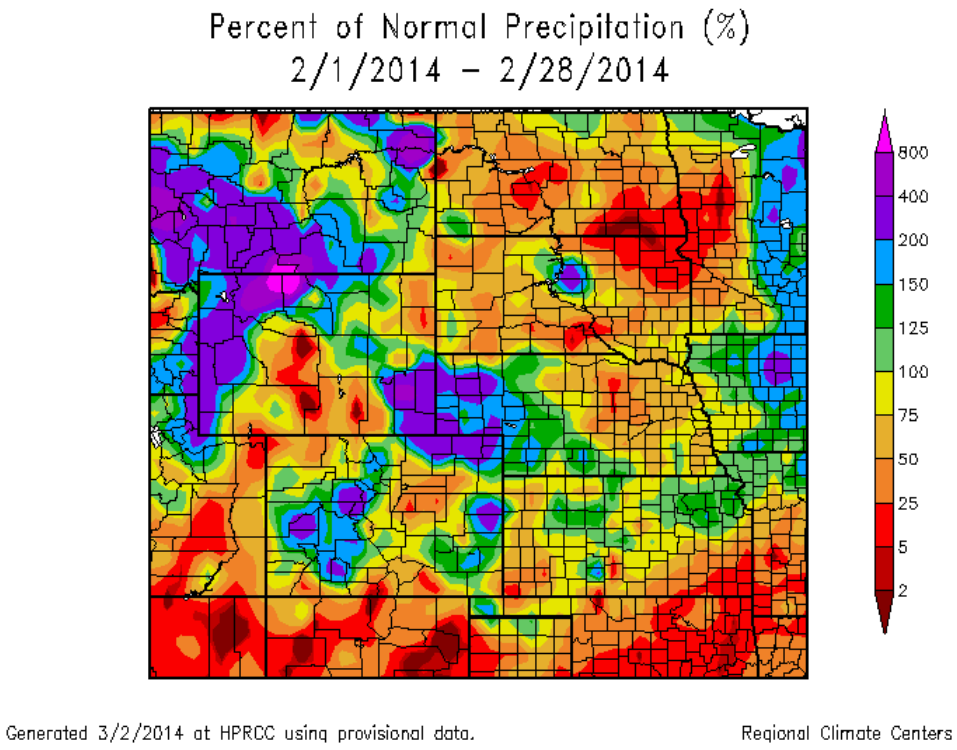


Figure 4. Monthly Percent of Normal Precipitation ending on February 28, 2014.

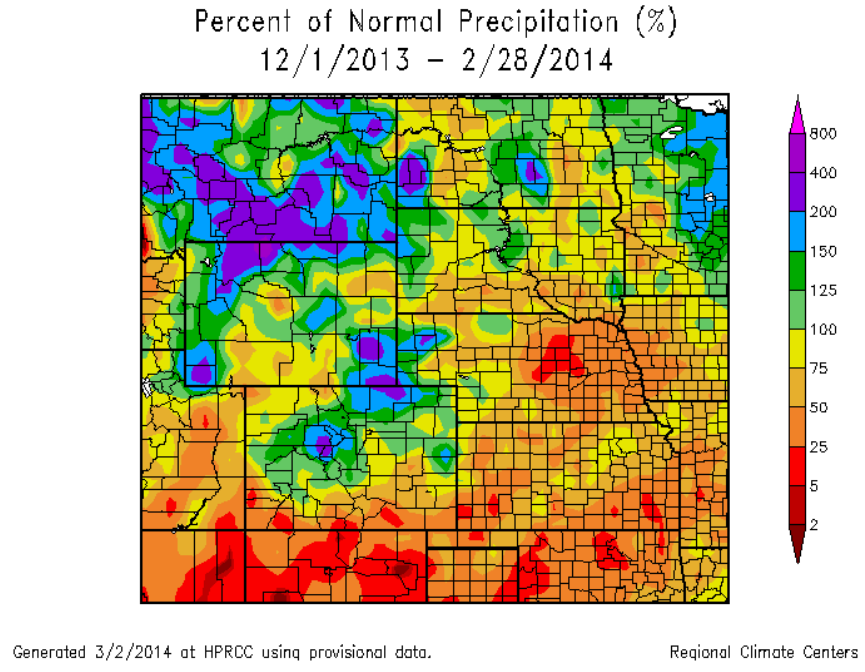


Figure 5. Three-month Percent of Normal Precipitation ending on February 28, 2014.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of February, courtesy of the High Plains Regional Climate Center, is shown in Figure 6. Temperatures have been well below normal across the majority of the basin. Each state in the basin as experienced greater than 10 deg F below normal over the past month with the most widespread areas in Montana, the Dakotas, and Wyoming. Most of the departures for the month were 6 to 10 deg F below normal.

Three-month (December-January- February) temperature departures ending on February 28, 2014 are shown in Figure 7. The three-month map indicates that temperatures have been 4 to 10 deg F colder than normal in the northern plains, 2 to 8 deg F colder than normal in the southern plains, and 2 to 6 deg F colder than normal in the mountainous regions.

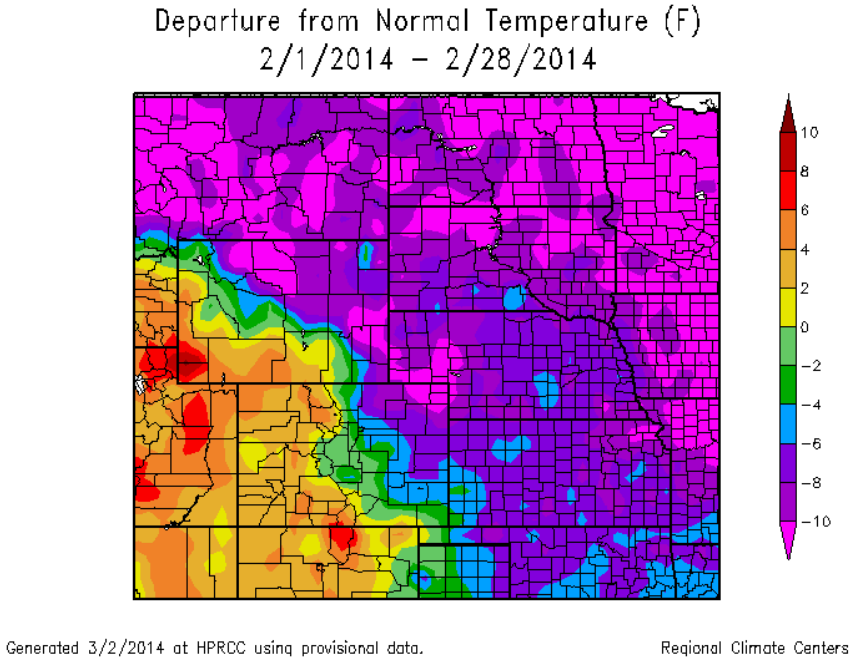


Figure 6. Monthly Departure from Normal Temperature (deg F) ending February 28, 2014.

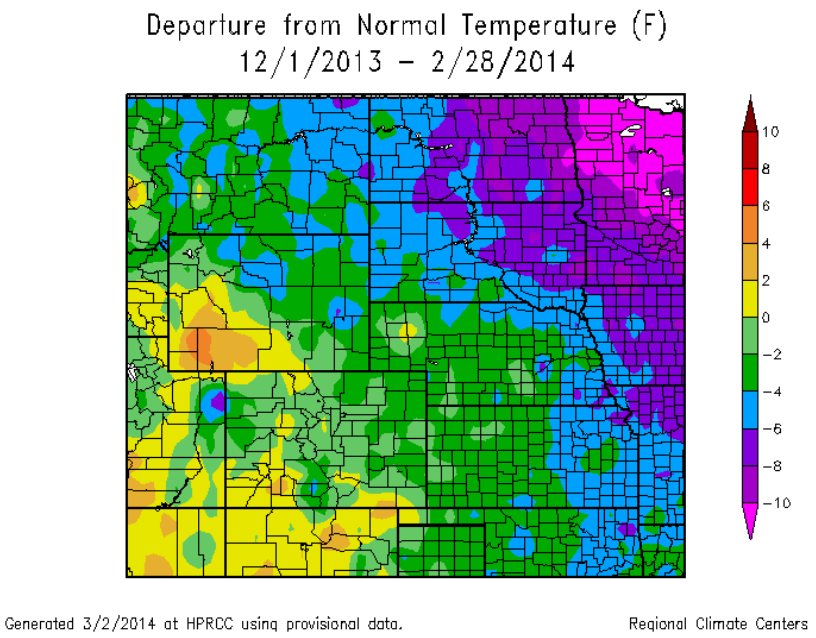


Figure 7. Three-month Departure from Normal Temperature (deg F) ending February 28, 2014.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Three estimates of soil moisture are presented in this report. Figure 8 shows the Climate Prediction Center's calculated soil moisture ranking percentiles on February 28, 2014. Figure 9 shows the Variable Infiltration Capacity model soil moisture percentiles on March 2, 2014. Figure 10 shows the NOAA NLDAS Drought Monitor soil moisture percentiles on February 27, 2014.

All three soil moisture estimates depict very wet soil moisture conditions throughout the upper Missouri River basin in Montana and Wyoming and western portions of North and South Dakota. CPC soil moisture conditions in these areas rank from the 85th to the 99st percentile. Soil moisture conditions in Nebraska, eastern Colorado, and Kansas are fairly normal, while Missouri and Iowa have drier than normal soil moisture conditions.

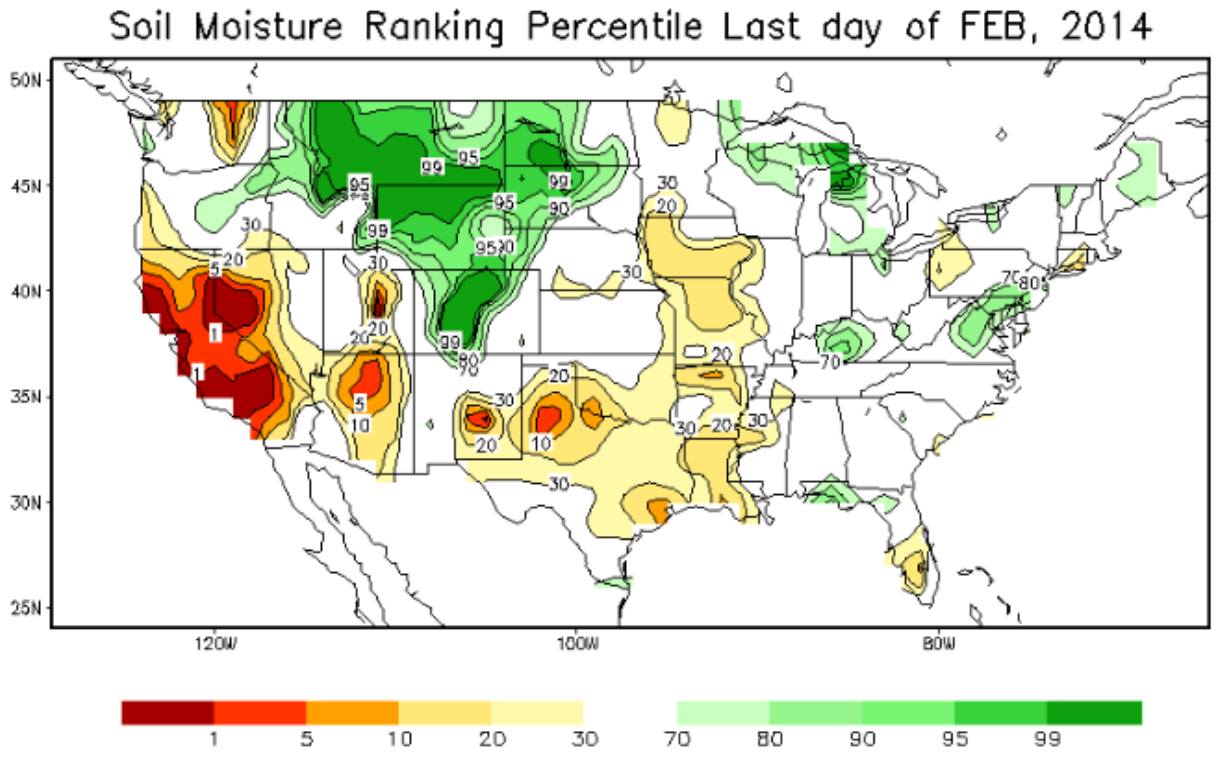


Figure 8. Calculated Soil Moisture Ranking Percentile on February 28, 2014. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

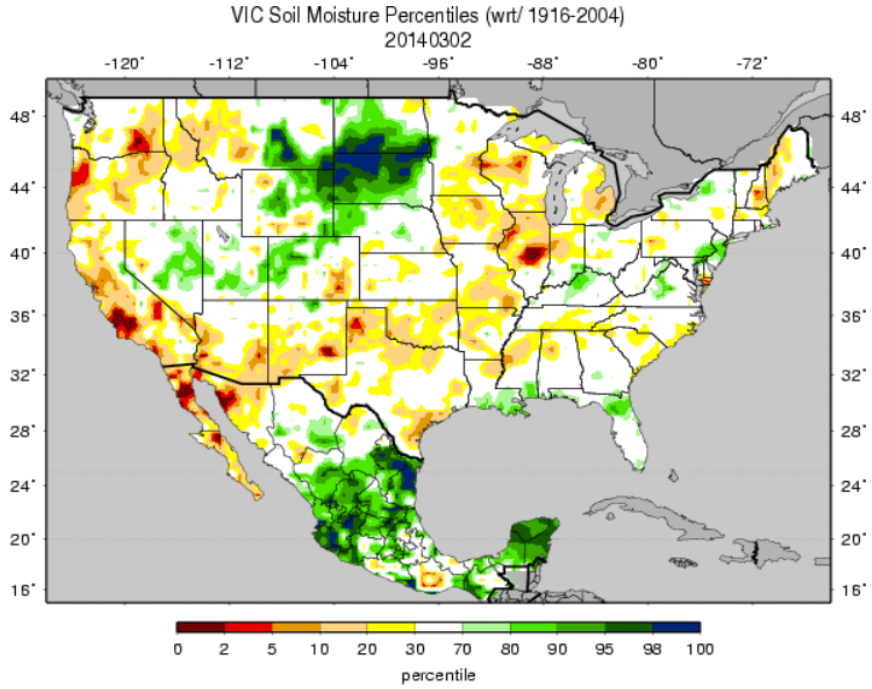


Figure 9. VIC modeled soil moisture percentiles as of March 2, 2014. Source: University of Washington.
http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

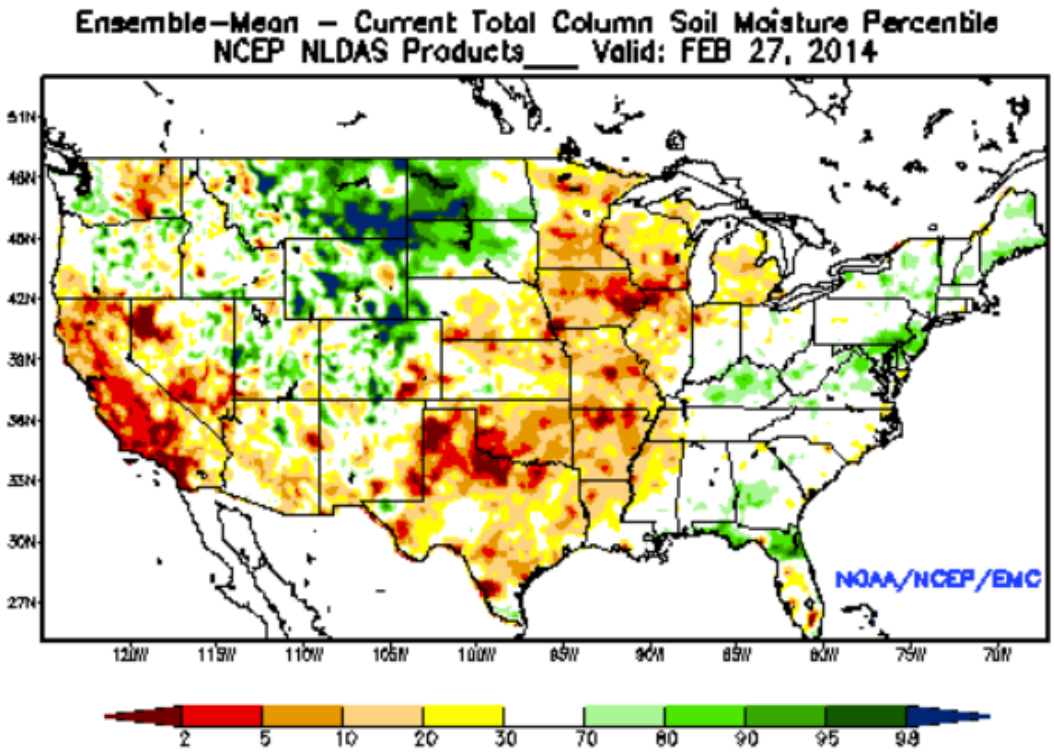


Figure 10. Total Column Soil Moisture Percentile as of February 27, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The CPC calculated soil moisture anomaly for the contiguous U.S. on February 28, 2014 is shown in Figure 11. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 20 mm (0.8 inches). Some areas in Montana and Wyoming have anomalies greater than 140 mm (5.5 inches) of moisture.

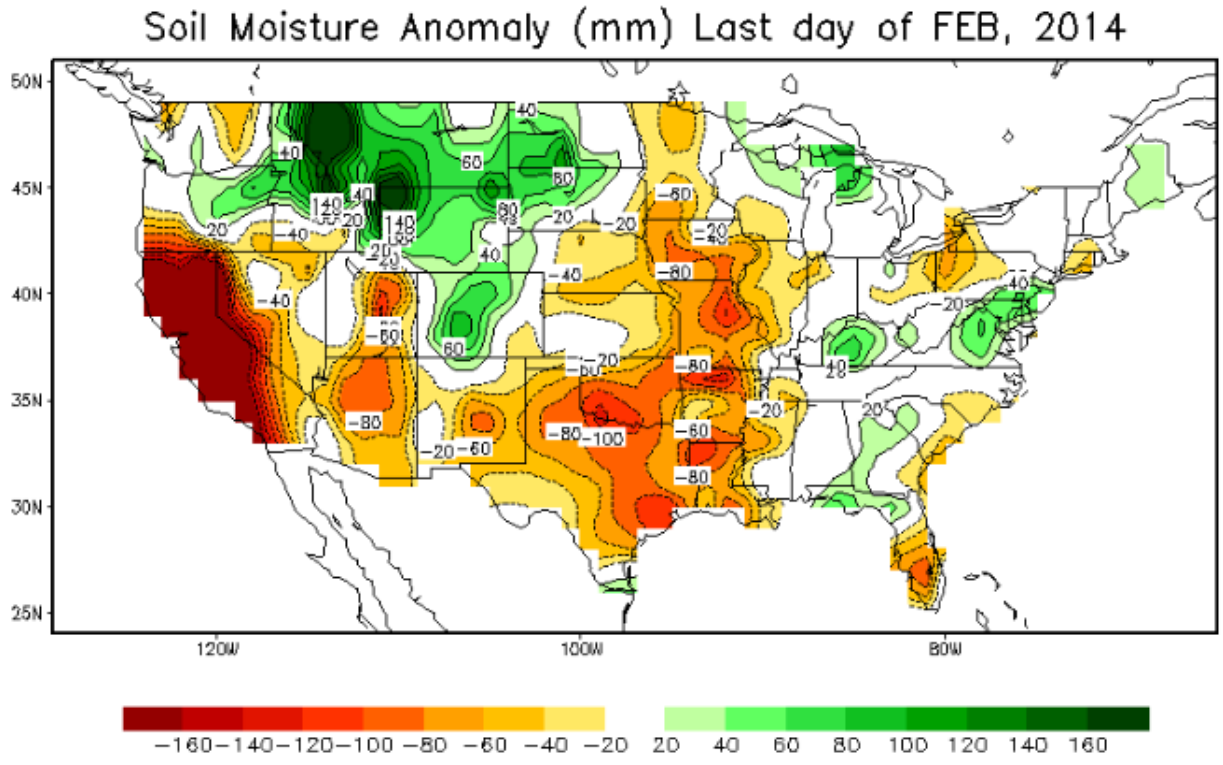


Figure 11. Calculated Soil Moisture Anomaly (mm) on February 28, 2014. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

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. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

Based on the National Operational Hydrologic Remote Sensing Center (NOHRSC) assessment (Figure 12) on March 1, 2014, most plains snow water equivalent (SWE) amounts ranged from trace to 1-inch throughout the upper Missouri River basin. The deepest amounts generally lie along the northern and eastern boundary of the upper Missouri basin ranging from 0 to 2 inches of water equivalent. There is an expanded footprint of plains snowpack, when compared with February 1, measuring 1-2 inches of SWE, near the foothills in Montana as well as areas around Great Falls and Billings.

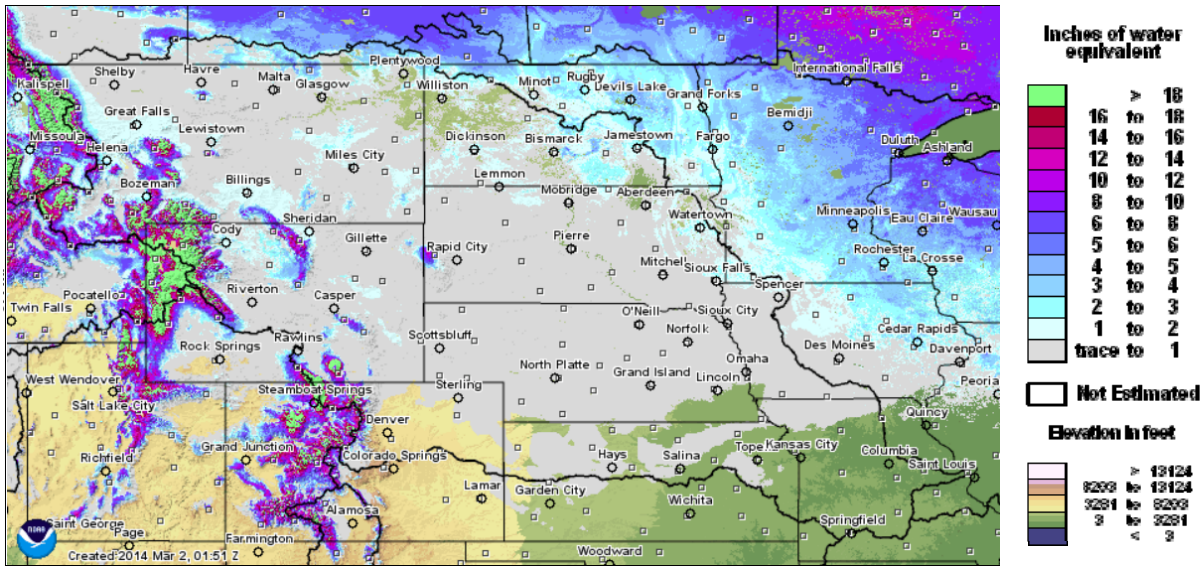


Figure 12. March 1, 2014, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Using the MRBWM snowpack classification method, plains snowpack as of March 1, 2014, was generally classified as Light to slightly less than Light across the upper Missouri River basin (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0 to 1 inch of SWE in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins and 0 to 2 inches in the Garrison and Gavins Point to Sioux City reaches.

Table 1. March 1, 2014 plains snowpack classification for runoff forecasting.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Light (0 – 1 inch SWE)
Fort Peck to Garrison	Light (0 – 2 inch SWE)
Garrison to Oahe	Light (0 – 1 inch SWE)
Oahe to Fort Randall	Average (0 – 0.5 inch SWE)
Fort Randall to Gavins Point	Average (0 – 0.5 inch SWE)
Gavins Point to Sioux City	Light (0 – 2 inch SWE)

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July 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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions.

As of March 3, 2014, the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 16.2 inches, which is 122% of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 14.8 inches, which is 133% of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by March 1, 79% of the peak snow accumulation has occurred in the mountains.

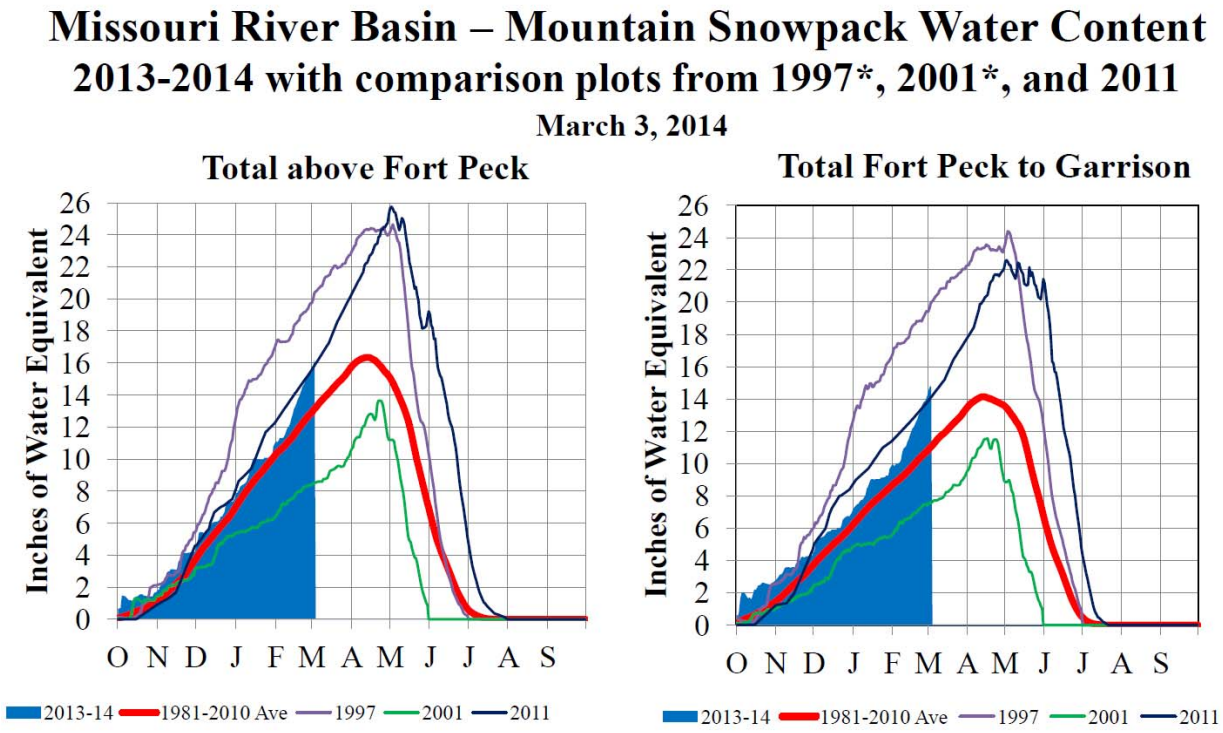


Figure 13. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions are expected to continue through the Northern Hemisphere through the spring of 2014, with a 50 percent chance of El Nino developing in the summer or fall 2014. El Nino can increase chances for above normal temperatures and below normal precipitation in the Missouri River Basin during the Northern Hemisphere winter.

The Climate Prediction Center's March outlook (Figure 13) is indicating increased chances for colder than normal conditions across the eastern half of the Missouri River Basin. With regard to precipitation, there are increased chances for below normal precipitation in the eastern Dakotas and northwest Iowa and equal chances for above, below or normal precipitation in all other areas.

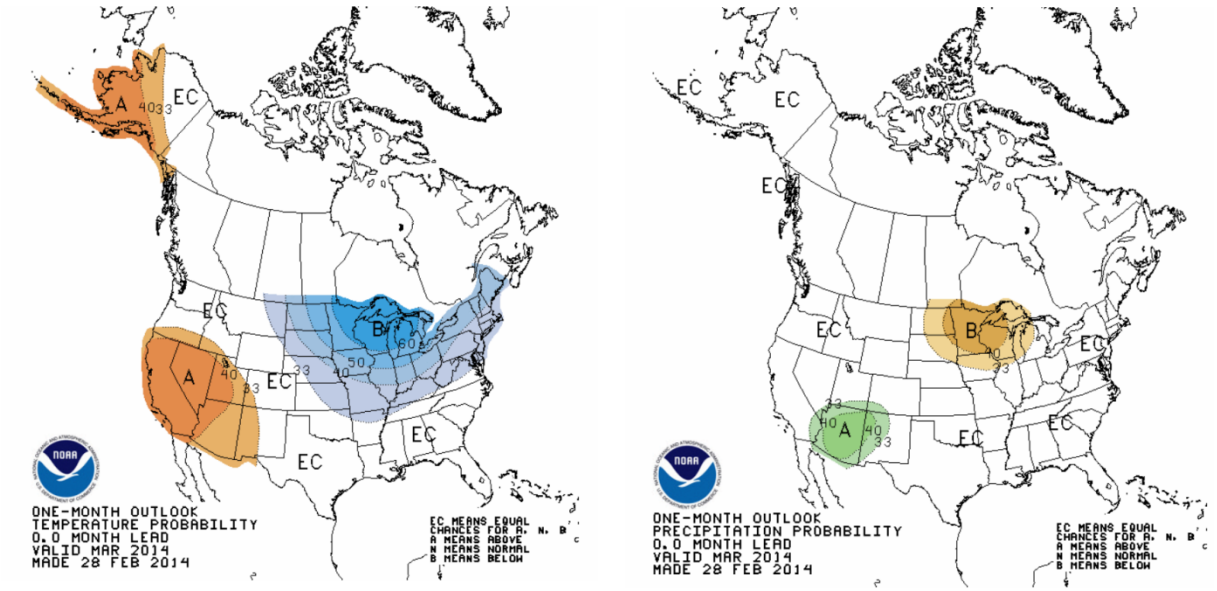


Figure 13. CPC March 2014 temperature and precipitation outlooks.

The three-month climate outlook through May 2014 (Figure 14) indicates increased chances for cooler than normal temperatures in North Dakota and northeast South Dakota, with equal chances in all other areas. In terms of precipitation, there are equal chances for all portions of the basin. Looking further into 2014, the CPC's climate outlook for June-August (Figure 15) indicates increased chances for warmer than normal temperatures in western Montana and equal chances for all portions of the basin. There are equal chances for above, below, or normal precipitation throughout the upper basin.

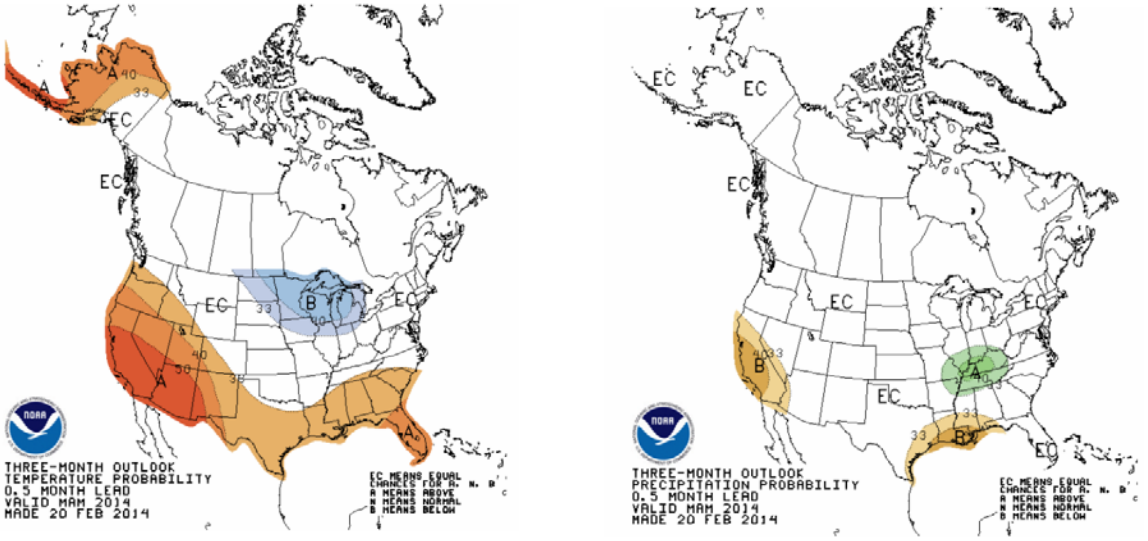


Figure 14. CPC March-April-May 2014 temperature and precipitation outlook.

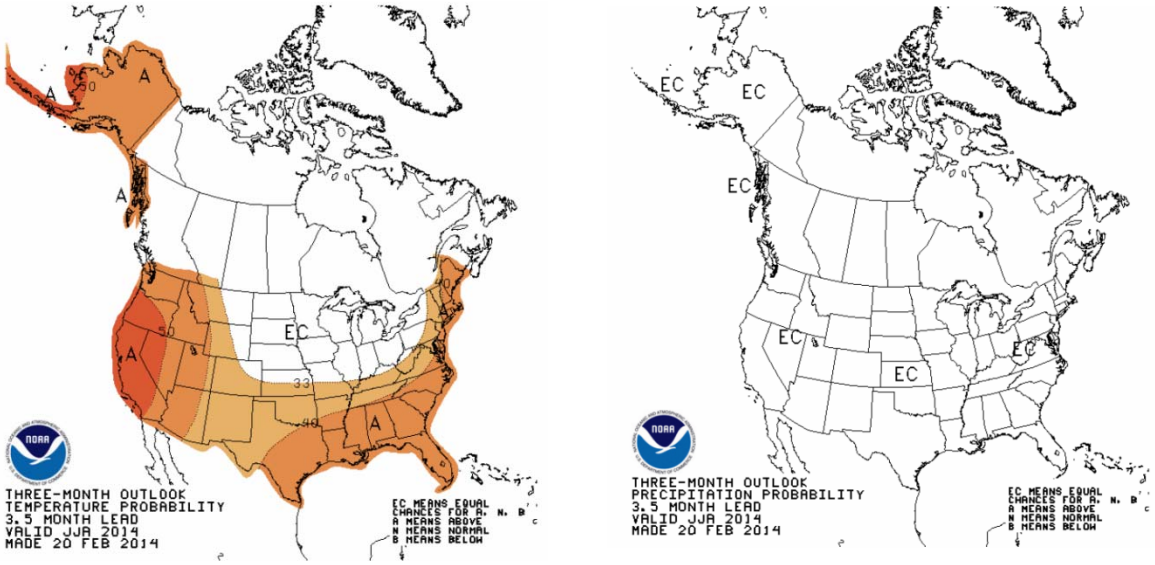


Figure 15. CPC June-July-August 2014 temperature and precipitation outlook.

Climate outlooks for September-November 2014 and December 2014 – February 2015 are provided in Figures 16 and 17. The CPC is indicating an increased probability for above normal temperatures in Montana, Wyoming, Colorado, western South Dakota, and western Nebraska for September through November. The precipitation outlook indicates equal chances for above, below and normal precipitation for all of the Missouri River basin. Finally, in the December through February outlook, the CPC is indicating an increased probability for above normal temperatures in the eastern parts of South Dakota, Nebraska, and Kansas along with Iowa and Missouri. Equal chances for above, below and normal temperatures are forecast for the rest of the basin, and equal chances for above, below and normal precipitation are predicted for the entire basin.

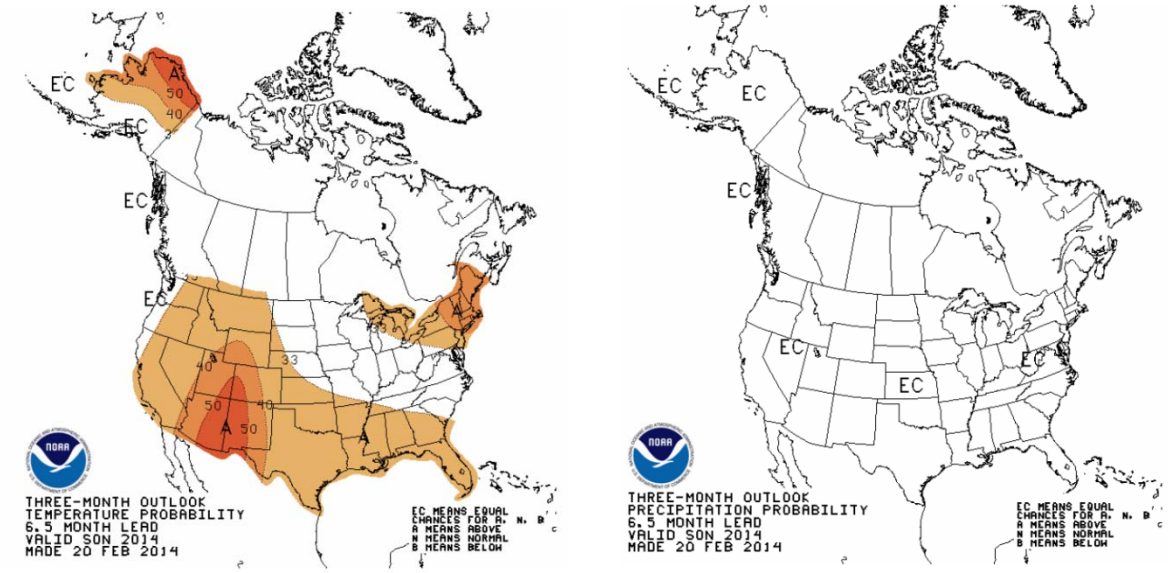


Figure 16. September-October-November 2014 temperature and precipitation outlook.

.

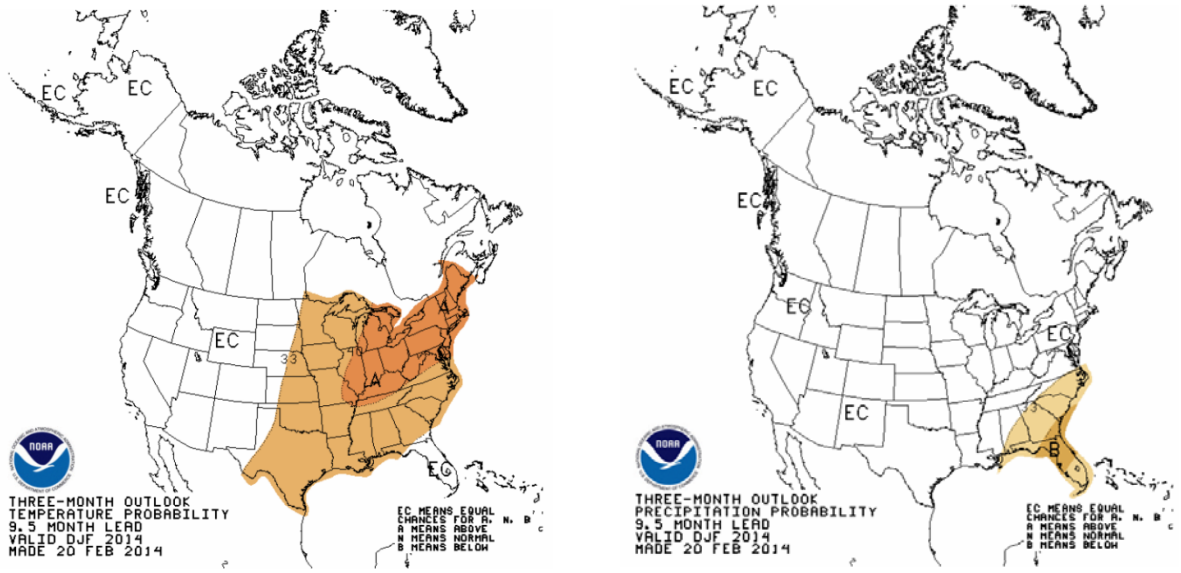


Figure 17. CPC December-January-February 2014-2015 temperature and precipitation outlook.

March 2014 Calendar Year Runoff Forecast

The calendar year runoff forecast is 30.6 MAF (121% of average) above Sioux City and 28.3 MAF (123% of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 10 months, the range of expected inflow is quite large and ranges from the 41.7 MAF upper basic forecast to the 20.9 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. It should be

noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

The increase since the February forecast is due to greater than predicted February runoff and an increase in the March-April runoff forecast due to wet soil conditions, frost depths, and continued above normal precipitation patterns. Also contributing to the increased runoff forecast is a rise in mountain snowpack resulting in increases to the May-July runoff forecast.

March-April

Plains snowpack is a significant factor influencing the volume of runoff in March and April; however, snow and rainfall precipitation during this time period are also very important factors that need consideration. Furthermore, antecedent accumulated precipitation and antecedent soil moisture conditions have a significant influence on March-April runoff.

The Plains Snowpack Category Runoff forecast method was used to initially estimate March-April runoff, and the values were adjusted for localized soil moisture and recent runoff conditions. Plains snowpack is Light in the Ft. Peck, Garrison, Oahe, and Sioux City reaches. Due to much wetter soil moisture conditions in Fort Peck, Garrison, and Oahe reaches, above normal runoff is forecast in these reaches in March-April. Soil moisture conditions in the Sioux City reach vary from above normal to below normal; however, this reach has maintained its snowpack over the last two months whereas in all other reaches, the snowpack has diminished. Above normal runoff is forecast in the Sioux City reach in March-April. Snowpack is average resulting in a normal runoff forecast level in the Fort Randall and Gavins Point reaches.

March runoff is expected to be 134% of normal primarily due to wet soil moisture conditions and extreme frost depths in the upper basin. April runoff is expected to be 139% of normal. Plains snowpack was first determined using the Plains Snowpack Runoff classification. It is much less than 2013 snowpack, however, wet soil conditions persist in the upper basin. Due to very wet soil moisture conditions, deep frost depths (multiple reports over 50 inches), and above normal precipitation over the past 90 days, volume factors were increased. The resultant forecast agreed with an alternative method that used antecedent precipitation, temperature, and soil moisture in a regression analysis. Finally, March-April runoff was weighted more heavily toward April due to the colder than normal temperature forecast during March.

May-June-July

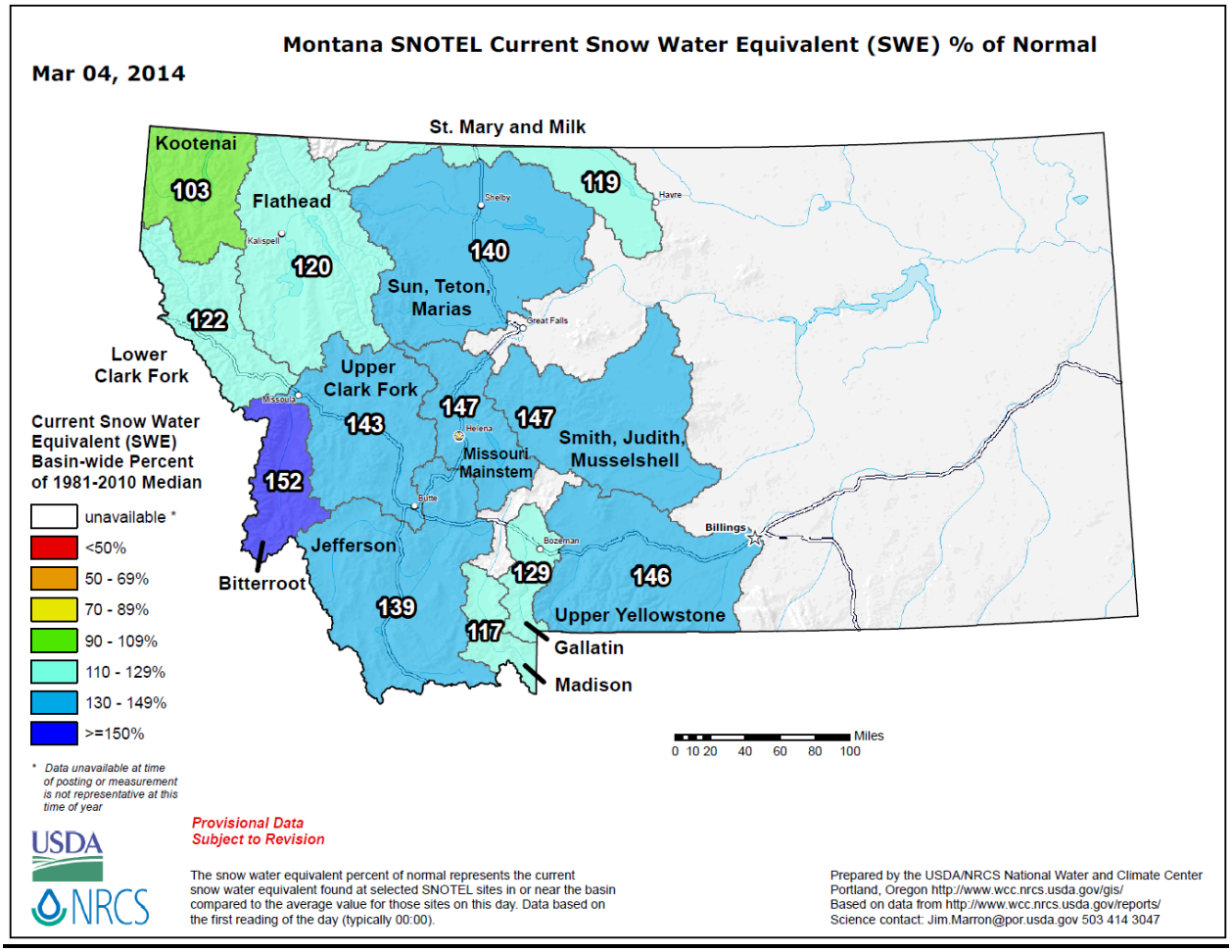
For this three-month period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. Using the March 1, 2014 mountain snowpack (122% of average in the reach above Fort Peck and 133% of average in the reach between Fort Peck and Garrison) and the CPC 3-month outlooks of spring precipitation and temperatures, the May-June-July runoff forecast is 123% of normal runoff above Fort Peck and 129% of normal runoff from Fort Peck to Garrison. Runoff in the

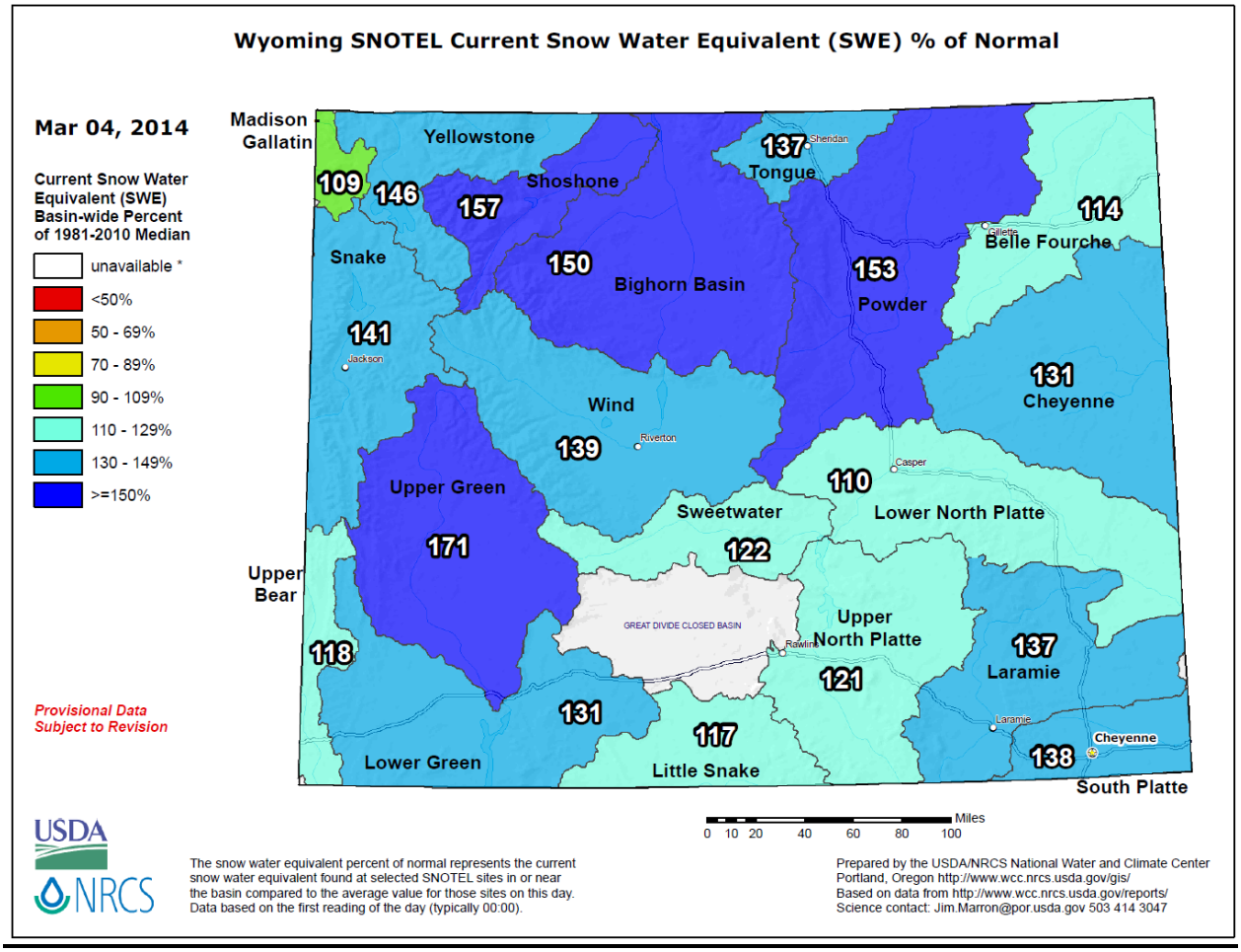
Oahe, Fort Randall, Gavins Point and Sioux City reaches is forecast to be 100% of normal because there is very little certainty in the rainfall and temperature forecasts at that time of year.

August through December

For the latter half of 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the basin and equal chances for above, below and normal precipitation. Consequently, runoff for all reaches is forecast to be essentially normal.

Additional Figures and Information




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Mar 04, 2014
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison Gallatin
Yellowstone
109
146
157
Shoshone
137
Tongue
Sheridan
114
Belle Fourche
Gillette
Snake
150
Bighorn Basin
153
Powder
141
Jackson
131
Cheyenne
Wind
139
Riverton
Casper
110
Upper Green
Sweetwater
Lower North Platte
171
122
Upper Bear
GREAT DIVIDE CLOSED BASIN
Upper North Platte
Rawlins
118
137
Laramie
121
131
117
Laramie
Cheyenne
Lower Green
Little Snake
138
South Platte
0 10 20 40 60 80 100
Miles
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

USDA NRCS National Water & Climate Center

USDA NRCS National Water & Climate Center
** - DATA CURRENT AS OF: March 06, 2014 12:35:08 PM*
- Based on March 01, 2014 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	97	100	112	103	90	81	97
	APR-SEP	112	100	129	119	106	96	112
St. Mary R at Int'l Boundary (2)	APR-JUL	420	97	520	460	380	320	435
	APR-SEP	485	96	590	525	440	380	505
Lima Reservoir Inflow (2)	APR-JUL	53	65	87	67	39	18.6	82
	APR-SEP	55	62	96	71	39	14.4	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	62	61	147	97	28	-15.0	101
	APR-SEP	75	63	168	113	38	-4.0	120
Jefferson R nr Three Forks (2)	APR-JUL	970	131	1400	1140	800	545	740
	APR-SEP	1060	133	1530	1250	870	590	800
Hebgen Reservoir Inflow (2)	APR-JUL	360	97	425	385	335	295	370
	APR-SEP	455	97	535	485	425	375	470
Ennis Reservoir Inflow (2)	APR-JUL	615	98	755	670	560	475	625
	APR-SEP	760	98	925	825	695	595	775
Missouri R at Toston (2)	APR-JUL	2070	116	2770	2350	1790	1380	1790
	APR-SEP	2400	116	3220	2730	2070	1590	2070
Smith R bl Eagle Ck (2)	APR-JUL	154	145	210	177	132	98	106
	APR-SEP	174	150	240	200	147	108	116
Gibson Reservoir Inflow (2)	APR-JUL	460	116	565	500	420	355	395
	APR-SEP	505	115	615	550	460	395	440
Marias R nr Shelby (2)	APR-JUL	390	113	570	465	320	210	345
	APR-SEP	405	113	595	480	325	210	360
Milk R at Western Crossing (3)	MAR-SEP	34	104	62	45	23	15.9	33*
Milk R at Eastern Crossing (3)	MAR-SEP	70	86	144	100	52	37	82*

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	64	108	73	68	60	55	59
	APR-SEP	79	107	91	84	74	67	74
Wind R ab Bull Lake Ck (2)	APR-JUL	615	135	725	660	570	505	455
	APR-SEP	665	136	795	715	615	535	490
Bull Lake Ck nr Lenore	APR-JUL	168	121	199	181	156	137	139
	APR-SEP	205	121	245	220	190	167	169
Boysen Reservoir Inflow (2)	APR-JUL	865	142	1250	1020	710	480	610
	APR-SEP	965	145	1390	1140	790	530	665
Greybull R nr Meeteetse	APR-JUL	181	138	220	196	166	143	131
	APR-SEP	245	138	295	265	225	197	177
Shell Ck nr Shell	APR-JUL	65	118	80	71	58	49	55
	APR-SEP	76	115	93	83	69	59	66
Bighorn R at Kane (2)	APR-JUL	1280	152	1800	1490	1070	760	840
	APR-SEP	1410	156	1970	1640	1180	840	905
NF Shoshone R at Wapiti	APR-JUL	580	126	680	620	540	480	460
	APR-SEP	645	125	755	690	600	535	515
SF Shoshone R nr Valley	APR-JUL	285	133	330	305	265	240	215
	APR-SEP	330	135	380	350	310	280	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	865	128	1020	930	800	705	675
	APR-SEP	965	130	1140	1040	895	790	745
Bighorn R nr St. Xavier (2)	APR-JUL	2020	146	2650	2280	1760	1390	1380
	APR-SEP	2220	152	2930	2510	1930	1510	1460
Little Bighorn R nr Hardin	APR-JUL	133	136	180	152	114	86	98
	APR-SEP	149	134	200	170	128	97	111
Tongue R nr Dayton (2)	APR-JUL	103	120	134	116	90	72	86
	APR-SEP	117	119	151	131	103	83	98
Tongue River Reservoir Inflow (2)	APR-JUL	250	130	360	290	205	138	193
	APR-SEP	275	128	390	320	225	158	215
NF Powder R nr Hazelton	APR-JUL	14.1	155	17.3	15.4	12.8	10.9	9.1
	APR-SEP	15.0	152	18.3	16.4	13.6	11.7	9.9
Powder R at Moorhead	APR-JUL	280	158	395	325	235	166	177
	APR-SEP	310	158	425	355	260	191	196
Powder R nr Locate	APR-JUL	320	161	455	375	265	184	199
	APR-SEP	355	161	500	415	295	210	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow	MAR-JUL	8.7	140	12.5	10.2	7.2	4.9	6.2
	APR-JUL	7.3	140	11.0	8.7	6.0	4.4	5.2
Pactola Reservoir Inflow	MAR-JUL	34	136	52	41	27	16.1	25
	APR-JUL	30	136	50	37	23	15.3	22

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average
* 1980-2008 median

Upper Missouri River Basin
April 2014 Calendar Year Runoff Forecast
April 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The April 1, 2014 calendar year forecast for the Missouri River Basin above Sioux City, IA is 32.0 MAF (127% of normal). Runoff above Gavins Point Dam is forecast to be 30.1 MAF (131% of normal). The increase since the March forecast is primarily due to a continuing rise in mountain snowpack resulting in increases to the May-July runoff forecast.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 9 months, the range of expected inflow is quite large and ranges from the 42.3 MAF upper basic forecast to the 23.2 MAF lower basic forecast. 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 9 months are being forecasted for this April 1 forecast (3 months observed/9 months forecast), the range of wetter than normal (upper basic) and drier than normal (lower basic) conditions is attributed to all 6 reaches for all 9 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 forecasted months decreases.

Current Conditions

ENSO

ENSO-neutral conditions continue in the equatorial Pacific, equatorial sea surface temperatures (SST) were above-average near the International Date Line and near-average in the east-central Pacific. ENSO-neutral conditions are expected to continue through the Northern Hemisphere through the spring of 2014, with a 50 percent chance of El Nino developing in the summer or fall 2014. El Nino can increase chances for above normal temperatures and below normal precipitation in the Missouri River Basin during the Northern Hemisphere winter.

Drought Analysis

According to the National Drought Mitigation Center (Figure 1), drought conditions on March 25, 2014 have greatly improved since last year at this time (Figure 2). Montana, North and South Dakota, and northern Wyoming are out of any drought category. The majority of Nebraska, Kansas, and Iowa have improved the past year to "Abnormally Dry to Severe Drought" conditions with "Extreme Drought" conditions isolated to southwest Nebraska and northwest Kansas. The U.S. Seasonal Drought Outlook shown in Figure 3 indicates drought conditions that are currently impacting central Nebraska and western Kansas will persist through winter and early spring 2014 with limited change in drought category. Further information about long-range climate factors that may impact drought conditions are discussed later in the climate outlook section.

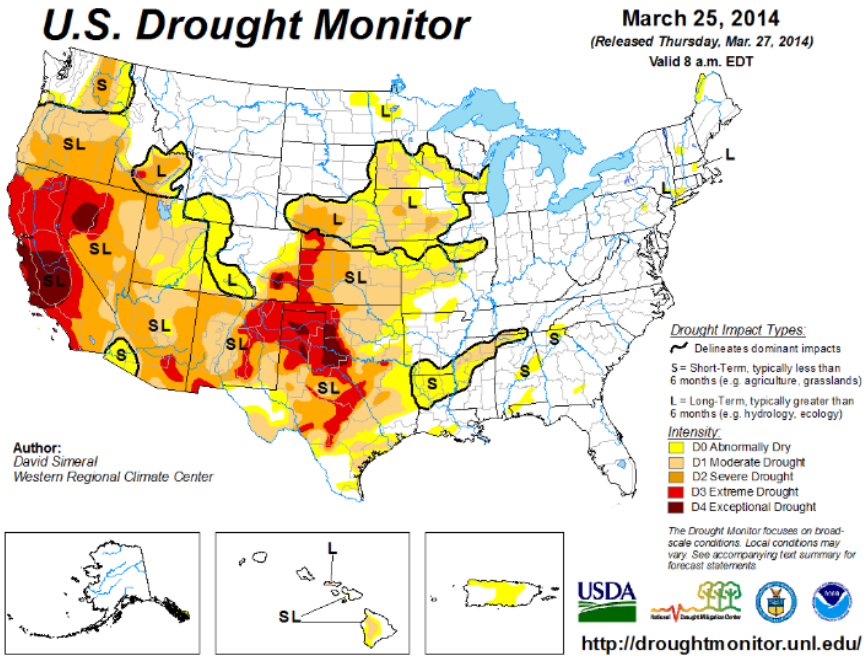


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for March 25, 2014.

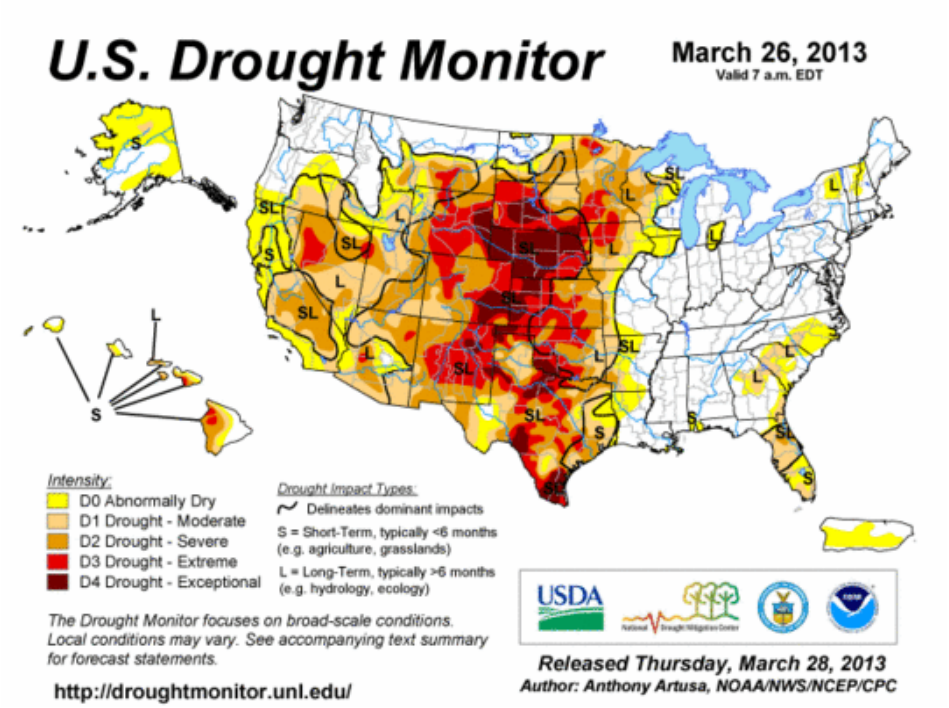


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for March 26, 2013.

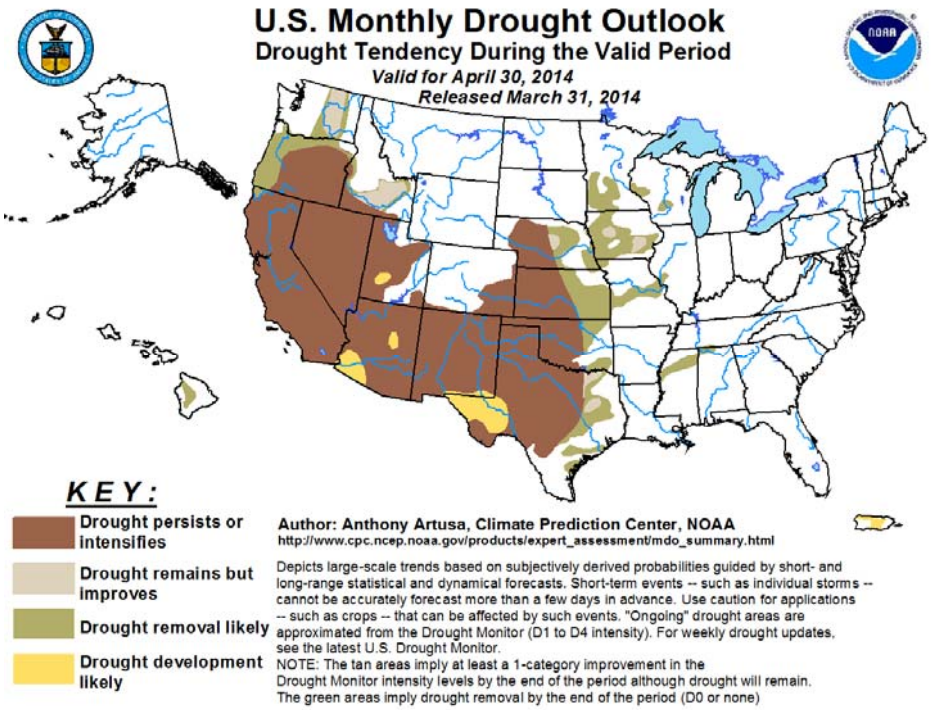


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation as a percent of normal during the month of March is shown in Figure 4. Below normal precipitation was realized in central Kansas and eastern Nebraska with less than 25% of normal precipitation. Above normal precipitation accumulations occurred in the Rocky Mountains with areas in western Montana and Wyoming up to 400% of normal. Although these areas received much higher than normal precipitation as a percent of average March precipitation, the actual departure from normal ranged from 1 to 2 inches in the plains and 2 to 3 inches above normal in the mountains. Well above normal precipitation occurred to a lesser extent in central Wyoming, northeastern Colorado, western South Dakota, and central North Dakota.

Accumulated precipitation over the three-month (January- February-March) period ending on April 3, 2014 is shown in Figure 5. Precipitation during this 3-month period is similar to the previous 1-month period described above.

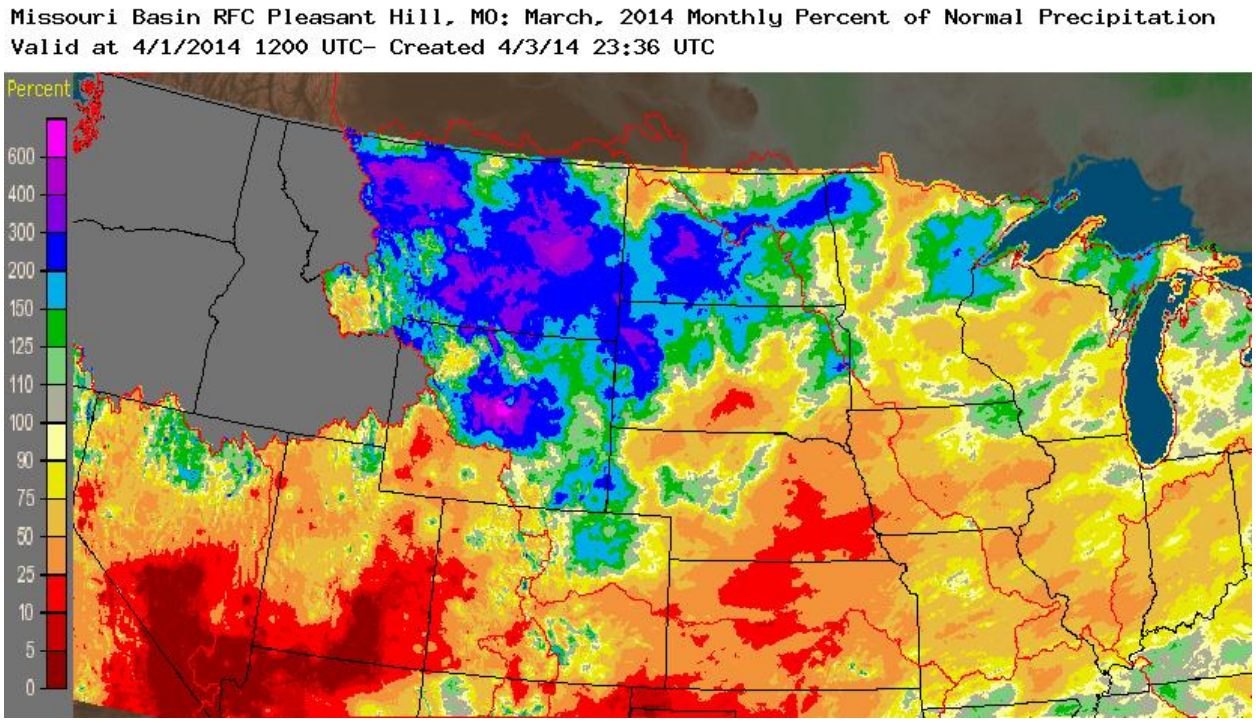


Figure 4. Monthly Percent of Normal Precipitation ending on April 3, 2014.

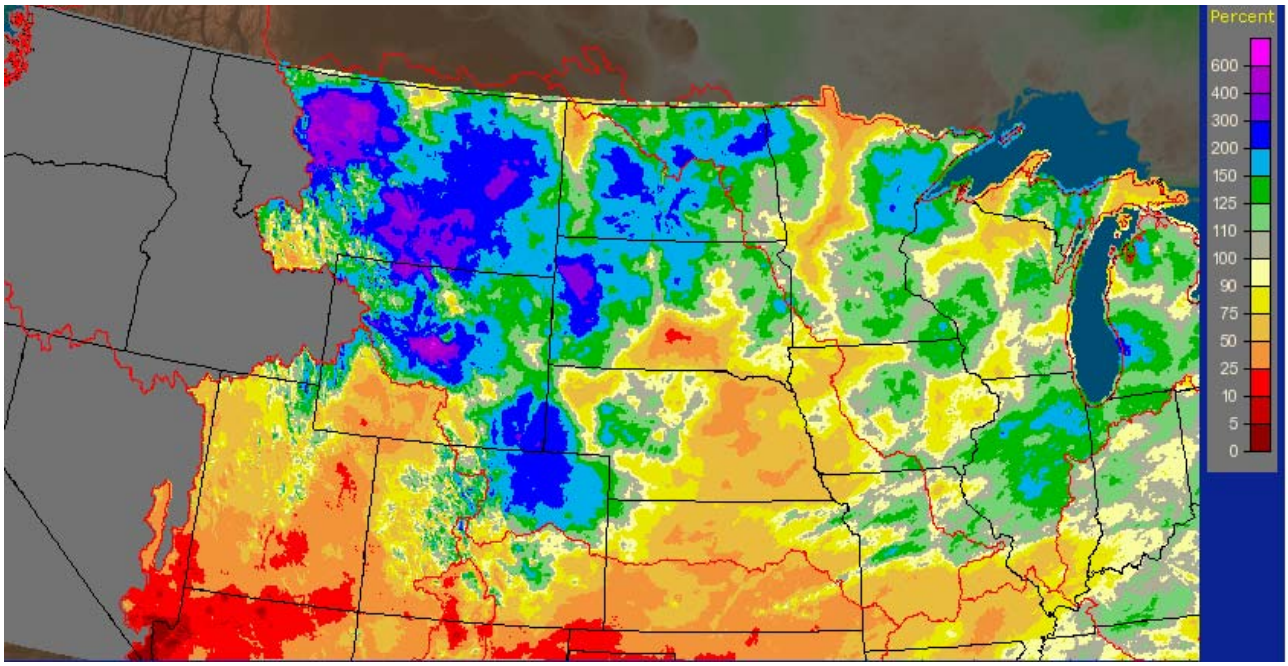


Figure 5. Three-month Percent of Normal Precipitation ending on April 3, 2014.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of March, courtesy of the High Plains Regional Climate Center, is shown in Figure 6. Temperatures have been well below normal across the majority of the basin. Most of the departures for the month were 2 to 5 deg F below normal.

Three-month (January- February-March) temperature departures ending on April 1, 2014 are shown in Figure 7. The three-month map indicates that temperatures have been 2 to 8 deg F colder than normal in the majority of the basin.

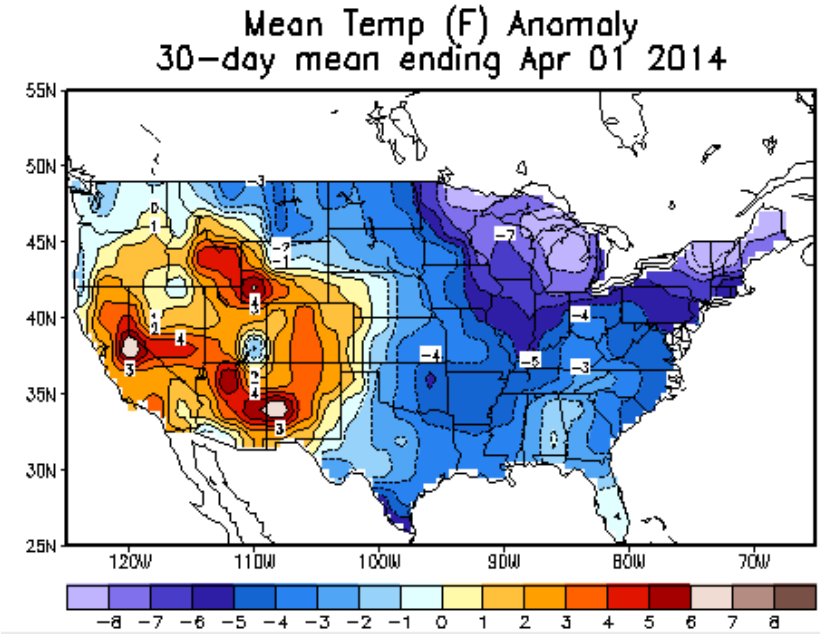


Figure 6. Monthly Departure from Normal Temperature (deg F) ending April 1, 2014.

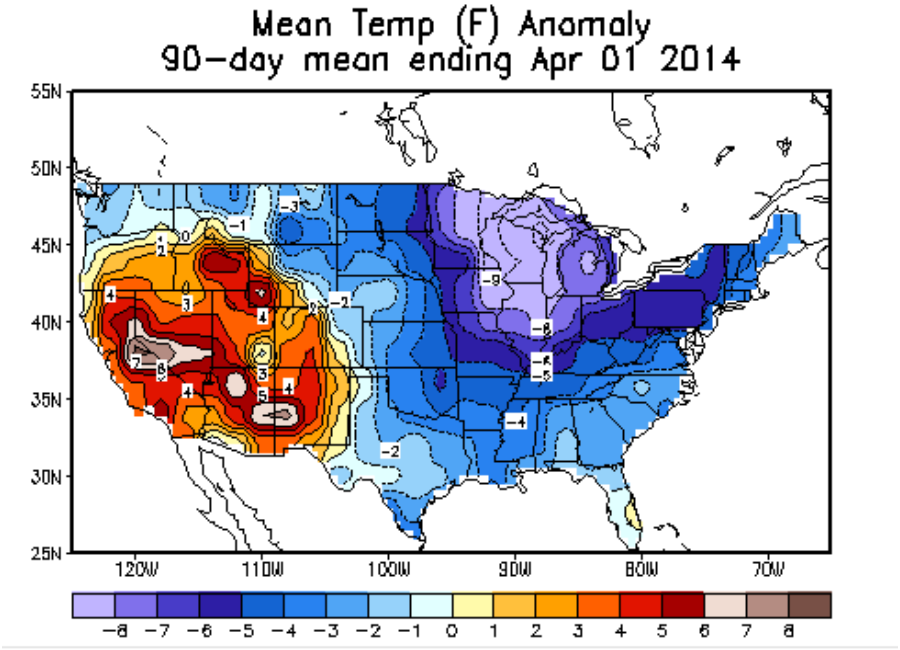


Figure 7. Three-month Departure from Normal Temperature (deg F) ending April 1, 2014.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil

moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Three estimates of soil moisture are presented in this report. Figure 8 shows the Climate Prediction Center's calculated soil moisture ranking percentiles on March 31, 2014. Figure 9 shows the Variable Infiltration Capacity model soil moisture percentiles on April 1, 2014. Figure 10 shows the NOAA NLDAS soil moisture percentiles on April 2, 2014.

All three soil moisture estimates depict very wet soil moisture conditions throughout the upper Missouri River basin in Montana and Wyoming and western portions of North and South Dakota. CPC soil moisture conditions in these areas rank from the 80th to the 99st percentile. Soil moisture conditions in Nebraska, eastern Colorado, and Kansas are fairly normal, while Missouri and Iowa have drier than normal soil moisture conditions.

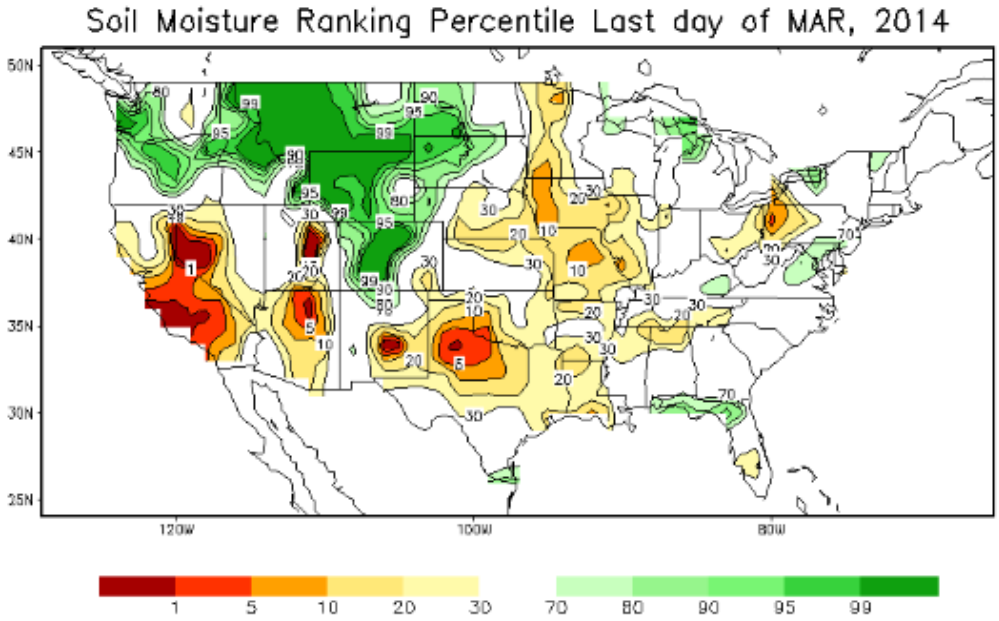


Figure 8. Calculated Soil Moisture Ranking Percentile on March 31, 2014. Source: Climate Prediction Center. **http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#**

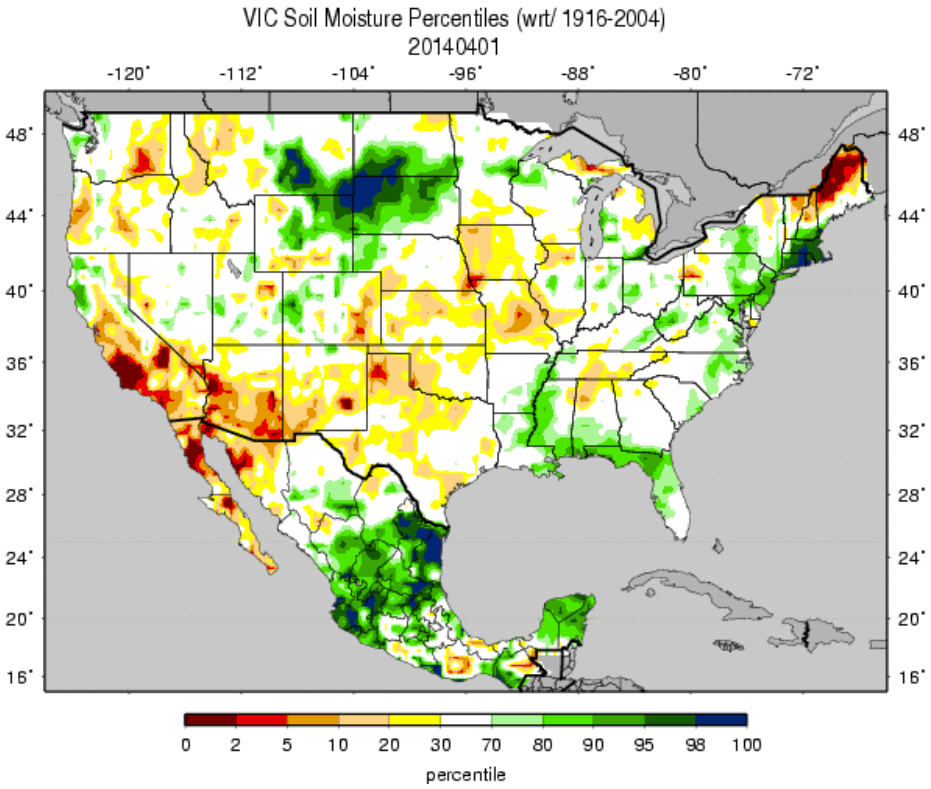


Figure 9. VIC modeled soil moisture percentiles as of April 1, 2014. Source: University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/main_sm.multimodel.shtml

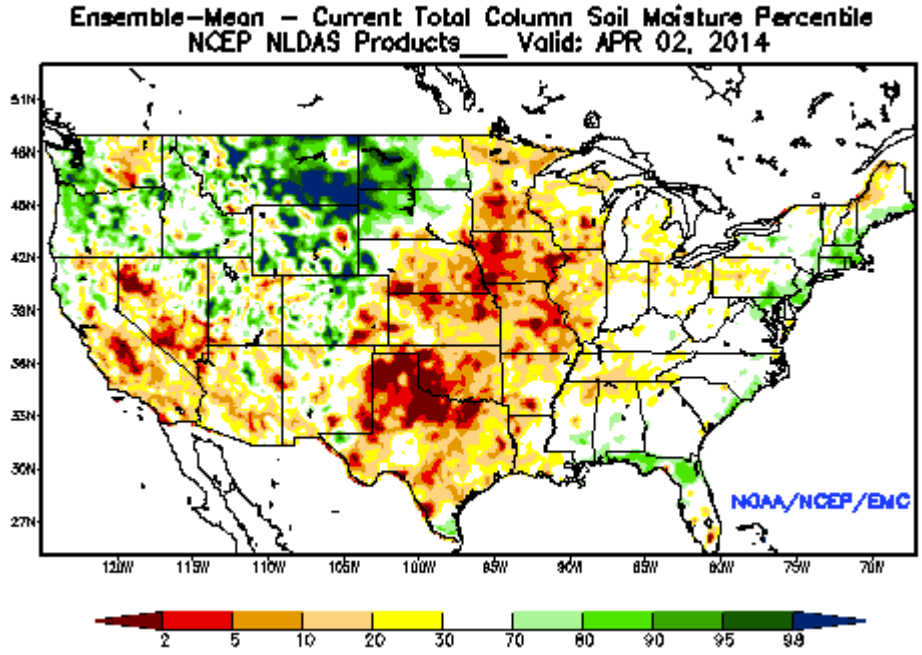


Figure 10. Total Column Soil Moisture Percentile as of April 2, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The CPC calculated soil moisture anomaly for the contiguous U.S. on March 31, 2014 is shown in Figure 11. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 20 mm (0.8 inches). Some areas in Montana and Wyoming have anomalies greater than 140 mm (5.5 inches) of moisture.

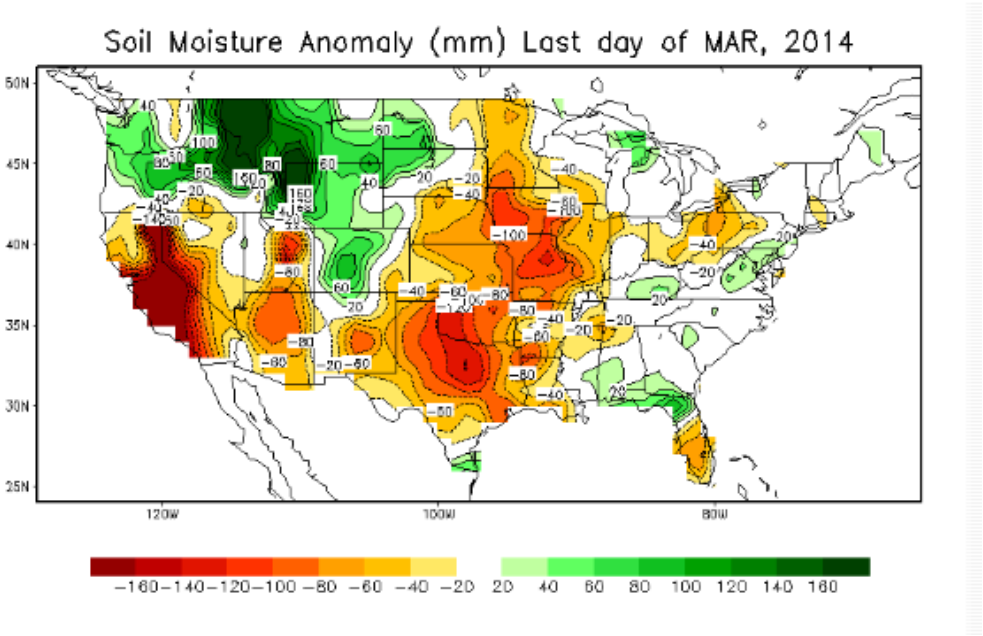


Figure 11. Calculated Soil Moisture Anomaly (mm) on March 31, 2014. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

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. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

Based on the National Operational Hydrologic Remote Sensing Center (NOHRSC) assessment (Figure 12) on April 3, 2014, most plains snow water equivalent (SWE) amounts ranged from trace to 1-inch throughout the upper Missouri River basin. The deepest amounts generally lie from eastern Montana through central North Dakota, ranging from 1 to 2 inches of water equivalent. The long term plains snowpack melted in mid-March, and the current snowpack is a product of recent plains snowfall.

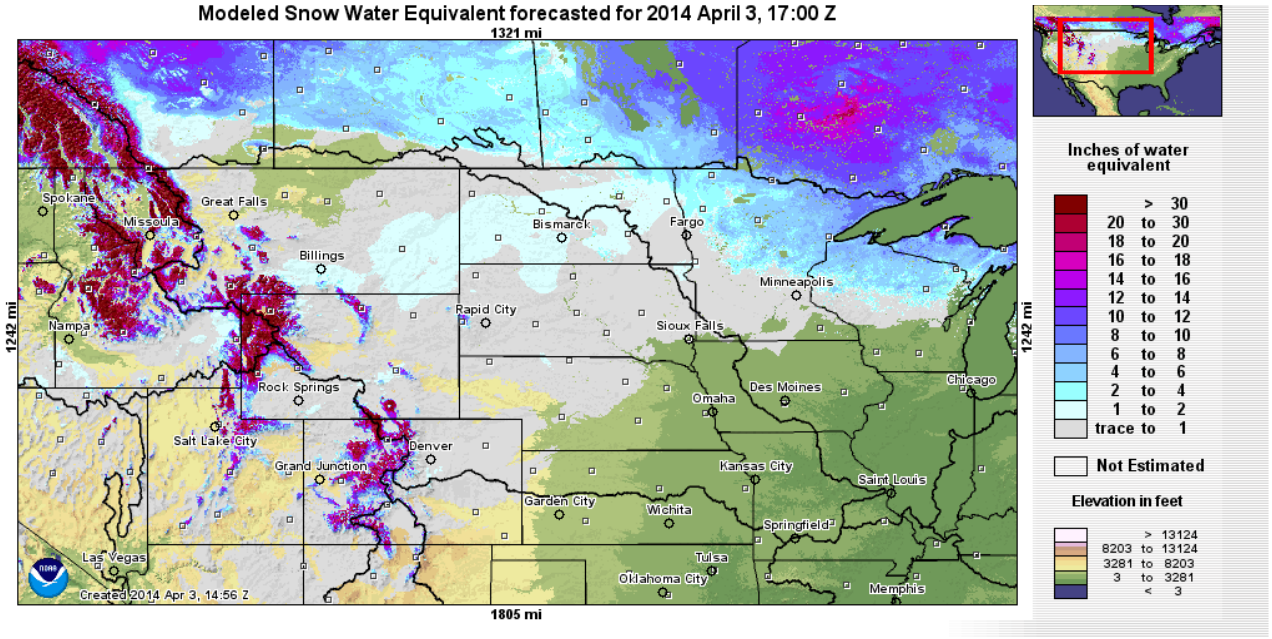


Figure 12. April 3, 2014, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Using the MRBWM snowpack classification method, long term plains snowpack, was generally classified as Light to slightly less than Light across the upper Missouri River basin (Table 1). This classification includes plains snowpack accumulations that fall between the range of 0 to 1 inch of SWE in the Fort Peck, Oahe, Fort Randall and Gavins Point subbasins and 0 to 2 inches in the Garrison and Gavins Point to Sioux City reaches.

Table 1. Plains snowpack classification based on plains snowpack as of March 1, 2014.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Light (0 – 1 inch SWE)
Fort Peck to Garrison	Light (0 – 2 inch SWE)
Garrison to Oahe	Light (0 – 1 inch SWE)
Oahe to Fort Randall	Average (0 – 0.5 inch SWE)
Fort Randall to Gavins Point	Average (0 – 0.5 inch SWE)
Gavins Point to Sioux City	Light (0 – 2 inch SWE)

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July 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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions.

As of April 1, 2014, the Corps of Engineers computed an average mountain SWE in the headwater basin above Fort Peck Dam of 21.2 inches, which is 132% of normal based on the 1981-2010 average SWE for the Fort Peck basin. In the subbasin between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 19.1 inches, which is 139% of normal based on the 1981-2010 average SWE for the Fort Peck to Garrison subbasin. Normally by April 1, 97% of the peak snow accumulation has occurred in the mountains.

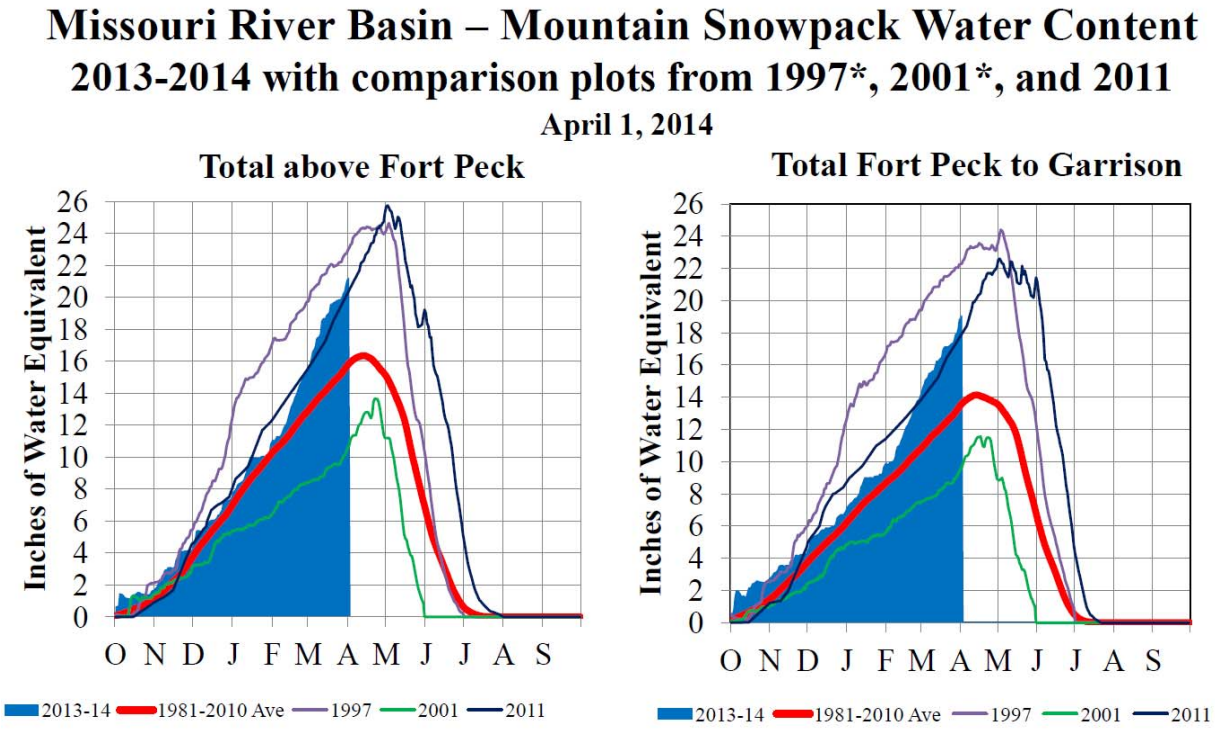


Figure 13. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific, equatorial sea surface temperatures (SST) were above-average near the International Date Line and near-average in the east-central Pacific. ENSO-neutral conditions are expected to continue through the Northern Hemisphere through the spring of 2014, with a 50 percent chance of El Nino developing in the summer or fall 2014. El Nino can increase chances for above normal temperatures and below normal precipitation in the Missouri River Basin during the Northern Hemisphere winter.

The Climate Prediction Center's April outlook (Figure 13) is indicating increased chances for colder than normal conditions over most of the Missouri River Basin. With regard to precipitation, there are equal chances for above, below or normal precipitation throughout the basin with the exception of southeastern Missouri.

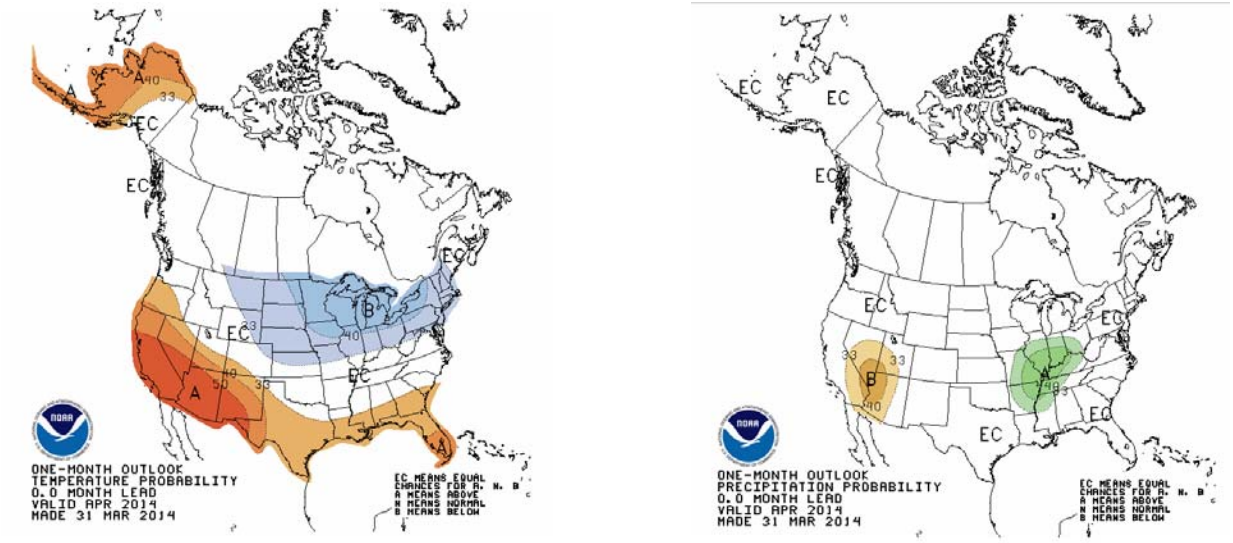


Figure 13. CPC April 2014 temperature and precipitation outlooks.

The three-month climate outlook through June 2014 (Figure 14) indicates increased chances for cooler than normal temperatures in Montana, North Dakota and South Dakota, with equal chances in all other areas. In terms of precipitation, there are equal chances for all portions of the basin. Looking further into 2014, the CPC's climate outlook for July-August-September (Figure 15) indicates increased chances for warmer than normal temperatures in Montana and Wyoming, and equal chances for all portions of the basin. There are equal chances for above, below, or normal precipitation throughout the upper basin.

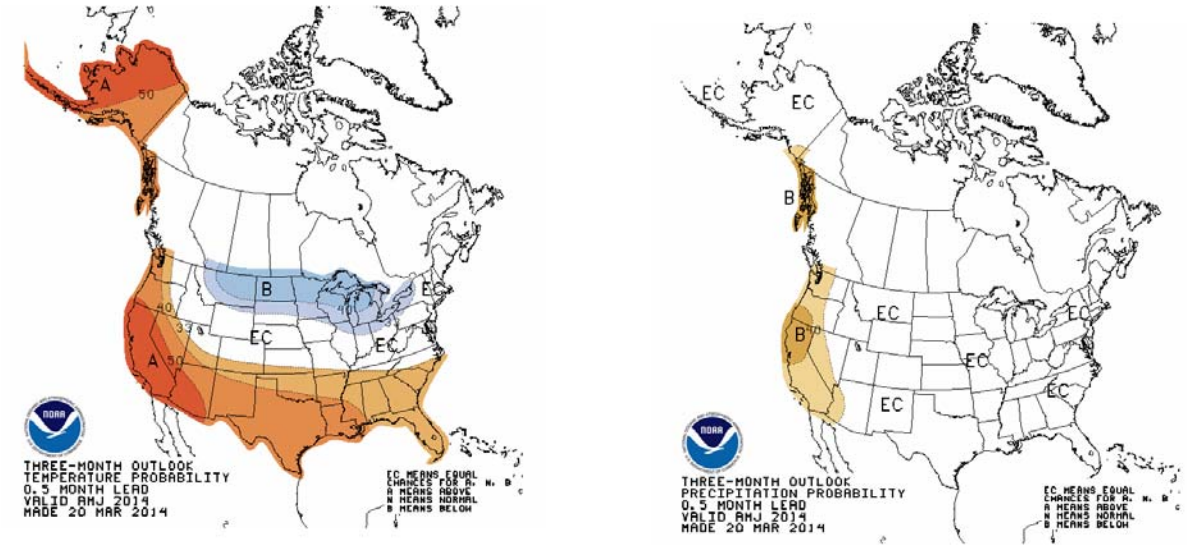


Figure 14. CPC April-May-June 2014 temperature and precipitation outlook.

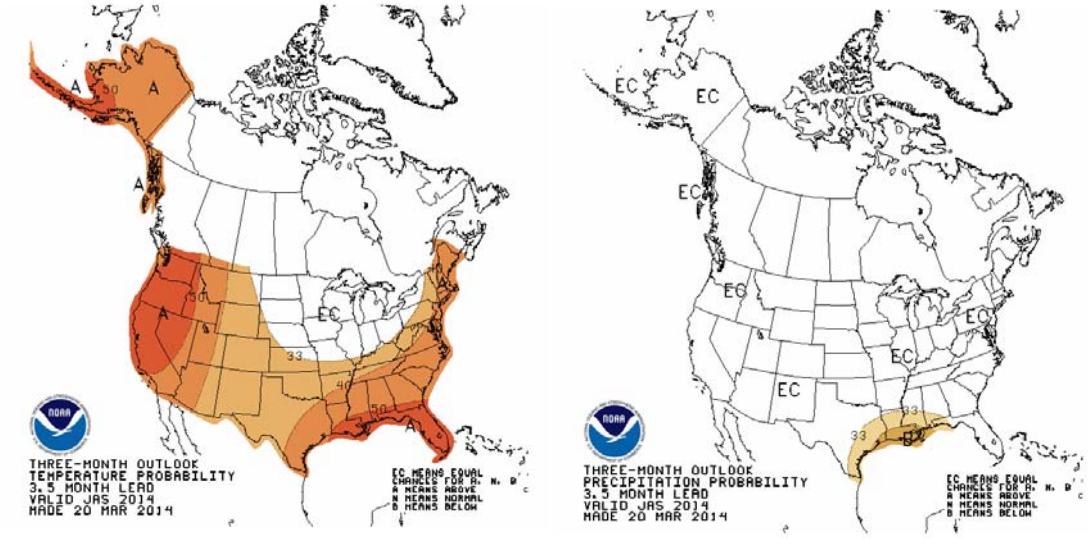


Figure 15. CPC July-August-September 2014 temperature and precipitation outlook.

Climate outlooks for September - November 2014 and December 2014 – February 2015 are provided in Figures 16 and 17. The CPC is indicating an increased probability for above normal temperatures in Montana, Wyoming, Colorado, western South Dakota, and western Nebraska for September through November. The precipitation outlook indicates equal chances for above, below and normal precipitation for all of the Missouri River basin. Finally, in the December through February outlook, the CPC is indicating an increased probability for above normal temperatures throughout the Basin. Equal chances for above, below and normal precipitation are predicted for the entire basin.

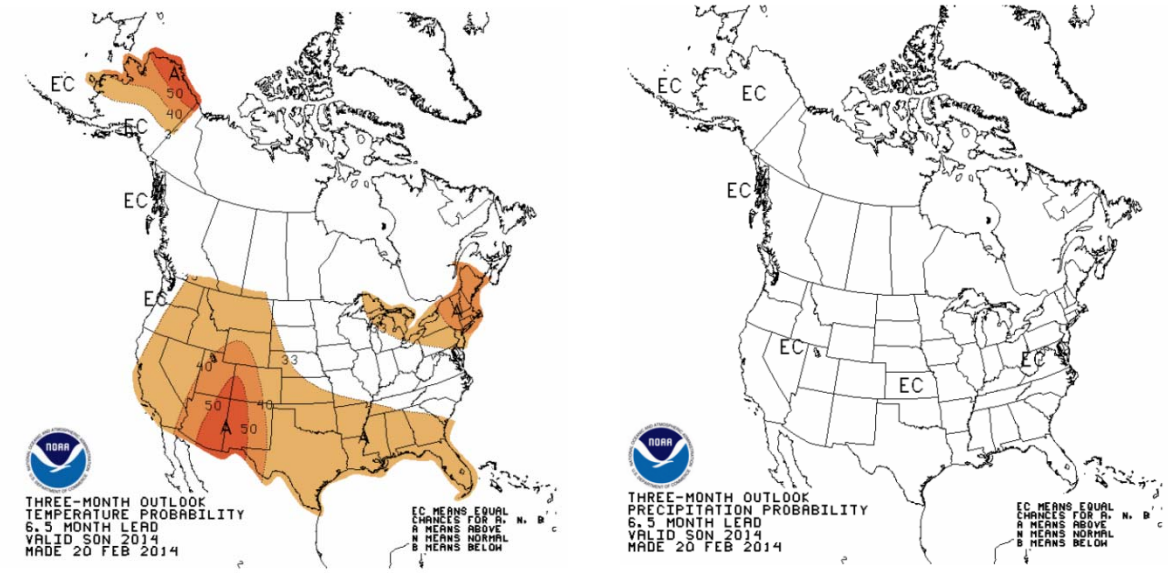


Figure 16. September-October-November 2014 temperature and precipitation outlook.

.

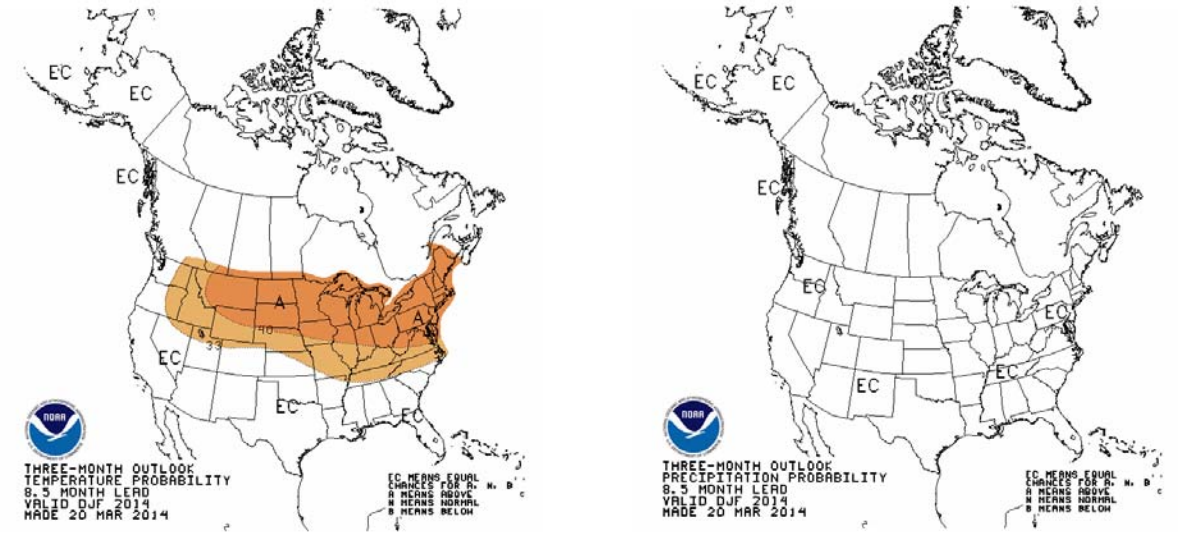


Figure 17. CPC December-January-February 2014-2015 temperature and precipitation outlook.

March 2014 Calendar Year Runoff Forecast

The calendar year runoff forecast is 32.0 MAF (127% of average) above Sioux City and 30.1 MAF (131% of average) above Gavins Point. Due to the amount of variability in precipitation that can occur over the next 9 months, the range of expected inflow is quite large and ranges from the 42.3 MAF upper basic forecast to the 23.2 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. It should be

noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

The increase since the March forecast is due to increased runoff forecast is a rise in mountain snowpack resulting in increases to the May-July runoff forecast.

March-April

Plains snowpack is a significant factor influencing the volume of runoff in March and April; however, snow and rainfall precipitation during this time period are also very important factors that need consideration. Furthermore, antecedent accumulated precipitation and antecedent soil moisture conditions have a significant influence on March-April runoff.

The Plains Snowpack Category Runoff forecast method was used to initially estimate March-April runoff, and the values were adjusted for localized soil moisture and recent runoff conditions. Plains snowpack is Light in the Ft. Peck, Garrison, Oahe, and Sioux City reaches. Due to much wetter soil moisture conditions in Fort Peck, Garrison, and Oahe reaches, above normal runoff is forecast in these reaches in March-April. Soil moisture conditions in the Sioux City reach vary from above normal to below normal.

March runoff above Sioux City was 4.2 MAF. This was primarily due snowmelt runoff from light plains snowpack over wet soil moisture conditions and frozen soils in the upper basin. In addition, heavy river ice melted in March on the Missouri River and its tributaries, contributing some additional runoff. April runoff is expected to be 117% of normal.

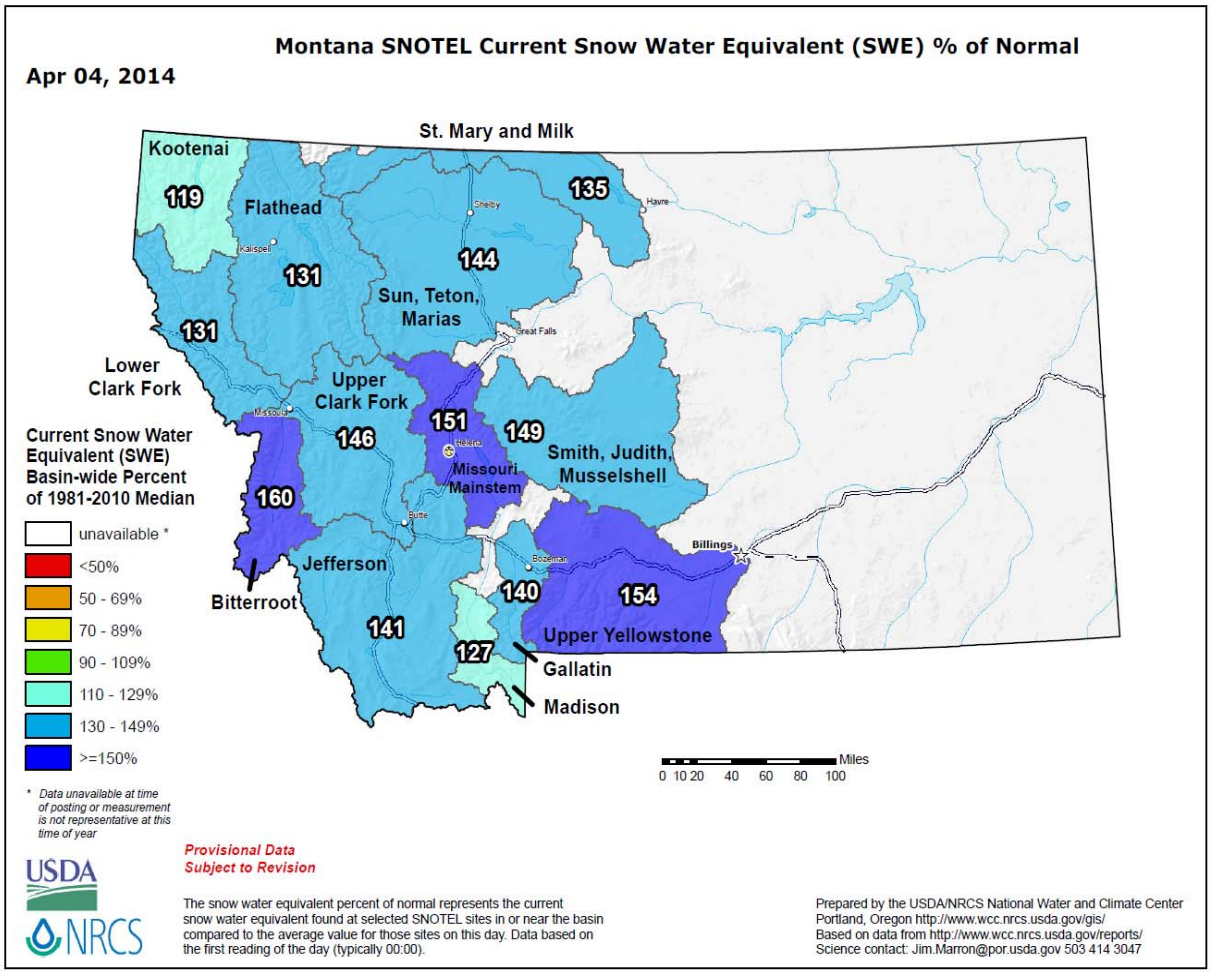
May-June-July

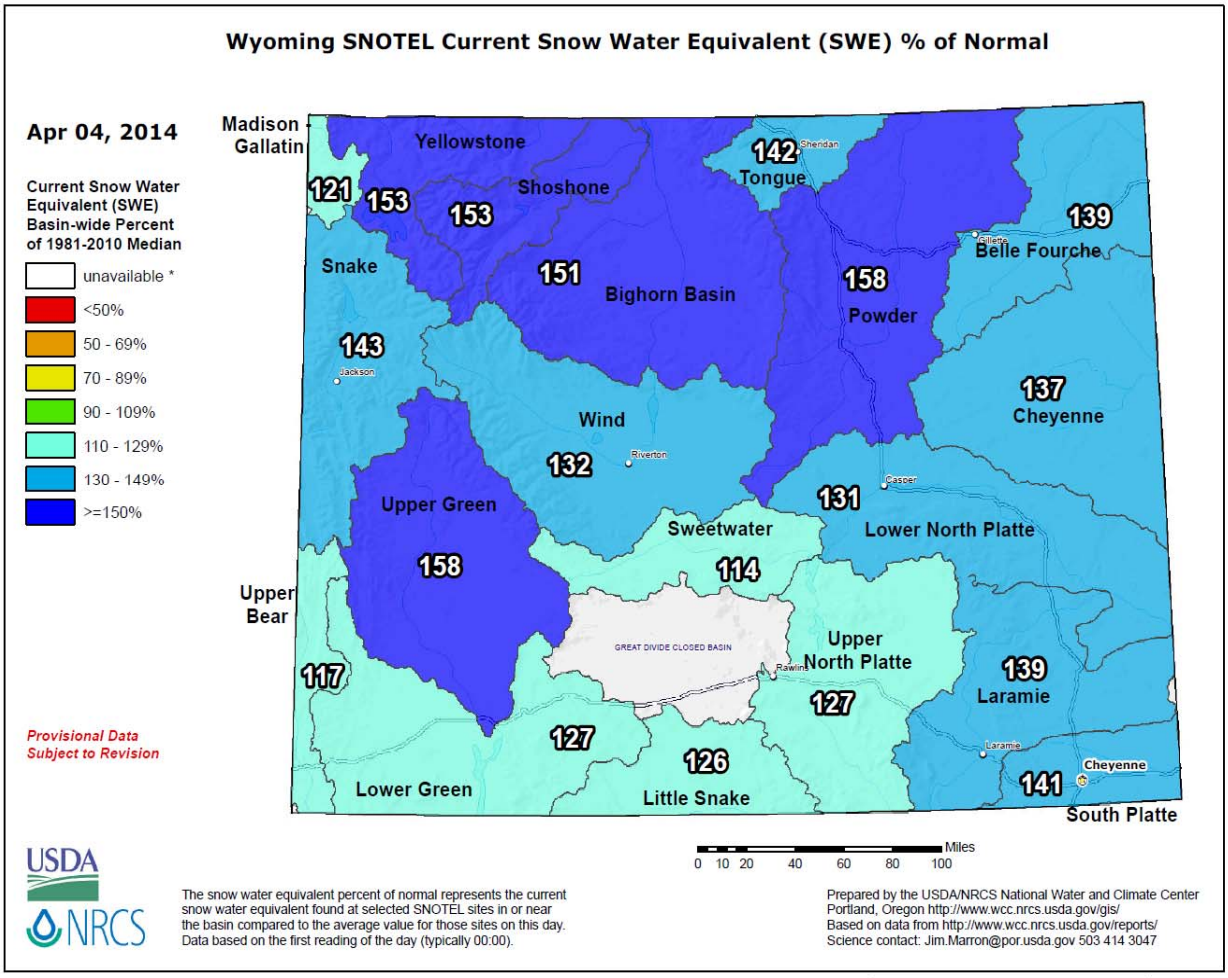
For this three-month period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. Using the April 1, 2014 mountain snowpack (132% of average in the reach above Fort Peck and 139% of average in the reach between Fort Peck and Garrison) and the CPC 3-month outlooks of spring precipitation and temperatures, the May-June-July runoff forecast is 149% of normal runoff above Fort Peck and 144% of normal runoff from Fort Peck to Garrison. Runoff in the Oahe, Fort Randall, Gavins Point and Sioux City reaches is forecast to be 100% of normal because there is very little certainty in the rainfall and temperature forecasts at that time of year.

August through December

For the latter half of 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the basin and equal chances for above, below and normal precipitation. Consequently, runoff for all reaches is forecast to be essentially normal.

Additional Figures and Information




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
Apr 04, 2014
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison Gallatin
Yellowstone
Shoshone
Snake
Bighorn Basin
Tongue
Sheridan
Belle Fourche
Powder
Jackson
Wind
Riverton
Cheyenne
Casper
Upper Green
Sweetwater
Lower North Platte
Upper Bear
GREAT DIVIDE CLOSED BASIN
Rawlins
Upper North Platte
Laramie
Lower Green
Little Snake
South Platte
121
153
153
142
139
151
158
143
137
132
131
158
114
117
127
139
127
126
141
0 10 20 40 60 80 100 Miles
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

USDA NRCS National Water & Climate Center

USDA NRCS National Water & Climate Center
** - DATA CURRENT AS OF: April 02, 2014 07:32:07 PM*
- Based on April 01, 2014 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	111	114	125	117	105	97	97
	APR-SEP	128	114	144	135	121	112	112
St. Mary R at Int'l Boundary (2)	APR-JUL	485	111	580	525	445	390	435
	APR-SEP	565	112	665	605	525	465	505
Lima Reservoir Inflow (2)	APR-JUL	66	80	83	73	59	49	82
	APR-SEP	70	79	90	78	62	50	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	98	97	165	125	71	31	101
	APR-SEP	119	99	190	148	90	48	120
Jefferson R nr Three Forks (2)	APR-JUL	1200	162	1550	1340	1070	860	740
	APR-SEP	1300	163	1680	1450	1140	915	800
Hebgen Reservoir Inflow (2)	APR-JUL	410	111	460	430	390	360	370
	APR-SEP	515	110	575	540	490	455	470
Ennis Reservoir Inflow (2)	APR-JUL	665	106	780	710	615	545	625
	APR-SEP	810	105	950	865	755	675	775
Missouri R at Toston (2)	APR-JUL	2470	138	3040	2700	2240	1900	1790
	APR-SEP	2810	136	3490	3080	2530	2120	2070
Smith R bl Eagle Ck (2)	APR-JUL	171	161	225	192	150	119	106
	APR-SEP	191	165	255	215	165	127	116
Gibson Reservoir Inflow (2)	APR-JUL	530	134	615	565	500	450	395
	APR-SEP	580	132	670	615	545	490	440
Marias R nr Shelby (2)	APR-JUL	500	145	665	570	435	340	345
	APR-SEP	520	144	700	595	445	340	360
Milk R at Western Crossing	APR-SEP	31	119	56	45	24	17.6	26*
Milk R at Eastern Crossing	APR-SEP	60	118	124	73	47	36	51*

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	67	114	74	70	64	60	59
	APR-SEP	86	116	97	90	82	75	74
Wind R ab Bull Lake Ck (2)	APR-JUL	660	145	755	700	620	565	455
	APR-SEP	710	145	825	755	665	595	490
Bull Lake Ck nr Lenore	APR-JUL	165	119	200	179	150	128	139
	APR-SEP	200	118	245	220	182	155	169
Boysen Reservoir Inflow (2)	APR-JUL	945	155	1280	1080	810	610	610
	APR-SEP	1040	156	1410	1190	895	670	665
Greybull R nr Meeteetse	APR-JUL	195	149	240	215	177	151	131
	APR-SEP	265	150	320	285	245	210	177
Shell Ck nr Shell	APR-JUL	71	129	86	77	66	57	55
	APR-SEP	83	126	99	90	76	67	66
Bighorn R at Kane (2)	APR-JUL	1430	170	1940	1640	1220	910	840
	APR-SEP	1570	173	2140	1800	1330	995	905
NF Shoshone R at Wapiti	APR-JUL	645	140	720	675	610	565	460
	APR-SEP	715	139	800	750	680	625	515
SF Shoshone R nr Valley	APR-JUL	305	142	345	320	290	270	215
	APR-SEP	350	143	395	370	330	305	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	1000	148	1130	1050	945	865	675
	APR-SEP	1090	146	1250	1160	1030	935	745
Bighorn R nr St. Xavier (2)	APR-JUL	2310	167	2920	2550	2060	1700	1380
	APR-SEP	2510	172	3210	2790	2230	1810	1460
Little Bighorn R nr Hardin	APR-JUL	152	155	193	169	135	110	98
	APR-SEP	168	151	215	186	149	122	111
Tongue R nr Dayton (2)	APR-JUL	120	140	147	131	109	92	86
	APR-SEP	134	137	164	146	122	104	98
Tongue River Reservoir Inflow (2)	APR-JUL	295	153	395	335	255	197	193
	APR-SEP	330	153	435	375	290	225	215
NF Powder R nr Hazelton	APR-JUL	16.4	180	18.8	17.4	15.4	14.0	9.1
	APR-SEP	17.5	177	20	18.6	16.4	14.9	9.9
Powder R at Moorhead	APR-JUL	345	195	460	390	300	230	177
	APR-SEP	380	194	500	430	330	260	196
Powder R nr Locate	APR-JUL	395	198	535	450	340	255	199
	APR-SEP	440	200	585	500	380	290	220

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	APR-JUL	8.5	163	11.5	9.7	7.3	5.5	5.2
Pactola Reservoir Inflow	APR-JUL	35	159	52	42	28	18.1	22

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
North Platte R nr Northgate	APR-JUL	350	156	445	390	310	255	225
	APR-SEP	390	156	495	435	345	285	250
Encampment R nr Encampment	APR-JUL	173	134	210	187	159	138	129
	APR-SEP	184	133	220	199	169	146	138
Rock Ck nr Arlington	APR-JUL	68	139	81	73	63	55	49
	APR-SEP	72	138	86	78	66	58	52
Seminoe Reservoir Inflow (2)	APR-JUL	1020	143	1380	1170	870	655	715
	APR-SEP	1100	143	1500	1270	945	705	770
Sweetwater R nr Alcova	APR-JUL	54	92	82	65	43	26	59
	APR-SEP	59	92	90	71	47	28	64
La Prele Ck ab La Prele Reservoir	APR-JUL	25	126	38	30	19.8	12.2	19.9
	APR-SEP	25	126	38	30	19.8	12.1	19.9
North Platte R-Alcova to Orin Gain	APR-JUL	126	247	255	178	74	7.0	51
	APR-SEP	91	455	220	144	38	12.0	20
North Platte R bl Glendo Res (2)	APR-JUL	1200	146	1460	1310	1090	940	820
	APR-SEP	1250	147	1520	1360	1130	970	850
North Platte R bl Guernsey Res (2)	APR-JUL	1240	151	1570	1370	1100	910	820
	APR-SEP	1300	153	1640	1440	1160	960	850
Laramie R nr Woods	APR-JUL	174	151	215	190	158	135	115
	APR-SEP	190	151	235	210	172	146	126
Little Laramie R nr Filmore	APR-JUL	69	135	85	76	62	53	51
	APR-SEP	75	136	94	83	67	56	55

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average
** Milk River medians are for years 1980-2008 & marked "30%" is 25% exceedance and marked "70%" is 75% exceedance*

Upper Missouri River Basin
May 2014 Calendar Year Runoff Forecast
May 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The May 1, 2014 calendar year forecast for the Missouri River Basin above Sioux City, IA is 31.7 MAF (125% of normal). Runoff above Gavins Point Dam is forecast to be 29.8 MAF (130% of normal). April runoff was 2.8 MAF, 96% of normal, and 0.6 MAF below the April forecast. Although the calendar year forecast decreased 0.3 MAF due to below average April runoff, forecast runoff for the remainder of 2014 increased slightly due to steady mountain snowpack, which has had limited melt, and the potential for additional runoff from rainfall on wet soil conditions. These increases were made in the Fort Peck, Garrison and Oahe reaches.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 8 months, the range of expected inflow is quite large and ranges from the 40.9 MAF upper basic forecast to the 24.0 MAF lower basic forecast. 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 8 months are being forecasted for this May 1 forecast (4 months observed/8 months forecast), the range of wetter than normal (upper basic) and drier than normal (lower basic) conditions is attributed to all 6 reaches for all 8 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 forecasted months decreases.

Current Conditions

ENSO (El Niño Southern Oscillation)

ENSO-neutral conditions continue in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average near the International Date Line and across much of the east-central Pacific Ocean based on CPC analysis. ENSO-neutral conditions are expected to continue through the Northern Hemisphere through the spring of 2014, with a greater than 50 percent chance of El Niño developing in the summer 2014. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

Drought Analysis

According to the National Drought Mitigation Center (**Figure 1**), drought conditions on April 29, 2014 have improved very little since March 25, 2014 (**Figure 2**). Montana, North and South Dakota, and northern Wyoming are out of any drought category. Some abnormally dry conditions have developed in eastern South Dakota due to the lack of precipitation over the past 90 days. The majority of Nebraska, Kansas, and Iowa have improved the past year to "Abnormally Dry to Severe Drought" conditions with "Extreme Drought" conditions isolated to southwest Nebraska and northwest Kansas. The U.S. Seasonal Drought Outlook shown in **Figure 3** indicates drought conditions that are currently impacting central Nebraska and western Kansas will persist through mid-summer 2014 with limited change in drought category. Improvement will likely occur in eastern Nebraska and western Iowa.

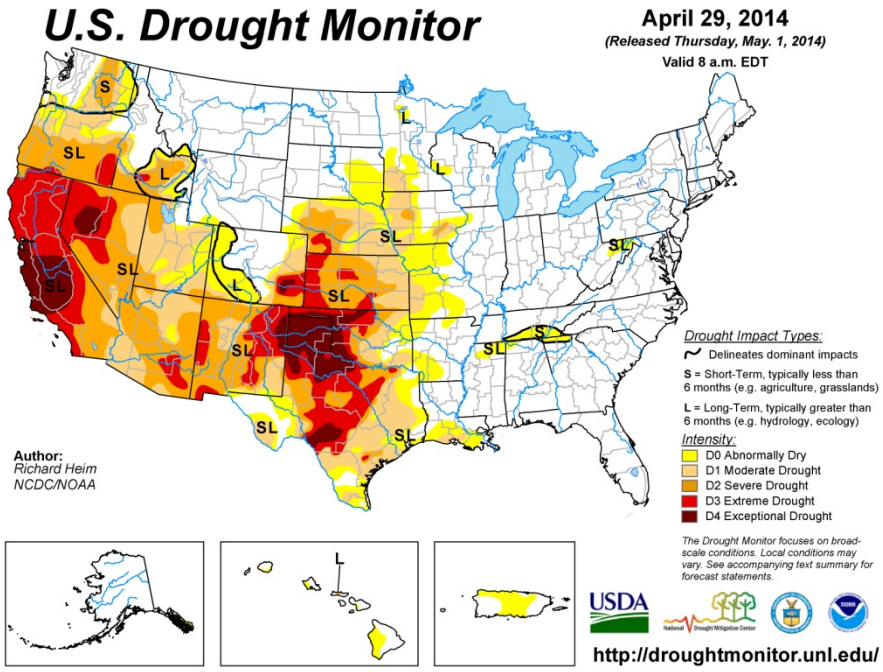


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for April 29, 2014.

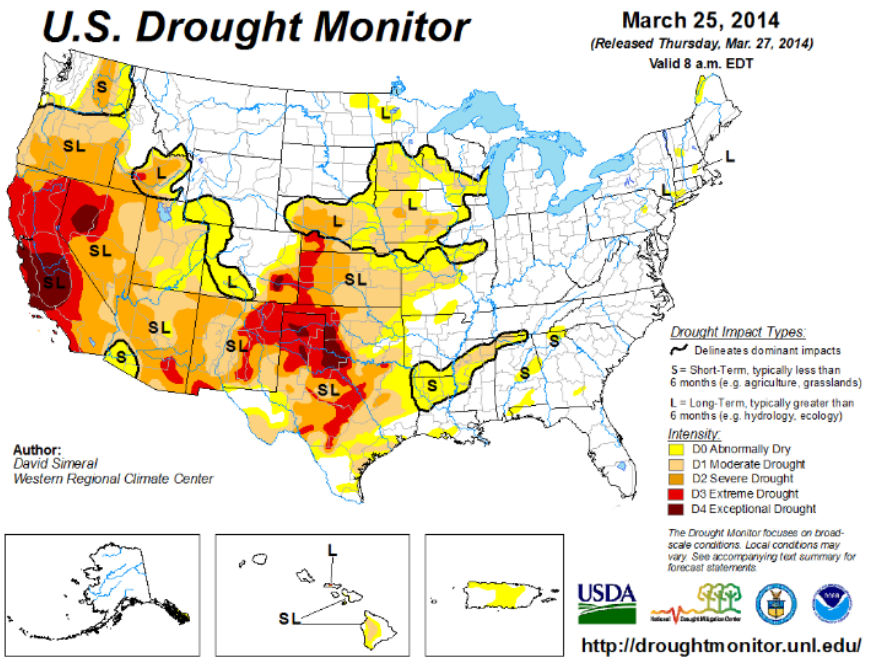


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for March 25, 2014.

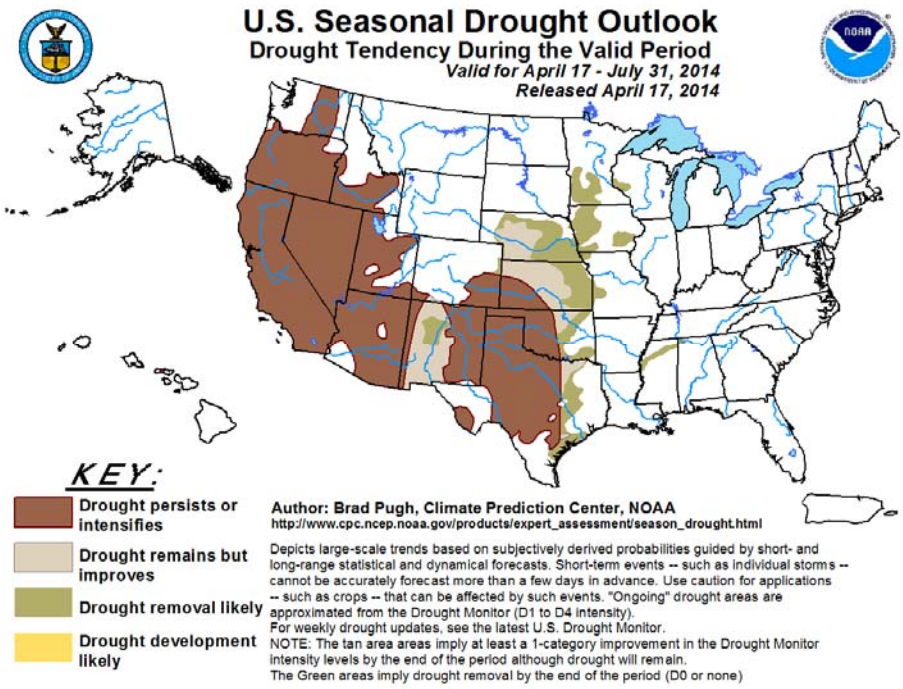


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation as a percent of normal during the month of April is shown in **Figure 4**. Below normal precipitation occurred in the lower Missouri basin below Sioux City, IA and in much of eastern South Dakota, which received less than 70 percent of normal precipitation. In contrast, precipitation was well above normal (greater than 130 percent) in North Dakota and locations in northern Montana. Much of this precipitation fell as rain and snow during the last 5 days of April. Precipitation departures in **Figure 5** associated with these areas of above normal precipitation ranged from 1 inch to slightly greater than 2 inches above normal. In spite of what was a wetter than normal month in these areas, runoff in the Garrison and Oahe reaches was about 120 percent of normal and below the April 1 forecasted runoff.

Accumulated precipitation over the three-month (February-March-April) period ending on April 30, 2014 is shown in **Figure 6**. Precipitation has been above normal in most of Montana, North Dakota, western South Dakota and Wyoming. Precipitation has been well below normal in eastern South Dakota and the lower basin below Sioux City, IA.

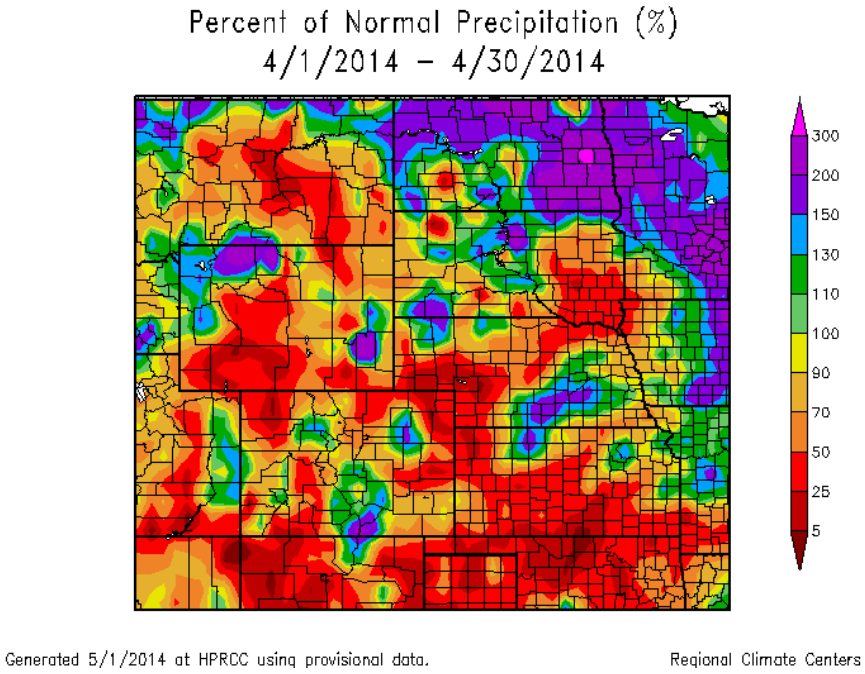


Figure 4. Monthly Percent of Normal Precipitation ending on April 30, 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

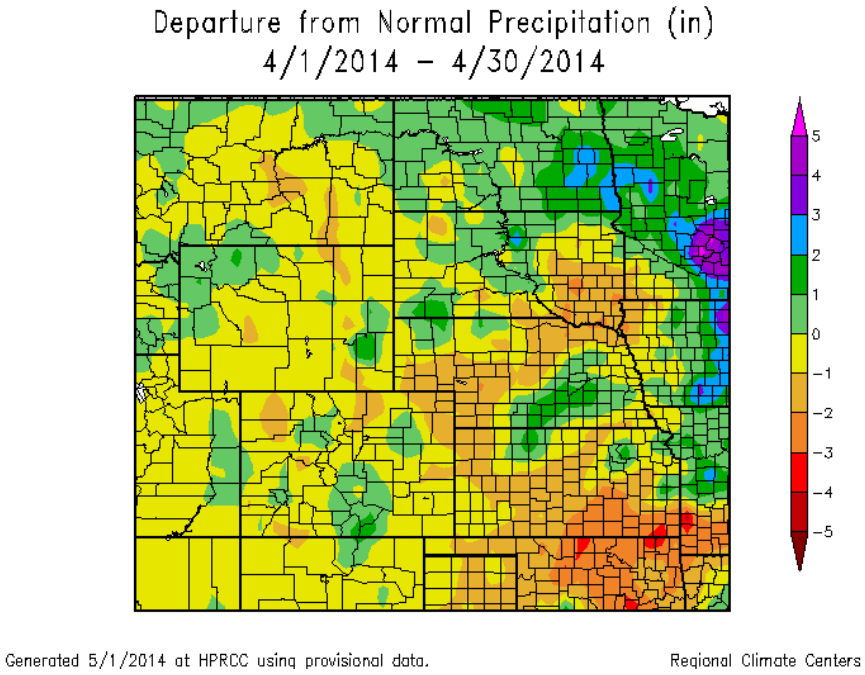


Figure 5. Monthly Precipitation Departure (inches) ending on April 30, 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

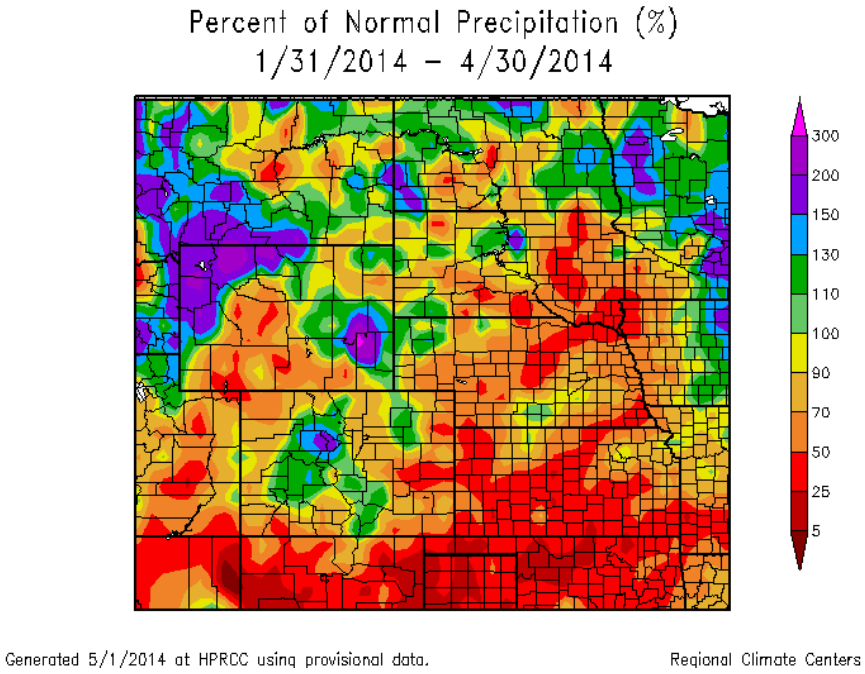


Figure 6. Three-month Percent of Normal Precipitation ending on April 30, 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of April, courtesy of the Climate Prediction Center, is shown in **Figure 7**. Temperatures have been below normal across the majority of the upper basin. Most of the departures for the month were 2 to 4 deg F below normal. Temperatures in the mountainous regions have been about normal to slightly above normal.

Three-month (January- February-March) temperature departures ending on April 1, 2014 are shown in **Figure 8**. The three-month map indicates that temperatures have been 3 to 6 deg F colder than normal in the majority of the basin.

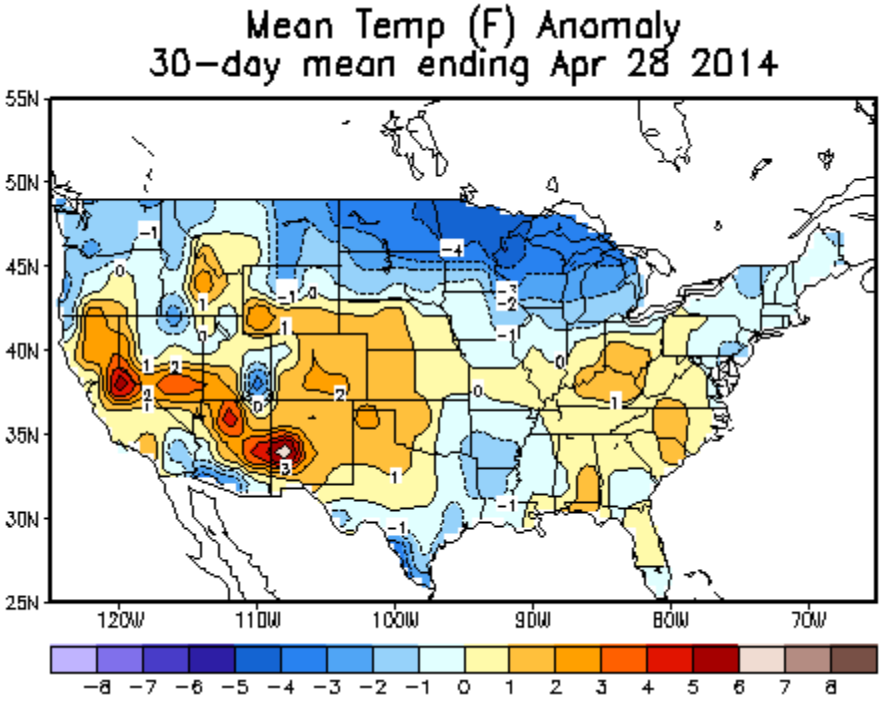


Figure 7. Monthly Departure from Normal Temperature (deg F) ending April 28, 2014.

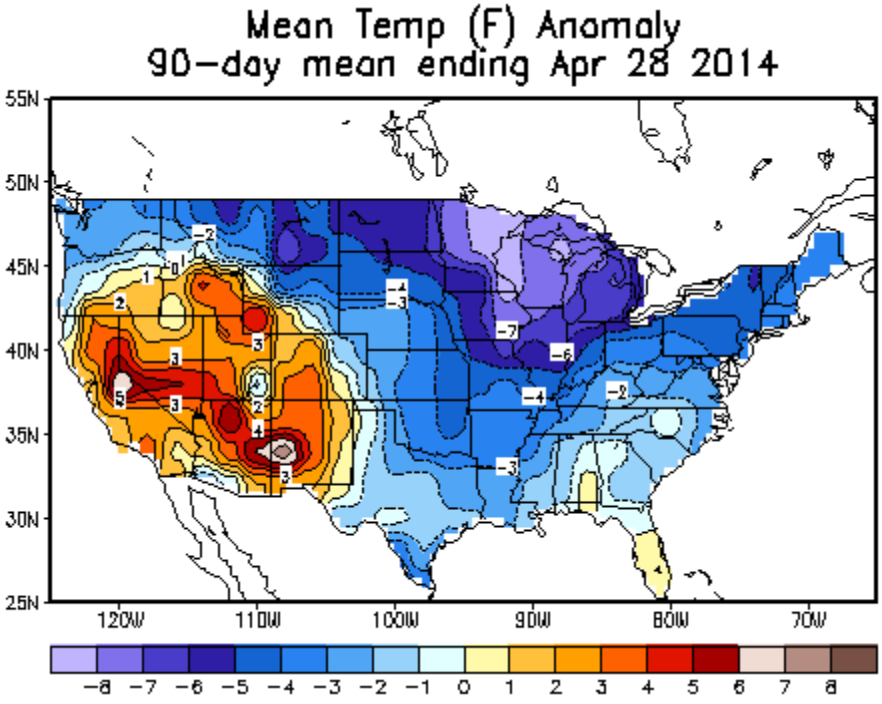


Figure 8. Three-month Departure from Normal Temperature (deg F) ending April 1, 2014.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Three estimates of soil moisture are presented in this report. **Figure 9** shows the Climate Prediction Center's calculated soil moisture ranking percentiles on April 29, 2014. **Figure 10** shows the Variable Infiltration Capacity model soil moisture percentiles on April 28, 2014. **Figure 11** shows the NOAA NLDAS soil moisture percentiles on April 25, 2014.

All three soil moisture estimates depict very wet soil moisture conditions throughout the upper Missouri River basin in Montana and Wyoming and western portions of North and South Dakota. CPC soil moisture conditions in these areas rank from the 80th to the 99th percentile. Soil moisture conditions in Nebraska, eastern Colorado, Kansas, Missouri and Iowa have drier than normal soil moisture conditions.

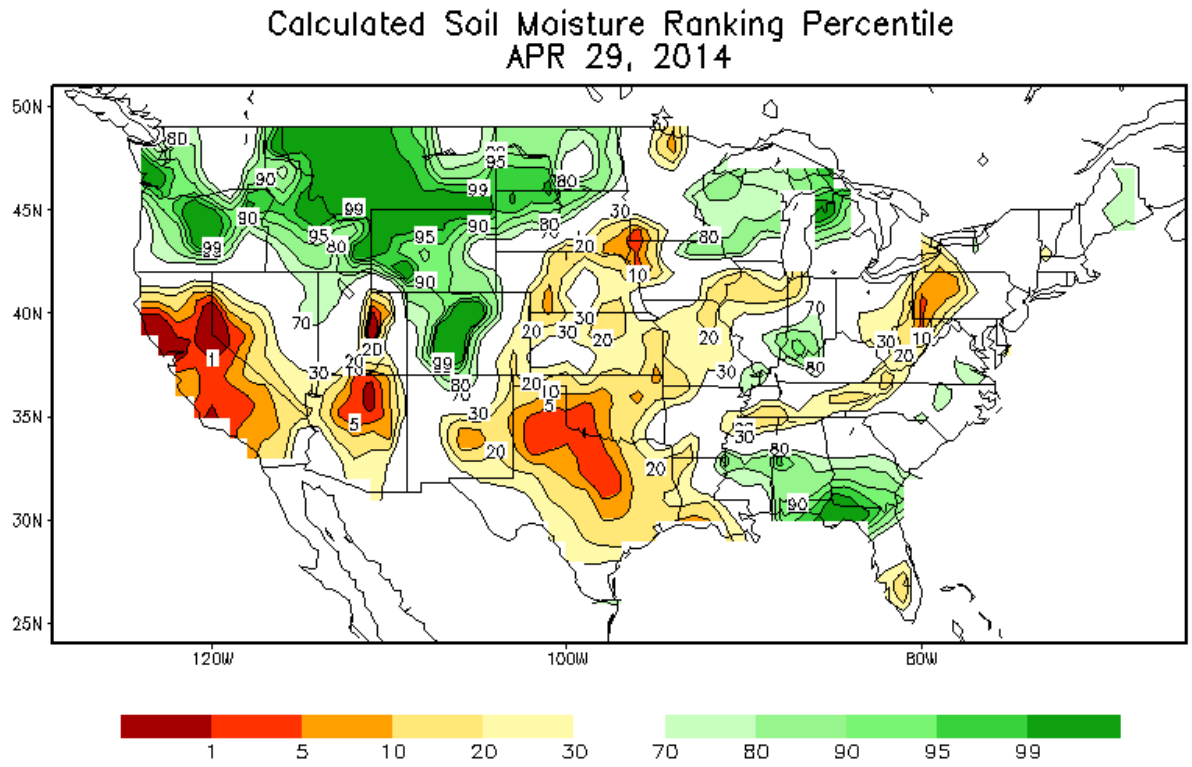


Figure 9. Calculated Soil Moisture Ranking Percentile on April 29, 2014. Source: Climate Prediction Center.
http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

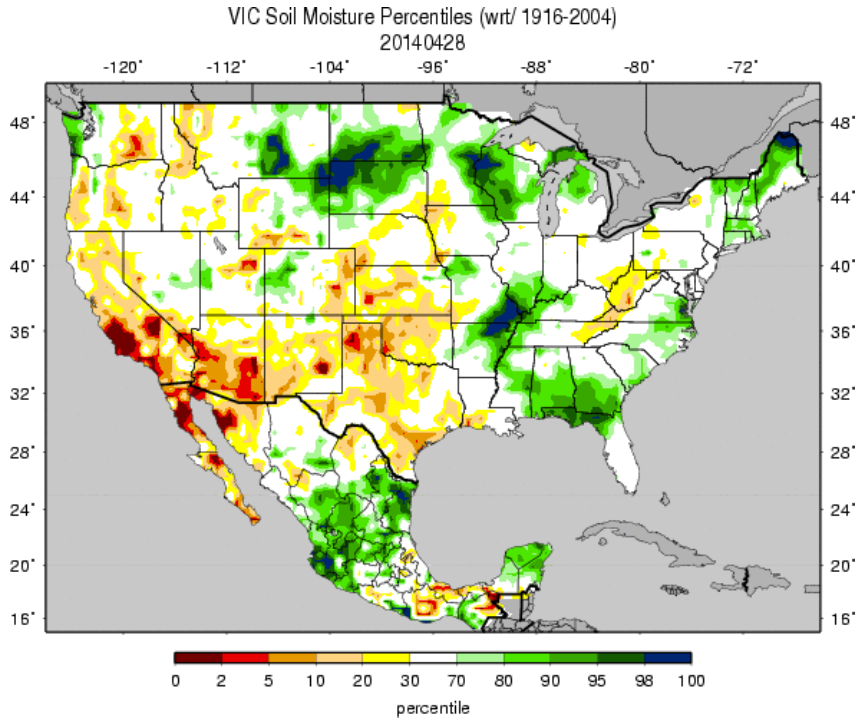


Figure 10. VIC modeled soil moisture percentiles as of April 25, 2014. Source: NOAA University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/CONUS.MEXICO.vic.sm_qnt.gif

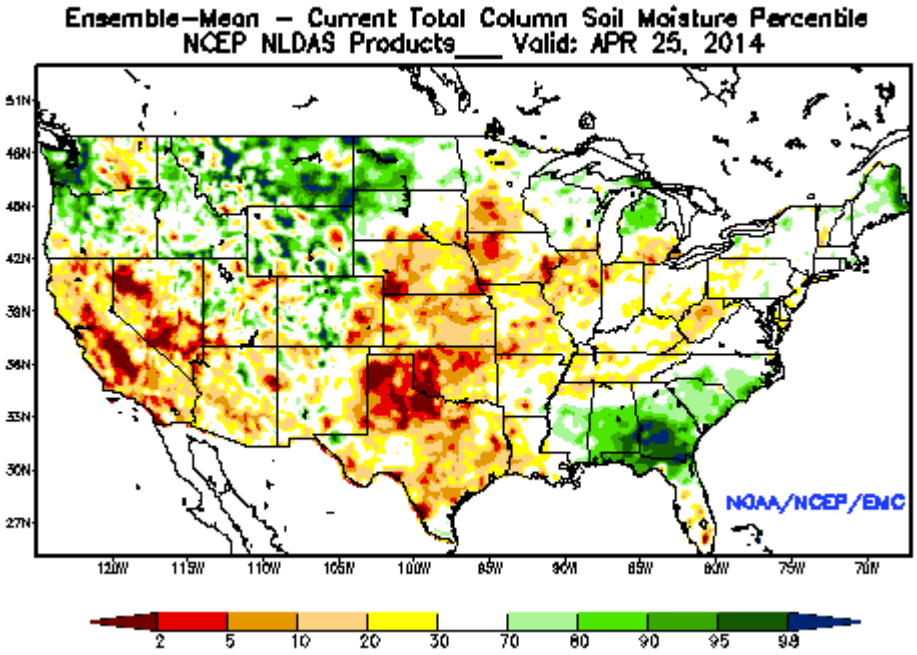


Figure 11. Total Column Soil Moisture Percentile as of April 25, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The CPC calculated soil moisture anomaly for the contiguous U.S. on April 29, 2014 is shown in **Figure 12**. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 40 mm (1.6 inches). Some areas in Montana and Wyoming have anomalies greater than 160 mm (6.3 inches) of moisture owing to the recent melt of low elevation mountain snowpack and precipitation. The modeled soil moisture rankings and anomalies indicate soil moisture conditions in the upper basin, especially in Montana, Wyoming and western North Dakota are very wet and have the potential to increase runoff volumes under normal precipitation.

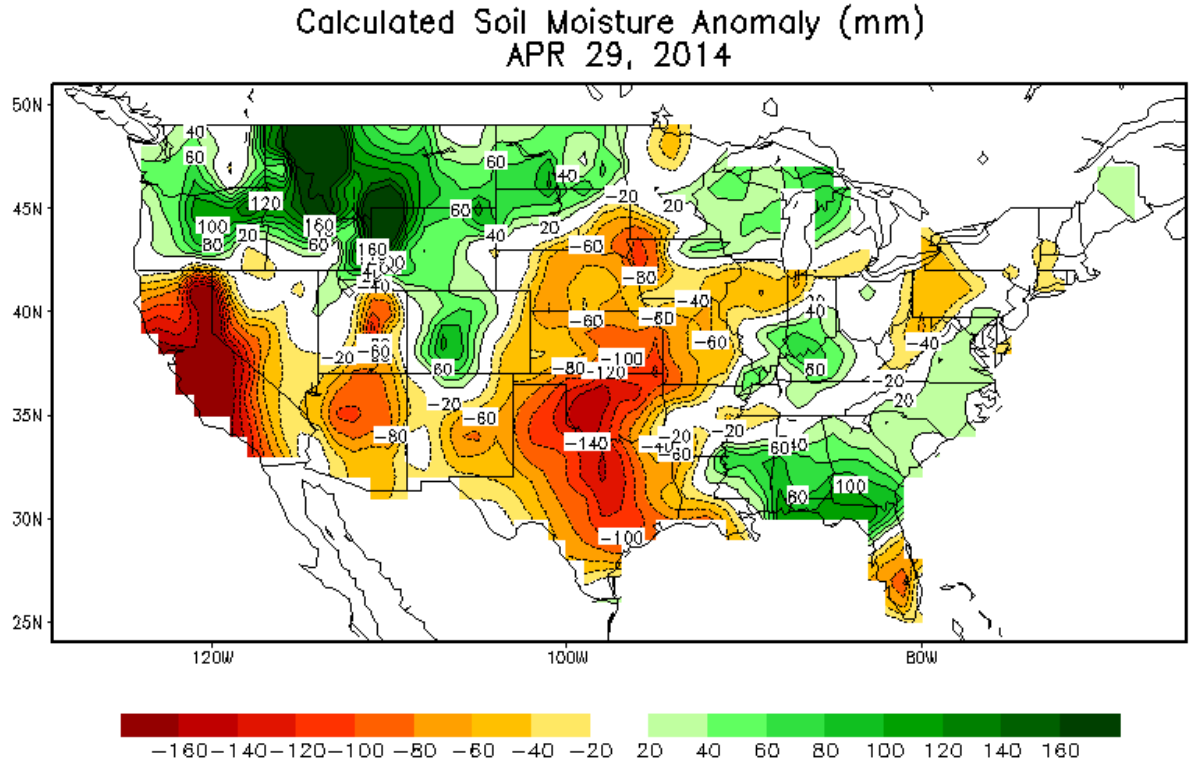


Figure 12. Calculated Soil Moisture Anomaly (mm) on April 29, 2014. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

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. A common misperception is that the March-April runoff is a result of plains snowmelt only. Historically, about 25% of annual runoff occurs in March and April, during the time when plains snow is melting, due to both melting snowpack and rainfall runoff. Runoff occurs in March and April whether or not there is any plains snow to melt. Exact rainfall amounts and locations are nearly impossible to predict more than a week in advance. Thus, the March-April runoff forecast is formulated based on existing plains snowpack and existing basin conditions and hydrologic forecasts, which for this year primarily includes long-term precipitation outlooks.

At the beginning of April, all seasonal plains snowpack accumulations had melted; therefore, the plains snowpack contribution to March and April runoff was no longer a factor. Since the beginning of April the upper basin has experienced some intermittent accumulation and melt of snow. Based on the National Operational Hydrologic Remote Sensing Center (NOHRSC) snow model, some plains snowpack accumulated at the end of April due to the large spring storm over the Northern Plains, but as of May 1, 2014 the plains snow has melted as shown in **Figure 13.**

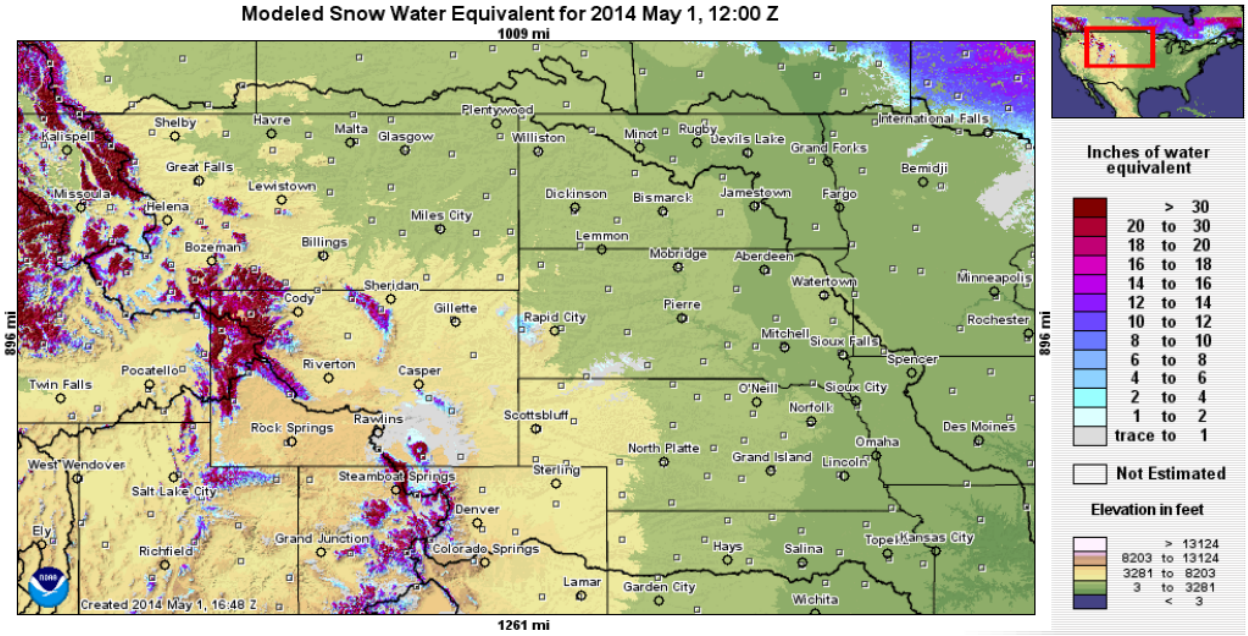


Figure 13. May 1, 2014, NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July 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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions. Average mountain snowpack for the headwater basin above Fort Peck Dam and for the subbasin between Fort Peck Dam and Garrison Dam are shown in **Figure 14**.

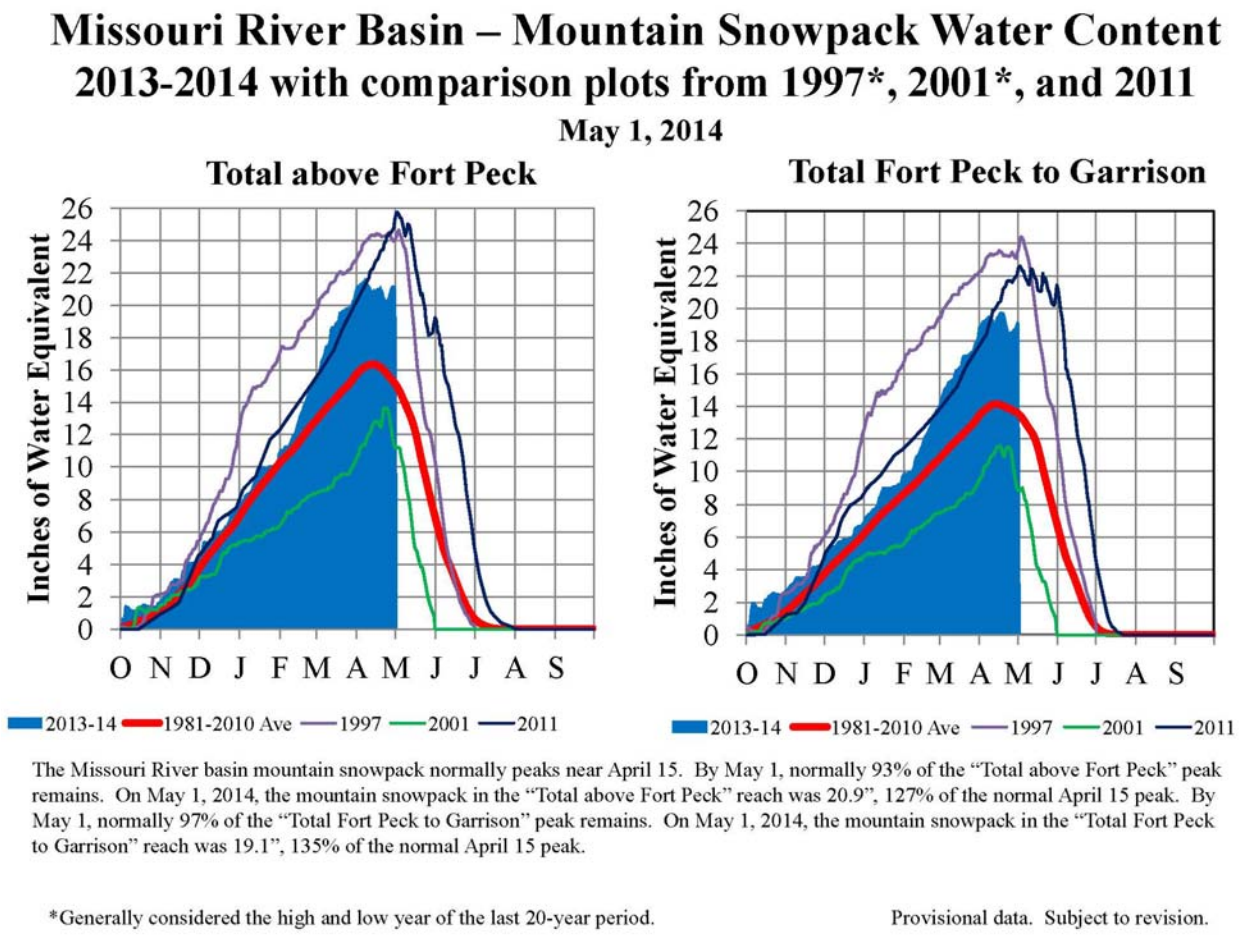


Figure 14. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

On April 7, 2014 the mountain snowpack above Fort Peck reached a high of 21.7 inches, which was 132 percent of the normal peak accumulation based on the 1981-2010 average peak SWE above Fort Peck. **The April 7, 2014 SWE is 4.1 inches lower than the May 2, 2011 peak SWE of 25.8 inches above Fort Peck.** Since April 7, the average SWE above Fort Peck has experienced some melt and accumulation. As of May 1, 2014, the Corps of Engineers computed an average mountain SWE above Fort Peck Dam of 20.9 inches, which is 127 percent of the average peak SWE accumulation based on 1981-2010 data, or 96 percent of the 21.7 inch accumulation on April 7.

On April 17, 2014 the mountain snowpack between Fort Peck and Garrison reached a high of 19.8 inches, which was 140 percent of the normal peak accumulation based on the 1981-2010 average peak SWE from Fort Peck to Garrison. **The April 17, 2014 SWE is 2.8 inches lower than the May 2, 2011 peak SWE of 22.6 inches above Garrison.** Since April 17, the average SWE from Fort Peck to Garrison has experienced some melt and accumulation. As of May 1, 2014, the Corps of Engineers computed an average mountain SWE from Fort Peck to Garrison of

19.1 inches, which is 135 percent of the average peak SWE accumulation based on 1981-2010 data, or 96 percent of the 19.8 inch accumulation on April 17.

Due to the continued cool and wet weather pattern some additional accumulation could occur; however, it is uncertain if the snowpack will exceed the high SWE levels above Fort Peck and Garrison on April 7 and April 17, respectively.

Climate Outlook

ENSO-neutral conditions continue in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average near the International Date Line and across much of the east-central Pacific Ocean based on CPC analysis. ENSO-neutral conditions are expected to continue through the Northern Hemisphere through the spring of 2014, with a greater than 50 percent chance of El Niño developing in the summer 2014. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

The Climate Prediction Center's May outlook (Figure 13) is indicating increased chances for colder than normal conditions over the upper Missouri River Basin including the states of Montana, North Dakota, South Dakota and the northern half of Wyoming. With regard to precipitation, there are increased chances for above normal precipitation in Montana, extending southeastward into the lower Missouri River basin.

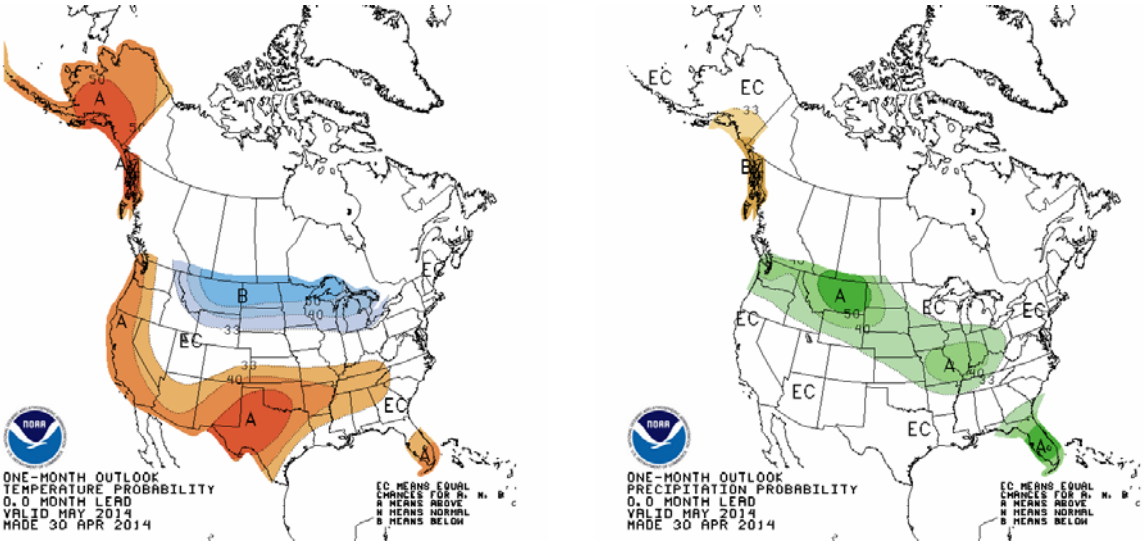


Figure 13. CPC May 2014 temperature and precipitation outlooks.

The three-month climate outlook through July 2014 (Figure 14) indicates increased chances for cooler than normal temperatures in Montana and North Dakota with equal chances in all other areas. In terms of precipitation, there are equal chances for above normal, below normal and normal precipitation over all of the upper Basin. Looking further into 2014, the CPC's climate outlook for August-September-October (Figure 15) indicates increased chances for warmer than normal temperatures in Montana and Wyoming, and equal chances for all portions of the basin. There are equal chances for above normal, below normal, and normal precipitation throughout the upper Basin.

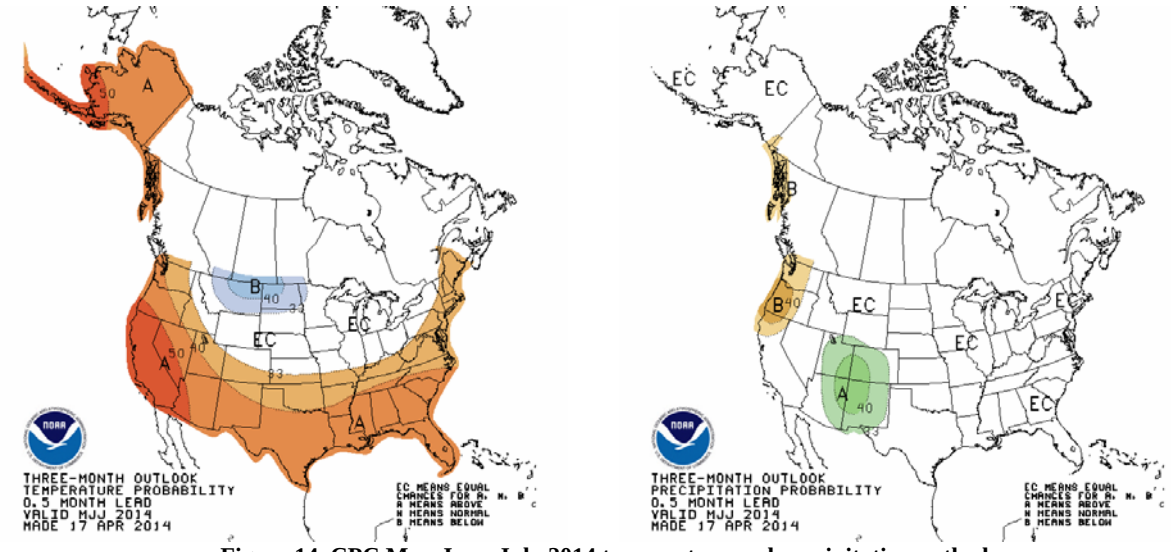


Figure 14. CPC May-June-July 2014 temperature and precipitation outlook.

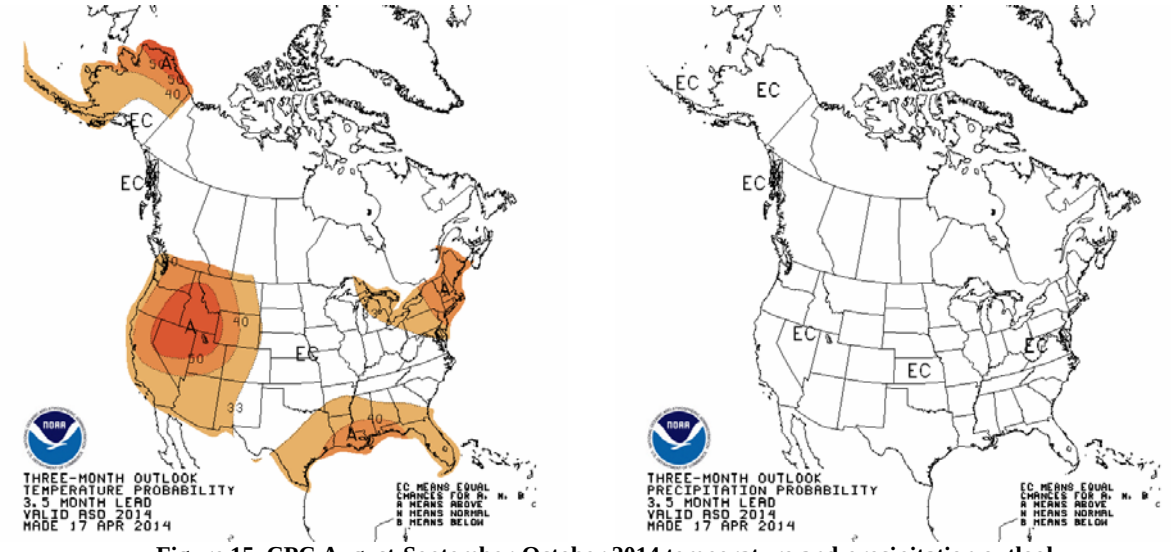


Figure 15. CPC August-September-October 2014 temperature and precipitation outlook.

Climate outlooks for November-December 2014 and January 2015 are provided in Figure 16. The CPC is indicating an increased probability for above normal temperatures in the entire Missouri River Basin during late fall and winter as a reflection of an El Niño episode developing during the 2014 summer. The precipitation outlook indicates equal chances for above normal, below normal and normal precipitation for all of the Missouri River Basin.

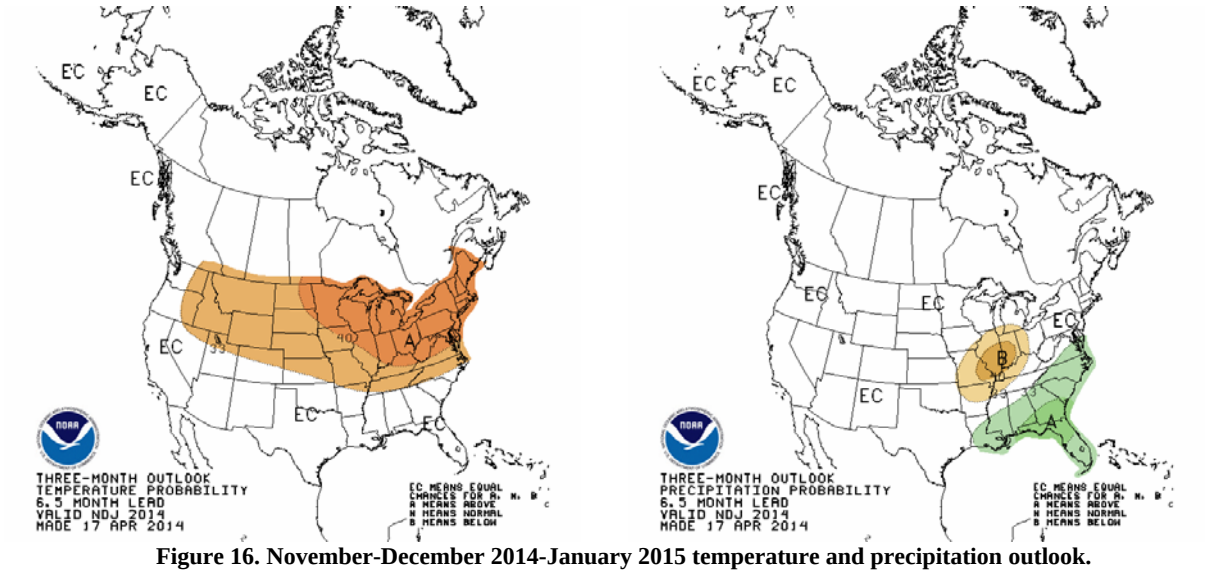


Figure 16. November-December 2014-January 2015 temperature and precipitation outlook.

May 2014 Calendar Year Runoff Forecast

The May 1, 2014 calendar year forecast for the Missouri River Basin above Sioux City, IA is 31.7 MAF (125% of normal). Runoff above Gavins Point Dam is forecast to be 29.8 MAF (130% of normal). Although the calendar year forecast decreased 0.3 MAF due to below average April runoff, forecast runoff for the remainder of 2014 increased slightly due to steady mountain snowpack, which had limited melt as of May 1, and there is potential for additional runoff from rainfall on wet soil conditions. These increases were made in the Fort Peck, Garrison and Oahe reaches.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 8 months, the range of expected inflow is quite large and ranges from the 40.9 MAF upper basic forecast to the 24.0 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. It should be noted, however, that it is possible, due to either much higher or much lower than forecasted precipitation occurring, that these ranges may be exceeded on either end.

April Recap

Plains snowpack is a significant factor influencing the volume of runoff in March and April; however, snow and rainfall precipitation during this time period are also very important factors that need consideration. Furthermore, antecedent accumulated precipitation and antecedent soil moisture conditions have a significant influence on March-April runoff.

April runoff was 2.8 MAF, 96% of normal, and 0.6 MAF below the April forecast. Plains snowmelt runoff was not an influential factor determining the April runoff volume. Areas of above normal precipitation occurred in some areas of the upper Basin; however, large areas of below normal runoff also occurred throughout the upper Basin. Moving forward into May, plains snow accumulation and snowmelt runoff will not likely be a factor influencing runoff.

May-June-July and August Runoff Forecasts

For the May-June-July period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. Although the only input into these equations is mountain SWE as a percent of normal, the equations predict total May-June-July runoff which is caused by mountain snowpack and rainfall runoff. More accurate predictions of runoff can be made as mountain snowpack nears its peak accumulation.

On April 7, 2014 the mountain snowpack above Fort Peck reached a high of 21.7 inches, which was 132 percent of the normal peak accumulation based on the 1981-2010 average peak SWE above Fort Peck. On April 17, 2014 the mountain snowpack between Fort Peck and Garrison reached a high of 19.8 inches, which was 140 percent of the normal peak accumulation based on the 1981-2010 average peak SWE from Fort Peck to Garrison. Mountain snowpack was steady with some slight losses as of May 1, so it is possible that the mountain snowpack could still peak given much colder and wetter conditions. Until the peak is determined, the April 7 and April 17 high snowpack levels will be used as a proxy for the peak accumulations above Fort Peck and Garrison.

As a result of using the peak equations, the May-June-July runoff forecasts are 5,200 kAF (146 percent of normal) above Fort Peck and 8,310 kAF (144 percent of normal) from Fort Peck to Garrison. Furthermore, August runoff forecasts were increased for Fort Peck and Garrison because of the high mountain snowpack to 510 kAF (143 percent of normal) and 750 kAF (123 percent of normal), respectively.

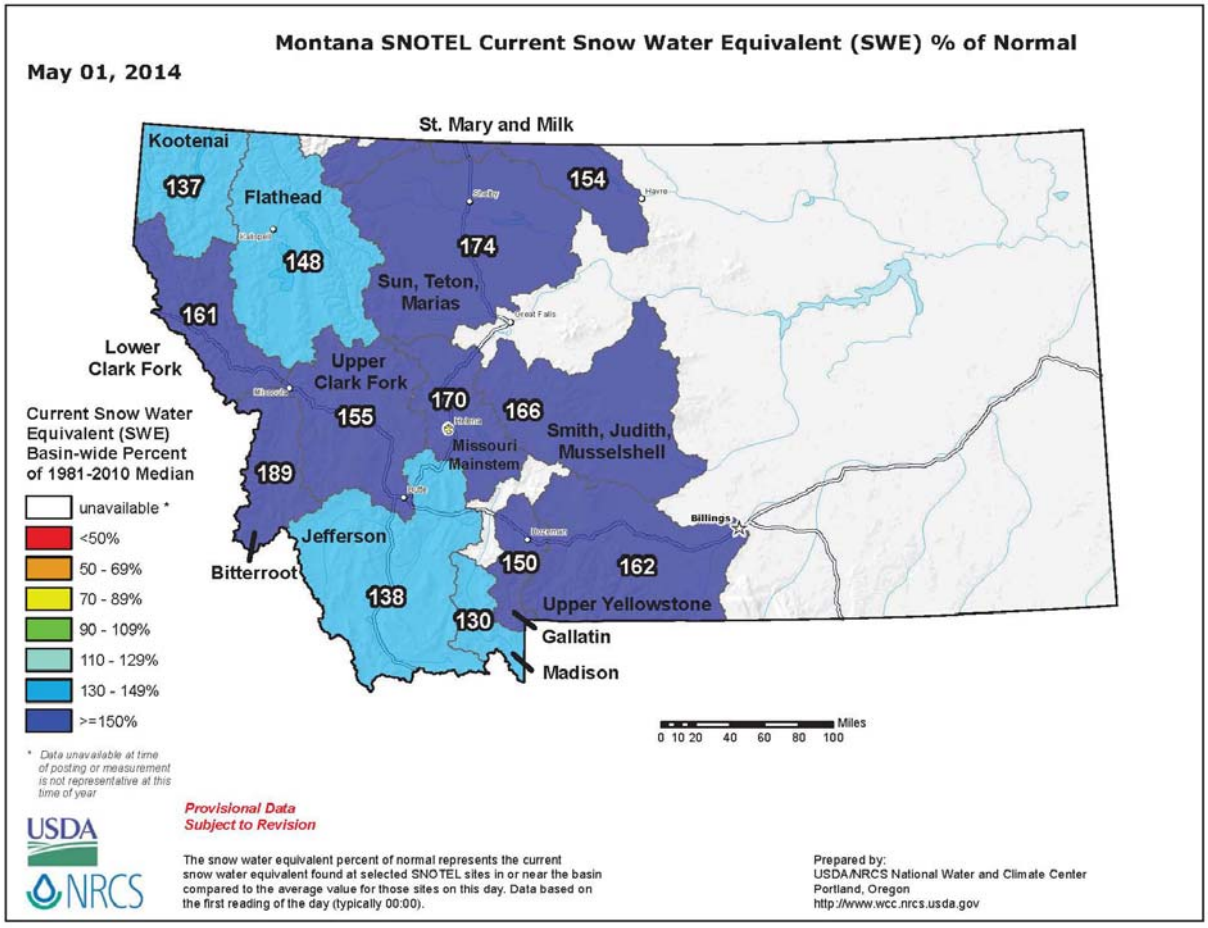
May, June and July runoff forecasts for Oahe were increased to 450 kAF (141 percent of normal), 520 kAF (118 percent of normal) and 200 kAF (108 percent of normal) because runoff into Oahe has been well-above normal each month during 2014. Furthermore, precipitation forecasts in early May and the May outlook for rainfall is indicating increased chances for precipitation in the Oahe reach.

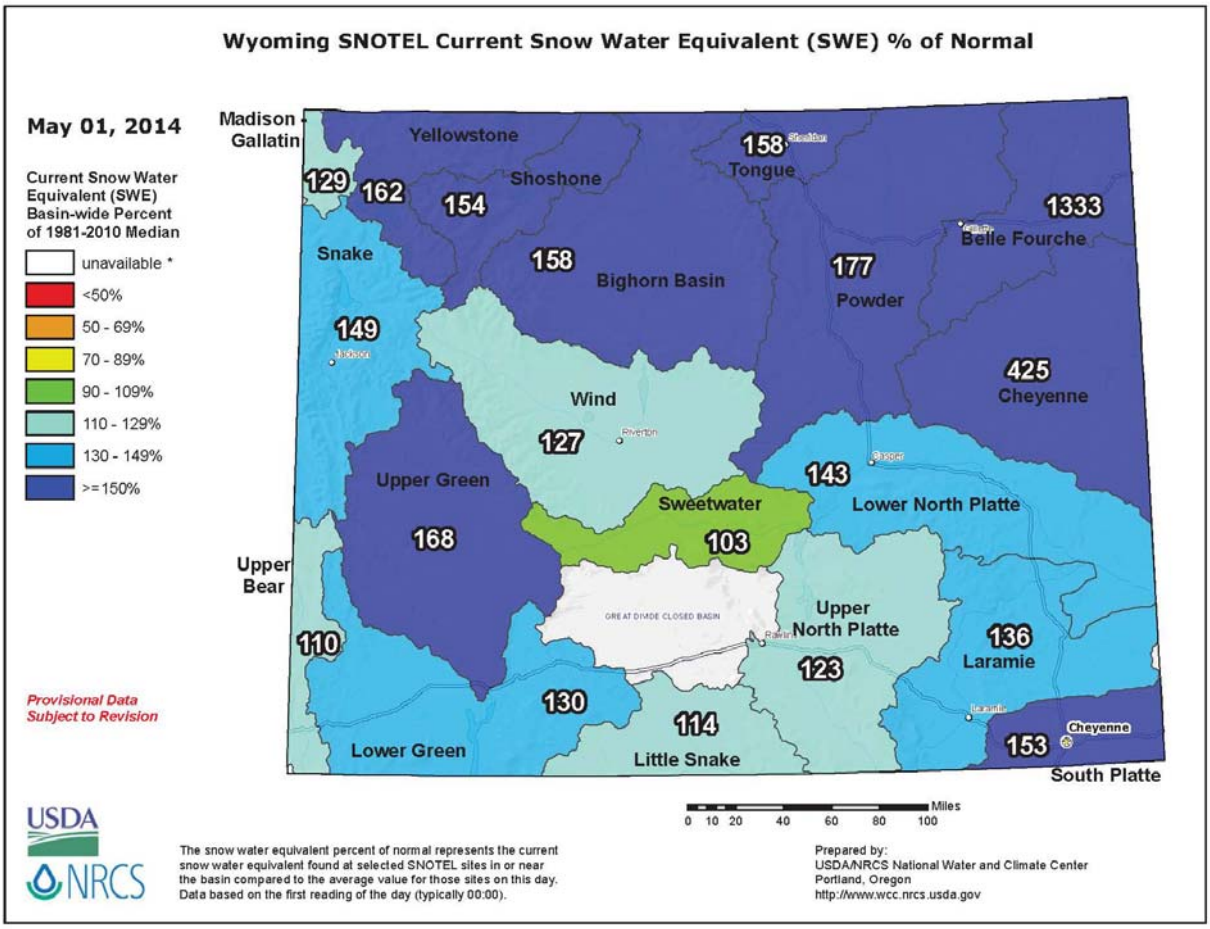
In the Fort Randall, Gavins Point and Sioux City reaches, runoff forecasts were decreased in May, and transitioned back to normal runoff volumes by June and July.

September through December Forecasts

For September through December 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the Basin and equal chances for above, below and normal precipitation. Consequently, runoff for all reaches is forecast to be essentially normal.

Additional Figures and Information




Wyoming SNOTEL Current Snow Water Equivalent (SWE) % of Normal
May 01, 2014
Current Snow Water Equivalent (SWE) Basin-wide Percent of 1981-2010 Median
unavailable *
<50%
50 - 69%
70 - 89%
90 - 109%
110 - 129%
130 - 149%
>=150%
Provisional Data Subject to Revision
Madison Gallatin
Yellowstone
Shoshone
Snake
Bighorn Basin
Tongue
Belle Fourche
Powder
Cheyenne
Wind
Riverton
Upper Green
Sweetwater
Lower North Platte
Upper Bear
GREAT DIVIDE CLOSED BASIN
Upper North Platte
Laramie
Lower Green
Little Snake
Cheyenne
South Platte
129
162
154
158
158
1333
149
177
425
127
143
168
103
110
123
136
130
114
153
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:
USDA/NRCS National Water and Climate Center
Portland, Oregon
http://www.wcc.nrcs.usda.gov

USDA NRCS National Water & Climate Center

* - DATA CURRENT AS OF: May 06, 2014 03:48:01 PM
  - Based on May 01, 2014 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	MAY-JUL	102	119	115	107	96	88	86
	MAY-SEP	118	117	135	125	112	102	101
St. Mary R at Int'l Boundary (2)	MAY-JUL	460	115	545	495	425	375	400
	MAY-SEP	530	113	625	570	490	435	470
Lima Reservoir Inflow (2)	MAY-JUL	41	72	60	49	33	22	57
	MAY-SEP	46	72	68	55	37	24	64
Clark Canyon Reservoir Inflow (2)	MAY-JUL	51	80	110	75	27	-7.7	64
	MAY-SEP	70	84	133	96	44	6.6	83
Jefferson R nr Three Forks (2)	MAY-JUL	840	146	1130	960	725	550	575
	MAY-SEP	930	146	1260	1060	795	600	635
Hebgen Reservoir Inflow (2)	MAY-JUL	360	118	410	380	340	310	305
	MAY-SEP	465	115	525	490	440	405	405
Ennis Reservoir Inflow (2)	MAY-JUL	615	116	725	660	570	505	530
	MAY-SEP	770	113	905	825	720	640	680
Missouri R at Toston (2)	MAY-JUL	2070	140	2540	2260	1890	1610	1480
	MAY-SEP	2420	138	3000	2650	2190	1850	1760
Smith R bl Eagle Ck (2)	MAY-JUL	141	158	187	159	122	95	89
	MAY-SEP	161	163	215	184	138	105	99
Gibson Reservoir Inflow (2)	MAY-JUL	455	128	520	480	430	390	355
	MAY-SEP	500	127	575	530	475	430	395
Marias R nr Shelby (2)	MAY-JUL	435	153	580	495	380	295	285
	MAY-SEP	455	152	620	520	390	295	300
Milk R at Western Crossing	MAY-SEP	22	116	52	35	16.2	11.0	18.9*
Milk R at Eastern Crossing	MAY-SEP	46	104	119	57	34	23	44*

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	MAY-JUL	67	118	74	70	64	60	57
	MAY-SEP	86	119	97	90	82	75	72
Wind R ab Bull Lake Ck (2)	MAY-JUL	555	129	650	595	515	460	430
	MAY-SEP	600	129	710	645	555	490	465
Bull Lake Ck nr Lenore (2)	MAY-JUL	147	109	176	159	135	118	135
	MAY-SEP	181	109	220	196	165	143	166
Boysen Reservoir Inflow (2)	MAY-JUL	630	113	875	730	530	385	560
	MAY-SEP	700	114	985	815	585	415	615
Greybull R nr Meeteetse	MAY-JUL	128	103	150	137	119	106	124
	MAY-SEP	177	104	225	196	158	130	170
Shell Ck nr Shell	MAY-JUL	65	125	79	71	60	52	52
	MAY-SEP	78	124	92	84	72	63	63
Bighorn R at Kane (2)	MAY-JUL	910	118	1230	1040	785	595	770
	MAY-SEP	1010	122	1360	1150	865	655	830
NF Shoshone R at Wapiti	MAY-JUL	635	148	715	665	600	555	430
	MAY-SEP	705	145	795	740	670	615	485
SF Shoshone R nr Valley	MAY-JUL	295	148	325	310	280	265	200
	MAY-SEP	345	147	380	360	330	310	235
Buffalo Bill Reservoir Inflow (2)	MAY-JUL	960	152	1080	1010	910	835	630
	MAY-SEP	1070	153	1200	1120	1010	925	700
Bighorn R nr St. Xavier (2)	MAY-JUL	1740	138	2130	1900	1580	1350	1260
	MAY-SEP	1910	143	2350	2090	1730	1470	1340
Little Bighorn R nr Hardin	MAY-JUL	138	162	168	150	125	107	85
	MAY-SEP	156	161	188	169	143	124	97
Tongue R nr Dayton (2)	MAY-JUL	111	139	138	122	100	85	80
	MAY-SEP	126	137	155	138	114	97	92
Tongue River Reservoir Inflow (2)	MAY-JUL	270	154	360	305	235	180	175
	MAY-SEP	300	152	395	335	260	200	198
NF Powder R nr Hazelton	MAY-JUL	13.1	158	15.8	14.2	12.0	10.4	8.3
	MAY-SEP	14.1	157	17.0	15.3	13.0	11.2	9.0
Powder R at Moorhead	MAY-JUL	265	175	350	300	230	178	151
	MAY-SEP	295	174	385	330	255	205	170
Powder R nr Locate	MAY-JUL	295	180	405	340	250	186	164
	MAY-SEP	330	178	450	380	280	210	185

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Deerfield Reservoir Inflow (2)	MAY-JUL	7.6	195	11.1	9.0	6.2	4.1	3.9
Pactola Reservoir Inflow (2)	MAY-JUL	33	189	52	41	25	14.2	17.5

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.

footnotes:
1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average
* Milk River medians are for years 1980-2008 & marked "30%" is 25% exceedance and marked "70%" is 75% exceedance

Upper Missouri River Basin
June 2014 Calendar Year Runoff Forecast
June 5, 2014

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.

2014 Calendar Year Forecast Synopsis

The June 1, 2014 calendar year runoff forecast for the Missouri River basin above Sioux City, IA is 31.1 MAF (123% of normal). Runoff above Gavins Point Dam is forecast to be 29.3 MAF (127% of normal). May runoff was 4.3 MAF, 130% of normal, and equivalent to the May forecast. The change in the calendar year runoff forecast is a product of adjustments to the June-July runoff forecasts for Fort Peck and Garrison. Fort Peck May runoff was 240 kAF less than previously forecast, while Garrison May runoff was 144 kAF more than previously forecast. Furthermore, mountain snowmelt is progressing at a slightly greater pace than forecast; therefore, the June-July runoff forecasts for Fort Peck and Garrison were lowered.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 7 months, the range of expected inflow is quite large and ranges from the 38.2 MAF upper basic forecast to the 25.3 MAF lower basic forecast. 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 wetter than normal (upper basic) and drier than normal (lower basic) conditions 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 forecasted months decreases.

Current Conditions

ENSO (El Niño Southern Oscillation)

ENSO-neutral conditions continue in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average across the equatorial Pacific Ocean based on CPC analysis. The chance of El Niño increases during the remainder of the year, exceeding 70% by summer and 80% by fall/winter. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

Drought Analysis

According to the National Drought Mitigation Center (**Figure 1**), drought conditions on May 27, 2014 show little change since April 29, 2014 (**Figure 2**). Montana, North Dakota and Wyoming are out of any drought category. The Abnormally Dry conditions (D0) in southeast South Dakota have been reclassified to Moderate Drought (D1) conditions due to the lack of precipitation over the past 90 days. Futhermore, Extreme Drought (D3) conditions have expanded in Nebraska and Kansas. The U.S. Seasonal Drought Outlook shown in **Figure 3** indicates drought conditions in South Dakota, Iowa and Nebraska will improve to a point of removal by the end of August; however, the most severe drought conditions in western Nebraska will remain due to the severity. No other change in conditions including development is expected in the upper Missouri River basin.

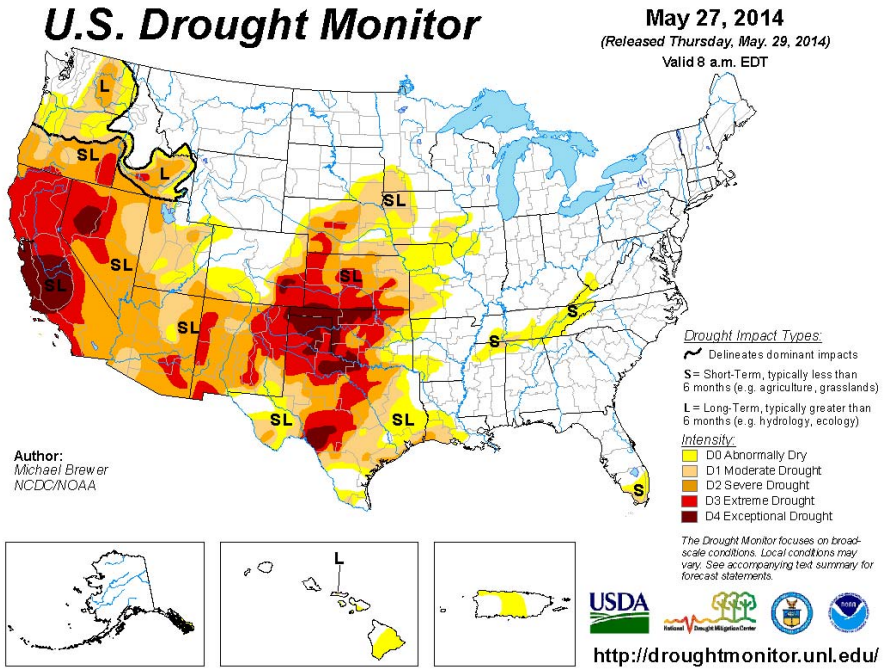


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for May 27, 2014.

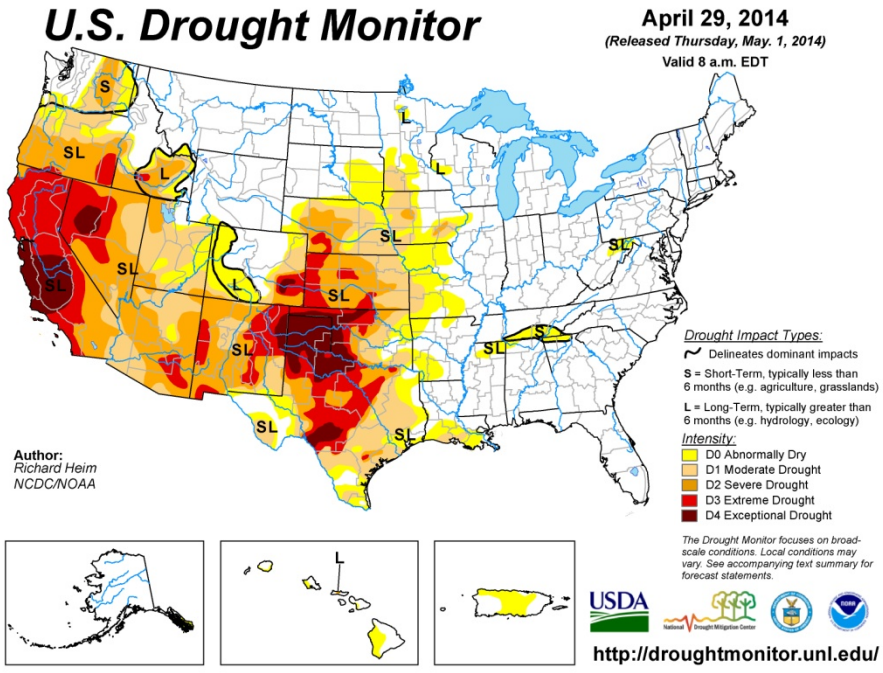


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for April 29, 2014.

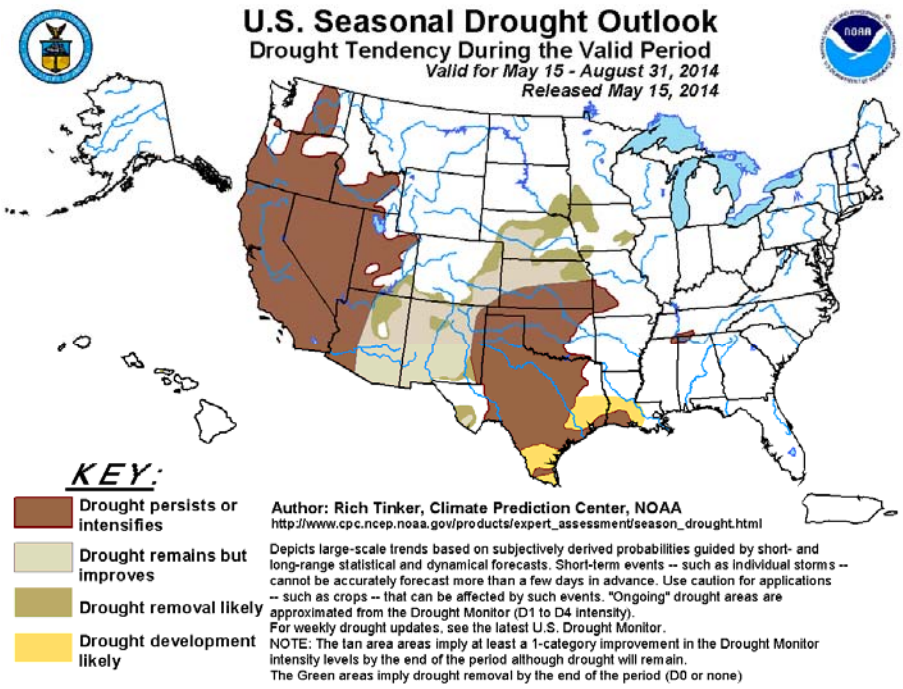


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation as a percent of normal during the month of May is shown in **Figure 4**. Below normal precipitation occurred over much of the upper Missouri River basin above Sioux City, IA with much of the area receiving less than 70% of normal precipitation. Areas of less than 50% of normal precipitation occurred over western Montana, central Wyoming, North Dakota and South Dakota. In contrast, several areas received greater than 150% of normal precipitation including a portion of eastern Montana, western and eastern North Dakota and northwest Nebraska. Precipitation departures in **Figure 5** associated with the areas of less than 70% of normal precipitation was 2 to 3 inches below normal in May. Departures in areas of greater than 150% of normal precipitation ranged from 1 to 2 inches above normal, while the greatest departures ranged from 2 to 3 inches above normal and as much as 4 inches above normal.

Accumulated precipitation over the three-month (March-April-May) is shown in **Figure 6**. Precipitation has been below normal, especially in western and central Montana, central Wyoming, South Dakota, northwest Iowa and northeast Nebraska. The lowest precipitation accumulations as a percent of normal were less than 50% of normal in southeast South Dakota, northeast Nebraska and northwest Iowa.

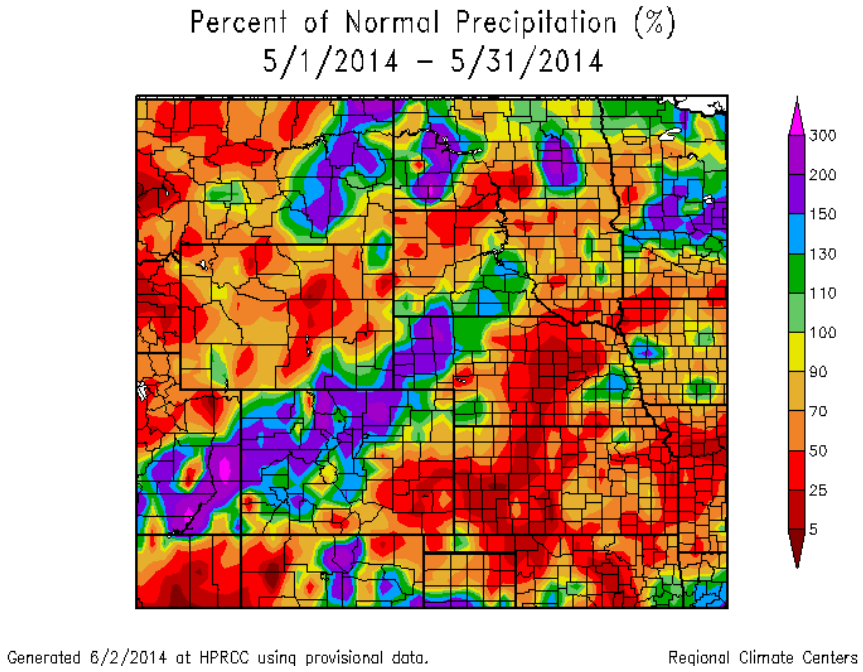


Figure 4. Monthly Percent of Normal Precipitation for May 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

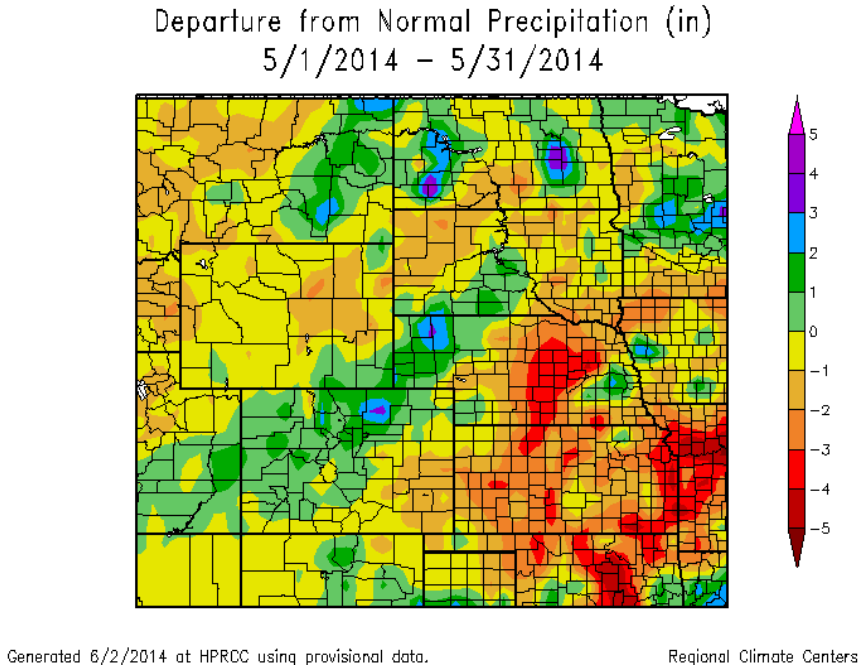


Figure 5. Monthly Precipitation Departure (inches) for May 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

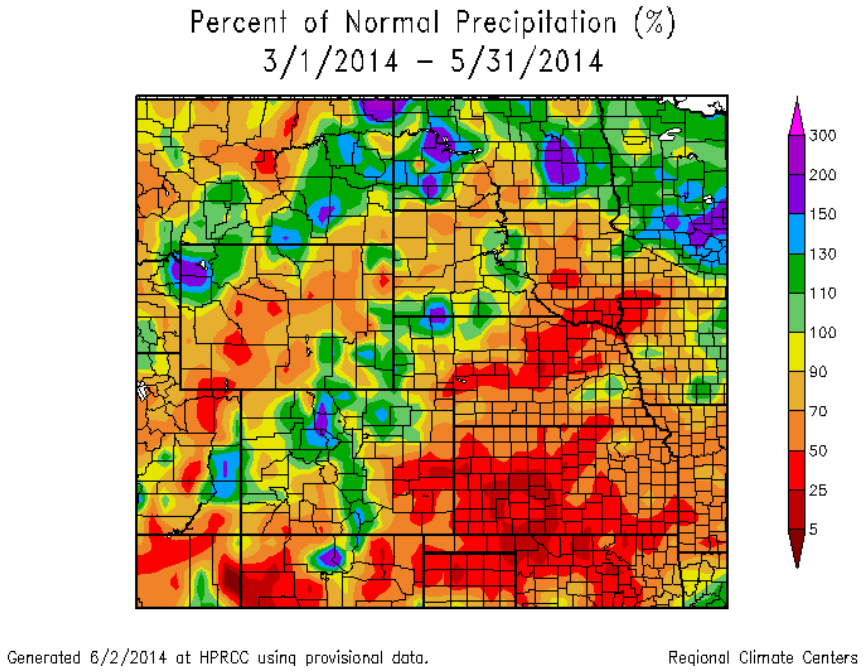


Figure 6. Three-month Percent of Normal Precipitation for March-April-May 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of May, courtesy of the Climate Prediction Center, is shown in **Figure 7**. Three-month (March-April-May) temperature departures ending on June 1, 2014 are shown in **Figure 8**. The three-month map indicates that temperatures have been near normal in the mountains to 2 degrees Fahrenheit colder than normal in the northeastern region of the upper basin.

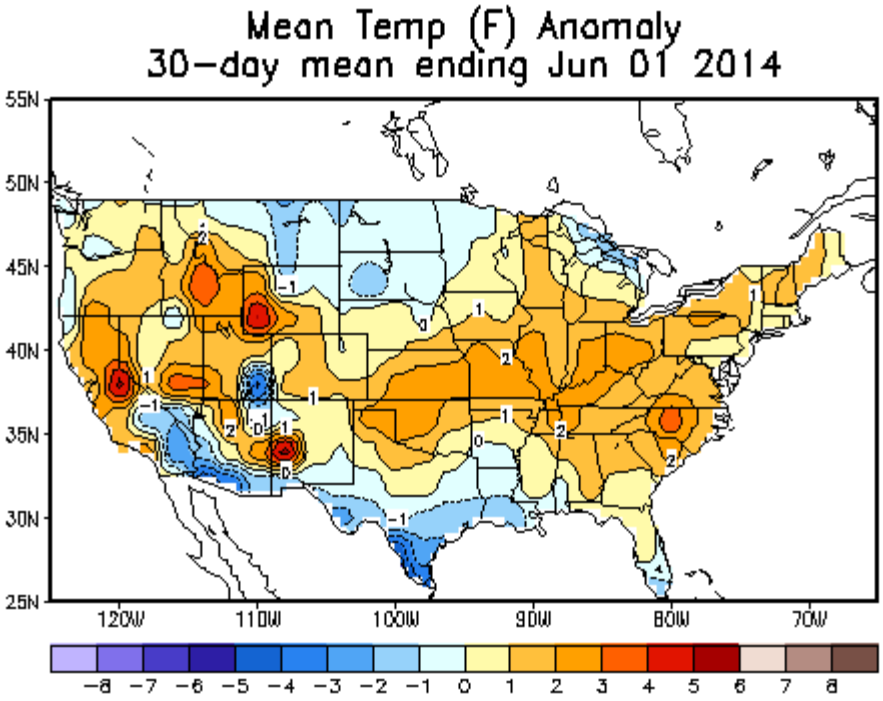


Figure 7. Monthly Departure from Normal Temperature (deg F) ending June 1, 2014.

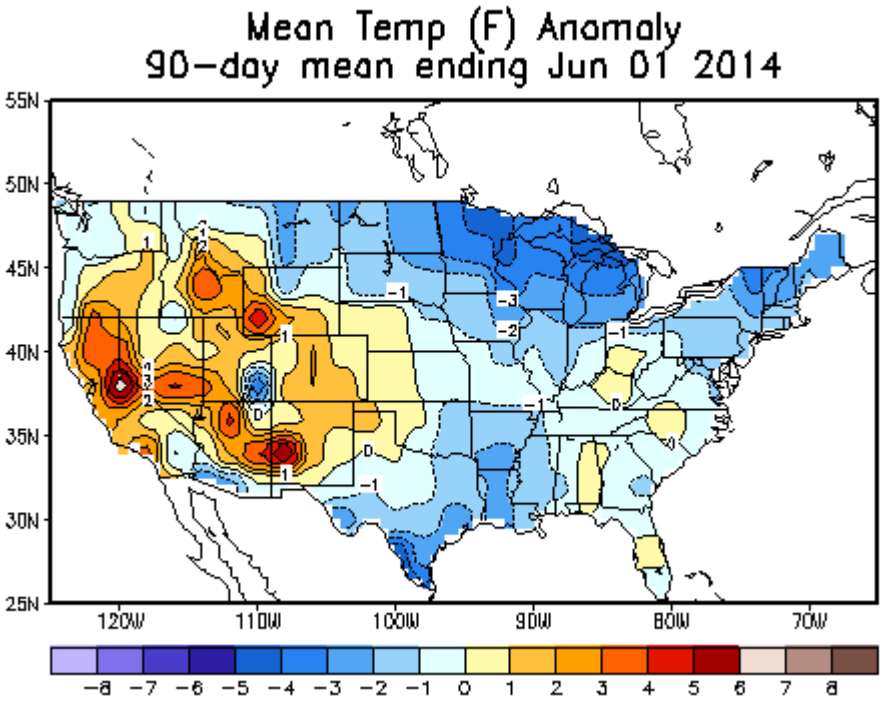


Figure 8. Three-month Departure from Normal Temperature (deg F) ending June 1, 2014.

Soil Moisture and Frost Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Three estimates of soil moisture are presented in this report. **Figure 9** shows the Climate Prediction Center's calculated soil moisture ranking percentiles on the last day of May, 2014. **Figure 10** shows the Variable Infiltration Capacity model soil moisture percentiles on June 3, 2014. **Figure 11** shows the NOAA NLDAS soil moisture percentiles on May 31, 2014.

All three soil moisture estimates depict very wet soil moisture conditions throughout the upper Missouri River basin in Montana and Wyoming and western portions of North and South Dakota. **Figure 9** depicts soil moisture conditions greater than the 99th percentile in much of western Montana and northwest Wyoming. In contrast, **Figures 10** and **11** depict soil moisture conditions in above-normal percentiles but much less coverage under the 99th percentile. This is especially true in **Figure 10**. In all figures, soil moisture conditions in southeast South Dakota, Nebraska, eastern Colorado, Kansas, Missouri and Iowa have drier than normal soil moisture conditions.

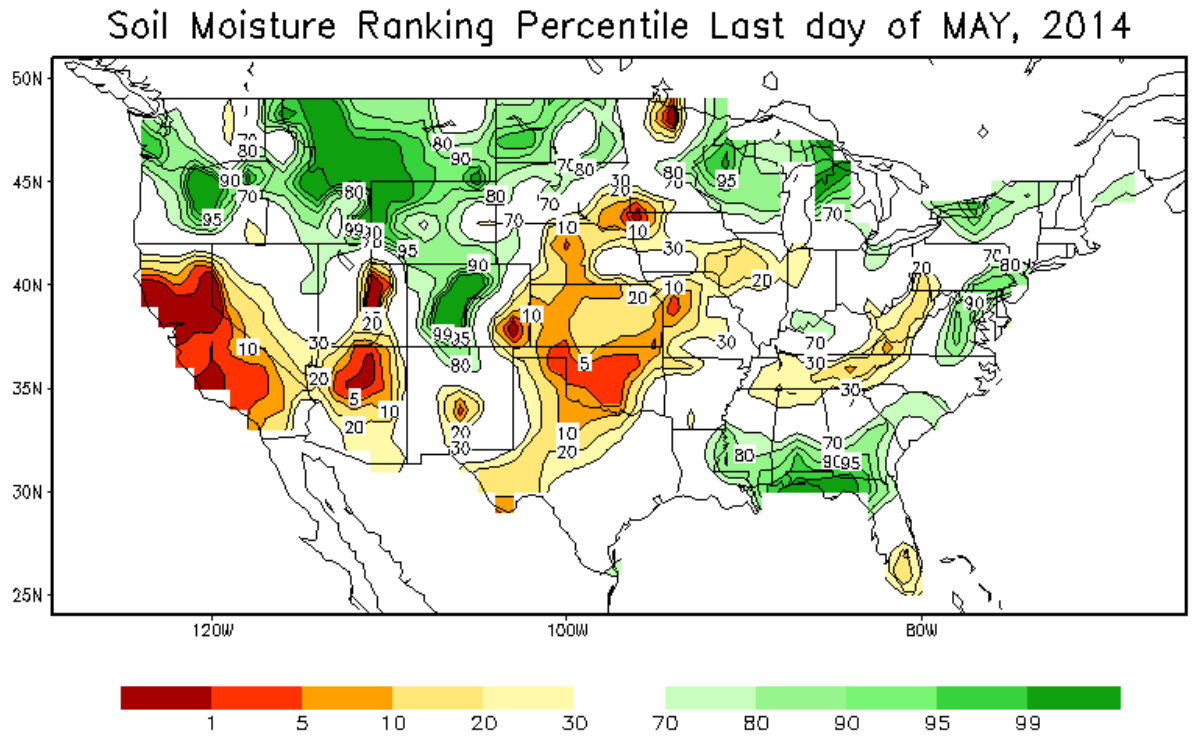


Figure 9. Calculated Soil Moisture Ranking Percentile on May 31, 2014. Source: Climate Prediction Center. http://www.cpc.ncep.noaa.gov/cgi-bin/US_Soil-Moisture-Monthly.sh#

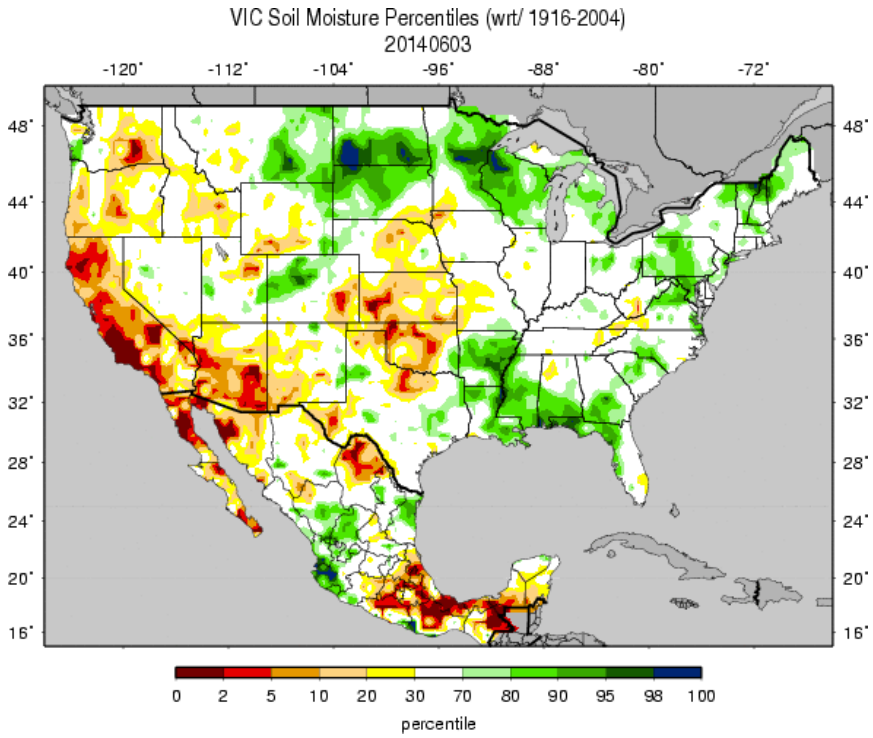


Figure 10. VIC modeled soil moisture percentiles on June 3, 2014. Source: NOAA University of Washington. http://www.hydro.washington.edu/forecast/monitor/curr/conus.mexico/CONUS.MEXICO.vic.sm_qnt.gif

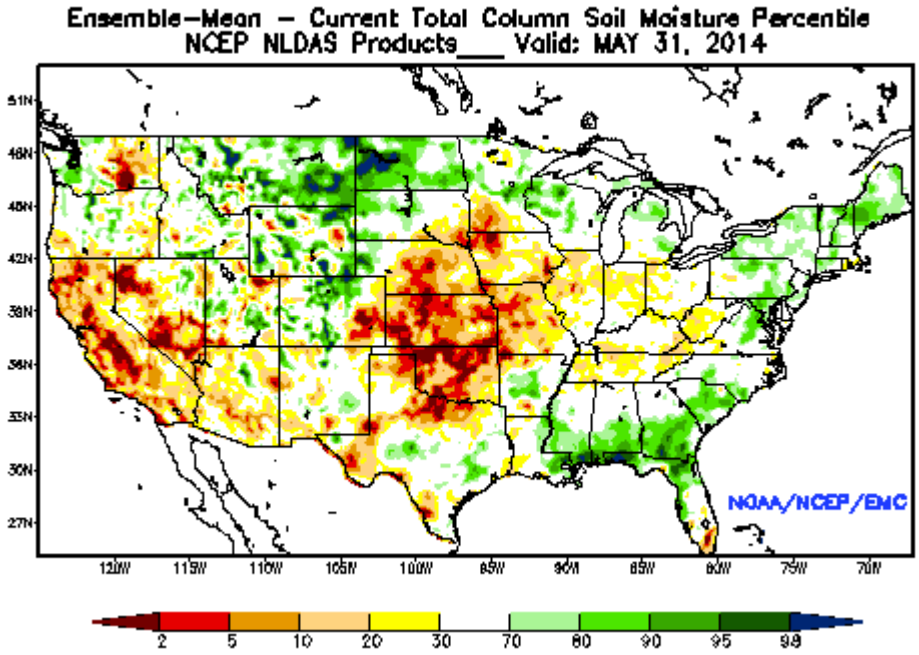


Figure 11. Total Column Soil Moisture Percentile on May 31, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on May 31, 2014 is shown in **Figure 12**. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 50 mm (1.96 inches) above normal. Some localized areas in Montana and Wyoming have anomalies much less than normal. Consistent with the soil moisture ranking percentiles, most of the lower basin below Sioux City, IA and a portion of southeast South Dakota have below normal anomalies exceeding -50 mm of moisture.

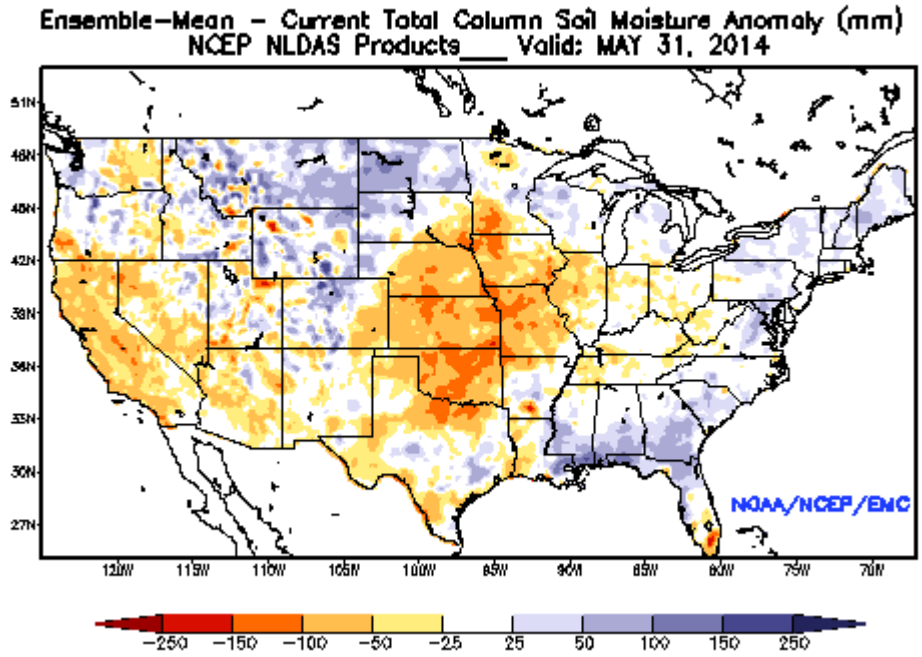


Figure 12. Calculated Soil Moisture Anomaly (mm) on May 31, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

Mountain Snow Pack

Mountain snowpack is the primary factor used to predict May-July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reaches. During the 3-month May-July 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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions. Average mountain snowpack for the headwater basin above Fort Peck Dam and for the subbasin between Fort Peck Dam and Garrison Dam are shown in **Figure 13**.

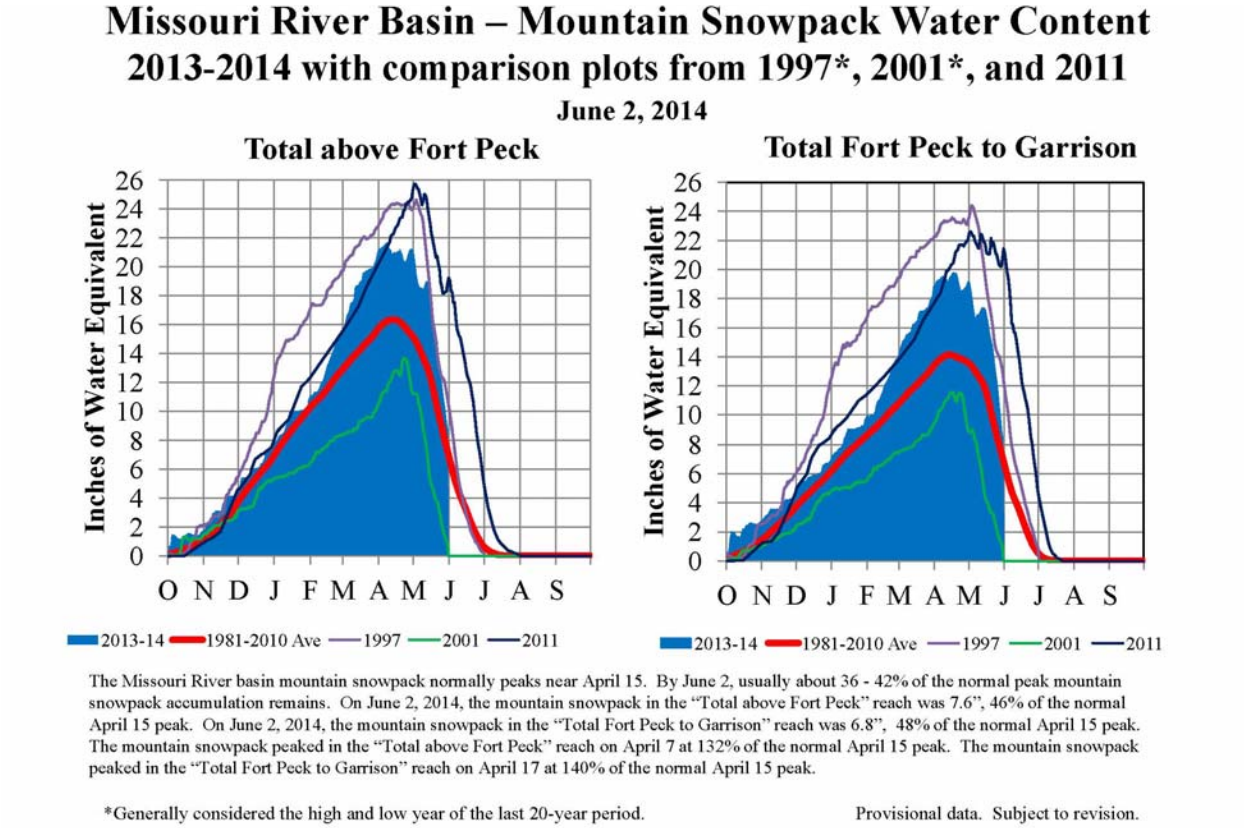


Figure 13. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

On April 7, 2014 the mountain snowpack above Fort Peck peaked at 21.7 inches, 132% of the normal peak accumulation based on the 1981-2010 average peak snow water equivalent (SWE) above Fort Peck. **The April 7, 2014 SWE is 4.1 inches lower than the May 2, 2011 peak SWE of 25.8 inches above Fort Peck.** As of June 2, 2014, the Corps of Engineers computed an average mountain SWE above Fort Peck Dam of 7.6 inches, which is 46% of the average peak SWE accumulation based on 1981-2010 data, or 35% of the 21.7 inch peak SWE in 2014.

On April 17, 2014 the mountain snowpack between Fort Peck and Garrison peaked at 19.8 inches, 140% of the normal peak accumulation based on the 1981-2010 average peak SWE from Fort Peck to Garrison. **The April 17, 2014 SWE is 2.8 inches lower than the May 2, 2011 peak SWE of 22.6 inches above Garrison.** As of June 2, 2014, the Corps of Engineers computed an average mountain SWE from Fort Peck to Garrison of 6.8 inches, which is 48% of the average peak SWE accumulation based on 1981-2010 data, or 34% of the 19.8 inch peak SWE in 2014. Overall mountain snowpack in Fort Peck and Garrison is slightly above normal for the beginning of June based on the current snowpack (shaded blue region in **Figure 13**) compared to the historic mountain snowpack (bold red line in **Figure 13**).

Climate Outlook

At the end of May 2014, ENSO-neutral conditions continued in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average across the equatorial Pacific Ocean based on CPC analysis. The chance of El Niño increases during the remainder of the year, exceeding 70% by summer and 80% by fall/winter. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

The Climate Prediction Center's June outlook (**Figure 14**) is indicating increased chances for colder than normal conditions over the upper Missouri River basin including the states of Montana, North Dakota, South Dakota and Wyoming. With regard to precipitation, there are increased chances for above normal precipitation in Montana, extending southeastward into the lower Missouri River basin. The highest probability for above normal precipitation is 50% centered in Nebraska.

The three-month climate outlook for June-July-August 2014 (**Figure 15**) indicates increased chances for cooler than normal temperatures in Montana, northeast Wyoming and the Dakotas with equal chances in all other areas. In terms of precipitation, there are increased chances for above normal precipitation over much of the upper basin, Colorado and Nebraska with the exception of North Dakota.

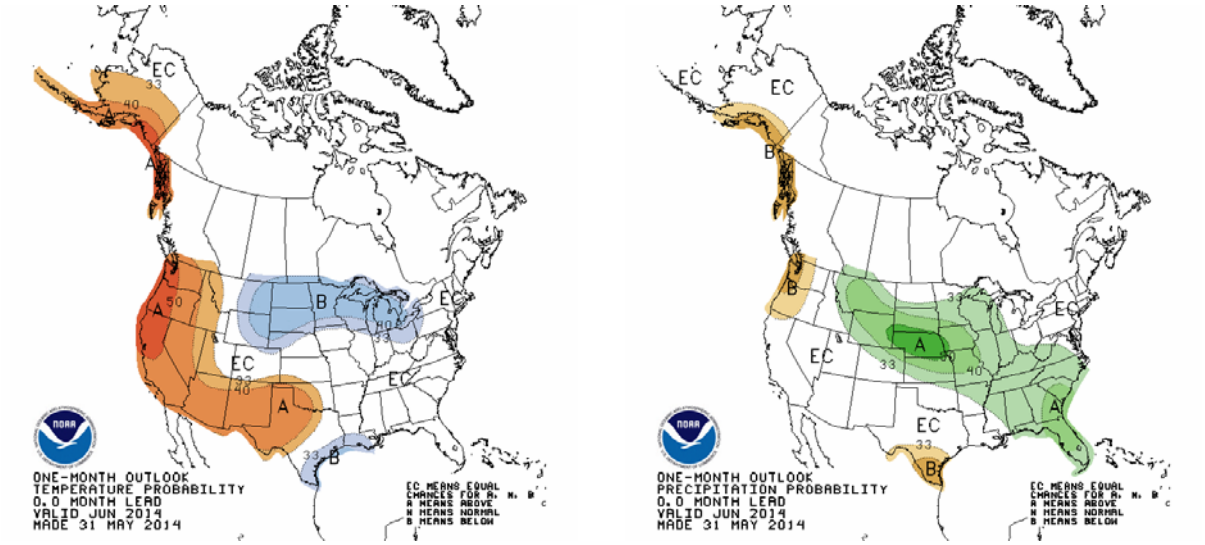


Figure 14. CPC June 2014 temperature and precipitation outlooks.

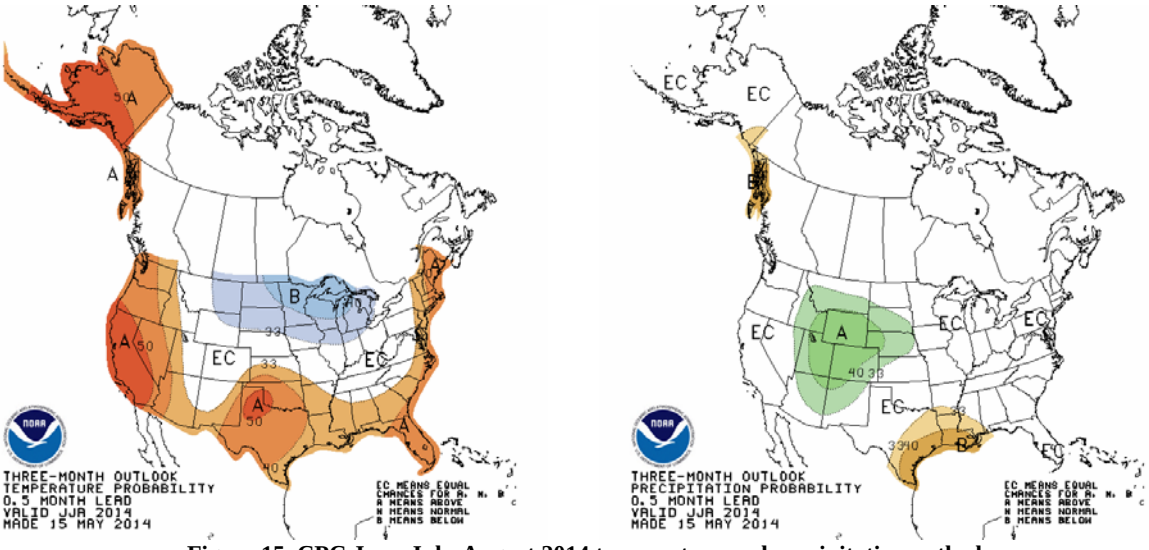


Figure 15. CPC June-July-August 2014 temperature and precipitation outlook.

Looking further into 2014, the CPC's climate outlook for September-October-November (**Figure 16**) indicates increased chances for warmer than normal temperatures in Montana and Wyoming, and equal chances for all portions of the basin. There are equal chances for above normal, below normal, and normal precipitation throughout the upper basin.

Climate outlooks for December 2014 and January-February 2015 are provided in **Figure 17**. The CPC is indicating an increased probability for above normal temperatures in almost the entire Missouri River basin during the climatological winter as a reflection of an El Niño episode developing during the 2014 summer. The precipitation outlook indicates equal chances for above normal, below normal and normal precipitation in much of the Missouri River basin, while there is an increased probability for below normal precipitation in Montana, Wyoming and the western Dakotas.

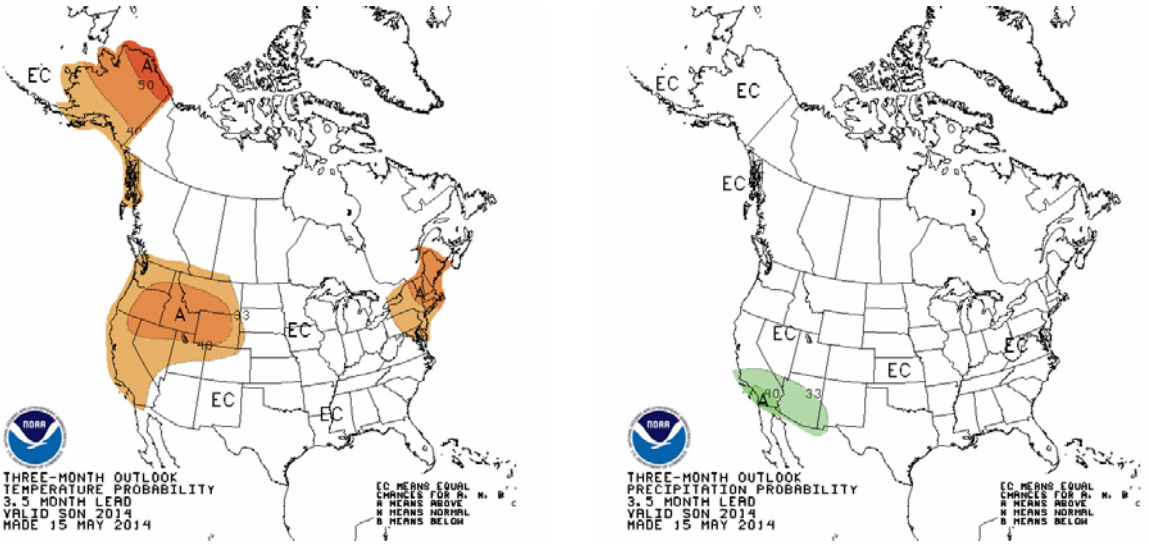


Figure 16. CPC September-October-November 2014 temperature and precipitation outlook.

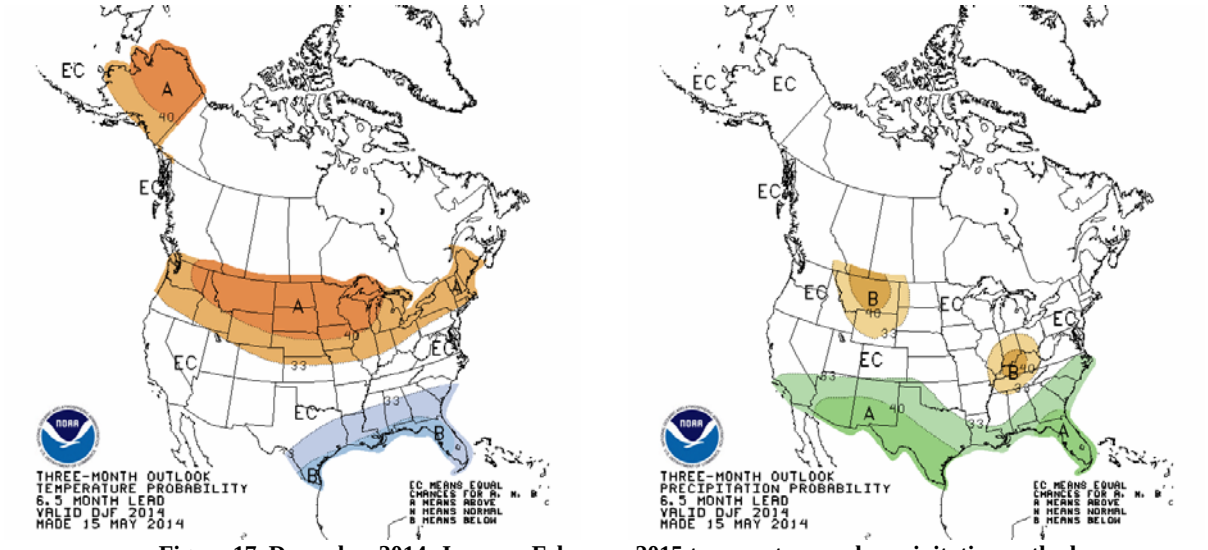


Figure 17. December 2014, January-February 2015 temperature and precipitation outlook.

May 2014 Calendar Year Runoff Forecast

The 2014 calendar year forecast for June 1, is 31.1 MAF (123% of normal) above Sioux City. May runoff was 4.3 MAF, 130% of normal, and equivalent to the May forecast. Runoff above Gavins Point Dam is forecast to be 29.3 MAF (127% of normal). The change in the calendar year runoff forecast is a product of adjustments to the June-July runoff forecasts for Fort Peck and Garrison.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 7 months, the range of expected inflow is quite large and ranges from the 38.2 MAF upper basic forecast to the 25.3 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.

May Recap

May runoff in the upper basin above Sioux City was 4.31 MAF, 130% of normal, and equivalent to the May 1 forecast. Runoff was 1201 kAF (111% of normal) above Fort Peck, 1954 kAF (155% of normal) into Garrison, 542 kAF (170% of normal) into Oahe, 238 kAF (163% of normal) into Fort Randall, 172 kAF (93% of normal) into Gavins Point, and 200 kAF (62% of normal) from Gavins Point to Sioux City. Runoff was less than forecast into Fort Peck and greater than forecast into Garrison. Runoff in May-June-July, the mountain snowmelt runoff period, appears to be progressing with less runoff volume than anticipated. This is mostly due to the below normal rainfall accumulations occurring over the Fort Peck and Garrison reservoir subbasins.

June-July Runoff Forecasts

For the May-June-July period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. Although the only input into these equations is mountain SWE as a percent of normal, the equations predict total May-June-July runoff which is caused by mountain snowpack and rainfall runoff. More accurate predictions of runoff can be made as mountain snowpack nears its peak accumulation.

The May 1, 2014 forecast was based on peak mountain SWE accumulations represented by an average of SNOTEL station data above Fort Peck and in the Fort Peck to Garrison subbasin. The June 1 forecast was adjusted based on the amount of SWE remaining in the two reservoir subbasins 10 to 14 days prior to June 1. The mountain SWE 10-14 days prior to June 1 is a sufficient amount of time required for mountain snowmelt to travel from its source to Fort Peck and Garrison reservoirs. The original June and July runoff volumes were adjusted proportionally to the amount of snowpack remaining resulting in lower runoff volumes in June and July than forecast on May 1. Furthermore, due to the above normal precipitation chances assigned to the upper basin by the Climate Prediction Center, additional runoff volume was added to the June-July period. The resulting runoff forecasts are lower than the May 1 forecast due to the aforementioned reasons. The Fort Peck June-July runoff forecast is 137% of normal runoff, while the Garrison runoff forecast is 136% of normal runoff.

Since May runoff into Oahe was 542 kAF (170% of normal) and the precipitation outlook favors above normal precipitation and likely above normal runoff, the Oahe June runoff forecast was adjusted to 600 kAF (136% of normal). The July forecast was also increased slightly to 220 kAF (119% of normal).

In the Fort Randall reservoir subbasin, runoff was increased slightly in June and July. Gavins Point and Sioux City reach runoff forecasts were decreased slightly in June and July.

September through December Forecasts

For September through December 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the upper basin with an increasing chance for below normal precipitation in Montana, Wyoming and the western Dakotas. Consequently, runoff for all reaches is forecast to be near normal.

Additional Information

USDA NRCS National Water & Climate Center

* - DATA CURRENT AS OF: June 04, 2014 07:54:51 PM
  - Based on June 01, 2014 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	JUN-JUL	64	114	77	69	59	51	56
	JUN-SEP	80	113	95	86	74	65	71
St. Mary R at Int'l Boundary (2)	JUN-JUL	300	109	370	330	275	230	275
	JUN-SEP	370	107	450	405	340	295	345
Lima Reservoir Inflow (2)	JUN-JUL	21	68	34	26	15.2	7.0	31
	JUN-SEP	26	67	44	33	18.9	8.4	39
Clark Canyon Reservoir Inflow (2)	JUN-JUL	27	77	71	45	9.1	-17.3	35
	JUN-SEP	44	80	94	64	24	-6.4	55
Jefferson R nr Three Forks (2)	JUN-JUL	460	130	655	540	385	270	355
	JUN-SEP	545	131	780	640	450	310	415
Hebgen Reservoir Inflow (2)	JUN-JUL	194	109	235	210	177	151	178
	JUN-SEP	295	105	345	315	275	245	280
Ennis Reservoir Inflow (2)	JUN-JUL	360	109	425	385	330	290	330
	JUN-SEP	510	105	590	540	475	425	485
Missouri R at Toston (2)	JUN-JUL	1200	128	1570	1350	1050	830	940
	JUN-SEP	1520	125	2030	1730	1320	1020	1220
Smith R bl Eagle Ck (2)	JUN-JUL	85	157	119	99	71	51	54
	JUN-SEP	103	158	149	121	85	57	65
Gibson Reservoir Inflow (2)	JUN-JUL	260	124	315	280	240	205	210
	JUN-SEP	310	124	370	335	285	250	250
Marias R nr Shelby (2)	JUN-JUL	220	154	330	265	176	110	143
	JUN-SEP	240	152	365	290	189	115	158

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	JUN-JUL	53	113	61	56	50	45	47
	JUN-SEP	72	114	83	76	68	61	63
Wind R ab Bull Lake Ck (2)	JUN-JUL	400	121	495	440	360	305	330
	JUN-SEP	440	121	550	485	395	330	365
Bull Lake Ck nr Lenore (2)	JUN-JUL	117	108	141	127	107	93	108
	JUN-SEP	149	107	181	162	136	117	139
Boysen Reservoir Inflow (2)	JUN-JUL	435	102	620	510	360	250	425
	JUN-SEP	500	103	730	595	405	270	485
Greybull R nr Meeteetse	JUN-JUL	105	109	130	115	95	80	96
	JUN-SEP	155	109	188	168	142	122	142
Shell Ck nr Shell	JUN-JUL	45	129	55	49	41	35	35
	JUN-SEP	58	126	69	63	53	47	46
Bighorn R at Kane (2)	JUN-JUL	630	111	870	725	530	385	570
	JUN-SEP	715	113	1020	835	590	410	630
NF Shoshone R at Wapiti	JUN-JUL	415	136	470	435	390	355	305
	JUN-SEP	480	133	550	510	450	405	360
SF Shoshone R nr Valley	JUN-JUL	215	137	240	225	205	189	157
	JUN-SEP	255	135	290	270	240	220	189
Buffalo Bill Reservoir Inflow (2)	JUN-JUL	630	135	735	675	590	530	465
	JUN-SEP	725	136	855	775	670	595	535
Bighorn R nr St. Xavier (2)	JUN-JUL	1150	125	1460	1270	1020	840	920
	JUN-SEP	1290	128	1700	1460	1130	890	1010
Little Bighorn R nr Hardin	JUN-JUL	83	157	111	94	71	54	53
	JUN-SEP	98	148	132	112	85	64	66
Tongue R nr Dayton (2)	JUN-JUL	66	135	82	72	59	50	49
	JUN-SEP	80	129	99	87	72	61	62
Tongue River Reservoir Inflow (2)	JUN-JUL	162	147	205	180	144	117	110
	JUN-SEP	189	141	245	210	166	133	134
NF Powder R nr Hazelton	JUN-JUL	6.2	138	8.4	7.1	5.3	4.0	4.5
	JUN-SEP	7.2	138	9.6	8.2	6.2	4.8	5.2
Powder R at Moorhead	JUN-JUL	140	152	194	162	118	85	92
	JUN-SEP	167	152	235	193	140	100	110
Powder R nr Locate	JUN-JUL	157	155	230	186	128	85	101
	JUN-SEP	189	155	280	225	152	98	122

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Averages are for the 1981-2010 period.
All volumes are in thousands of acre-feet.
footnotes:

1) Max and Min are 5% and 95% chance that actual volume will exceed forecast
2) streamflow is adjusted for upstream storage
3) median value used in place of average

Upper Missouri River Basin
July 2014 Calendar Year Runoff Forecast
July 2, 2014

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.

2014 Calendar Year Forecast Synopsis

The July 1, 2014 calendar year runoff forecast for the Missouri River basin above Sioux City, IA is **33.0 MAF** (131% of normal). Runoff above Gavins Point Dam is forecast to be **30.1 MAF** (131% of normal). The change in the calendar year runoff forecast is a product of well-above normal runoff in June and a continuation of wetter than normal conditions in the upper basin for the next two to three months. A very limited quantity of mountain snowpack remains at very high elevations

The June runoff summation above Sioux City was 8.3 MAF (153% of normal) compared to the 7.2 MAF June forecast. The June runoff summation above Gavins Point was 7.2 MAF (141% of normal) compared to the 6.9 MAF June forecast. Very heavy rainfall in the Big Sioux River basin caused record flooding on the Big Sioux River and contributed to the very high runoff in the Sioux City reach. Runoff from the Big Sioux River enters the Missouri River at Sioux City, below Gavins Point Dam; therefore, it did not enter the Mainstem Reservoir System. Computed Fort Peck June runoff was 546 kAF below the forecast, 364 kAF above the Garrison forecast, 456 kAF above the Oahe forecast, 19 kAF below the Fort Randall forecast, 88 kAF above the Gavins Point forecast and 779 kAF above the Sioux City forecast.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 6 months, the range of expected inflow is quite large and ranges from the 36.1 MAF upper basic forecast to the 29.9 MAF lower basic forecast. 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 6 months are being forecasted for this July 1 forecast (6 months observed/6 months forecast), the range of wetter than normal (upper basic) and drier than normal (lower basic) conditions is attributed to all 6 reaches for all 6 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 forecasted months decreases.

Current Conditions

Drought Analysis

According to the National Drought Mitigation Center (**Figure 1**), drought conditions on June 24, 2014 show little change since May 27, 2014 (**Figure 2**). In contrast to the end of May, drought conditions were nearly erased in South Dakota, northwest Iowa, and eastern Nebraska due to abundant rainfall. At present Montana, Wyoming, and North Dakota are mostly drought free. Extreme Drought (D3) conditions have deteriorated in Nebraska and Kansas. The U.S. Seasonal Drought Outlook shown in **Figure 3** indicates drought conditions will likely improve in Nebraska and Kansas. No other change in conditions including development is expected in the upper Missouri River basin.

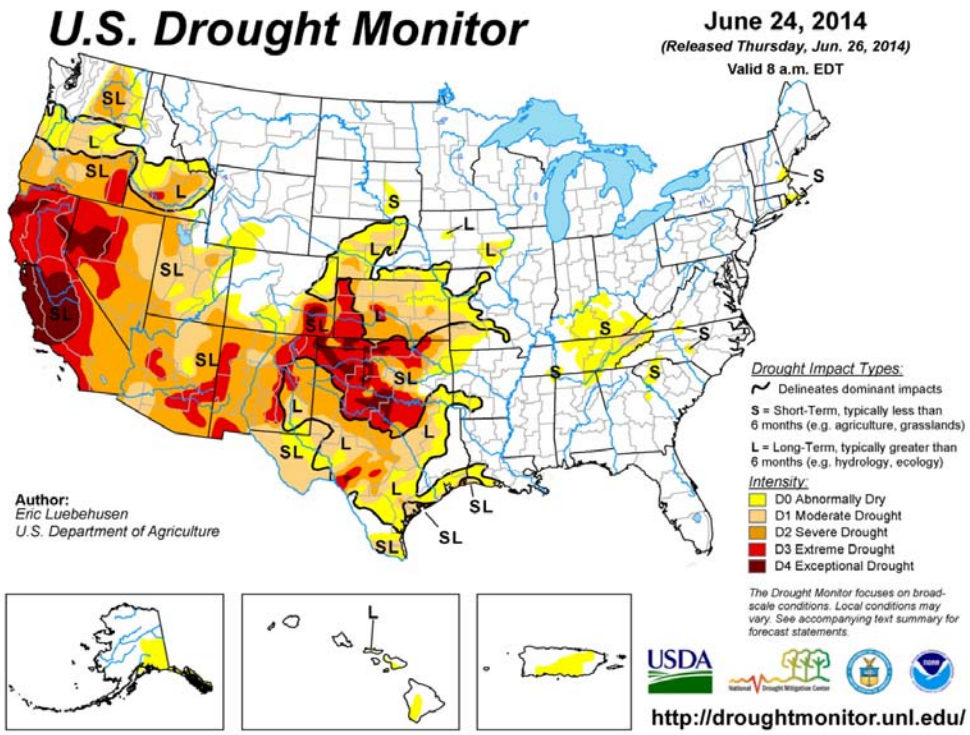


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for June 24, 2014.

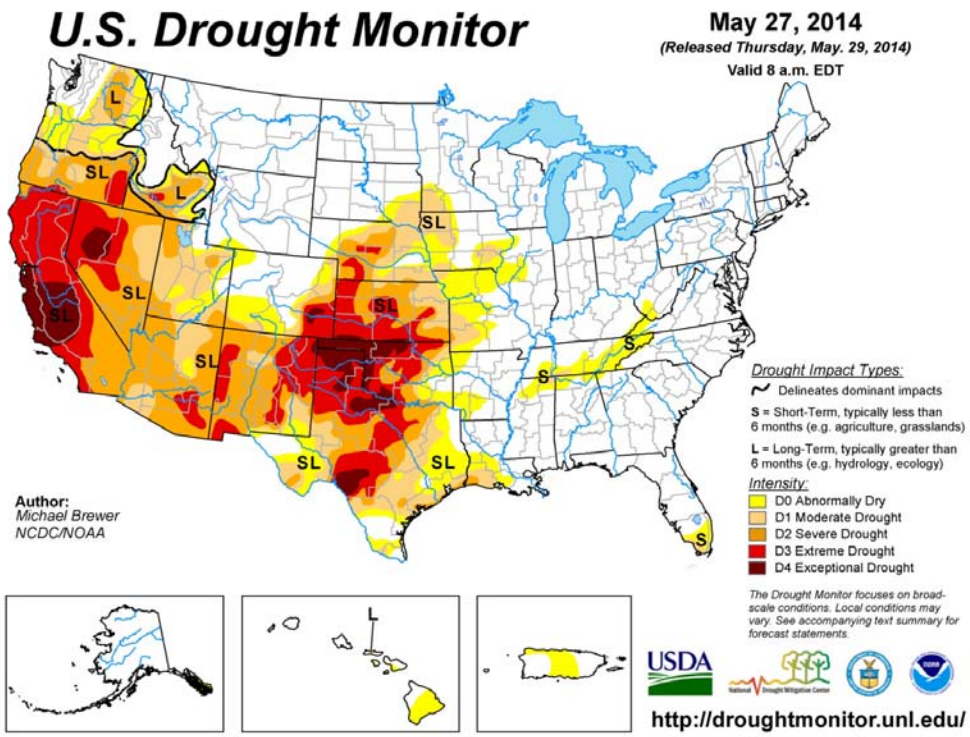


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for May 27, 2014.

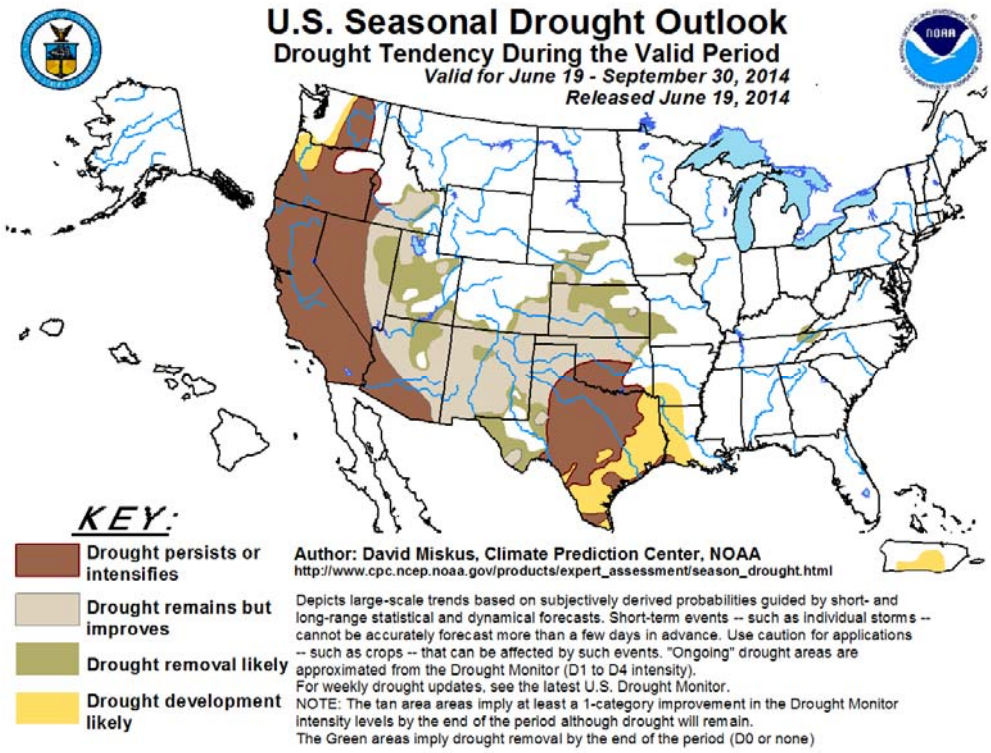


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation in inches and as a percent of normal during the month of May are shown in **Figure 4**. Very heavy rainfall occurred in the plains of southeast South Dakota, Iowa and Nebraska in June. The heaviest rainfall amounts ranged from 8 to 16 inches. As a percent of normal June rainfall ranged from 150% to greater than 300% of normal in an area spanning northeast Nebraska, southeast South Dakota and northwest Iowa. A few notable monthly rainfall totals include 16.6 inches in Sioux City, 13.7 inches in Sioux Falls, 19.7 inches in Canton, SD; 10.5 inches in Omaha and 11.4 inches in Norfolk, NE (**Table 1**). June rainfall in Montana and Wyoming varied substantially from less than normal to areas of greater than 150% of normal rainfall in western and eastern regions.

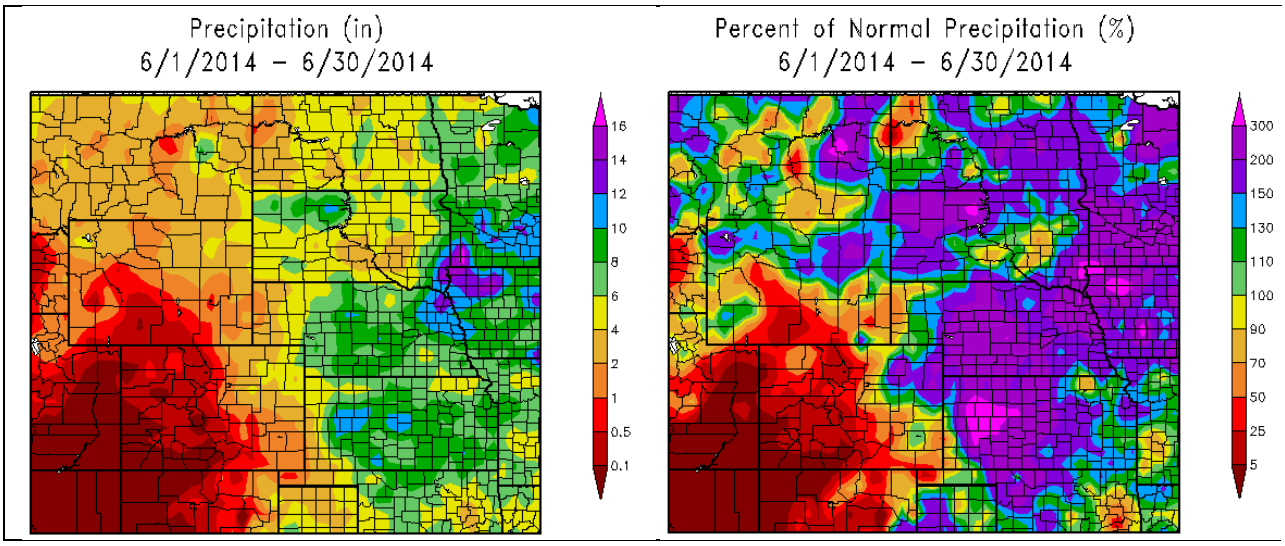


Figure 4. June 2014 Precipitation and Percent of Normal Precipitation (%). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Table 1. June 2014 rainfall totals and departures in inches.

Location	June Rainfall inches	Departure inches
Bozeman, MT	4.08	1.68
Great Falls, MT	4.18	1.65
Lewistown, MT	2.64	-0.44
Glasgow, MT	2.26	-0.07
Billings, MT	1.75	-0.37
Miles City, MT	4.29	1.78
Williston, ND	1.44	-1.08
Bismarck, ND	3.02	-0.15
Jamestown, ND	6.36	3.17
Rapid City, SD	6.05	2.89
Mobridge, SD	7.91	4.75
Aberdeen, SD	3.31	-0.39
Watertown, SD	4.60	1.02
Sioux Falls, SD	13.70	9.78
Pierre, SD	4.39	0.82
Sioux City, IA	16.65	12.76
Omaha, NE	10.52	6.34

Accumulated precipitation as a percent of normal over the April-May-June period is shown in **Figure 5**. Precipitation has been below normal, especially in western and central Montana and Wyoming. June precipitation had a dramatic impact on precipitation accumulations in the Dakotas, Nebraska and Iowa resulting in above normal precipitation across most of these states. The greatest three-month precipitation accumulations ranged from 130% to over 200% of normal in northeast Montana, eastern North Dakota, western and eastern Nebraska and South Dakota.

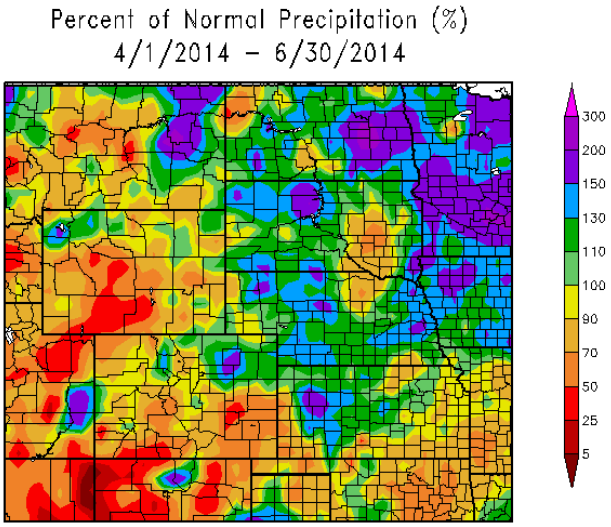


Figure 5. Percent of Normal Precipitation for April-May-June 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of May, courtesy of the Climate Prediction Center, is shown in **Figure 6**. June temperatures were well-below normal in most of the upper basin above Sioux City, IA ranging from 1 to 6 degrees Fahrenheit below normal. Three-month (April-May-June) temperature departures ending on June 30, 2014 are shown in **Figure 7**. The three-month map indicates that temperatures have been near normal in the mountains to 2 degrees Fahrenheit colder than normal in plains region of the upper basin.

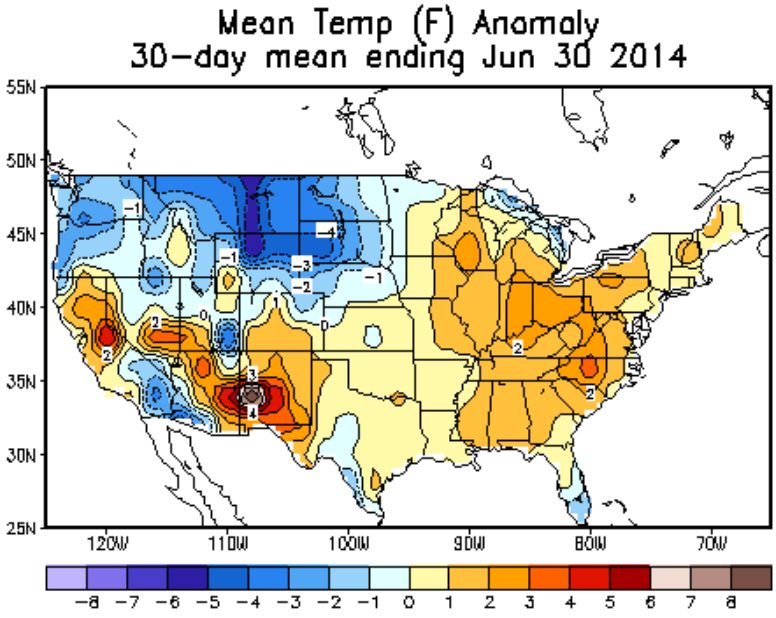


Figure 6. Monthly Departure from Normal Temperature (deg F) ending June 30, 2014.

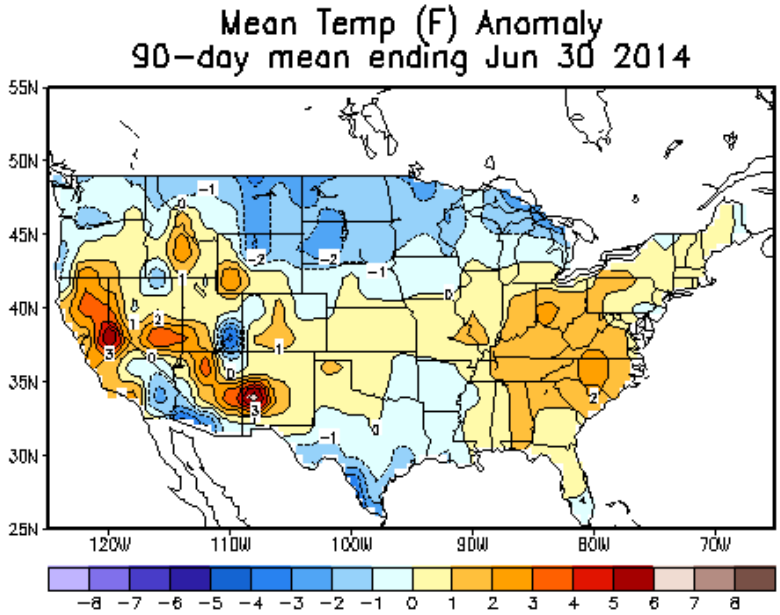


Figure 7. Three-month Departure from Normal Temperature (deg F) ending June 30, 2014.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on June 28, 2014. This modeled estimate depicts very wet soil moisture conditions throughout the upper Missouri River basin in Montana and Wyoming and western portions of North and South Dakota. Soil moisture is typically greater than the 70th percentile and in some cases greater than the 98th percentile.

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on June 28, 2014 is shown in **Figure 9**. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 50 mm (1.96 inches) above normal and in many locations greater than 100 mm (3.92 inches) above normal. Some localized areas in Wyoming have anomalies much less than normal.

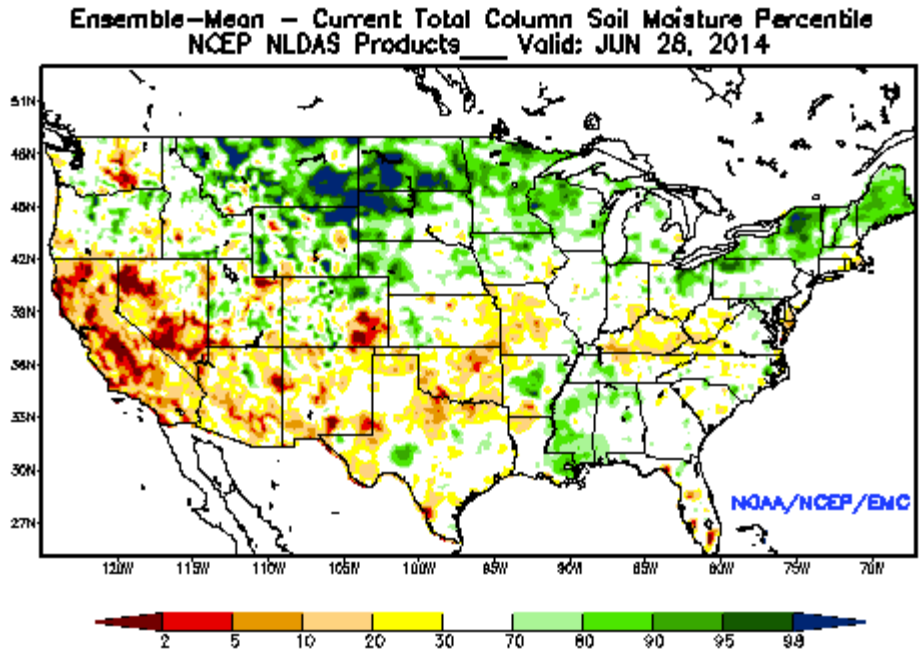


Figure 8. Total Column Soil Moisture Percentile on June 28, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

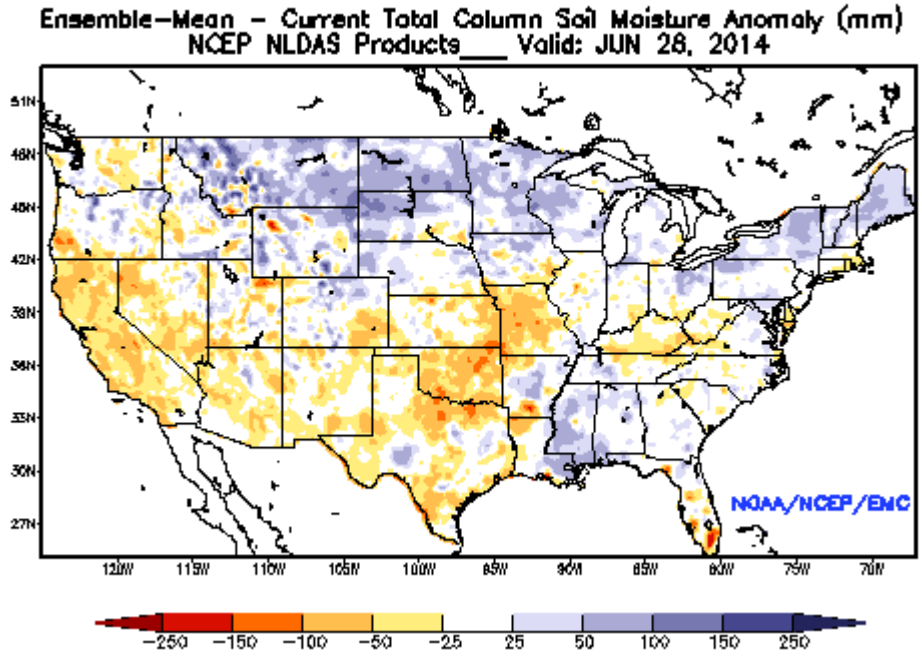


Figure 9. Calculated Soil Moisture Anomaly (mm) on June 28, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

Mountain Snow Pack

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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions. Average mountain snowpack for the headwater basin above Fort Peck Dam and for the subbasin between Fort Peck Dam and Garrison Dam are shown in **Figure 10**.

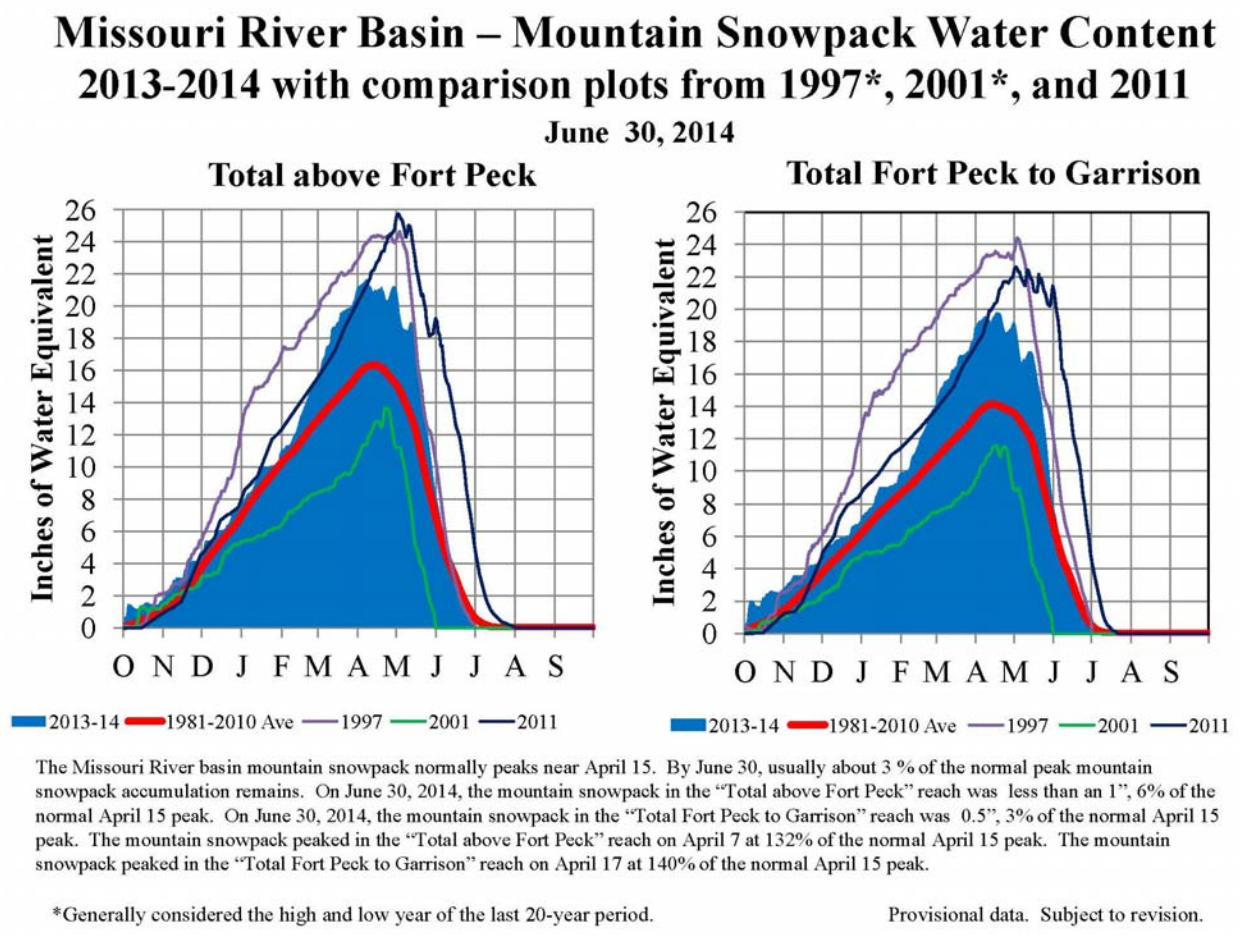


Figure 10. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

On April 7, 2014 the mountain snowpack above Fort Peck peaked at 21.7 inches, 132% of the normal peak accumulation based on the 1981-2010 average peak snow water equivalent (SWE) above Fort Peck. As of June 30, 2014, the Corps of Engineers computed an average mountain

SWE above Fort Peck Dam of 1.0 inches, which is 6% of the average peak SWE accumulation based on 1981-2010 data. Only 4 of the 48 SNOTEL stations above Fort Peck that are used by the Corps to track snowpack contained any snowpack as of June 30, 2014.

On April 17, 2014 the mountain snowpack between Fort Peck and Garrison peaked at 19.8 inches, 140% of the normal peak accumulation based on the 1981-2010 average peak SWE from Fort Peck to Garrison. As of June 30, 2014, the Corps of Engineers computed an average mountain SWE from Fort Peck to Garrison of 0.5 inches, which is 3% of the average peak SWE accumulation based on 1981-2010 data. Only 3 of the 49 SNOTEL stations from Fort Peck Dam to Garrison Dam that are used by the Corps to track snowpack contained any snowpack as of June 30, 2014.

Climate Outlook

ENSO (El Niño Southern Oscillation)

ENSO-neutral conditions continue in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average across the equatorial Pacific Ocean based on CPC analysis. The chance of El Niño increases during the remainder of the year, exceeding 70% by summer and 80% by fall/winter. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

Temperature and Precipitation Outlooks

The Climate Prediction Center's July outlook (**Figure 11**) is indicating increased chances for cooler than normal conditions over eastern Montana and Wyoming, the Dakotas, Nebraska and Iowa and equal chances over central Montana. With regard to precipitation, there are increased chances for above normal precipitation in Montana and Wyoming, and equal chances for above normal, normal and below normal precipitation in the remainder of the Missouri Basin.

The three-month climate outlook for July-August-September 2014 (**Figure 12**) indicates increased chances for cooler than normal temperatures in eastern Montana, Wyoming, and the Dakotas, and equal chances in the remainder of Montana. In terms of precipitation, there are increased chances for above normal precipitation over most of the upper basin. Looking further into 2014, the CPC's climate outlook for October-November-December (**Figure 13**) indicates increased chances for warmer than normal temperatures in the upper basin and equal chances for above normal, normal and below normal temperatures in the remainder of the Missouri Basin. There are equal chances for above normal, below normal, and normal precipitation throughout the entire Missouri River basin.

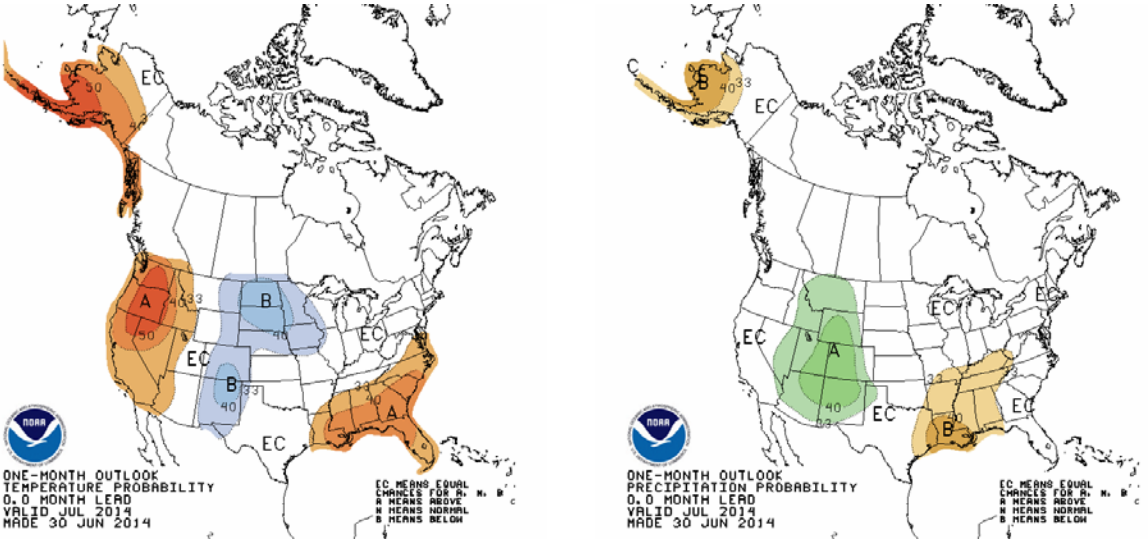


Figure 11. CPC July 2014 temperature and precipitation outlooks.

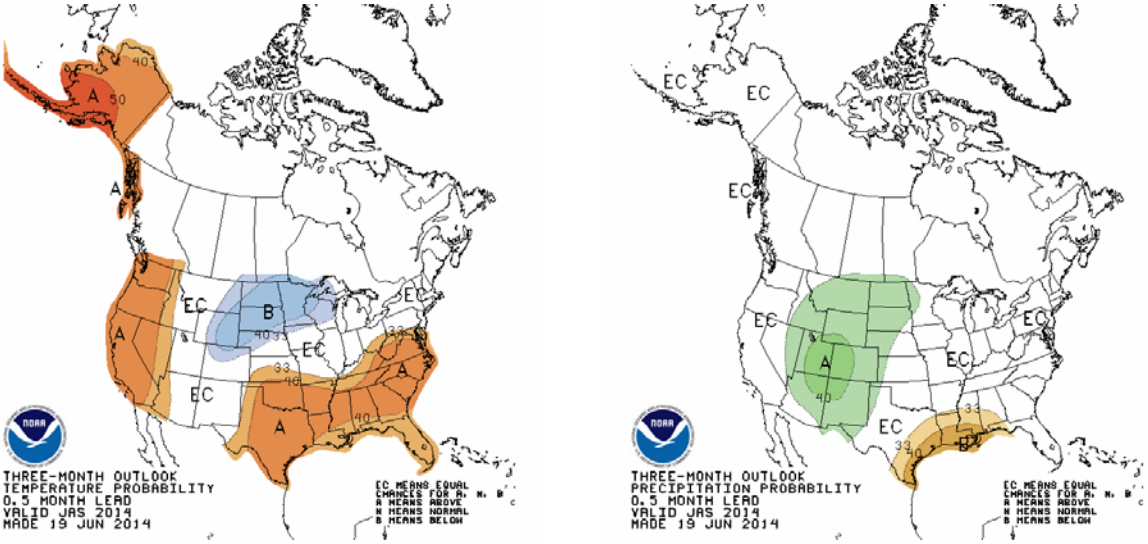


Figure 12. CPC July-August-September 2014 temperature and precipitation outlook.

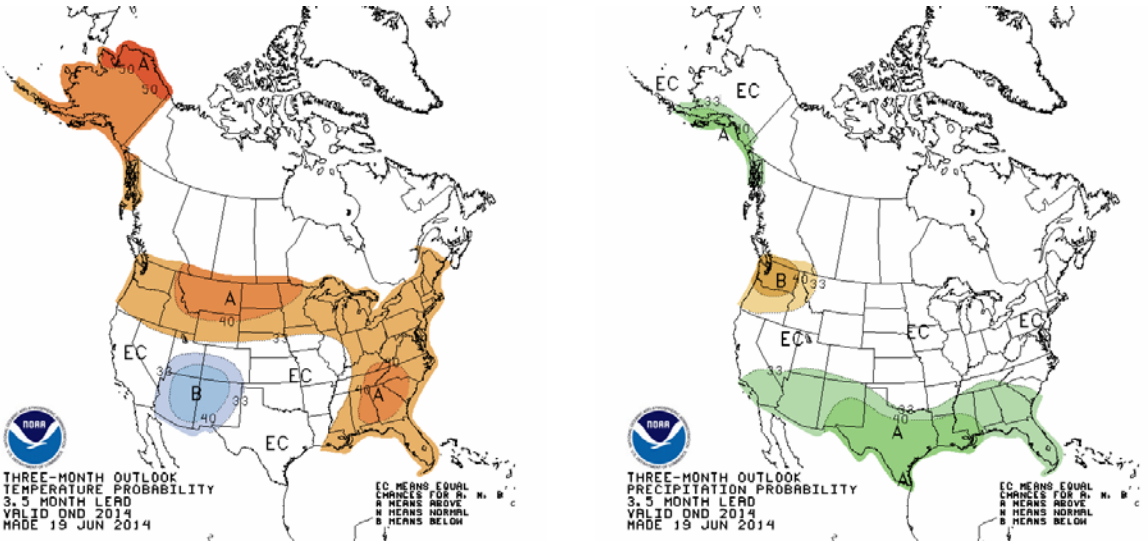


Figure 13. CPC October-November-December 2014 temperature and precipitation outlook.

July 2014 Calendar Year Runoff Forecast

The 2014 calendar year forecast for July 1, is **33.0 MAF** (131% of normal) above Sioux City and **30.1 MAF** (131% of normal) above Gavins Point. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 6 months, the range of expected inflow is quite large and ranges from the 36.1 MAF upper basic forecast to the 29.9 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.

June Recap

June runoff was 8.3 MAF, 153% of normal, and 1.2 MAF greater than forecast; however, about 0.8 MAF of this additional runoff occurred in the Gavins Point to Sioux City reach as a result of the record flooding that occurred on the Big Sioux River. Runoff was 1704 kAF (104% of normal) above Fort Peck, 4034 kAF (149% of normal) into Garrison, 1056 kAF (240% of normal) into Oahe, 181 kAF (113% of normal) into Fort Randall, 268 kAF (145% of normal) into Gavins Point, and 1096 kAF (346% of normal) from Gavins Point to Sioux City. Runoff was less than forecast into Fort Peck and Fort Randall, and it was greater than forecast in all other reaches as a result of above normal rainfall.

July-August Runoff Forecast

For the May-June-July period, the most reliable method for predicting runoff into Fort Peck and Garrison reservoirs is through regression equations that relate mountain snowpack to runoff. More accurate predictions of runoff can be made as mountain snowpack nears its peak accumulation and recorded precipitation and temperature data in April, May and June can be factored into the prediction.

As of June 30, 2014, nearly all mountain snowpack had melted with only a few stations in each of the two mountain subbasins reporting snowpack; therefore, mountain snowpack runoff will have a limited contribution to runoff in the Fort Peck and Garrison subbasins in July. The main source of runoff will be receding baseflows and rainfall runoff in these basins. Since rainfall is difficult to predict more than three days in advance, trend methods were primarily employed to predict July runoff. The resulting forecast is for average runoff into Fort Peck and 149% of average runoff into Garrison. Similarly, July runoff is forecast to be well-above average in Oahe (238%), Fort Randall (207%), Gavins Point (115%) and Sioux City (172%). Runoff as a percent of average declines in August, yet is still above long term average runoff volumes in each reach. The CPC's long range outlook that precipitation could be above normal in July and September was considered in this forecast.

September through December Forecast

For September through December 2014, NOAA's climate outlook indicates increased chances for above normal temperatures throughout the upper basin with equal chances for above normal, normal and below normal precipitation in the entire Missouri River basin. Long term records do not indicate clearly that runoff during El Nino episodes will shift toward wetter or drier conditions, and El Nino impacts can vary substantially throughout the basin. Furthermore, runoff during this time period is usually driven by river baseflows and fall rainfall, which cannot be predicted accurately at this time. In the July 1 forecast, normal runoff has been predicted from September through December.

Upper Missouri River Basin
August 2014 Calendar Year Runoff Forecast
August 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The August 1, 2014 calendar year runoff forecast for the Missouri River basin above Sioux City, IA is **32.5 MAF** (129% of normal). Runoff above Gavins Point Dam is forecast to be **29.5 MAF** (128% of normal). July runoff was 4.3 MAF, 133% of normal, or about 0.3 MAF less than the July forecast. Computed runoff was above normal in all reaches except in the Fort Randall and Gavins Point reaches. Above normal runoff in July was driven by the remaining high elevation mountain snowmelt runoff resulting in higher tributary streamflows originating in the Rocky Mountains. In the Oahe and Sioux City reaches, high streamflows persisted due to very wet conditions experienced in June 2014. By reservoir reach, July runoff was 868 kAF (104% of normal) above Fort Peck, 2487 kAF (137% of normal) into Garrison, 442 kAF (239% of normal) into Oahe, 18 kAF (31% of normal) into Fort Randall, 58 kAF (42% of normal) into Gavins Point, and 475 kAF (195% of normal) from Gavins Point to Sioux City.

Updated upper and lower basic forecast factors were used to determine the upper and lower basic forecasts associated with the August 1 calendar year runoff forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 5 months, expected inflow ranges from the 34.0 MAF upper basic forecast to the 31.0 MAF lower basic forecast. The updated upper and lower basic forecast factors incorporate a slight increase in

runoff variability that can occur during the forecast months of August through December. The result is an upper basic forecast that is 0.4 MAF greater than the upper basic forecast determined using the superseded upper basic method and a lower basic forecast that is 0.3 MAF less than the lower basic forecast determined using the superseded lower basic method.

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 5 months are being forecasted for this August 1 forecast (5 months observed/7 months forecast), the range of wetter than normal (upper basic) and drier than normal (lower basic) conditions is attributed to all 6 reaches for all 5 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 forecasted months decreases.

Current Conditions

Drought Analysis

According to the National Drought Mitigation Center (**Figure 1**), the drought monitor on July 29, 2014 shows an expansion of Abnormally Dry (D0) conditions in central and eastern South Dakota since June 24, 2014 (**Figure 2**). Also, a small area of Moderate Drought (D1) conditions developed in central South Dakota as a result of dry conditions in July. The U.S. Seasonal Drought Outlook shown in **Figure 3** indicates drought conditions will be removed in portions of Nebraska and Kansas, but no change or further development is expected in the upper Missouri River basin.

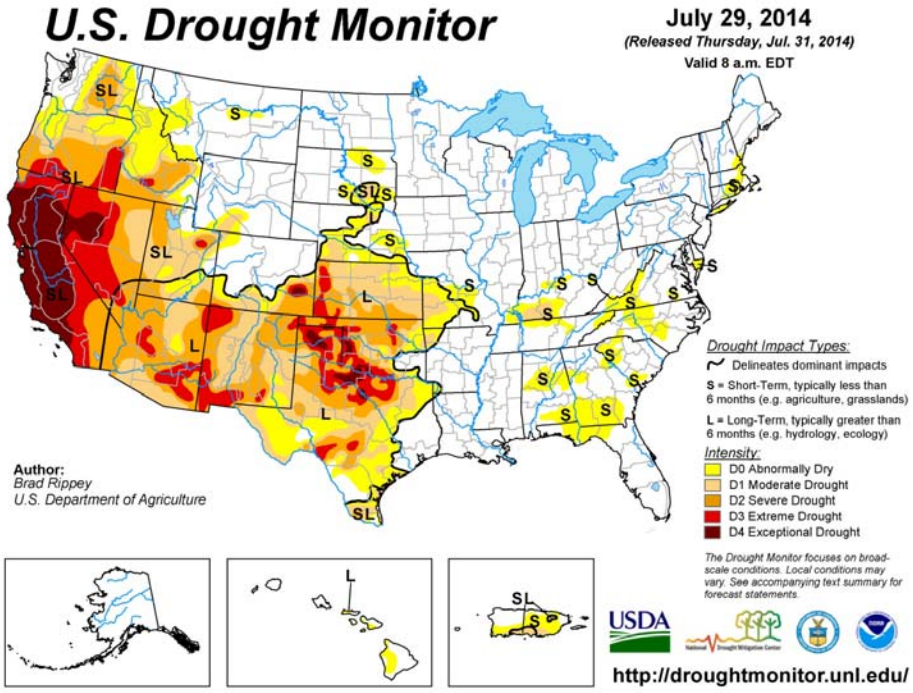


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for July 29, 2014.

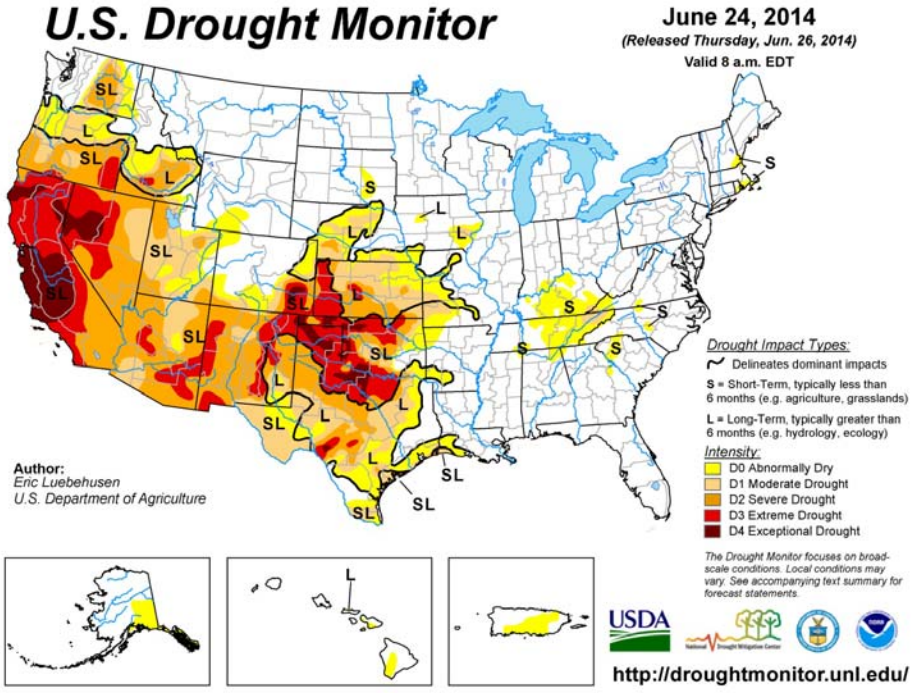


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for June 24, 2014.

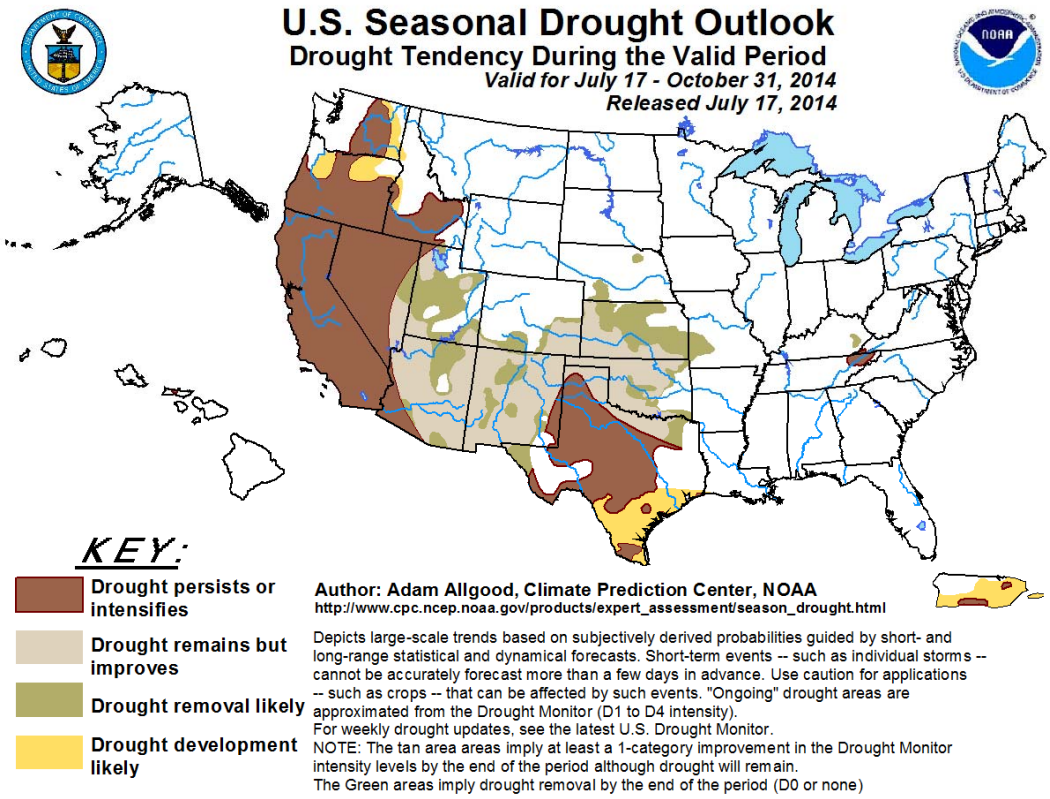


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated precipitation in inches and as a percent of normal during the month of July is shown in **Figure 4**. Very limited amounts of rainfall occurred over the upper Missouri River basin. Rainfall amounts ranged from 0.1 to 1 inch over large areas of Montana, Wyoming, North Dakota and South Dakota, while 1 to 2 inches accumulated in surrounding areas. As a percent of normal, the aforementioned areas received 5 to 50 percent of normal rainfall. **Figure 5** shows a mixture of below normal and above normal precipitation accumulations as a percent of normal over the May-June-July period. Central and western Montana and Wyoming received less than 70 percent of normal precipitation, while accumulations were higher in eastern Montana, eastern Wyoming and the western Dakotas. Rainfall accumulations were much drier than normal over much of eastern South Dakota; however, very heavy precipitation accumulations occurred in June over southeast South Dakota, northwest Iowa and northeast Nebraska, resulting in three-month accumulations that are substantially above normal. In addition to this region, greater than normal precipitation accumulations occurred over north central and northeast Colorado, southeast Wyoming and western Nebraska. In the lower basin below Omaha, NE, precipitation accumulations were below normal.

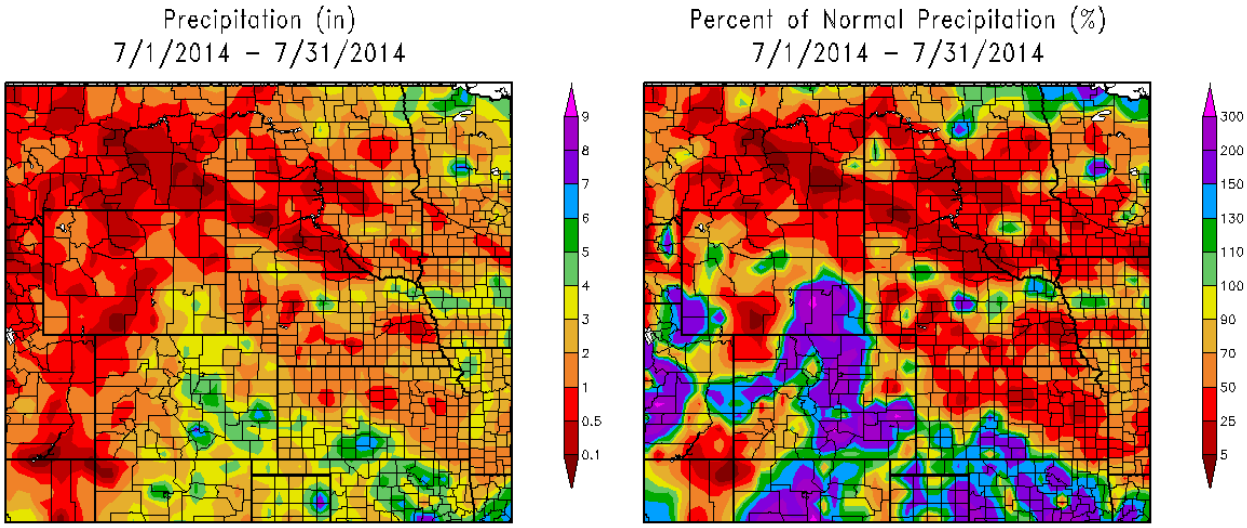


Figure 4. July 2014 Precipitation and Percent of Normal Precipitation (%). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

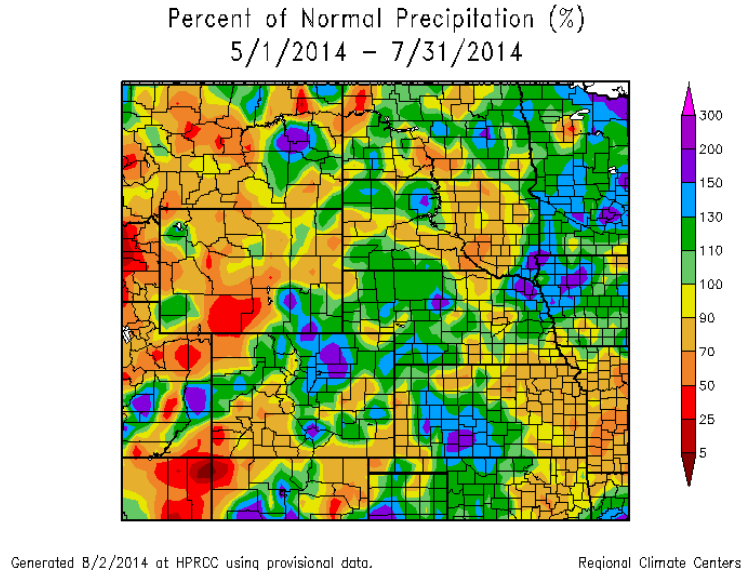


Figure 5. Percent of Normal Precipitation for May-June-July 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

Departure from Normal Temperatures (degrees Fahrenheit) in the month of July, courtesy of the Climate Prediction Center, is shown in **Figure 6**. July temperatures were well-below normal in most of the upper basin above Sioux City, IA ranging from 1 to 4 degrees Fahrenheit below normal. Temperatures in Montana and Wyoming ranged from normal to 4 degrees Fahrenheit above normal. Three-month (May-June-July) temperature departures are shown in **Figure 7**. The three-month map indicates that temperatures ranged from normal to 2 degrees Fahrenheit below normal over much of the upper basin; however, temperatures have ranged from normal to 1 degree Fahrenheit above normal in western Montana and western Wyoming.

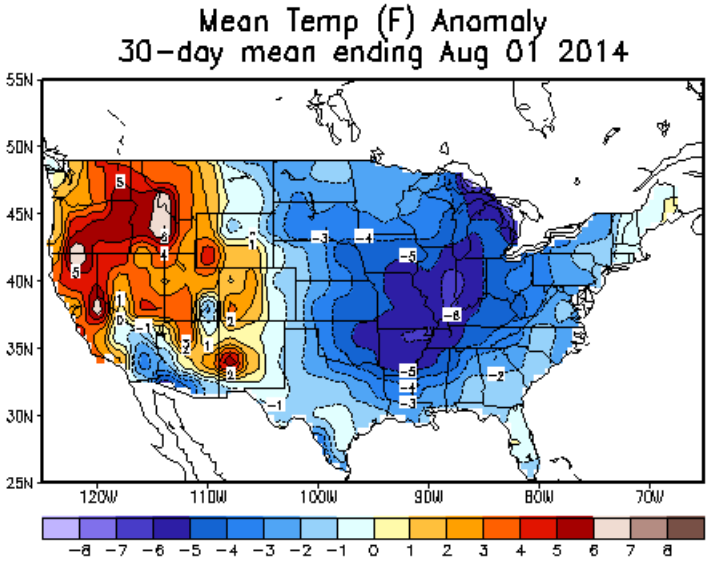


Figure 6. Monthly Departure from Normal Temperature (deg F) ending August 1, 2014.

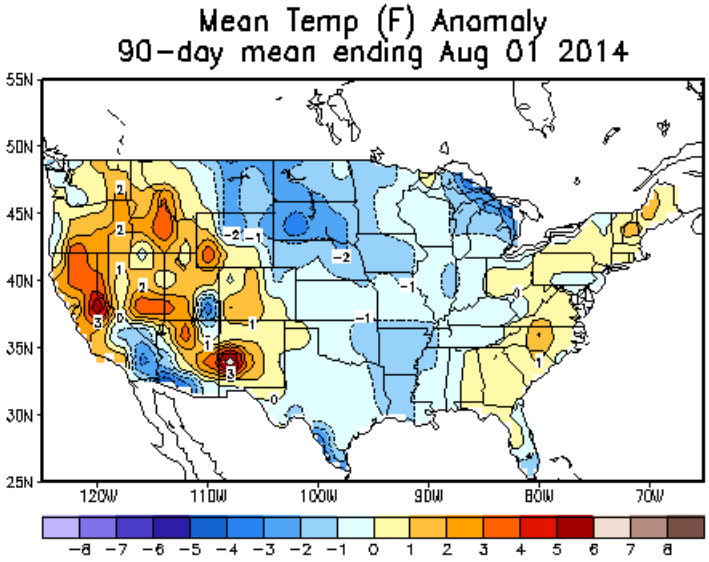


Figure 7. Three-month Departure from Normal Temperature (deg F) ending August 1, 2014.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on July 31, 2014. This modeled estimate depicts above normal soil moisture conditions throughout the upper

Missouri River basin in Montana and Wyoming and western portions of North and South Dakota. Soil moisture is typically greater than the 70th percentile and in some cases greater than the 95th percentile. Soil moisture conditions are drier in eastern South Dakota, Nebraska, Iowa and the lower basin below Omaha, where they are much drier than normal.

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on July 31, 2014 is shown in **Figure 9**. According to the analysis, soil moisture anomalies in a large portion of the upper basin are greater than 25 mm (0.98 inches) above normal and in many locations greater than 50 mm (1.96 inches) above normal. Some localized areas in Wyoming have anomalies much less than normal, while much of eastern South Dakota and the lower basin below Sioux City, IA have anomalies 50 to 100 mm (1.96 to 3.92 inches) below normal.

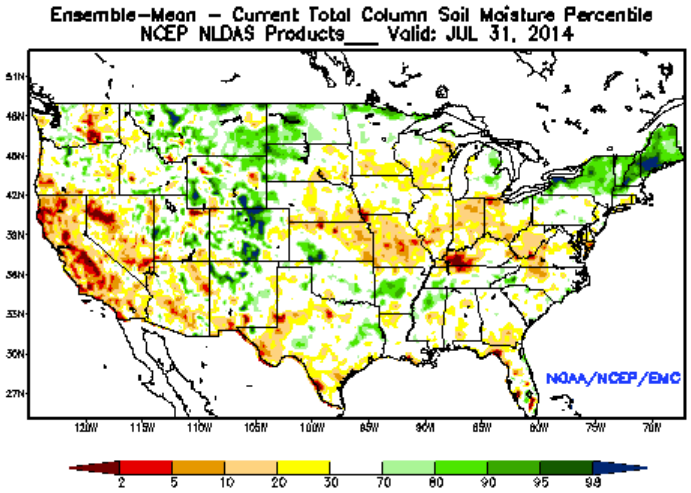


Figure 8. Total Column Soil Moisture Percentile on July 31, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

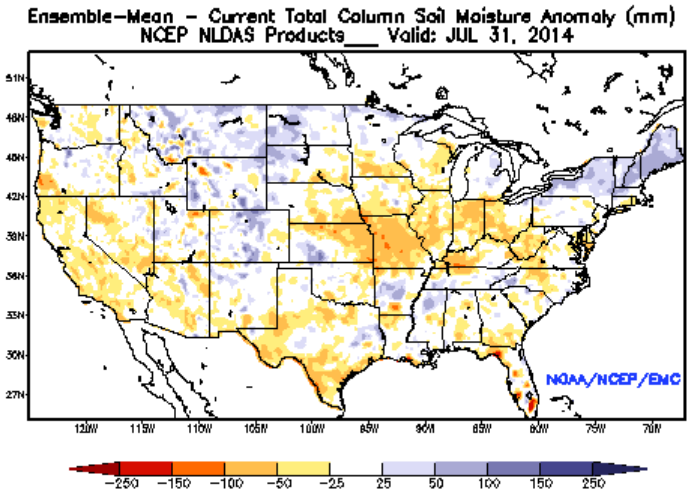


Figure 9. Calculated Soil Moisture Anomaly (mm) on July 31, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

Mountain Snow Pack

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-July runoff volumes, especially when mountain soil moisture conditions have been wetter than normal as in the past three years. For example, we would expect to see greater than average runoff from an average mountain snowpack this year due to wetter than normal soil moisture conditions. Average mountain snowpack for the headwater basin above Fort Peck Dam and for the subbasin between Fort Peck Dam and Garrison Dam are shown in **Figure 10**. As of July 19, 2014 there was nominal, un-measureable snowpack in the Rocky Mountains.

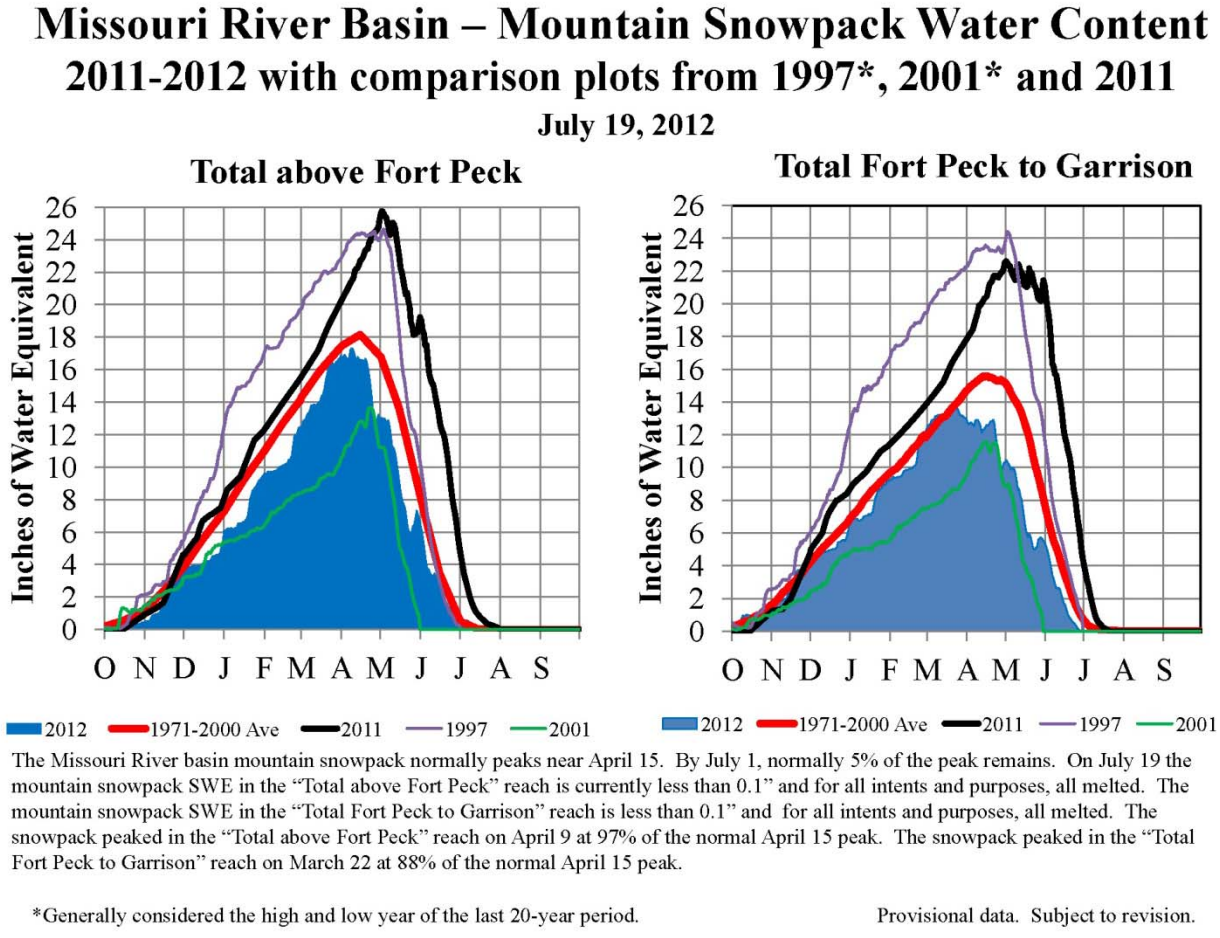


Figure 10. Mountain snowpack water content snow accumulation compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO (El Niño Southern Oscillation)

ENSO-neutral conditions continue in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average across the equatorial Pacific Ocean based on CPC analysis. The chance of El Niño increases during the remainder of the year, exceeding 70% by summer and 80% by fall/winter. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

Temperature and Precipitation Outlooks

The Climate Prediction Center's August outlook (**Figure 11**) indicates equal chances for above normal, normal and below normal precipitation in the upper basin accompanied by increased chances for below normal temperatures. The three-month climate outlook for August-September-October 2014 (**Figure 12**) indicates equal chances for precipitation in Montana and the Dakotas and increased chances for above normal precipitation in Wyoming and southwest South Dakota. With regard to temperatures the CPC outlooks indicate equal chances in western Montana and Wyoming and an increased chance for below normal temperatures in the plains. Looking further into 2014, the CPC's climate outlook for November-December-January (**Figure 13**) indicates increased chances for below normal precipitation developing in the upper basin accompanied by increased chances for above normal temperatures. This is a result of the CPC's latest projection with 80% certainty that El Nino will develop during the fall and winter.

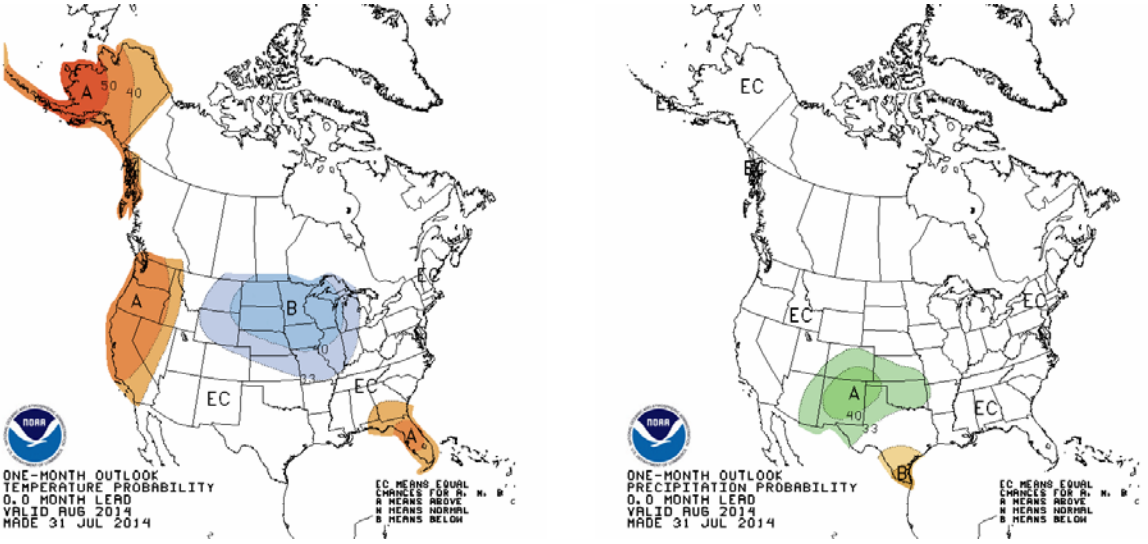


Figure 11. CPC August 2014 temperature and precipitation outlooks.

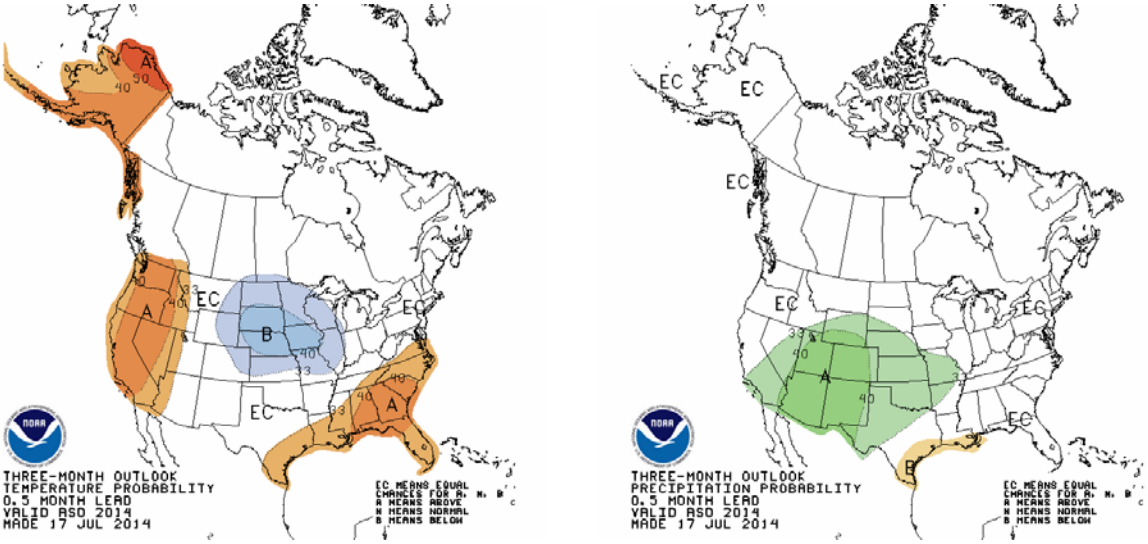


Figure 12. CPC August-September-October 2014 temperature and precipitation outlook.

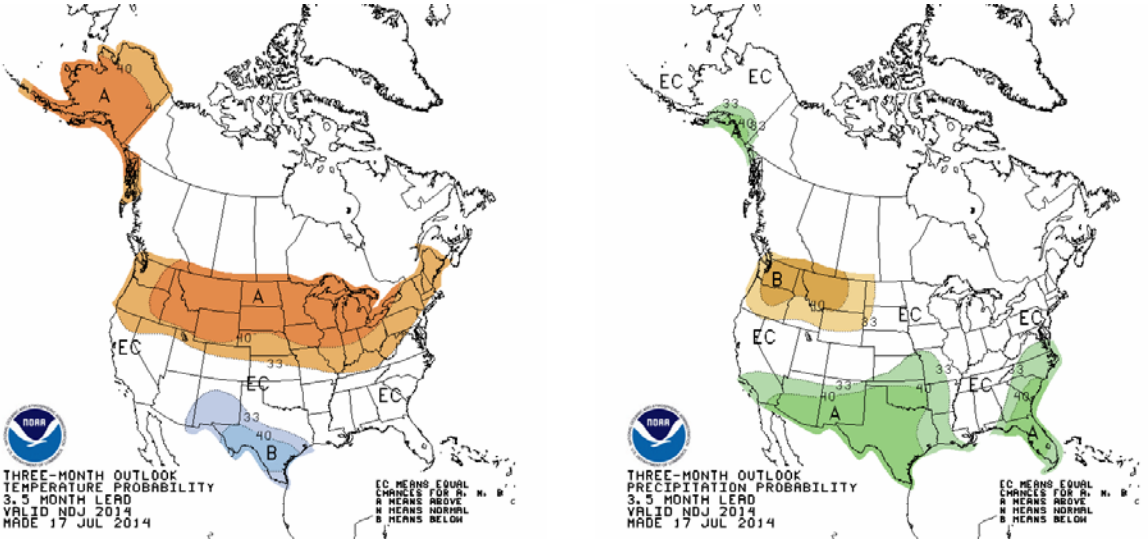


Figure 13. CPC November-December 2014-January 2015 temperature and precipitation outlook.

August 2014 Calendar Year Runoff Forecast

The 2014 calendar year forecast for August 1, is **32.5 MAF** (129% of normal) above Sioux City and **29.5 MAF** (128% of normal) above Gavins Point. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 5 months, the range of expected inflow is quite large and ranges from the 34.0 MAF upper basic forecast to the 31.0 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.

July Recap

July runoff was 4.7 MAF, 143% of normal, and nearly equivalent to the July forecast runoff. At the beginning of the month, higher than normal mountain streamflows caused by the remaining snowmelt runoff generated runoff rates that were much higher than average runoff rates. As streamflows receded with very little contribution from rainfall runoff rates fell below normal; however, the overall average monthly runoff was above normal as indicated above. By reach runoff was 868 kAF (104% of normal) above Fort Peck, 2487 kAF (137% of normal) into Garrison, 442 kAF (239% of normal) into Oahe, 18 kAF (31% of normal) into Fort Randall, 58 kAF (42% of normal) into Gavins Point, and 475 kAF (195% of normal) from Gavins Point to Sioux City.

August-December Runoff Forecast

Runoff will continue to decline in August; however, it is expected to be above normal (as a percent of normal) in the Garrison, Oahe and Sioux City reaches due to existing higher than normal streamflow and an outlook for above normal precipitation in August. Runoff is expected to be about normal above Fort Peck, while it will be well below normal in Fort Randall and Gavins Point.

September through December Forecast

For September through December 2014, the CPC's climate outlook indicates increased chances for above normal temperatures throughout the Missouri basin with increased chances for below normal precipitation in the Northern Rocky Mountains and western plains. Long term records do not indicate clearly that runoff during El Nino episodes will shift toward wetter or drier conditions during the season that it develops, and El Nino impacts can vary substantially throughout the basin. Furthermore, runoff during this time period is usually driven by existing streamflows and fall rainfall, which cannot be predicted accurately at this time. In the August 1 forecast, normal to steadily declining runoff has been predicted in all reaches except the Fort Randall and Gavins Point reaches. In the latter reaches, below normal will likely continue; however, modest increases in runoff as a percent of normal are expected. If El Nino occurs, it could have its greatest impact on mountain snow accumulation. Mountain snowmelt runoff, which occurs in May, June and July, will not be predicted until January 1, 2015.

Upper Missouri River Basin
September 2014 Calendar Year Runoff Forecast
September 5, 2014

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.

2014 Calendar Year Forecast Synopsis

The September 1, 2014 calendar year runoff forecast for the Missouri River basin above Sioux City, IA is **35.6 MAF** (141% of normal). Runoff above Gavins Point Dam is forecast to be **32.7 MAF** (142% of normal). August runoff was **3.2 MAF**, 241% of normal, 1.6 MAF above the August 1 forecast, and the 3rd highest August runoff summation behind 4.1 MAF in 1993 and 3.4 MAF in 2011. August runoff was caused by monthly record amounts of rainfall in central and northeast Montana as well as southwest North Dakota and northwest South Dakota. As a result, August runoff into Fort Peck was the 2nd highest August runoff of record, while August runoff into Oahe was the highest August runoff of record.

By reservoir reach, August runoff was 899 kAF (253% of normal) above Fort Peck, 1121 kAF (184% of normal) into Garrison, 821 kAF (1156% of normal) into Oahe, 136 kAF (331% of normal) into Fort Randall, 95 kAF (82% of normal) into Gavins Point, and 158 kAF (107% of normal) from Gavins Point to Sioux City.

The forecast for the remainder of the calendar year takes into account the current high streamflows, wet soil moisture conditions, and the CPC climate outlooks. Given these conditions, September runoff is forecast to be 1.9 MAF or 170% of normal, with 1.6 MAF of

that runoff occurring in the Fort Peck, Garrison and Oahe reaches. In October, 1.6 MAF or 137% of normal runoff is forecast, with 1.4 MAF of that monthly total to occur in the Fort Peck, Garrison and Oahe reaches. Runoff is forecast to be above normal throughout the remainder of the calendar year.

Updated upper and lower basic forecast factors were used to determine the upper and lower basic forecasts associated with the September 1 calendar year runoff forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 4 months, expected inflow ranges from the 37.1 MAF upper basic forecast to the 34.3 MAF lower basic forecast. The updated upper and lower basic forecast factors incorporate a slight increase in runoff variability that can occur during the forecast months of August through December. The result is an upper basic forecast that is 0.3 MAF greater than the upper basic forecast determined using the superseded upper basic method and a lower basic forecast that is 0.2 MAF less than the lower basic forecast determined using the superseded lower basic method.

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 4 months are being forecasted for this September 1 forecast (8 months observed/4 months forecast), the range of wetter than normal (upper basic) and drier than normal (lower basic) conditions is attributed to all 6 reaches for all 4 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 forecasted months decreases.

Current Conditions

Drought Analysis

The latest National Drought Mitigation Center's drought monitor, released on August 26, 2014 (**Figure 1**), shows a contraction of Abnormally Dry (D0) conditions in central and eastern South Dakota and in central Montana since July 29, 2014 (**Figure 2**). Drought conditions have also improved in central Nebraska. The U.S. Seasonal Drought Outlook shown in **Figure 3** indicates that new drought conditions are not likely to develop in the upper Missouri River basin through late November. Lingering Dry (D0) conditions in central South Dakota will likely be removed.

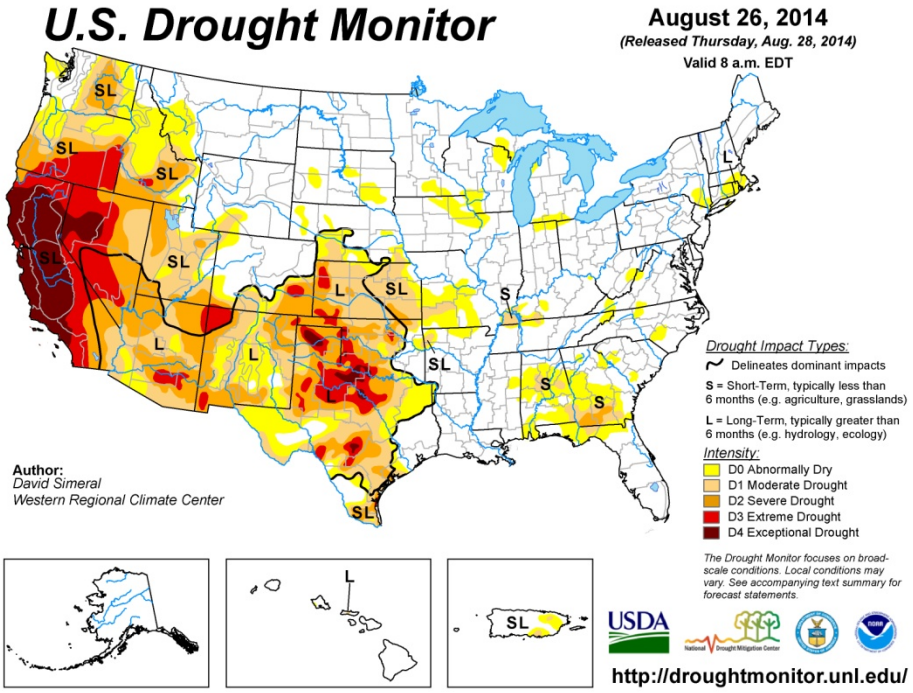


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for August 26, 2014.

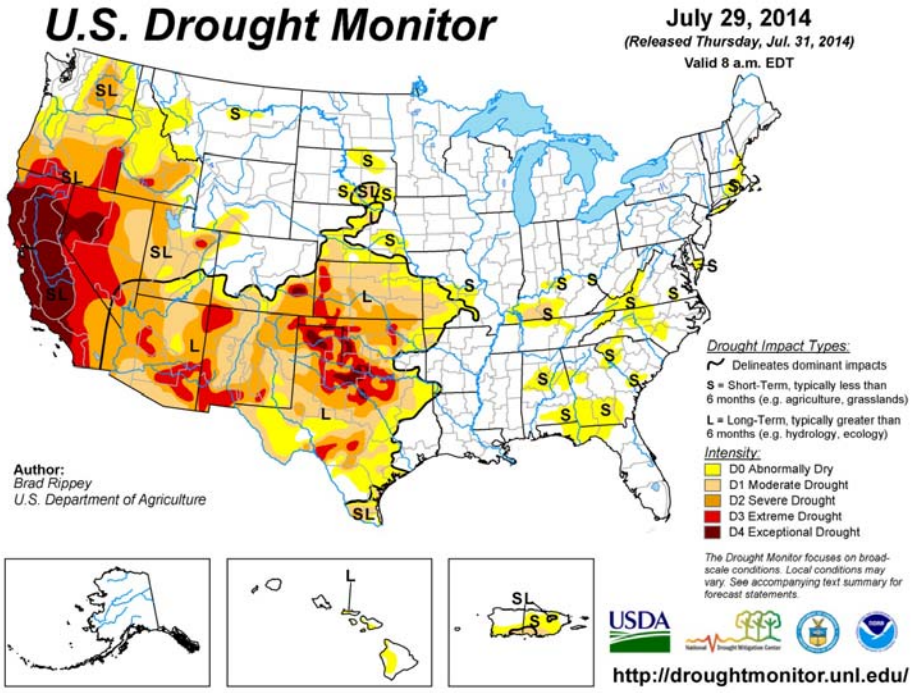


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for July 29, 2014.

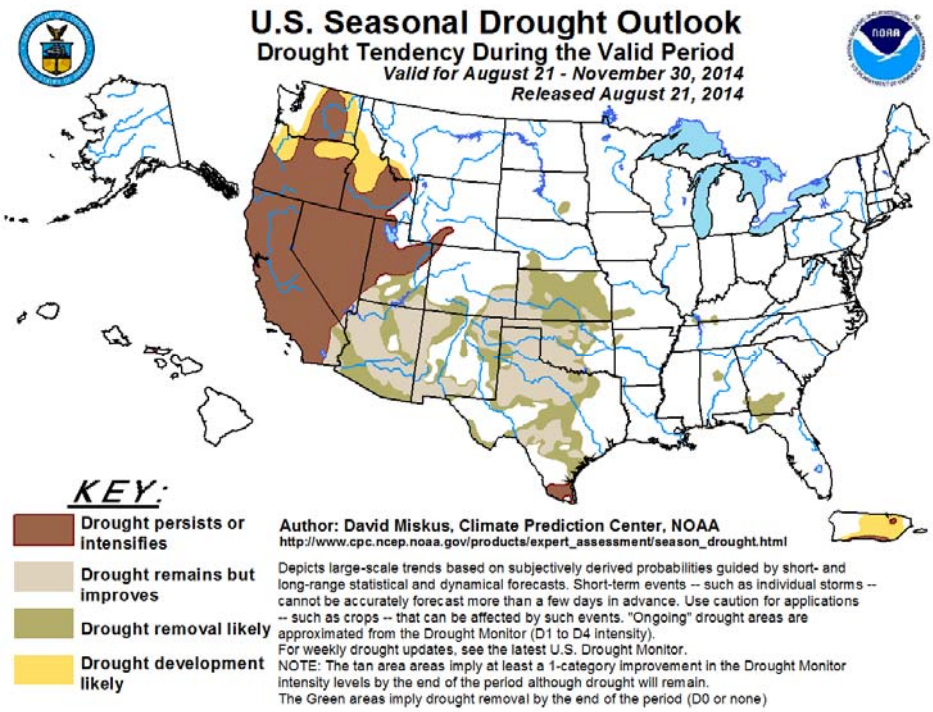


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Accumulated August precipitation in inches and as a percent of normal are shown in **Figure 4**. Very heavy precipitation occurred in late August over the upper Missouri River basin as a result of a slow moving storm system. During the last half of August a large portion of central and north central Montana received greater than 5 inches of rain while some areas received greater than 10 inches. Southwest North Dakota and northwest South Dakota also received rain during this period, but lesser amounts. As a percent of normal, August rainfall was greater than 150% of normal over a majority of the upper basin above Sioux City, while areas of Montana, north central Wyoming and the western Dakotas received more than 200% of normal August precipitation. Furthermore, areas in north central Montana and the western Dakotas received greater than 400% of normal precipitation.

Glasgow, MT, which is the National Weather Service weather forecast office in northeast Montana, received 6.7 inches of rain in August 2014, 5.5 inches above normal. At Glasgow August 2014 was the wettest August on record and the 5th wettest month of all time. The wettest month of record was June 1923 with 10.29 inches followed by June 1906 with 7.12 inches. Glasgow received 6.97 inches in May 2011.

Individual one-day rainfall totals in Montana, ending at approximately 6:00 a.m. on August 24, included 5.4 inches at Judith Peak, 4.84 inches at Winifred, 4.69 inches at Landusky, 4.40 inches

at Lewistown, and 3.33 inches at Glasgow. One-day rainfall totals in Montana ending August 25 included 3.3 inches at Lewistown, 2.75 inches at Harlem and 2.09 inches at Saco.

Figure 5 shows the percent of normal precipitation for June 1 – August 31, 2014. Rainfall accumulated from June 1 – August 31 has been above normal throughout most of the upper basin. Areas where rainfall has been greater than 150% of normal include north central and eastern Montana, southwest North Dakota, northwest South Dakota, southeast South Dakota, northeast Nebraska, western Iowa and central Nebraska.

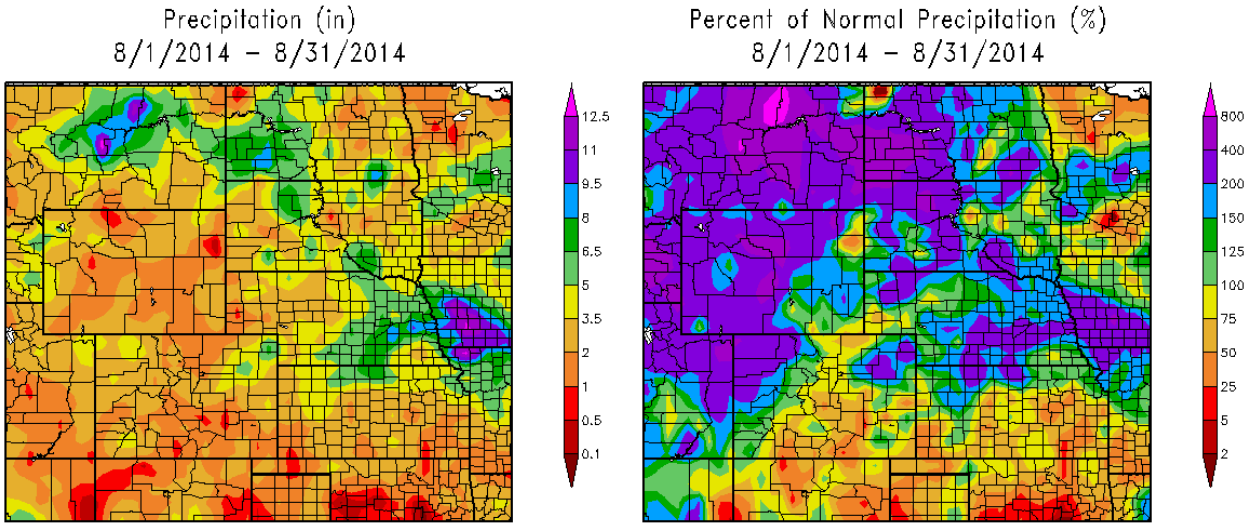


Figure 4. August 2014 Precipitation (inches) and Percent of Normal Precipitation (%). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

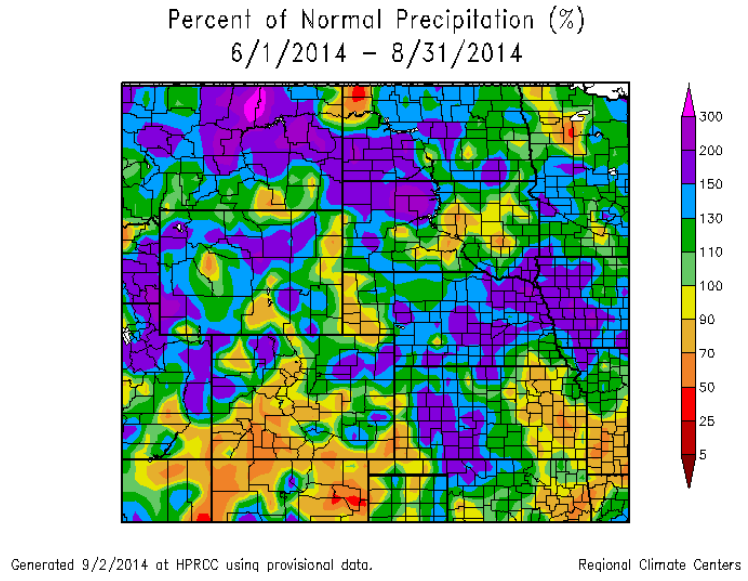


Figure 5. Percent of Normal Precipitation for June 1 – August 31, 2014. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

August temperature departures from normal in degrees Fahrenheit (degrees F), courtesy of the Climate Prediction Center, are shown in **Figure 6**. August temperatures in most of the upper basin above Sioux City, IA ranged from 1 to 3 degrees F below normal. Temperatures in Montana ranged from 1 degree F above normal in western Montana to 2 degrees F below normal in central Montana. Three-month (June-July-August) temperature departures are shown in **Figure 7**. The three-month map indicates that temperatures ranged from 2 to 4 degrees F below normal over much of the upper basin; however, temperatures have ranged from normal to 1 degree F above normal in western Montana and northwest Wyoming.

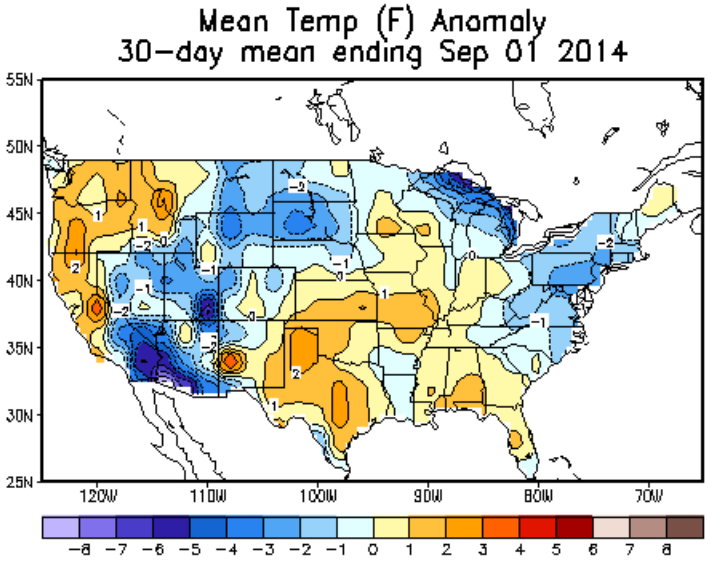


Figure 6. Monthly Departure from Normal Temperature (degrees F) ending September 1, 2014.

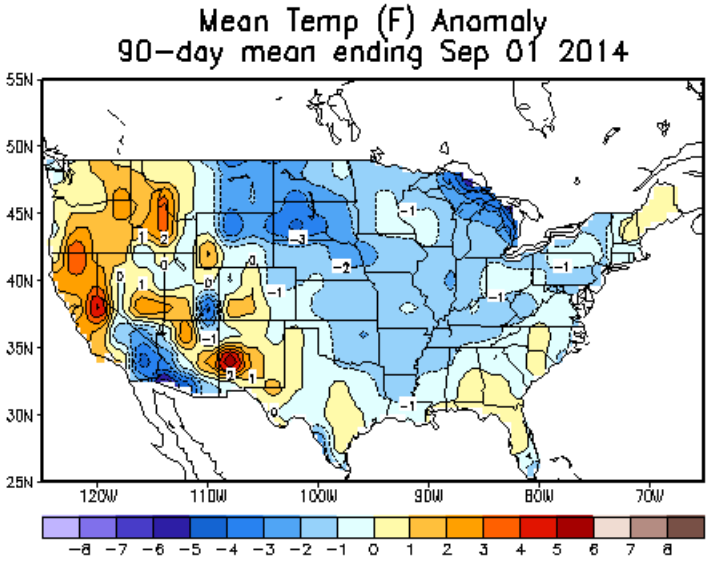


Figure 7. Three-month Departure from Normal Temperature (degrees F) ending September 1, 2014.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on August 29, 2014. This modeled estimate depicts well above normal soil moisture conditions throughout the upper Missouri River basin in Montana, Wyoming, North Dakota and South Dakota. Soil moisture is typically greater than the 80th percentile and greater than the 98th percentile in areas of central and eastern Montana and the western Dakotas. These high soil moisture conditions developed as a result of the record August precipitation.

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on August 29, 2014 is shown in **Figure 9**. According to the modeled estimate, soil moisture anomalies in a large portion of the upper basin range from 50 – 100 mm (1.96 – 3.92 inches) above normal. Very wet soil conditions are also present in western North and South Dakota with anomalies ranging from 100 – 150 mm (3.92 – 5.91 inches). In north central Montana the highest soil moisture anomalies are greater than 150 mm (5.91 inches)

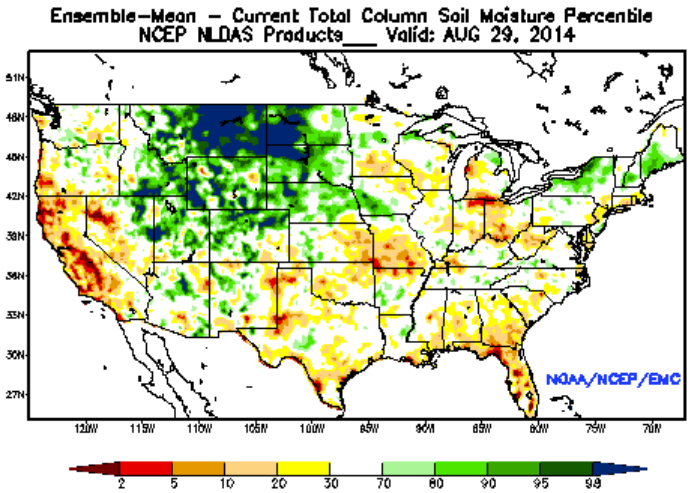


Figure 8. Total Column Soil Moisture Percentile on August 29, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

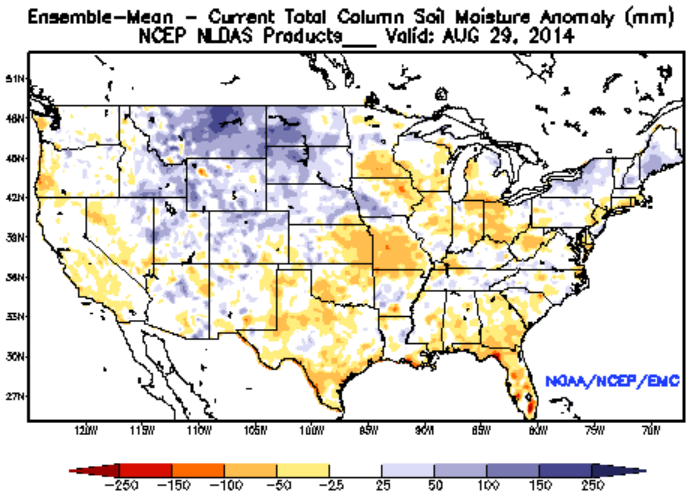


Figure 9. Calculated Soil Moisture Anomaly (mm) on August 29, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

Climate Outlook

ENSO (El Niño Southern Oscillation)

ENSO-neutral conditions continue in the equatorial Pacific; however, equatorial sea surface temperatures (SST) were above-average across the equatorial Pacific Ocean based on CPC analysis. The chance of El Niño developing in the fall or winter is 65% based on the CPC analysis. The El Niño reduction of 15% has increased the chance of an ENSO-neutral condition, which is the climate phase the upper basin was in this last winter. El Niño can decrease the potential for extreme temperatures during the summer; however, there are potentially higher chances for convective activity in the Dakotas. During the winter El Niño can increase chances for warmer and drier conditions in the northern Plains.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) precipitation outlook (**Figure 10**) for September indicates equal chances for above normal, normal and below normal precipitation in most of the upper basin accompanied by increased chances for below normal temperatures. There is a slight increase in the probability for above normal precipitation in eastern South Dakota and the remaining lower basin. The long-range outlook for September through November (**Figure 11**) shows equal chances for precipitation in Montana and the Dakotas and most of Wyoming. There are increased chances for above normal precipitation over most of the lower basin below Sioux City. Switching to temperature, the September through November temperature outlook indicates increased chances for above normal temperatures in Montana and small portions of North Dakota and South Dakota, while there are equal chances in the remainder of the upper basin.

Looking further ahead, the December through February (**Figure 12**) precipitation outlooks indicate increased chances for below normal precipitation developing in Montana and Wyoming accompanied by increased chances for warmer than normal temperatures in the upper basin. For this winter, the outlook is partially based on the CPC prediction that El Niño will develop during the fall and early winter.

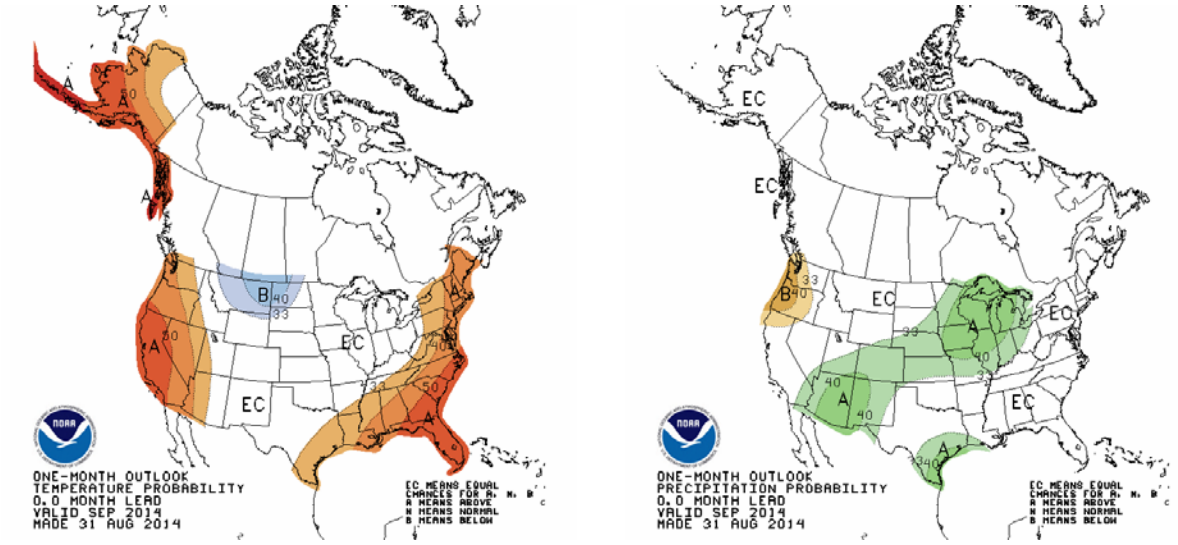


Figure 10. CPC September 2014 temperature and precipitation outlooks.

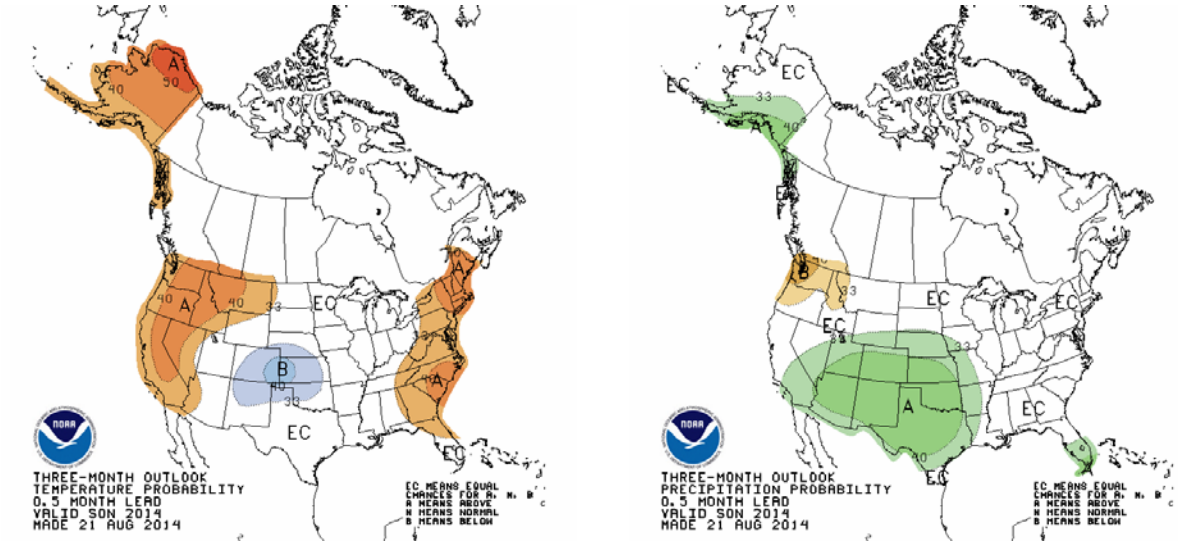


Figure 11. CPC September-October-November 2014 temperature and precipitation outlook.

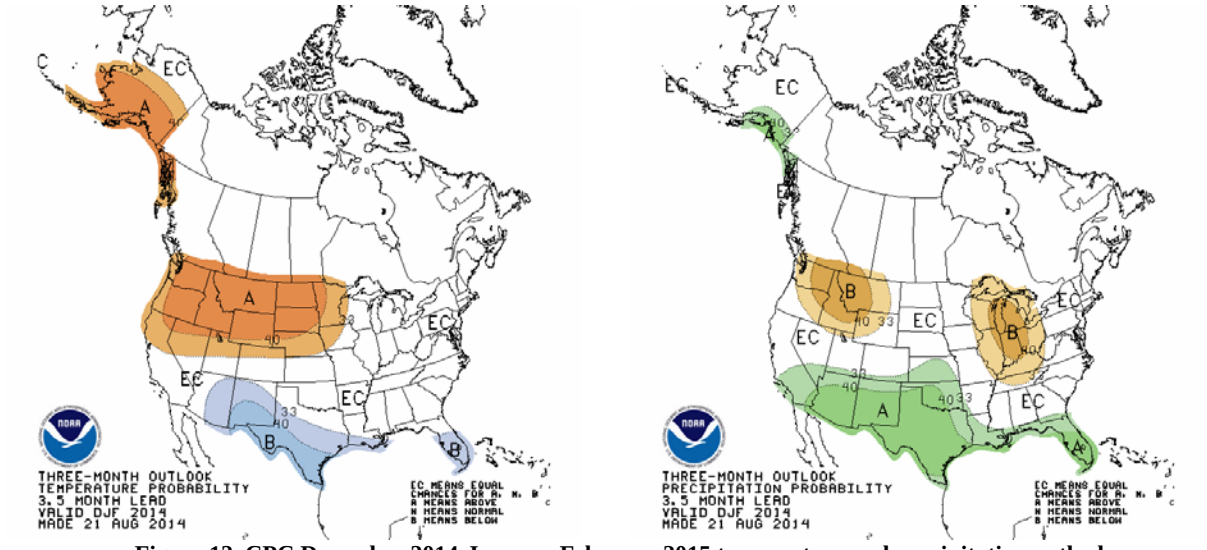


Figure 12. CPC December 2014-January-February 2015 temperature and precipitation outlook.

August 2014 Calendar Year Runoff Forecast

The September 1, 2014 calendar year runoff forecast for the Missouri River basin above Sioux City, IA is 35.6 MAF (141% of normal). Runoff above Gavins Point Dam is forecast to be 32.7 MAF (142% of normal). Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 4 months, the range of expected inflow ranges from the 37.1 MAF upper basic forecast to the 34.3 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.

August Recap

September runoff was 3.2 MAF, 241% of normal, 1.6 MAF above the August forecast, and the 3rd highest August runoff summation behind 4.1 MAF in 1993 and 3.4 MAF in 2011. August runoff was caused by record amounts of rainfall in central and northeast Montana as well as southwest North Dakota and northwest South Dakota. As a result, August runoff into Fort Peck was the 2nd highest August runoff of record, while August runoff into Oahe was the highest August runoff of record. By reservoir reach, August runoff was 899 kAF (253% of normal) above Fort Peck, 1121 kAF (184% of normal) into Garrison, 821 kAF (1156% of normal) into Oahe, 136 kAF (331% of normal) into Fort Randall, 95 kAF (82% of normal) into Gavins Point, and 158 kAF (107% of normal) from Gavins Point to Sioux City.

September Runoff Forecast

The forecast for the remainder of the calendar year takes into account the current high streamflows, wet soil moisture conditions, and the CPC climate outlooks. Record August rainfall caused very high runoff in August, resulting in very wet soil conditions ranking near the

98th percentile in many areas of Montana and the western Dakotas. As a result it is very likely that well-above normal runoff will continue in the month of September even under normal rainfall conditions. The September precipitation outlook indicates precipitation chances are equal with the exception of a slight increase in the above normal precipitation probability in eastern South Dakota. Furthermore, there is still a 65% chance that El Nino will develop in the fall or early winter. Given these conditions, a statistical analysis was performed to determine the range of runoff that could occur. September runoff is forecast to be 1.9 MAF or 170% of normal, with 1.6 MAF of that runoff occurring in the Fort Peck, Garrison and Oahe reaches.

October through December Forecast

In October, 1.6 MAF or 137% of normal runoff is forecast, with 1.4 MAF of that monthly total to occur in the Fort Peck, Garrison and Oahe reaches. Runoff is forecast to be above normal throughout the remainder of the calendar year. The CPC's climate outlook indicates increased chances for above normal temperatures throughout the upper Missouri basin with increased chances for below normal precipitation in the Northern Rocky Mountains and western plains. Long-term records indicate slightly better chances that runoff during El Niño episodes will be wetter than normal in the late fall and early winter; however El Niño impacts are not statistically significant during fall and early winter. If El Niño occurs, it could have its greatest impact on mountain snow accumulation, which occurs from November through April. Mountain snowmelt runoff, which occurs in May, June and July, will not be predicted until January 1, 2015.

Upper Missouri River Basin
October 2014 Calendar Year Runoff Forecast
October 3, 2014

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.

2014 Calendar Year Forecast Synopsis

The October 1, 2014 calendar year runoff forecast or Basic forecast for the upper Missouri River Basin (Basin) above Sioux City, IA is **35.5 MAF** (141% of normal). Runoff above Gavins Point Dam is forecast to be **32.4 MAF** (141% of normal).

September runoff above Sioux City, IA was **1.8 MAF**, 157% of normal. Above Gavins Point Dam, September runoff was 1.5 MAF, 149% of normal. September runoff was a result of higher-than-normal streamflow from the late August heavy precipitation in the northwest portion of the upper Basin. By reservoir reach, September runoff was 401 kAF (121% of normal) above Fort Peck, 898 kAF (200% of normal) into Garrison, 233 kAF (212% of normal) into Oahe, 51 kAF (139% of normal) into Fort Randall, -38 kAF (-34% of normal) into Gavins Point, and 255 kAF (238% of normal) from Gavins Point to Sioux City.

The runoff forecast for the last three months of the calendar year considers higher-than-normal streamflows due to moderate to heavy end-of-September precipitation in western South Dakota, wet soil moisture conditions throughout most of the upper Basin, and the NOAA Climate Prediction Center (CPC) climate outlooks. Given these conditions, October runoff is forecast to be 1.6 MAF or 135% of normal above Sioux City, and 1.5 MAF or 132% of normal above

Gavins Point. We are expecting runoff to continue to be above normal throughout the remainder of the calendar year as well as during January and February of 2015.

Updated Upper Basic and Lower Basic forecast factors were used to determine the Upper Basic and Lower Basic forecasts associated with the October 1 calendar year runoff forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next three months, expected inflow ranges from the 36.4 MAF Upper Basic forecast to the 34.6 MAF Lower Basic forecast. The updated Upper Basic and Lower Basic forecast factors incorporate a slight increase in runoff variability that can occur during the forecast months of October through December. The result is an Upper Basic forecast that is 0.2 MAF greater than the forecast determined using the superseded Upper Basic method and a Lower Basic forecast that is 0.1 MAF less than the forecast determined using the superseded Lower Basic method.

The Upper Basic 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 three months are being forecasted for this October 1 forecast (nine months observed/three months forecast), the range of wetter than normal (Upper Basic) and drier than normal (Lower Basic) conditions is attributed to all six reaches for all three 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 forecasted months decreases.

Current Conditions

Drought Analysis

The latest National Drought Mitigation Center's drought monitor, for September 30, 2014 (**Figure 1**), shows small areas of Abnormally Dry (D0) conditions in central South Dakota and in far western Montana. Since the August 26 (**Figure 2**) Abnormally Dry (D0) conditions in the South Dakota have contracted, while there has been some expansion of D0 conditions and development of Moderate Drought (D1) conditions in western Montana. The U.S. Seasonal Drought Outlook shown in **Figure 3** indicates that new drought conditions are not likely to develop in the upper Missouri River Basin with the exception of some drought development in southwest Montana.

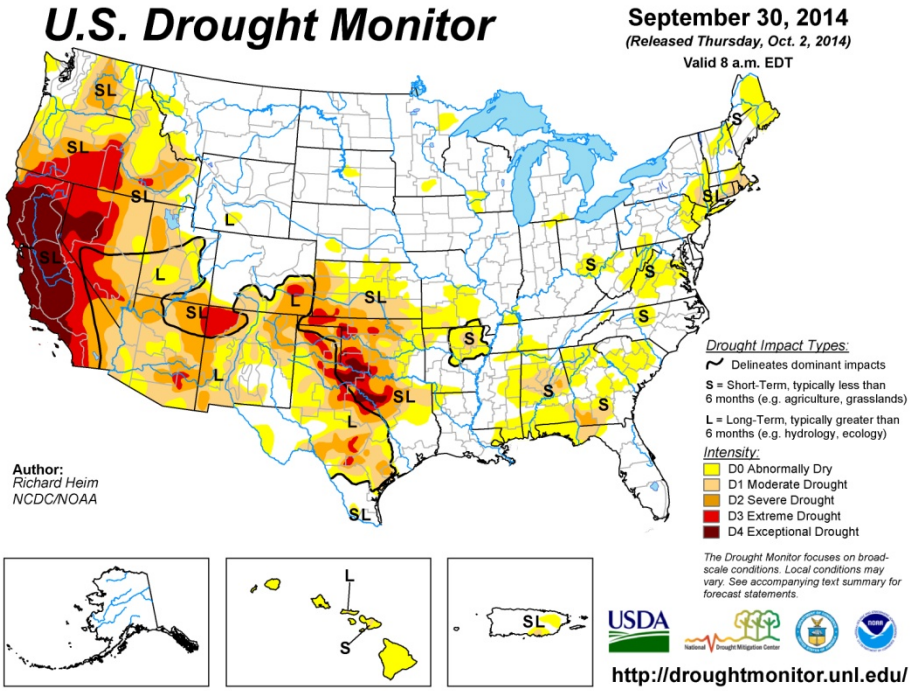


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for September 30, 2014.

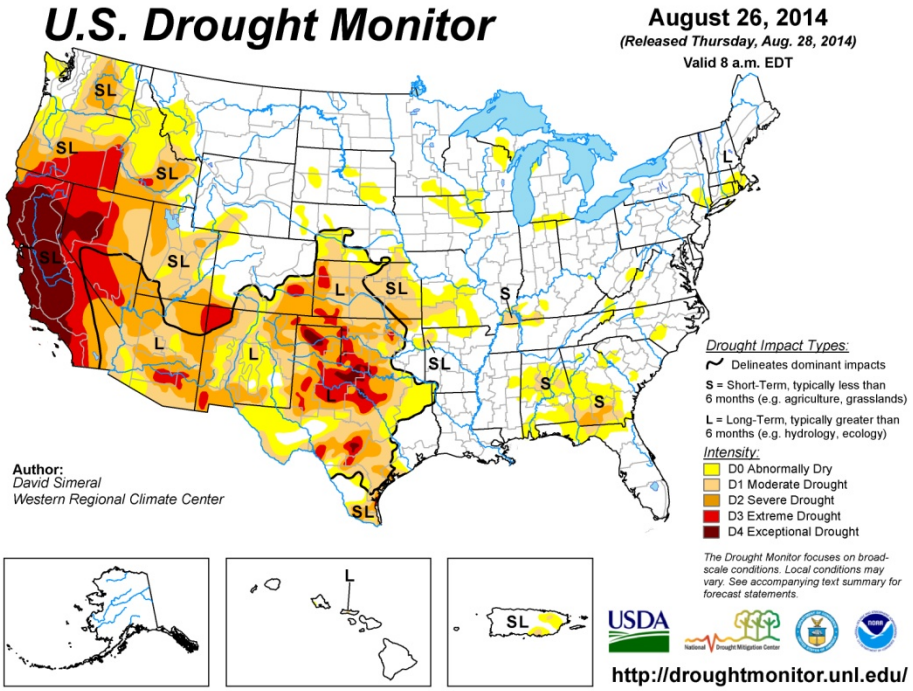


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for August 26, 2014.

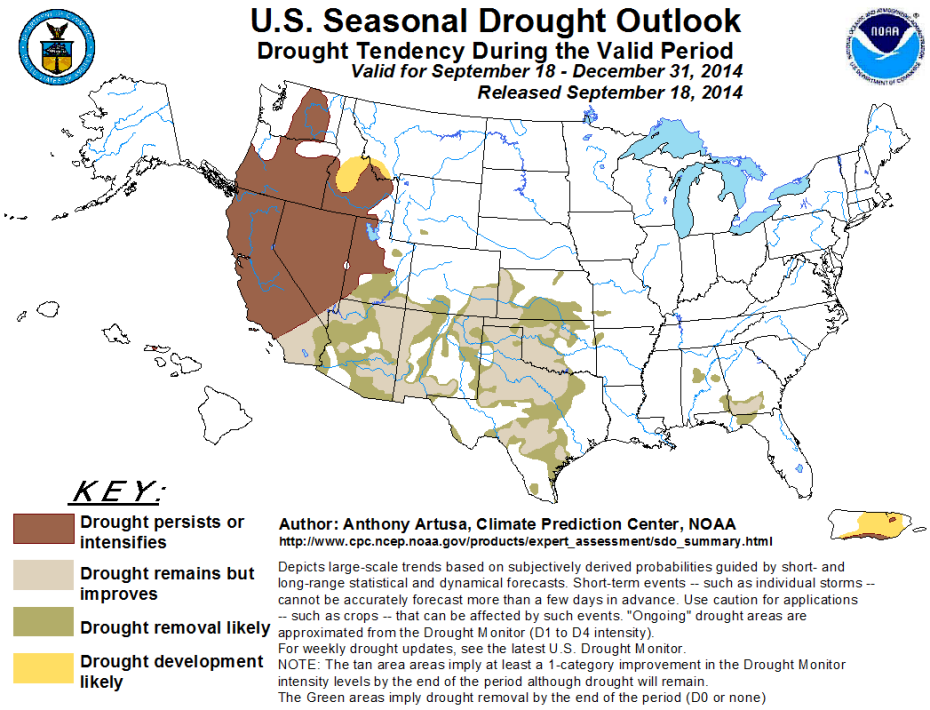


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

September precipitation accumulations are shown in **Figure 4** as both inches of rain and percent of normal monthly rain. During the first three weeks of September most of the upper Missouri Basin had received well below normal precipitation; however, during the last week of September, moderate to heavy precipitation occurred over western and central Montana, Wyoming, western South Dakota and western Nebraska. Rainfall amounts ranged from 1.5 to 4 inches in southwest South Dakota and eastern Wyoming, while daily rainfall totals in western Nebraska ranged from 2.5 to 5 inches. While September precipitation was well above normal in the aforementioned portions of the upper Basin, September precipitation was below normal in most other areas highlighted by less than 50 percent of normal precipitation in far western and eastern-central Montana, and the central and eastern Dakotas.

July-August-September precipitation accumulations are shown in **Figure 5** as both inches of rain and percent of normal monthly rain. Over the three-month period, Montana and Wyoming have received above normal precipitation, driven largely by the late August and late September heavy precipitation. Above normal areas of precipitation extend into the western Dakotas; however, accumulations in the eastern Dakotas have been below normal. Precipitation accumulations have been above normal in eastern Nebraska and western Iowa where three-month accumulations have ranged from 10 to 19 inches (110 to 200 percent of normal).

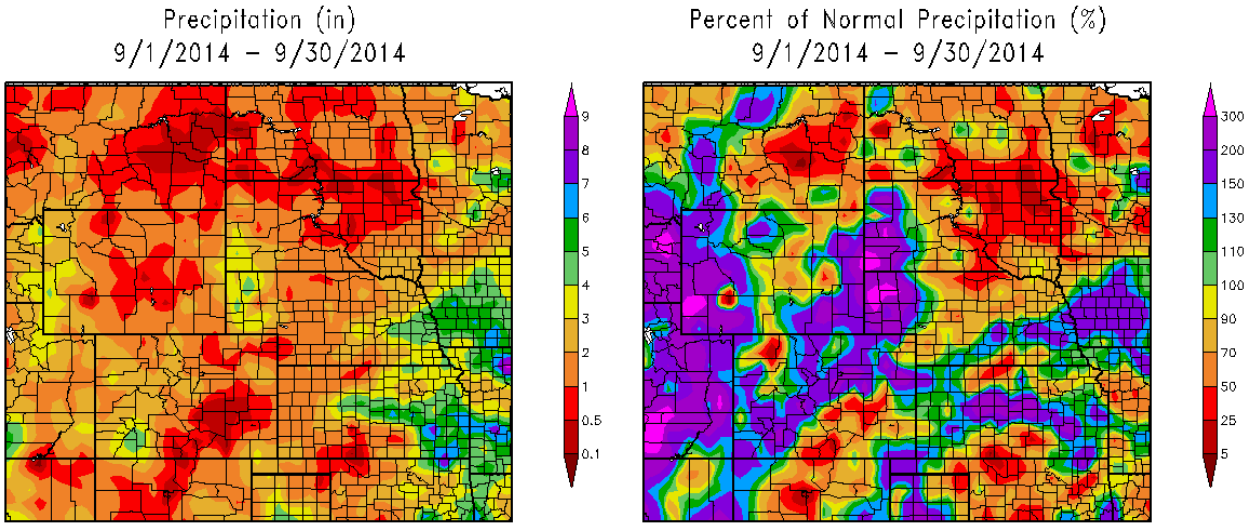


Figure 4. September 2014 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

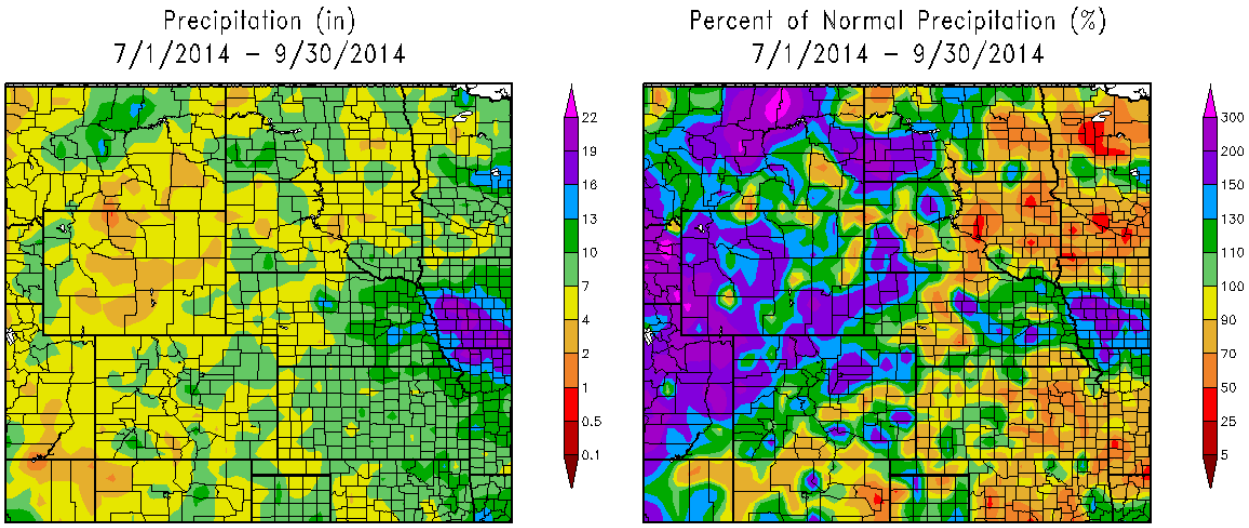


Figure 5. July 1 – September 30, 2014 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

September temperature departures from normal in degrees Fahrenheit (degrees F) are shown in **Figure 6**. September temperatures in most of the upper Basin above Sioux City, IA ranged from 1 to 3 degrees F below normal. Three-month (July-August-September) temperature departures are shown in **Figure 7**. The three-month map indicates a contrast in average temperatures between western and eastern regions of the upper Basin. Temperatures averaged over the three-month period have been 1 to 3 degrees F above normal in western Montana and normal to 2 degrees F above normal in western and southern Wyoming. In the Northern Plains, average three-month temperatures have ranged from normal to more than 3 degrees F below normal. This is particularly evident from **Figure 7** in the Dakotas, Nebraska and Iowa.

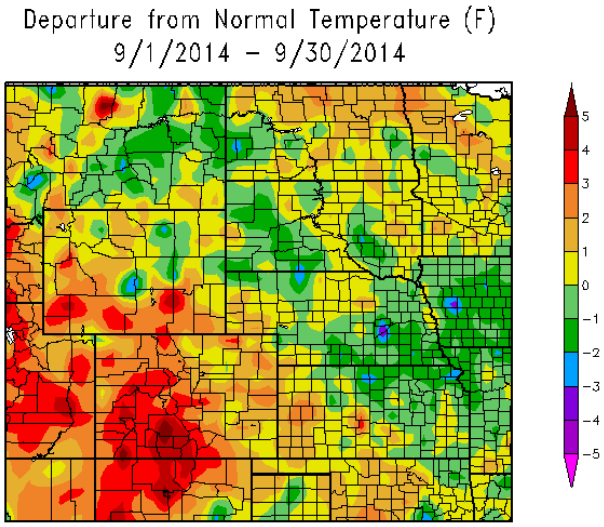


Figure 6. September 2014 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

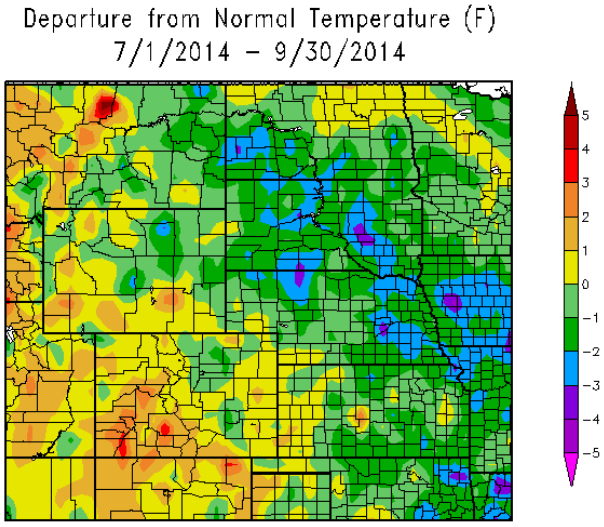


Figure 7. July-August-September 2014 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on September 28, 2014. This modeled estimate depicts well above normal soil moisture conditions throughout the upper Basin in Montana, Wyoming, North Dakota and South Dakota with the exception of the

eastern Dakotas. Soil moisture is typically greater than the 80th percentile in the aforementioned areas and greater than the 98th percentile in areas of central and eastern Montana and the western Dakotas. These high soil moisture conditions developed as a result of the record August rainfall, but these maps do not account for additional moisture received after September 28.

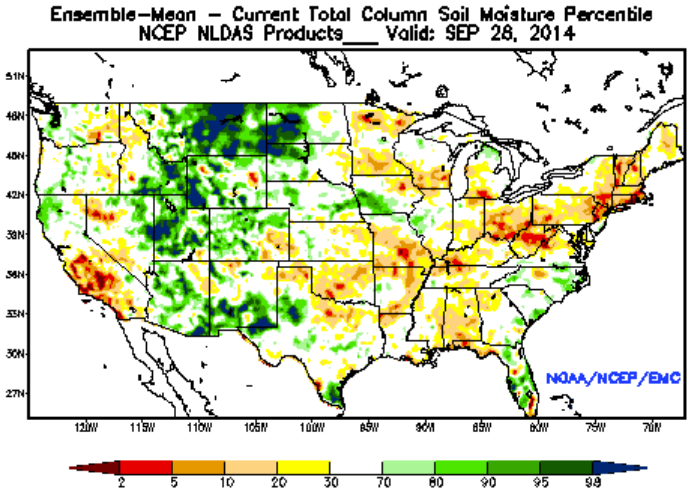


Figure 8. Total Column Soil Moisture Percentile on September 28, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on September 28, 2014 is shown in **Figure 9**. According to the modeled estimate, soil moisture anomalies in a large portion of the upper Basin including the western Dakotas, Montana and western Wyoming range from 50 – 150 mm (1.96 – 5.91 inches) above normal. The wettest soil moisture conditions have anomalies exceeding 150 mm (5.91 inches) based on the ensemble mean of the soil moisture simulations.

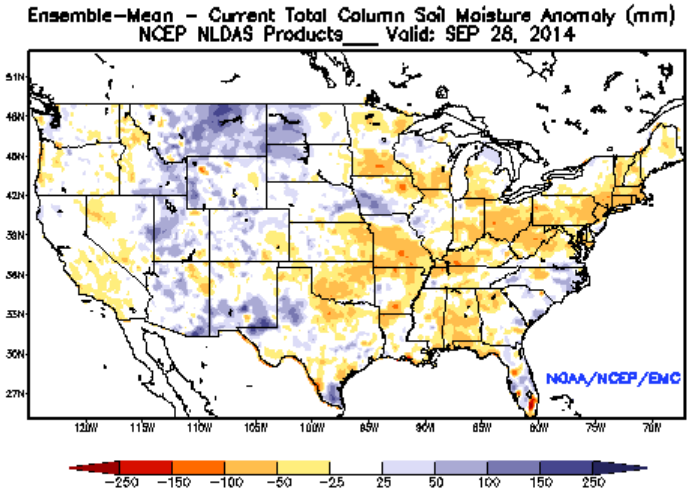


Figure 9. Calculated Soil Moisture Anomaly (mm) on September 28, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

Climate Outlook

ENSO (El Niño Southern Oscillation)

Based on the CPC analysis of equatorial sea surface temperatures (SST) during the June-July-August analysis period, ENSO-neutral conditions continue in the equatorial Pacific. The chance of El Niño developing in the fall or winter is 60 to 65 percent based on the CPC model runs. As the probability of El Niño development decreases, the probability of an ENSO-neutral winter increases; the probability of La Niña development during the fall and winter continues to be very small. During the winter, El Niño can increase chances for warmer and drier conditions in the Northern Plains. If El Niño has an impact on temperature and precipitation during the winter, the impact to upper Basin runoff is not realized until the spring and summer following an El Niño winter since most winter precipitation is snowfall. In some years El Niño has reduced the amount of mountain snowpack due to the warmer-than-normal temperatures, therefore reducing the volume of May-June-July runoff. The influence of a potential winter El Niño has been factored into the CPC's temperature and precipitation outlooks, and is discussed in the following section.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center precipitation outlook for October (**Figure 10**) indicates equal chances for above normal, normal and below normal precipitation in much of the upper Basin west of the Missouri River, and the CPC indicates increased chances for above normal precipitation in much of North Dakota and eastern South Dakota. In October there are increased chances for above normal temperatures in western Montana, equal chances in central Montana and Wyoming, and increased chances for below normal temperatures in the Dakotas.

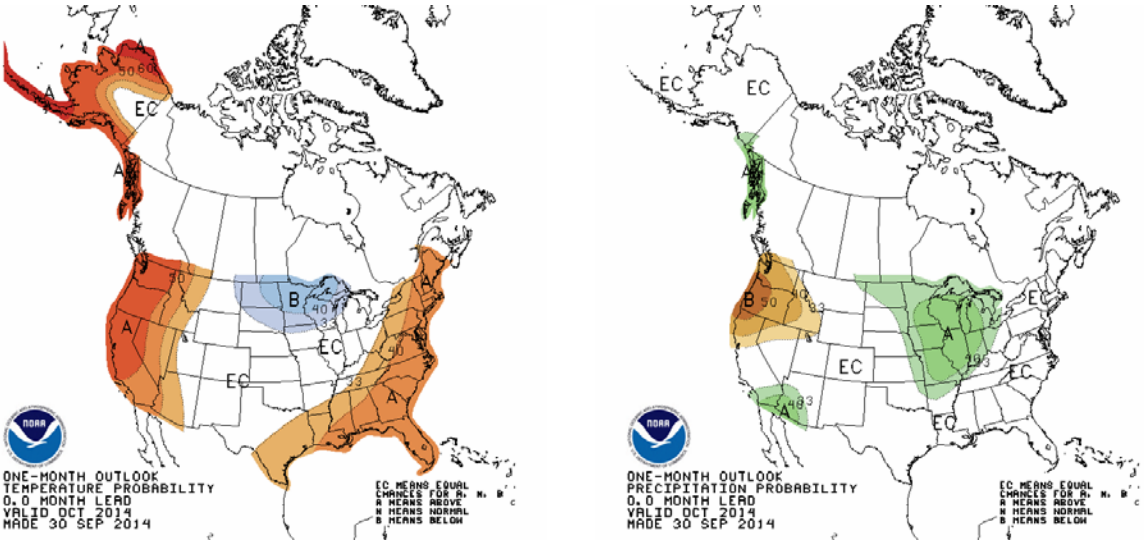


Figure 10. CPC October 2014 temperature and precipitation outlooks.

The October through December outlook (**Figure 11**) indicates equal chances for precipitation for the upper Basin, with the exception of increased chances for below normal precipitation in western Montana. Switching to temperature, there are increased chances for above normal temperatures throughout the entire upper Basin, which is a reflection of a possible El Niño development. Looking into 2015, the CPC outlooks (**Figure 12**) indicate that January through March precipitation will have equal chances to be above normal, normal or below normal. January through March temperatures will have increased chances to be above normal on the chance that El Niño develops during the winter. The two caveats of the extended climate outlooks including October through December and January through March are: 1) they are highly dependent on a possible El Niño development this winter, and 2) extended climate outlooks generally have low skill; therefore, these outlooks should be interpreted and used with limited certainty.

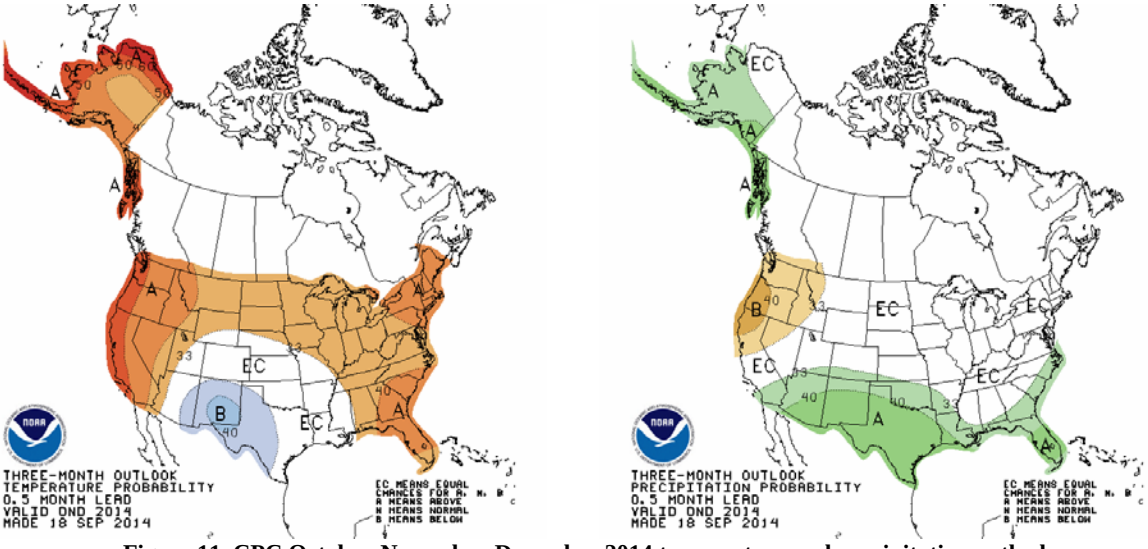


Figure 11. CPC October-November-December 2014 temperature and precipitation outlook.

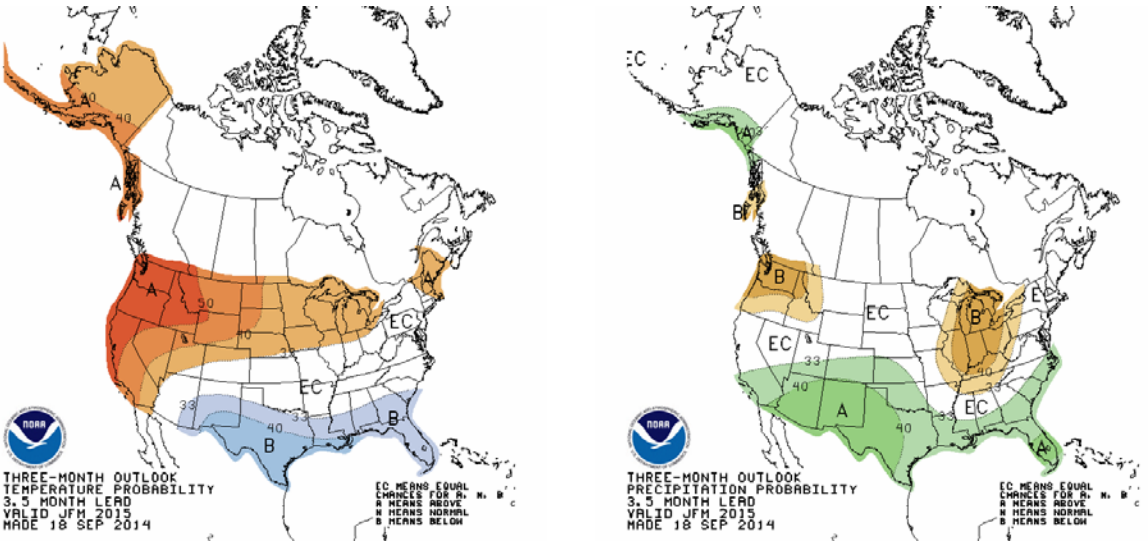


Figure 12. CPC January-February-March 2015 temperature and precipitation outlook.

October 2014 Calendar Year Runoff Forecast

The October 1, 2014 calendar year runoff forecast or Basic forecast for the Missouri River basin above Sioux City, IA is 35.5 MAF (141% of normal). Runoff above Gavins Point Dam is forecast to be 32.4 MAF (141% of normal). Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next four months, expected inflow ranges from the 36.4 MAF Upper Basic forecast to the 34.6 MAF Lower Basic forecast. The Upper Basic and Lower Basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions.

September Recap

September runoff above Sioux City was 1.8 MAF, 157% of normal. September runoff was a result of higher-than-normal streamflow from the late August heavy precipitation in the northwest portion of the upper Basin. By reservoir reach, September runoff was 401 kAF (121% of normal) above Fort Peck, 898 kAF (200% of normal) into Garrison, 233 kAF (212% of normal) into Oahe, 51 kAF (139% of normal) into Fort Randall, -38 kAF (-34% of normal) into Gavins Point, and 255 kAF (238% of normal) from Gavins Point to Sioux City.

October-November-December Runoff Forecast

The runoff forecast for the last three months of the calendar year considers higher-than-normal streamflows due to end-of-September precipitation in western South Dakota, wet soil moisture conditions throughout most of the upper Basin, and the NOAA CPC climate outlooks. The climate outlook for October indicates there is a greater probability for colder-than-normal temperatures in the Northern Plains, equal chances in Wyoming and central Montana, and increased chances for above normal temperatures in western Montana. With regard to precipitation, there are equal chances for above normal, normal and below normal precipitation throughout much of the upper Basin with the exception of increased chances for above normal precipitation in North Dakota and eastern South Dakota. Given the wetter conditions and the October climate outlook, October runoff is forecast to be 1.6 MAF or 135% of normal above Sioux City, and 1.5 MAF or 132% of normal above Gavins Point.

In November and December, runoff is forecast to continue to be above normal due to wet soil conditions and the CPC outlook for equal chances of precipitation. Furthermore, long-term records indicate slightly better chances that runoff during El Niño winters will be above normal in the late fall and early winter; however, El Niño has not developed as of October 1. If El Niño occurs, it could have its greatest impact on mountain snow accumulation, which occurs from November through April. Mountain snowmelt runoff, which occurs in May, June and July, will not be predicted until January 1, 2015. Runoff is also forecast to be higher than normal in January and February of 2015 (110 percent) due to forecasted warmer temperatures and wet soil conditions (baseflow).

Upper Missouri River Basin
November 2014 Calendar Year Runoff Forecast
November 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The November 1, 2014 calendar year runoff forecast or Basic forecast for the upper Missouri River Basin (Basin) above Sioux City, IA is **34.7 MAF** (138% of normal). Runoff above Gavins Point Dam is forecast to be **31.8 MAF** (138% of normal).

October runoff above Sioux City, IA was **1.25 MAF**, 105% of normal. Above Gavins Point Dam, October runoff was 1.15 MAF, 105% of normal. October runoff was slightly above normal despite well-below normal precipitation across much of the upper Basin. By reservoir reach, October runoff was 363 kAF (96% of normal) above Fort Peck, 668 kAF (127% of normal) into Garrison, 132 kAF (184% of normal) into Oahe, -21 kAF (-428% of normal) into Fort Randall, 13 kAF (11% of normal) into Gavins Point, and 94 kAF (105% of normal) from Gavins Point to Sioux City.

The runoff forecast for the last two months of the calendar year considers higher-than-normal streamflows in locations in Montana and the western Dakotas, drier-than-normal soil moisture conditions in the eastern Dakotas, and the NOAA Climate Prediction Center (CPC) climate outlooks. Given these conditions, November runoff is forecast to be 1.1 MAF or 105% of normal above Sioux City, and 1.0 MAF or 105% of normal above Gavins Point.

We are expecting runoff to continue to be average to above average in the Garrison, Oahe and Sioux City reaches, but below normal in the Fort Peck, Fort Randall and Gavins Point reaches through the remainder of the calendar year.

Updated Upper Basic and Lower Basic forecast factors were used to determine the Upper Basic and Lower Basic forecasts associated with the November 1 calendar year runoff forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next two months, expected inflow ranges from the 35.1 MAF Upper Basic forecast to the 34.3 MAF Lower Basic forecast.

The Upper Basic 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 two months are being forecasted for this November 1 forecast (ten months observed/two months forecast), the range of wetter-than-normal (Upper Basic) and drier-than-normal (Lower Basic) conditions is attributed to all six reaches for November and December.

Current Conditions

Drought Analysis

The latest National Drought Mitigation Center's drought monitor for October 28, 2014 (**Figure 1**), shows small areas of Abnormally Dry (D0) conditions in central and northeastern South Dakota. There is also a small area of Moderate Drought (D1) that has developed in northeast South Dakota. The drought monitor for September 30, 2014 is shown in **Figure 2**. The U.S. Seasonal Drought Outlook in **Figure 3** indicates that new drought conditions are not likely to develop in the upper Basin with the exception of some drought development in southwest and western Montana.

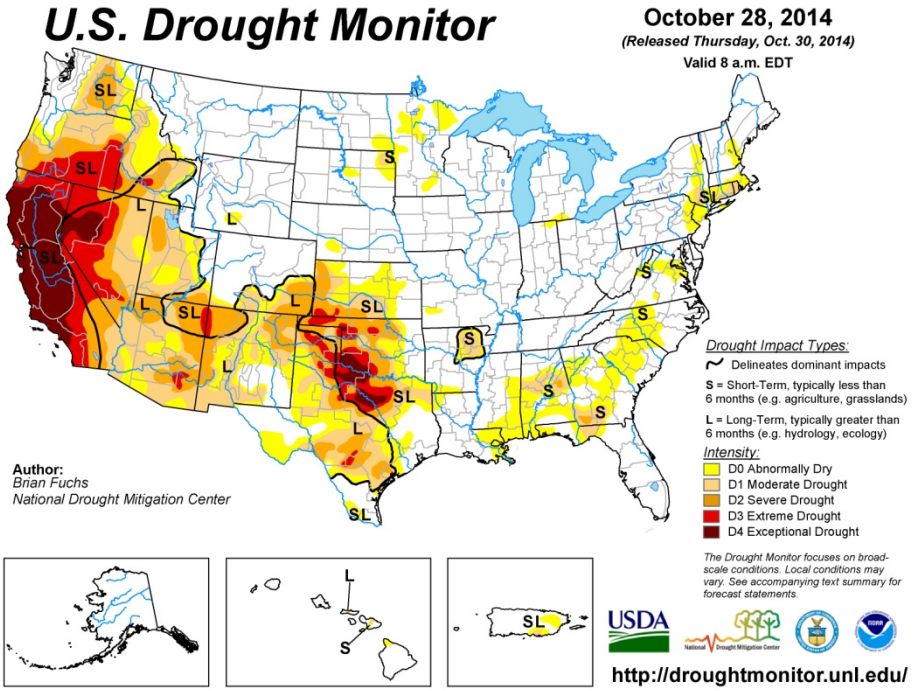


Figure 1. National Drought Mitigation Center U.S. Drought Monitors for October 28, 2014.

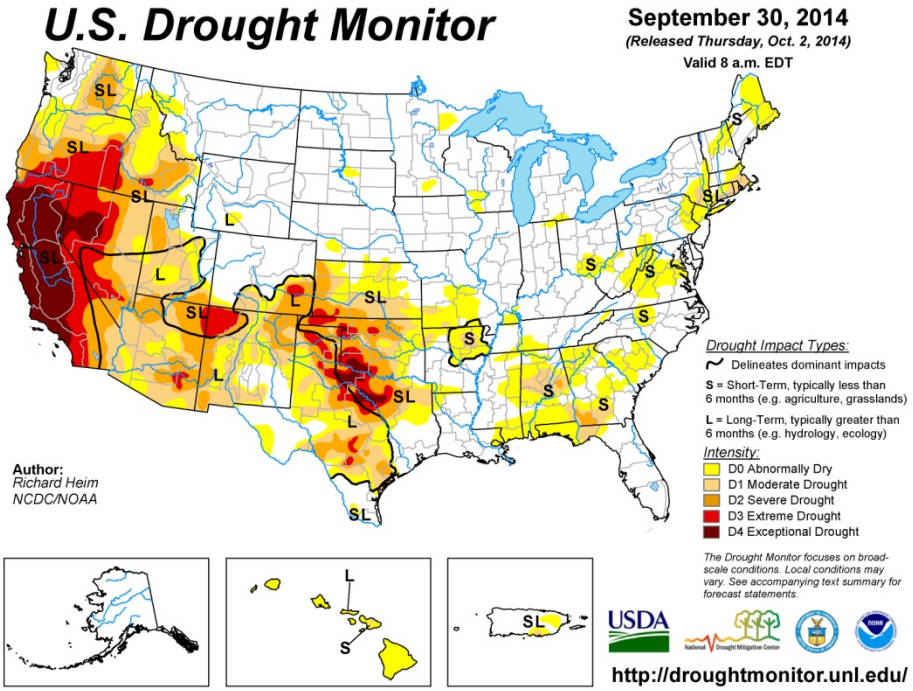


Figure 2. National Drought Mitigation Center U.S. Drought Monitors for September 30, 2014.

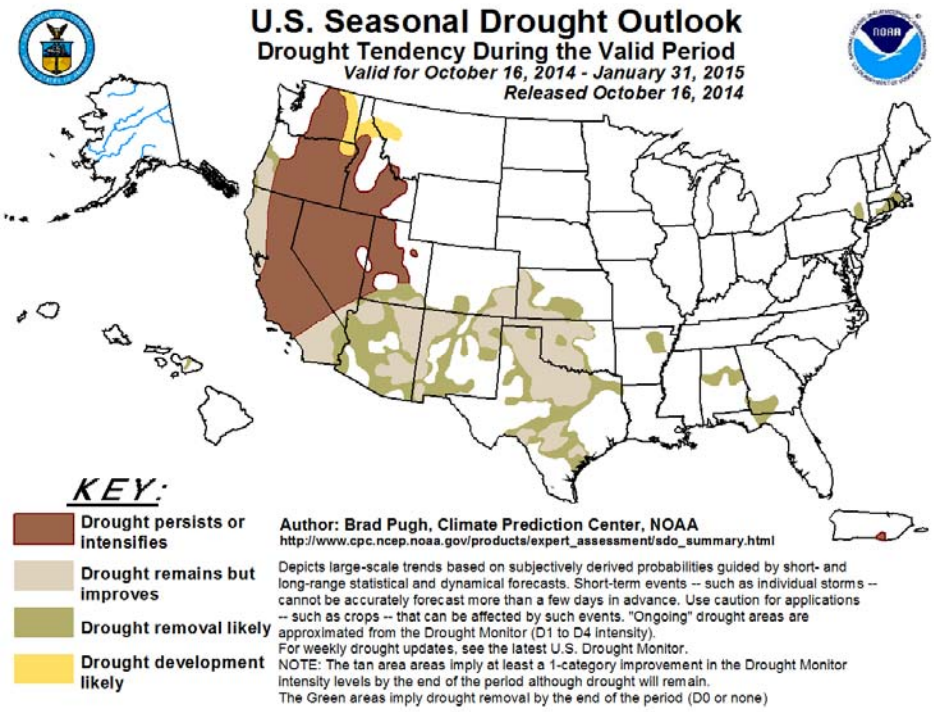


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

October precipitation accumulations are shown in **Figure 4** as both inches of rain and percent of normal monthly rain. From a climatological perspective, October is historically a dry month in the upper Basin. Rainfall amounts ranged from 0.1 to 1 inch over a majority of the upper Basin with some areas receiving between 1 and 2 inches. As a percent of normal, a majority of the upper Basin received less than 50 percent of normal over the Dakotas, southern Montana, and Wyoming. October precipitation in northern Montana fared better than southern Montana with some localized areas receiving between 130 and 200 percent of normal precipitation; however, the rainfall depth accumulation ranged from 1 to 2 inches.

August-September-October precipitation accumulations are shown in **Figure 5** as both inches of rain and percent of normal monthly rain. Over the three-month period, north central Montana, the western Dakotas and the lower Missouri River Basin including eastern Nebraska, Iowa and Missouri have received the most abundant precipitation. Rainfall amounts in north central Montana ranged from 7 to 13 inches compared to 13 to 19 inches in the lower Basin. These high rainfall accumulations and departures were caused by heavy rainfall that occurred primarily at the end of August, with additional heavy rain in mid and late September. As a percent of normal these areas received similar amounts ranging from 150 to 300 percent of normal. These wet areas stand in contrast to dry areas in the eastern Dakotas that have received less than 70 percent of normal precipitation during the past three months.

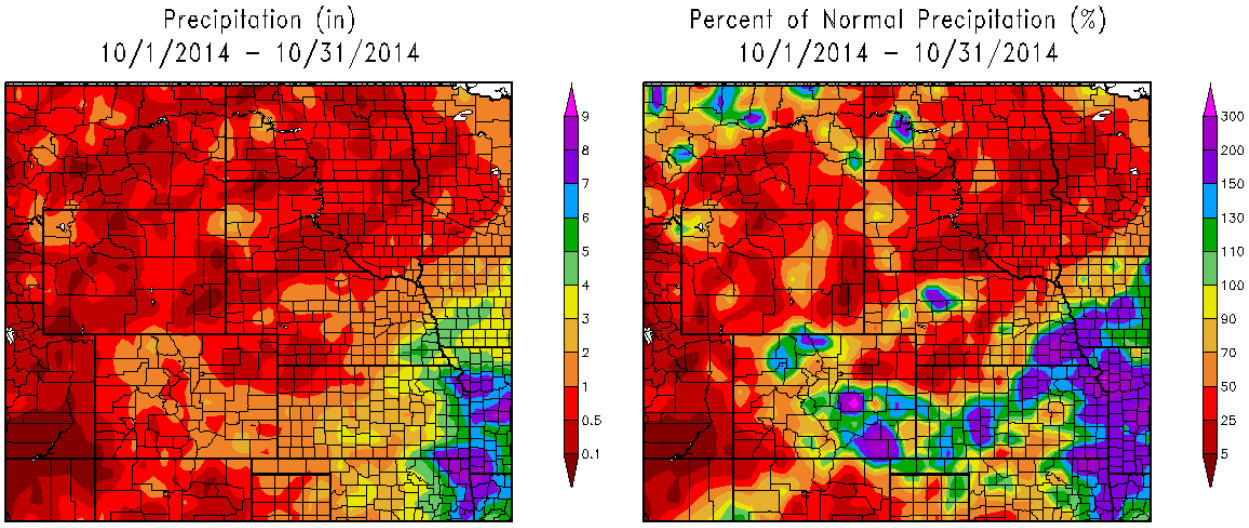


Figure 4. October 2014 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

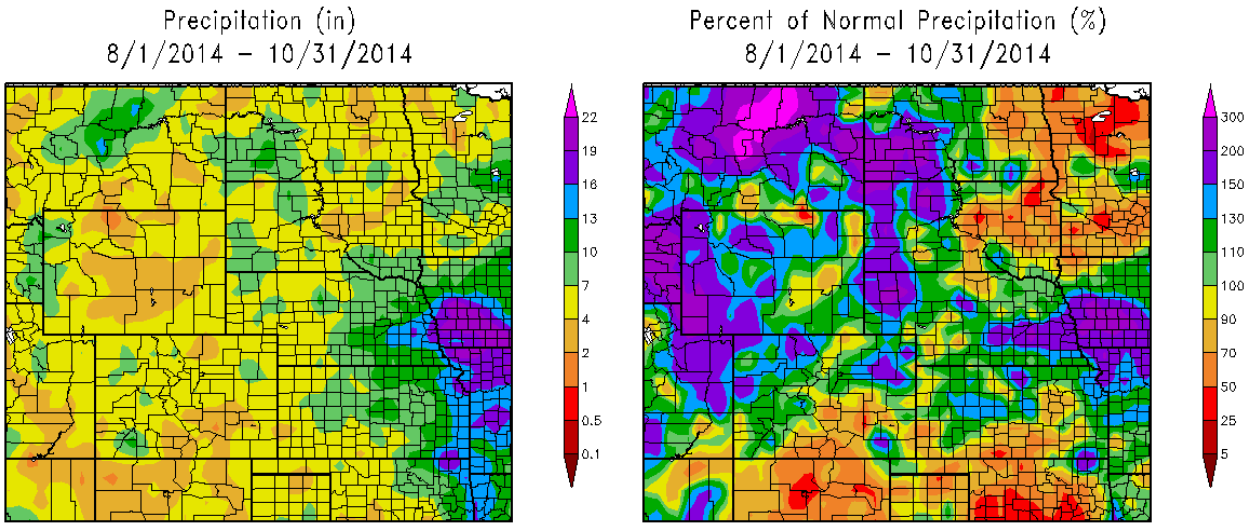


Figure 5. August 1 – October 31, 2014 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

October temperature departures from normal in degrees Fahrenheit (degrees F) are shown in **Figure 6**. October temperatures in most of the upper Basin including the High Plains and Northern Plains ranged from 2 to 6 degrees F above normal. Temperature departures in several localized areas of Montana, the Dakotas and Wyoming exceeded 6 degrees F. Three-month (August-September-October) temperature departures are shown in **Figure 7**. The map indicates above normal departures and a continuing above normal temperature trend in the upper Basin. Temperatures averaged over the three-month period have been 1 to 3 degrees F above normal in most of the upper Basin, with departures in several areas ranging from 3 to 5 degrees F above normal.

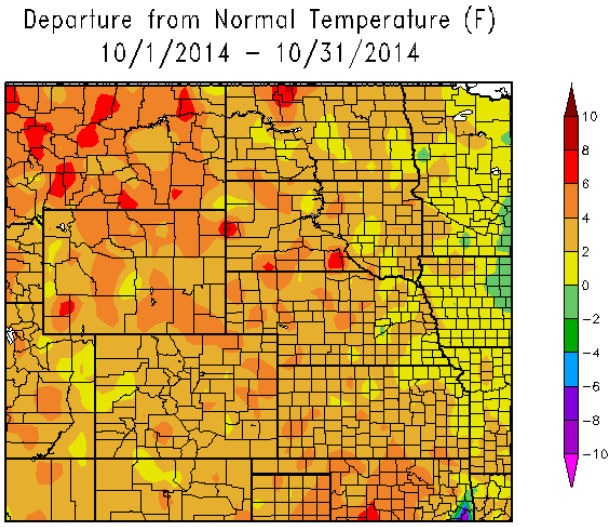


Figure 6. November 2014 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

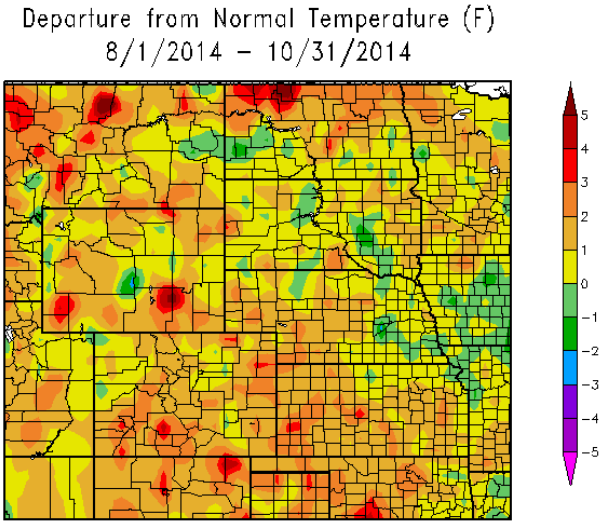


Figure 7. August-September-October 2014 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture and Streamflow Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on October 29, 2014. This modeled estimate depicts well above normal soil moisture conditions throughout the upper Basin in Montana, Wyoming, western North Dakota and western South Dakota with the

exception of the eastern Dakotas. Soil moisture is typically greater than the 70th percentile in the aforementioned areas and greater than the 98th percentile in north central Montana. These high soil moisture conditions developed as a result of the record August rainfall. In contrast, soil moisture in the eastern Dakotas is less than the 30th percentile with some conditions ranging from the 5th to 20th percentile.

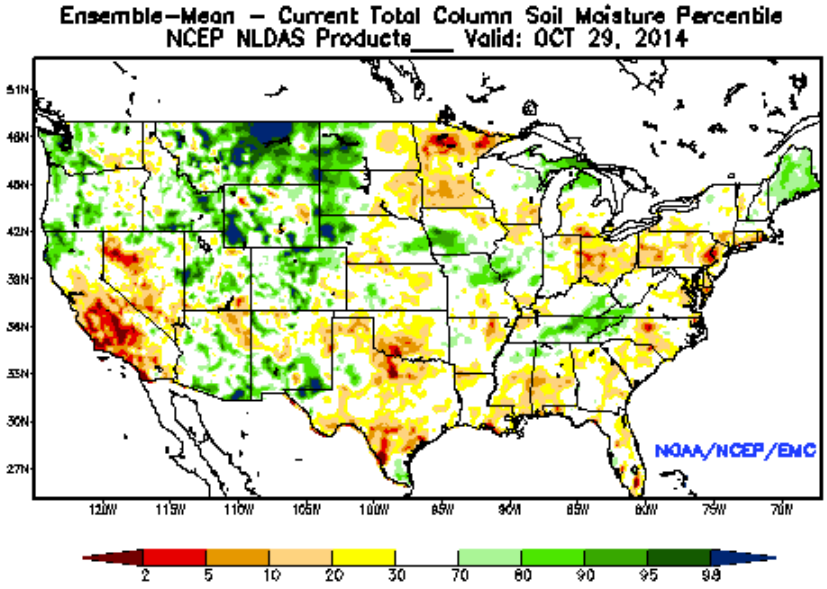


Figure 8. Total Column Soil Moisture Percentile on October 29, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

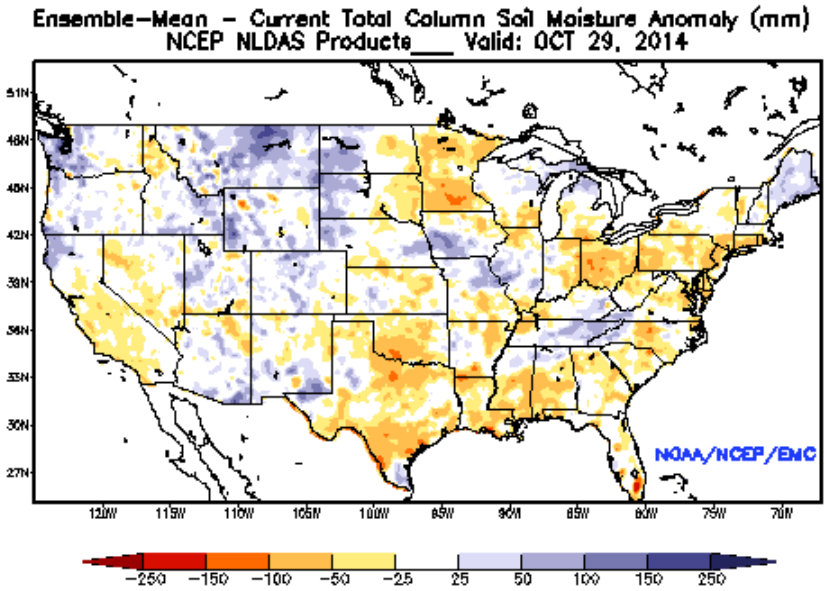


Figure 9. Calculated Soil Moisture Anomaly (mm) on October 29, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on October 29, 2014 is shown in **Figure 9**. According to the modeled estimate, soil moisture anomalies in a large portion of the upper Basin including the western Dakotas, Montana and western Wyoming range from 50 – 100 mm (1.96 – 3.94 inches) above normal. Anomalies in the eastern Dakotas range from 25 – 100 mm (0.98 – 3.94 inches) below normal.

Missouri Basin streamflow conditions represented as percentile classes for October 2014 are shown in **Figure 10**. Streamflow conditions during October generally ranged from normal (25th – 75th percentile) to much above normal (>90th percentile) in the upper Basin. The highest streamflows during the month occurred in central and northeast Montana and the western Dakotas. Normal to below normal streamflows occurred in the eastern Dakotas.

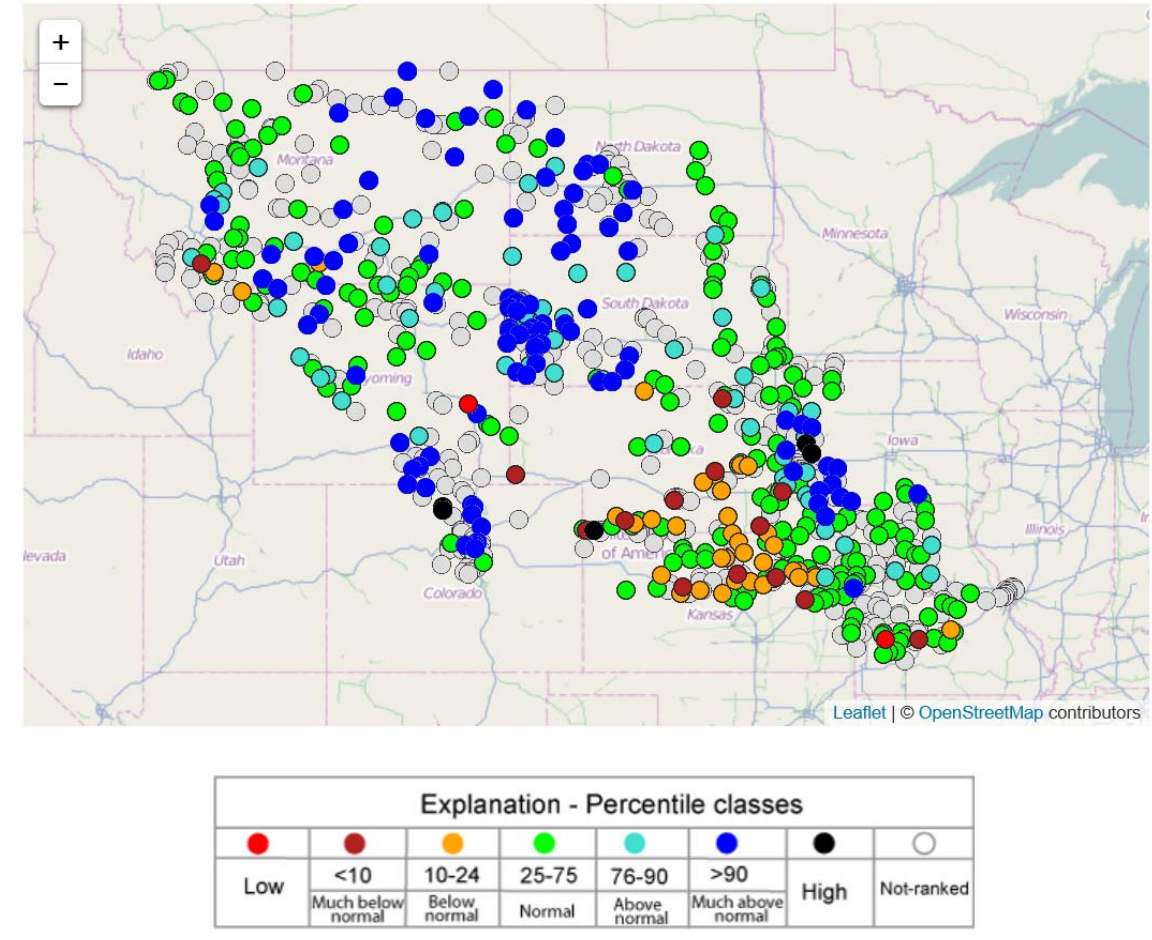


Figure 10. October USGS Streamflow Conditions as a Percentile of Normal in the Missouri River Basin. Source: USGS. http://waterwatch.usgs.gov/index.php

Climate Outlook

ENSO (El Niño Southern Oscillation)

Based on the CPC analysis of equatorial sea surface temperatures (SST), positive anomalies continue across the Pacific Ocean. The neutral phase of ENSO continues; however, El Niño is favored to begin in the next one to two months and last into the Northern Hemisphere spring 2015. The chance of El Niño developing in the fall or winter is 60 to 65 percent based on the CPC model runs. During the winter, El Niño can increase chances for warmer and drier conditions in the Northern Plains. If El Niño has an impact on temperature and precipitation during the winter, the impact to upper Basin runoff is not realized until the spring and summer following an El Niño winter since most winter precipitation is snowfall. In some years El Niño has reduced the amount of mountain snowpack due to the warmer-than-normal temperatures, therefore reducing the volume of May-June-July runoff. The influence of a potential winter El Niño has been factored into the CPC's temperature and precipitation outlooks, and is discussed in the following section.

Temperature and Precipitation Outlooks

The NOAA CPC precipitation outlook for October (**Figure 11**) indicates a slight increase in the probability for above normal temperatures in the upper Missouri River Basin above Sioux City, IA during November. The 40 percent probability for above normal temperatures shown in **Figure 11** is offset by a 60 percent probability that temperatures will be normal to below normal in that region. With regard to precipitation, there are equal chances that precipitation will be above normal, normal, or below normal during October over most of the upper Basin, with the exception of a slight increase in the probability for above normal precipitation in far western Montana.

The November through January outlook (**Figure 12**) indicates an increased probability for above normal temperatures throughout the entire upper Basin at probabilities similar to the November outlook. With regard to precipitation, there are equal chances for above normal, normal and below normal precipitation throughout most of the Upper Basin, and a slight increase in the probability for below normal precipitation in the western half of Montana and northwest Wyoming. The probability for below normal precipitation ranges from 33 to 40 percent, while the probability for normal to above normal precipitation ranges from 67 to 60 percent. Looking at February through April of 2015, the CPC outlooks (**Figure 13**) indicate there is an increased probability for above normal temperatures in Montana and western Wyoming, with equal chances in the remainder of the upper Basin. With regard for precipitation there is a slight increase in the probability for below normal precipitation in western Montana and equal chances throughout the remainder of the upper Basin.

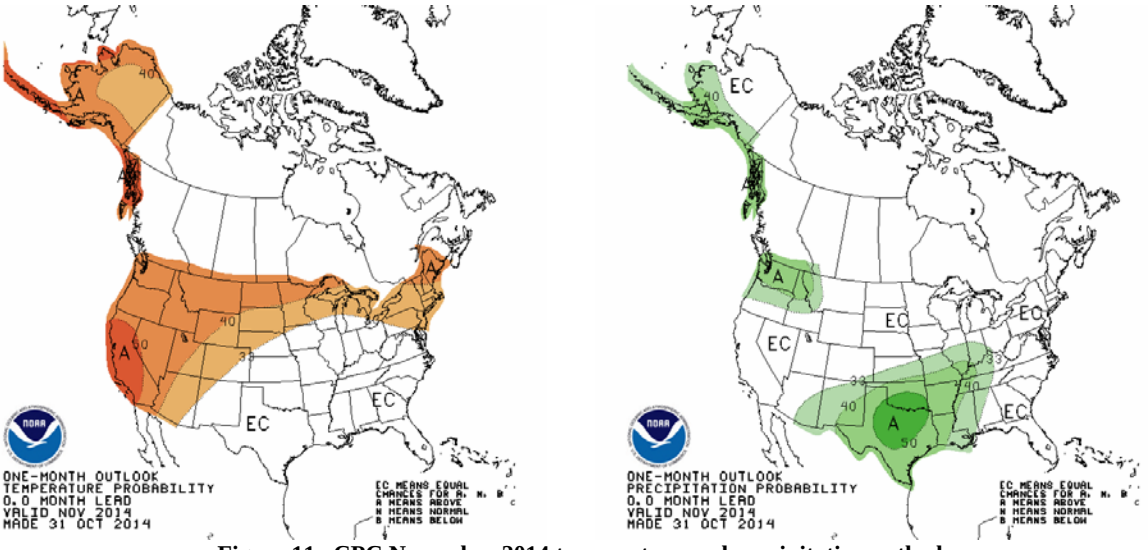


Figure 11. CPC November 2014 temperature and precipitation outlooks.

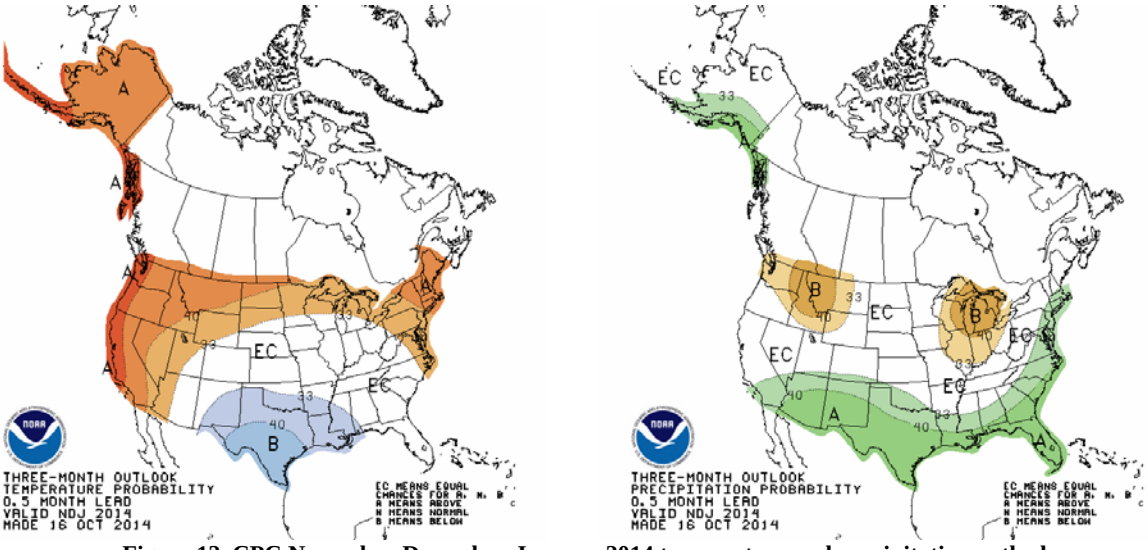


Figure 12. CPC November-December-January 2014 temperature and precipitation outlook.

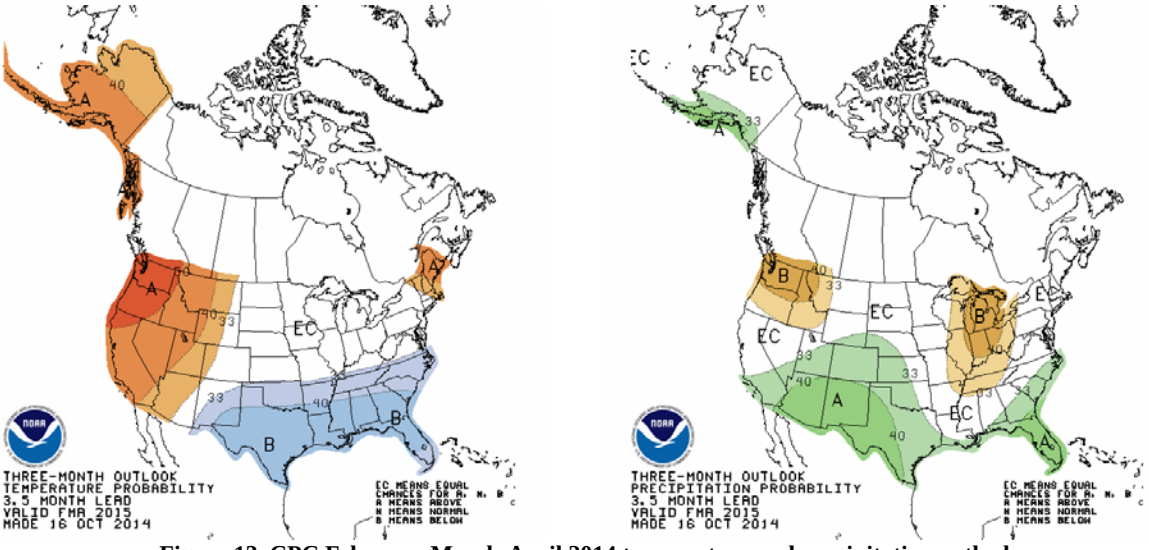


Figure 13. CPC February-March-April 2014 temperature and precipitation outlook.

November 2014 Calendar Year Runoff Forecast

The November 1, 2014 calendar year runoff forecast or Basic forecast for the Missouri River basin above Sioux City, IA is 34.7 MAF (138% of normal). Runoff above Gavins Point Dam is forecast to be 31.8 MAF (138% of normal). Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next two months, expected inflow ranges from the 35.1 MAF Upper Basic forecast to the 34.3 MAF Lower Basic forecast. The Upper Basic and Lower Basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions.

October Recap

October runoff above Sioux City, IA was 1.2 MAF, 105% of normal. Above Gavins Point Dam, October runoff was 1.15 MAF, 105% of normal. October runoff was slightly above normal despite well-below normal precipitation across much of the upper Basin. By reservoir reach, October runoff was 363 kAF (96% of normal) above Fort Peck, 668 kAF (127% of normal) into Garrison, 132 kAF (184% of normal) into Oahe, -21 kAF (-428% of normal) into Fort Randall, 13 kAF (11% of normal) into Gavins Point, and 94 kAF (105% of normal) from Gavins Point to Sioux City.

November-December Runoff Forecast

The runoff forecast for the last two months of the calendar year considers higher-than-normal streamflows, which continued to decline through October due to below normal precipitation accumulations, wet soil moisture conditions in the Upper Basin, and the NOAA CPC climate outlooks. Soil moisture conditions continue to be above normal over much of the Upper Basin (**Figures 8 and 9**). As shown in **Figure 10**, streamflow conditions are above normal at most

locations throughout the upper Basin. Furthermore, there are equal chances for above normal, normal and below normal precipitation over most of the upper Basin and a slight increase in the probability for above normal precipitation in western Montana. Although below normal precipitation in September and October has begun to reduce runoff to more normal levels, November and December runoff is forecast to be above normal in the Garrison and Oahe reaches. In the Fort Peck, Fort Randall and Gavins Point reaches, November and December runoff is forecast to be below normal.

Furthermore, long-term records indicate that during the onset of El Niño winters, November and December runoff has a slightly better chance of being above normal in the late fall and early winter; however, El Niño has not developed as of November 1. If El Niño occurs, it could have its greatest impact on mountain snow accumulations, which occur from November through April. Mountain snowmelt runoff, which occurs in May, June and July, will not be predicted until January 1, 2015. Runoff is also forecast to be higher than normal in January and February of 2015 (105 percent) due to forecasted warmer temperatures and wet soil conditions.

Upper Missouri River Basin
December 2014 Calendar Year Runoff Forecast
December 4, 2014

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.

2014 Calendar Year Forecast Synopsis

The December 1, 2014 calendar year runoff forecast or Basic forecast for the upper Missouri River Basin (Basin) above Sioux City, IA is **34.5 MAF** (137% of normal). Runoff above Gavins Point Dam is forecast to be **31.5 MAF** (137% of normal).

November runoff above Sioux City, IA was **0.87 MAF**, 83% of normal. Above Gavins Point Dam, November runoff was 0.74 MAF, 77% of normal. November runoff was well below normal despite above normal runoff during nine of the ten previous months in 2014. Very cold temperatures caused many of the northern Missouri River tributaries to freeze earlier than normal, thus reducing natural runoff into the Mainstem System reservoirs. By reservoir reach, November runoff was 331 kAF (87% of normal) above Fort Peck, 165 kAF (42% of normal) into Garrison, 166 kAF (247% of normal) into Oahe, 8 kAF (208% of normal) into Fort Randall, 69 kAF (58% of normal) into Gavins Point, and 131 kAF (162% of normal) from Gavins Point to Sioux City.

The runoff forecast for December considers upper Basin streamflow, which was greater than normal prior to the freeze-up, drier-than-normal soil moisture conditions in the eastern Dakotas, wetter-than-normal soil moisture conditions in the western Dakotas, Montana and Wyoming, and

the NOAA Climate Prediction Center (CPC) climate outlooks. Given these conditions, we are predicting December runoff to be 0.8 MAF (108% of normal).

Updated Upper Basic and Lower Basic forecast factors were used to determine the Upper Basic and Lower Basic forecasts associated with the December 1 calendar year runoff forecast. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next month, expected inflow ranges from the 34.7 MAF Upper Basic forecast to the 34.3 MAF Lower Basic forecast.

The Upper Basic 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 one month is being forecast in this December 1 forecast (11 months observed/one month forecast), the range of wetter-than-normal (Upper Basic) and drier-than-normal (Lower Basic) conditions is attributed to all six reaches for December.

Current Conditions

Drought Analysis

The latest National Drought Mitigation Center's drought monitor for November 25, 2014 (**Figure 1**), when compared to the drought monitor for October 28, 2014 (**Figure 2**), shows a large expansion of Abnormally Dry (D0) conditions in the upper Midwest including eastern North Dakota, eastern South Dakota, and part of northwest Iowa. There is also a small area of Moderate Drought (D1) that has developed in northeast South Dakota. No changes to conditions west of the Missouri River have occurred since the end of October. The U.S. Seasonal Drought Outlook in **Figure 3** indicates that drought conditions will persist or intensify in northeast South Dakota and southeast North Dakota.

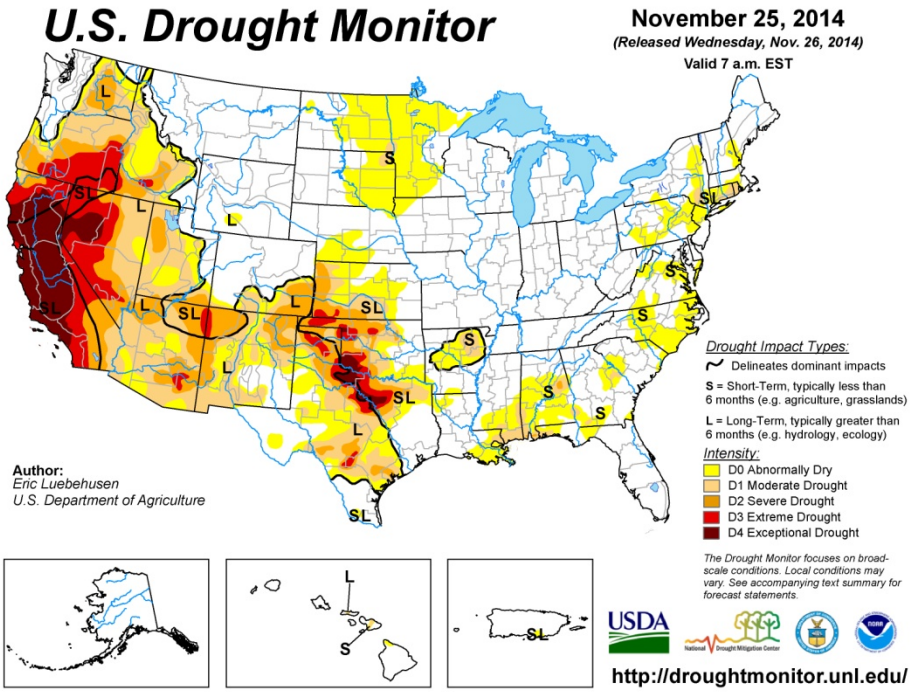


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for November 25, 2014.

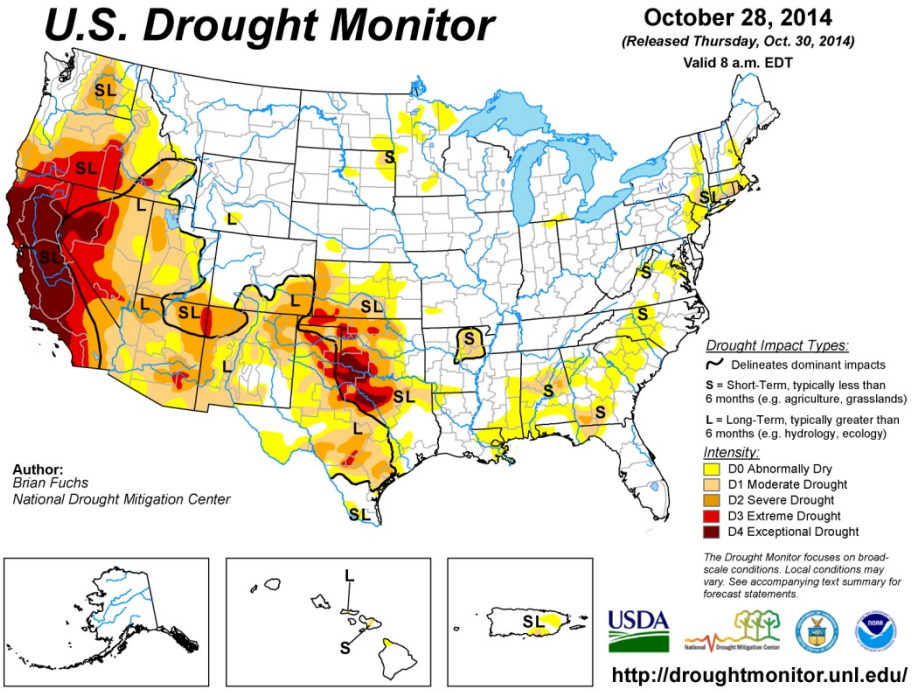


Figure 2. National Drought Mitigation Center U.S. Drought Monitor for October 28, 2014.

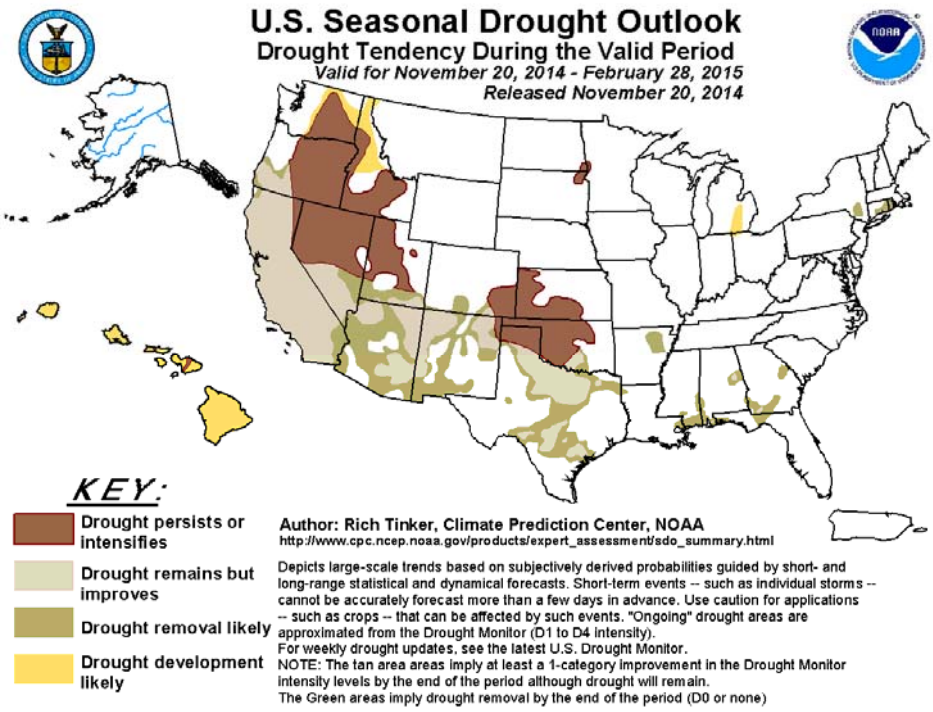


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

November precipitation accumulations are shown in **Figure 4** as both inches of rain and percent of normal monthly rain. From a climatological perspective, November is historically a dry month in the upper Basin. In November 2014, rainfall amounts ranged from less than 0.5 inches to 1 inch in North Dakota and South Dakota, much of Wyoming and Montana. The greatest amounts of precipitation occurred in the mountainous areas of southwest Montana and northwest Wyoming ranging from 1.5 to over 3.5 inches. As a percent of normal, greater than 150% of normal precipitation occurred in western and central Montana and northwestern and north central Wyoming. Normal to below normal accumulation occurred in the Dakotas. The lower Missouri River Basin below Sioux City, IA including some of the incremental drainage area between Oahe and Sioux City received well below 50% of normal precipitation in November.

September-October-November precipitation accumulations are shown in **Figure 5** as both inches of rain and percent of normal monthly rain. Over the three-month period, much of the upper Basin has received less than 4 inches of precipitation with the exception of the mountainous upper Yellowstone basin in southwest Montana and northwest Wyoming, and the Black Hills in western South Dakota. These areas received greater than 6 inches of precipitation over the three-month period, and compared to normal, precipitation accumulations have been well above normal. In contrast, much drier conditions have persisted in eastern Montana and the central and eastern Dakotas, with accumulations generally less than 70% of normal.

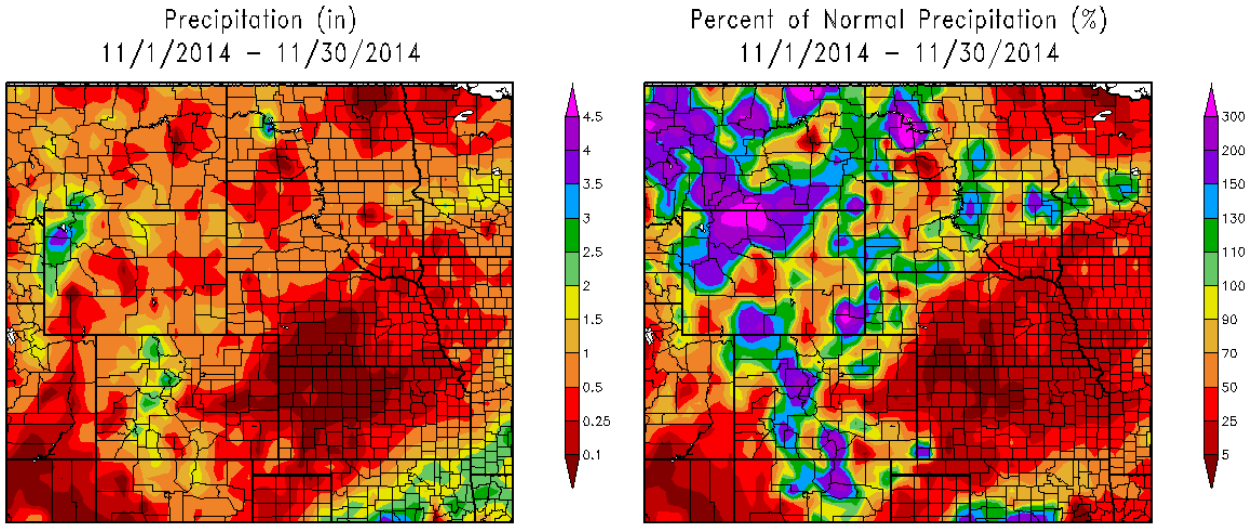


Figure 4. November 2014 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

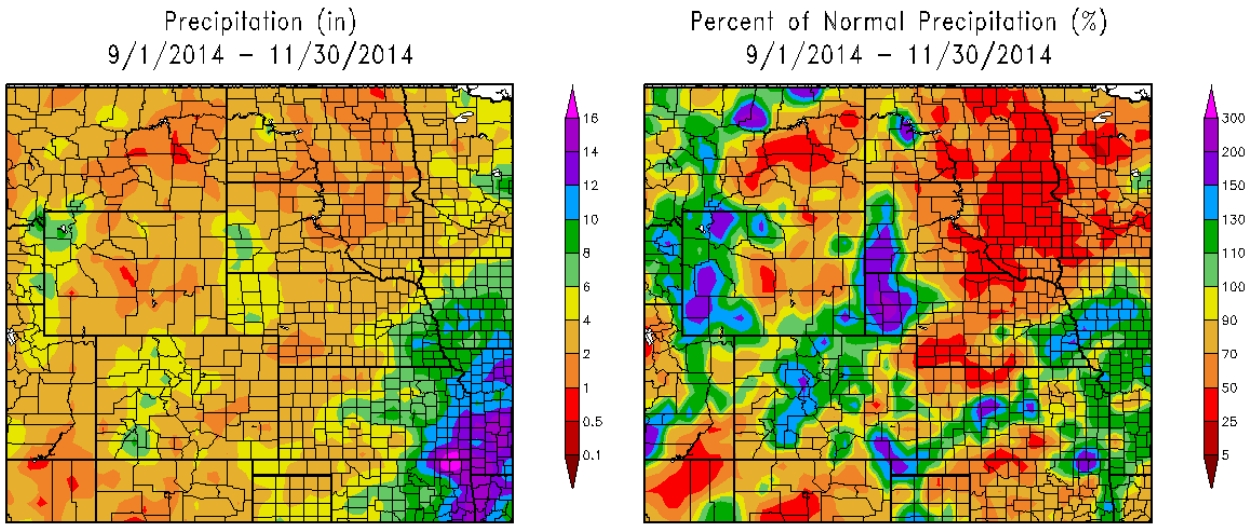


Figure 5. September 1 – November 30, 2014 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

November temperature departures from normal in degrees Fahrenheit (degrees F) are shown in **Figure 6**. November temperatures in the upper Basin ranged from 2 degrees F below normal in the Rocky Mountains to 8 degrees F below normal in the Northern Plains and Midwest. Three-month (September-October-November) temperature departures are shown in **Figure 7**. The map indicates temperatures in the Rocky Mountains and adjacent plains have been normal to 3 degrees F above normal. Due to the cold November temperatures, departures over the three-month period in the Plains and Midwest have been normal to 3 degrees F below normal.

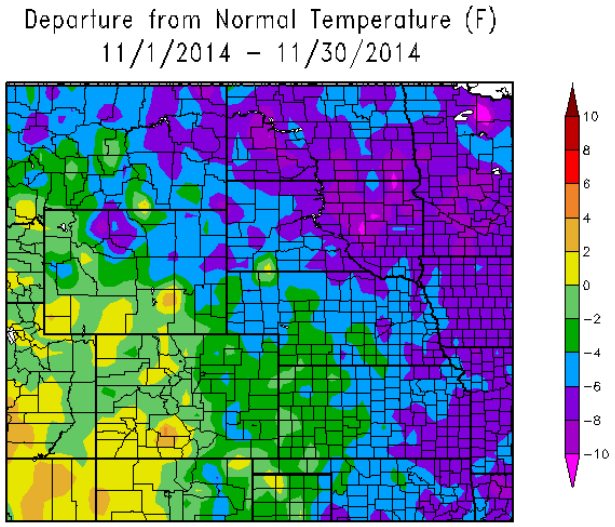


Figure 6. November 2014 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

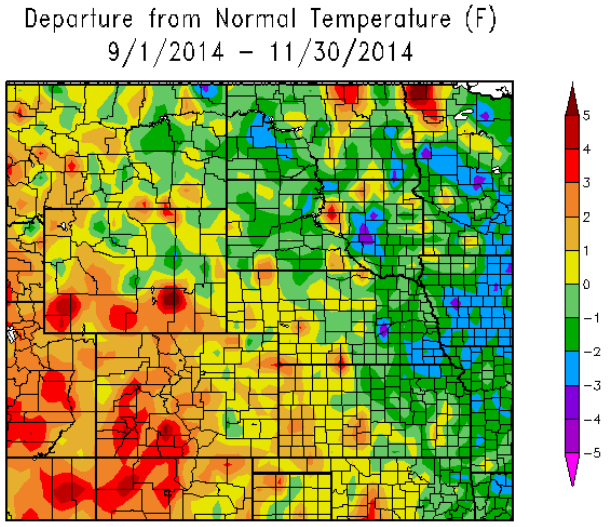


Figure 7. September-October-November 2014 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture and Streamflow Conditions

Soil moisture is factored into the forecast as an indicator of wet or dry hydrologic basin conditions. Typically when soil moisture conditions are wet or greater than normal, rainfall and snowmelt runoff is greater than when soil moisture is dry or less than normal. Not only is soil moisture a physical parameter that influences runoff, it can be used as an indicator of future monthly runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on November 27, 2014 for the total soil column. The NLDAS soil moisture depiction is an ensemble of modeled soil moisture over a 2-meter depth. The modeled estimate in **Figure 8** shows well above normal

soil moisture conditions throughout the upper Basin in Montana, Wyoming, western North Dakota and western South Dakota. Soil moisture is typically greater than the 70th percentile in the aforementioned areas and greater than the 98th percentile in north central Montana. These high soil moisture conditions developed as a result of the record August rainfall. In contrast, soil moisture in the eastern Dakotas is less than the 30th percentile with some conditions ranging from the 5th to 20th percentile.

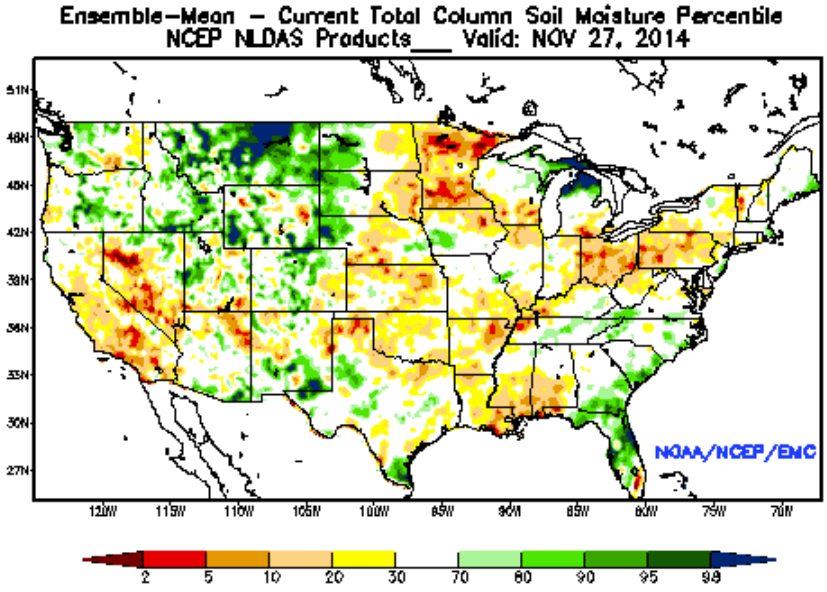


Figure 8. Total Column Soil Moisture Percentile on November 27, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

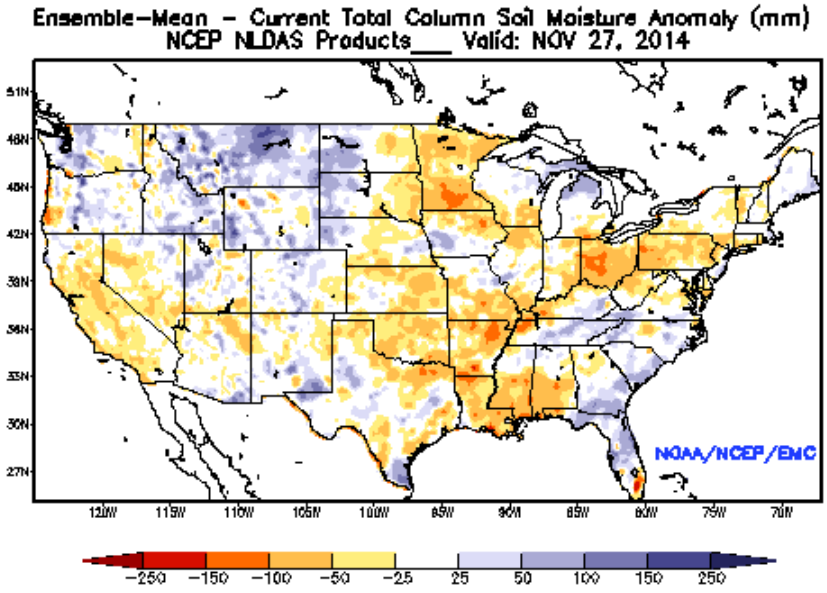


Figure 9. Calculated Soil Moisture Anomaly (mm) on November 27, 2014. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

The Ensemble Mean current total column soil moisture anomaly for the contiguous U.S. on November 27, 2014 is shown in **Figure 9**. According to the modeled estimate, soil moisture anomalies in a large portion of the upper Basin including the western Dakotas, Montana and western Wyoming range from 50 – 100 mm (1.96 – 3.94 inches) above normal with some of north central Montana achieving 100 – 150 mm anomalies (3.95 – 5.91 inches). In contrast, anomalies in the eastern Dakotas range from 25 – 100 mm (0.98 – 3.94 inches) below normal.

Since early November when the initial wave of very cold air entered the Missouri Basin, surface soils froze across the upper Basin, and the soil is likely to remain frozen through the remainder of the winter. **Figure 10** shows depth of frost penetration at National Weather Service (NWS) Warning Forecast Office (WFO) locations in the Missouri Basin. While some frost depth measurements are missing, a majority of measurements indicate frost formation depths range from 4 to 14 inches in the upper Basin. Due to the development of soil frost, moisture from precipitation or snowmelt will be inhibited from infiltrating into the soil profile, thus soil moisture conditions are not expected to change throughout the winter as long as frost persists in the surface layer.

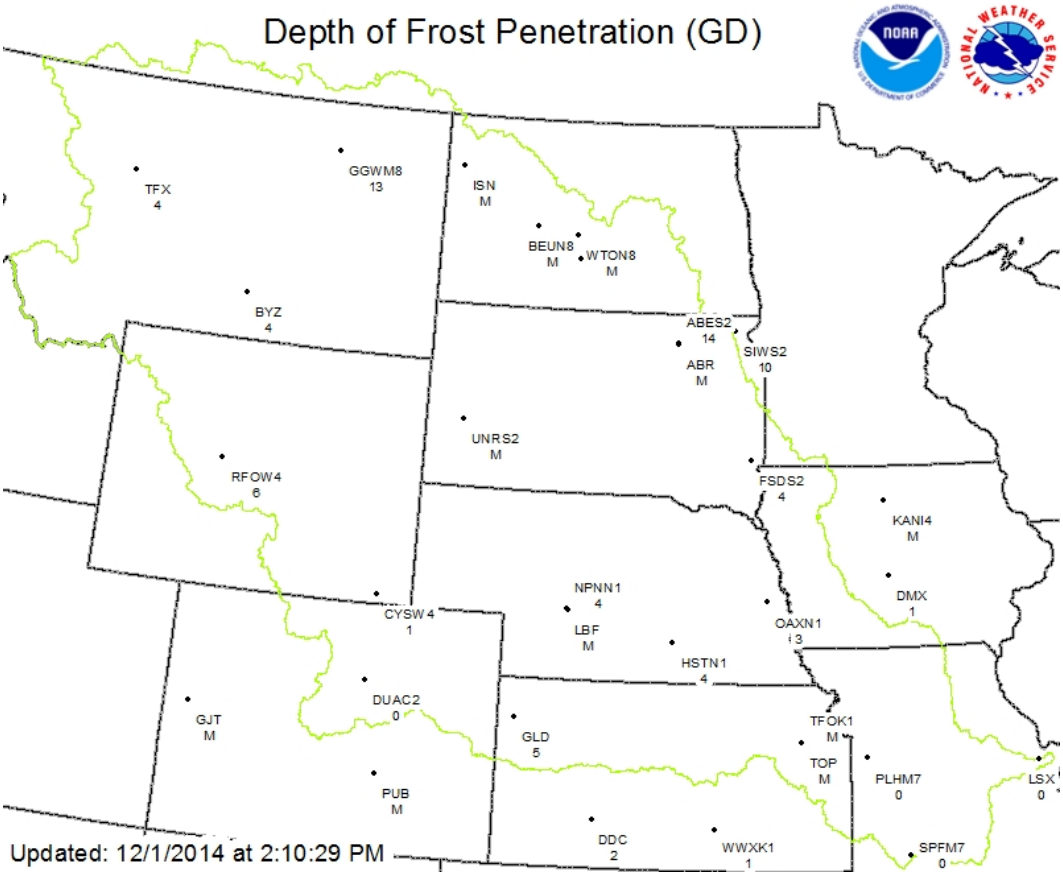


Figure 10. Measured frost depth (inches) at NWS WFO offices as of December 1, 2014. Source: NWS MBRFC.
http://www.crh.noaa.gov/mbrfc

Missouri Basin streamflow conditions represented as percentile classes on November 10, 2014 are shown in **Figure 11**. These conditions are based on the ranking of the current day's streamflow versus the historical record of streamflow for that date. Streamflow conditions on November 10 were normal (25th – 75th percentile) in the eastern Dakotas within the Missouri Basin, and in portions of north central Wyoming and western Montana. Much-above normal streamflow conditions (> 90th percentile) stand out as the blue and black gage locations on the map in many areas of Montana, Wyoming and the western Dakotas in the upper Basin, and in eastern Nebraska and western Iowa in the lower Basin.

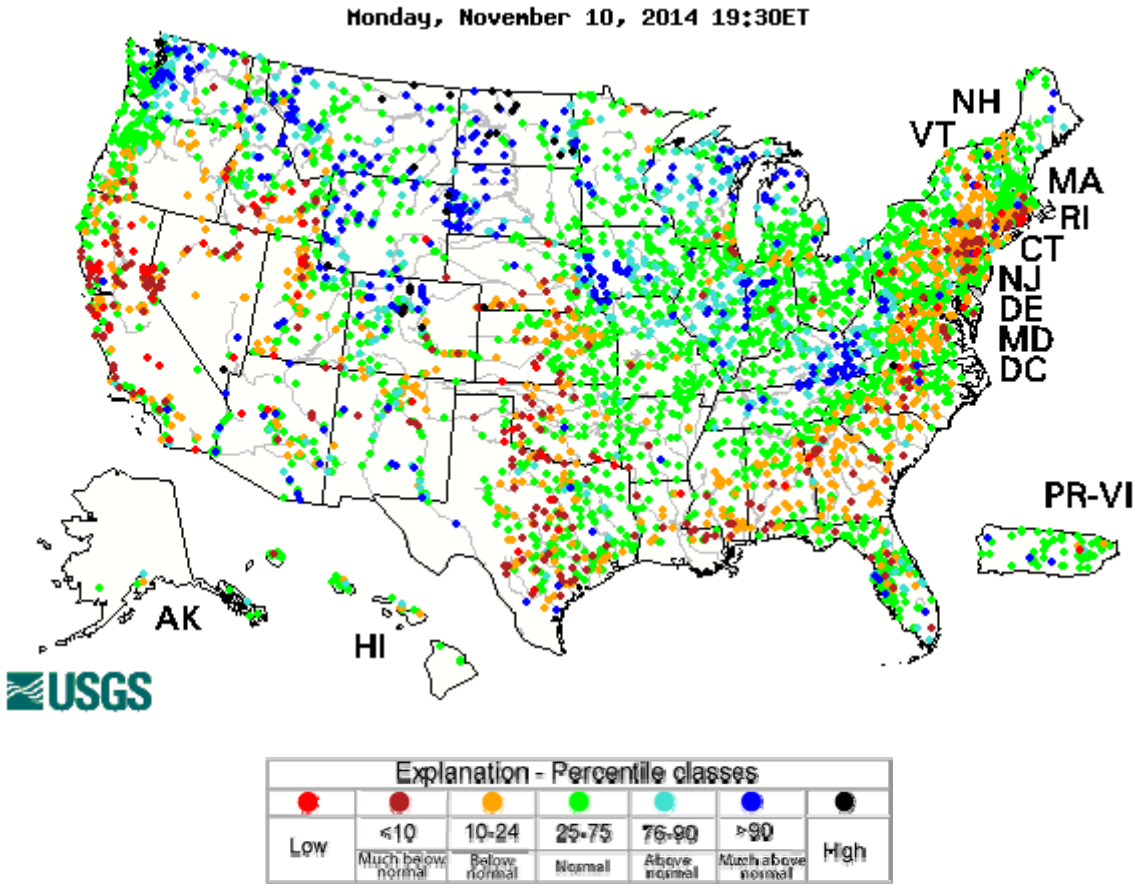


Figure 11. USGS Streamflow Conditions as a Percentile of Normal in the Missouri River Basin as of November 10, 2014.
Source: USGS. http://waterwatch.usgs.gov/index.php

Climate Outlook

ENSO (El Niño Southern Oscillation)

Based on the CPC analysis of equatorial sea surface temperatures (SST), positive anomalies continue across the Pacific Ocean. The neutral phase of ENSO continues; however, El Niño is favored to begin in the next one to two months and last into the Northern Hemisphere spring 2015. The chance of El Niño developing in the fall or winter is 58% based on the CPC model runs. During the winter, El Niño can increase chances for warmer and drier conditions in the Northern Plains. If El Niño has an impact on temperature and precipitation during the winter, the impact to upper Basin runoff is not realized until the spring and summer following an El Niño winter since most winter precipitation is snowfall. In some years El Niño has reduced the amount of mountain snowpack due to the warmer-than-normal temperatures, therefore reducing the volume of May-June-July runoff. The influence of a potential winter El Niño has been factored into the CPC's temperature and precipitation outlooks, and is discussed in the following section.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center climate outlook for December (**Figure 12**) indicates an increased probability for above normal temperatures across the entire upper Basin. The probability for above normal temperatures is greater than 40% while the probability that temperatures will be normal to below normal is 60%. There are increased chances for above normal temperatures in the entire upper Basin during the middle two weeks of December. With regard to precipitation, there is with an increased probability, ranging from 33 to greater than 40%, for below normal precipitation in Montana, northern Wyoming and the western Dakotas, and equal chances in all other regions.

The winter (December-January-February) temperature outlook (**Figure 13**) indicates equal chances for below normal, normal and above normal temperatures in all areas except the Rocky Mountains where there is a slightly higher chance (greater than 33%) for above normal temperatures. The winter precipitation outlook indicates mostly equal chances for below normal, normal and above normal precipitation in the upper Basin tilted slightly toward below normal precipitation in western Montana. Looking at March through May 2015, the CPC outlooks (**Figure 14**) indicate there is a slight increase in the probability that temperatures will be above normal in the Rocky Mountains with equal chances for below normal, normal and above normal temperatures in most of the Missouri Basin. With regard to precipitation there is a slight increase in the probability for below normal precipitation in western Montana and equal chances throughout the remainder of the upper Basin.

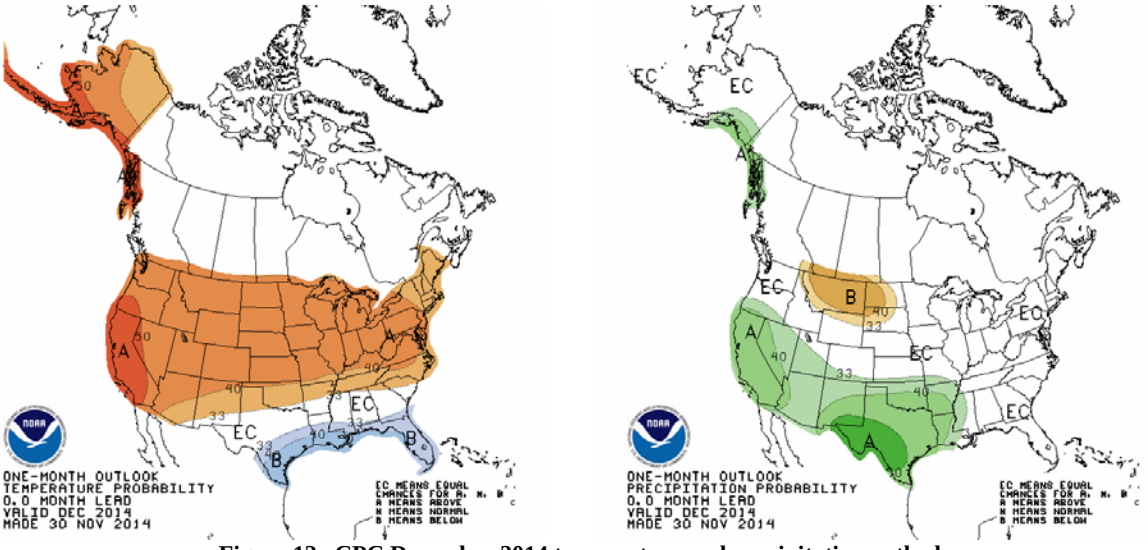


Figure 12. CPC December 2014 temperature and precipitation outlooks.

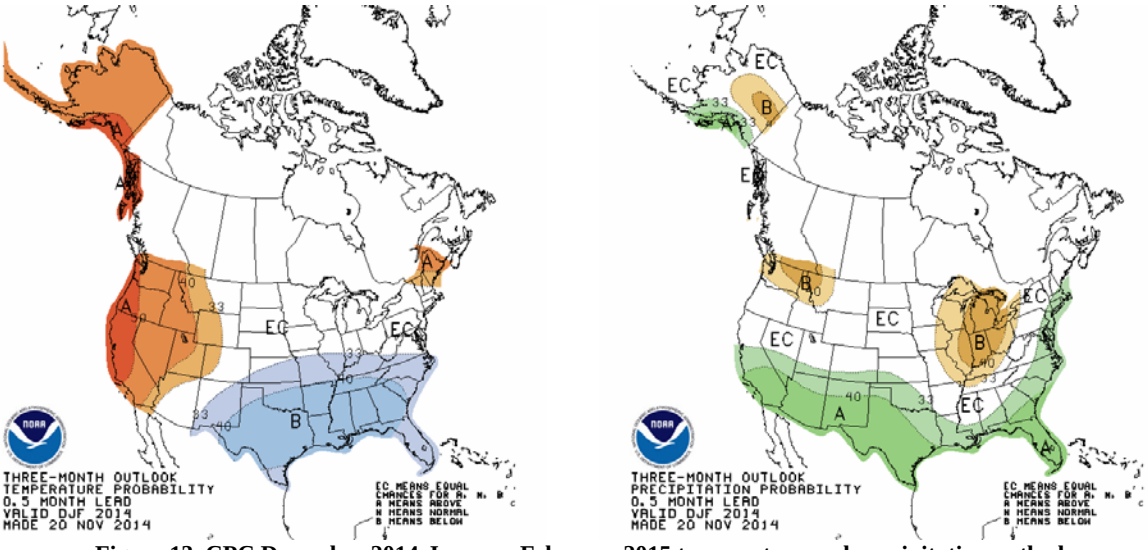


Figure 13. CPC December 2014-January-February 2015 temperature and precipitation outlooks.

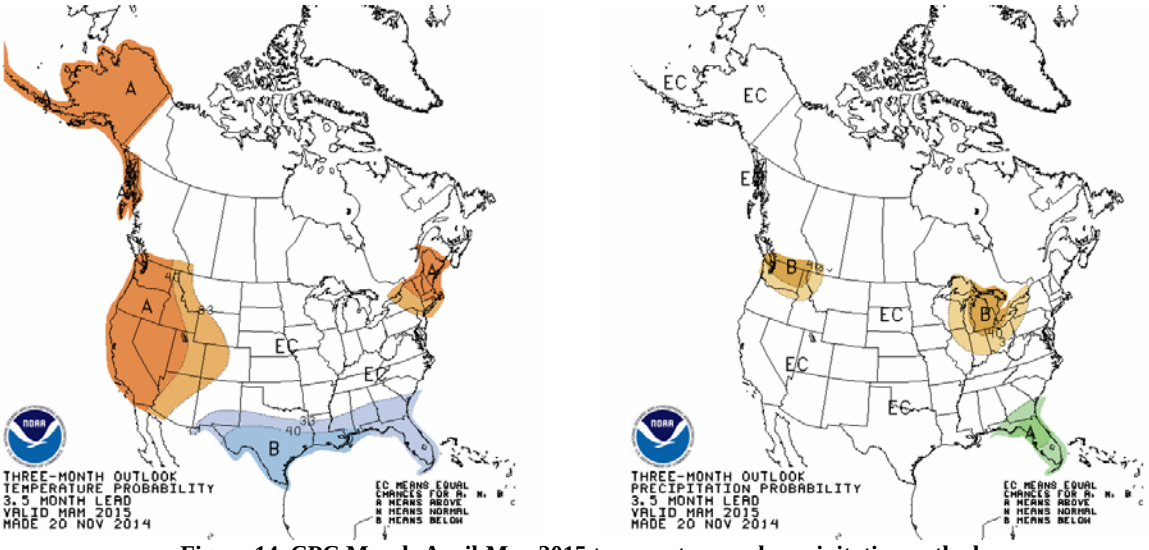


Figure 14. CPC March-April-May 2015 temperature and precipitation outlooks.

December 2014 Calendar Year Runoff Forecast

The December 1, 2014 calendar year runoff forecast or Basic forecast for the Missouri River basin above Sioux City, IA is 34.5 MAF (137% of normal). Runoff above Gavins Point Dam is forecast to be 31.5 MAF (137% of normal). Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next two months, expected inflow ranges from the 34.7 MAF Upper Basic forecast to the 34.3 MAF Lower Basic forecast. The Upper Basic and Lower Basic forecasts provide a likely range of runoff scenarios that could occur given much wetter conditions or much drier conditions.

November Recap

November runoff above Sioux City, IA was **0.87 MAF**, 83% of normal. Above Gavins Point Dam, November runoff was 0.74 MAF, 77% of normal. November runoff was well below normal despite above normal runoff during nine of the ten previous months in 2014. Very cold temperatures caused many of the northern Missouri River tributaries to freeze earlier than normal, thus reducing natural runoff into the Mainstem System reservoirs. By reservoir reach, November runoff was 331 kAF (87% of normal) above Fort Peck, 165 kAF (42% of normal) into Garrison, 166 kAF (247% of normal) into Oahe, 8 kAF (208% of normal) into Fort Randall, 69 kAF (58% of normal) into Gavins Point, and 131 kAF (162% of normal) from Gavins Point to Sioux City.

December Runoff Forecast

The runoff forecast for December considers upper Basin streamflow, which was greater than normal prior to the freeze-up, drier-than-normal soil moisture conditions in the eastern Dakotas, wetter than normal soil moisture conditions (**Figures 8 and 9**) in the western Dakotas, Montana

and Wyoming, and the CPC climate outlooks. The CPC's December temperature outlook indicates a higher probability for warmer than normal temperatures in the upper Basin (**Figure 12**). Given these conditions, we are predicting December runoff to be 0.8 MAF (108% of normal) because streamflow conditions were high prior to the freeze-up, and we expect runoff to rebound to more normal volumes based on the much warmer-than-normal temperature forecast.

2015 Runoff Forecast

The 2014 calendar year runoff forecast of 34.5 MAF (137% of normal) should not be used as an indicator for the 2015 calendar year runoff forecast, which is highly dependent on plains and mountain snowpack, which has just begun to accumulate, spring precipitation, and fall soil moisture conditions. Plains and mountain snowpack accumulations on January 1 combined with soil moisture and drought conditions will provide the basis to develop the initial 2015 calendar year runoff forecast on January 1.

Expert Discussions

Prior to the December calendar year runoff forecast, MRBWM held a conference call on November 24 with Dr. Adnan Akyuz, North Dakota State Climatologist; Dr. Dennis Todey, South Dakota State Climatologist, and Mr. Scott Dummer, Missouri Basin River Forecast Center (MBRFC), to discuss the hydrologic state of the upper Missouri River Basin. These discussions were held in order to attain expert assessments of various hydrologic factors that the Corps considers in it runoff forecasts. A summary of the major points of this discussion follows.

Fall Precipitation and Streamflow

Fall precipitation is a very useful indicator of spring runoff in North Dakota, with the Red River Basin of the north being prime example of its usefulness. Higher fall precipitation accumulations generally lead to higher fall streamflow, higher spring runoff and streamflow due to higher (wetter) soil moisture conditions, and higher levels of water in surface storage such as the prairie pothole lakes. At the onset of the winter freeze, much of this moisture is locked up in frozen soil moisture and will not be released until the spring thaw. Fall precipitation in 2014 has been well below normal over a large majority of the upper Missouri Basin (**Figure 5**), though there have been some regionally wet areas, especially west of the Missouri River near the Montana border. Compared to 2011, fall precipitation in 2014 has been much lower, and on the dry side of the fall precipitation spectrum.

At the start of river freeze-up streamflow conditions were near their 90^{th} percentile rankings at many stream gages in the upper Missouri Basin. According to Scott Dummer of the MBRFC, higher streamflow conditions increase the potential for freeze-up jams in the winter.

Soil Moisture, Soil Frost and Surface Storage

The NLDAS product is a modeled total column soil moisture product that is highly regionalized and the soil depth representation is very generalized. Therefore, anecdotal information from local observers is only accurate at the location and not regionally. Soil moisture over the upper Missouri Basin is quite varied as represented by the NLDAS ensemble mean soil moisture maps shown in **Figure 8** and **Figure 9**. The eastern Dakotas are dry, while the western Dakotas have above normal soil moisture averaged over the soil profile. According to Dr. Todey, the top 3 feet of soil in most areas of South Dakota are fairly dry; however, there is good soil moisture at 3 to 4 foot depths due to low summer evapotranspiration demands. This is illustrated in **Table 1** and **Table 2**, percent soil moisture by depth at two USDA Soil Climate Analysis Network (SCAN) locations in the upper Basin. Over the last seven days in November, soil moisture has declined rapidly in the top 2 inches of the soil profile at the EROS Data Center near Dell Rapids, SD and Mandan, ND, while less rapid declines have occurred at 4 inches. Comparing the November 30,

2014 soil moisture by depth at both locations shows that soil moisture at 20-inch and 40-inch depths are much greater than the 2-inch through 8-inch depths.

Table 1. Percent soil moisture by depth at the EROS Data Center USDA SCAN Site near Dell Rapids, SD.

USDA SCAN Site - EROS Data Center, Dell Rapids, SD					
Date	Percent Soil Moisture By Depth				
	2-inch	4-inch	8-inch	20-inch	40-inch
11/24/2014	37.1	28.5	23.6	26.4	30.3
11/25/2014	34.2	29.4	23.7	26.3	30.3
11/26/2014	27.4	29.1	23.8	26.1	30.1
11/27/2014	21.6	28.8	24.0	26.5	29.8
11/28/2014	17.8	20.2	24.1	26.4	29.9
11/29/2014	18.5	20.4	23.5	26.5	30.0
11/30/2014	19.1	20.9	23.7	26.4	29.7

Table 2. Percent soil moisture by depth at the USDA SCAN Site near Mandan, ND.

USDA SCAN Site - Mandan, ND					
Date	Percent Soil Moisture By Depth				
	2-inch	4-inch	8-inch	20-inch	40-inch
11/24/2014	32.7	17.3	12.3	26.9	33.2
11/25/2014	30.4	17.3	12.2	26.9	32.8
11/26/2014	28.6	17.3	12.1	27.0	33.0
11/27/2014	24.0	17.3	12.3	26.9	33.1
11/28/2014	19.7	17.1	12.3	26.9	33.0
11/29/2014	19.5	16.7	12.1	27.0	32.8
11/30/2014	19.5	16.3	12.3	27.0	32.9

According to Dr. Akyuz, the state of the soil prior to snow accumulation is important. Frozen soils, somewhat independent of soil moisture content, act as an impervious surface to water. Prior to the first snow accumulation in early November, soil frost developed due to the very cold temperatures in the upper Basin. Since the soils are currently frozen, the amount of runoff will depend on the amount of accumulated plains snow, the rate of snowmelt in the spring and spring rainfall.

Furthermore, substantial surface or wetland storage in the prairie potholes region of North Dakota and South Dakota is available to store meltwater in the spring, rendering some of this region as non-contributing area to the Missouri River basin.

Winter Weather Forecast

The dominant factor influencing winter weather in the Missouri Basin is the Arctic oscillation, which describes the oscillation of cold air from the Canadian Arctic into the lower latitudes. The Arctic oscillation has typically brought cold air into the Missouri Basin during more severe winters. This factor is not typically predictable beyond a few weeks; therefore, no forecast can be made for the entire winter season based on this factor.