Upper Missouri River Basin
January 2022 Calendar Year Runoff Forecast
January 5, 2022

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. The Calendar Year Runoff Forecast is available at http://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

The 2021 calendar year runoff summation for the Missouri Basin above Sioux City, IA was **15.2 MAF**, **59% of average**. This was the 10th lowest annual runoff for the Missouri River Basin in 123 years of record keeping.

December runoff was 0.75 MAF, 97% of average. Runoff was near-normal due to the above-normal temperatures and above-normal precipitation over most of the upper Basin in December.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **21.7 MAF, 84% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **19.4 MAF**, **83% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 12 months, expected inflow could range from the 30.1 MAF upper basic forecast to the 14.3 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 twelve months are being forecast for this January 1 forecast, the range of possible wetter-than-expected (upper basic) and drier-than-expected (lower basic) conditions is very large, and is attributed to all six reaches for the entire year. The result is a range or "bracket" for each reach, and thus, for the total runoff forecast.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for December 28, 2021 is shown in **Figure 1**. The drought monitor is available at http://droughtmonitor.unl.edu/. The U.S. Drought Monitor shows Moderate Drought (D1) or worse conditions in areas of every state in the Basin. Exceptional Drought (D4) is present over a large area of Montana along the headwaters of the Missouri River. The Seasonal Drought Outlook in **Figure 2**, which extends through the end of March, indicates no expansion of drought conditions within the Missouri River Basin during the outlook period and drought improvement over most of Montana.

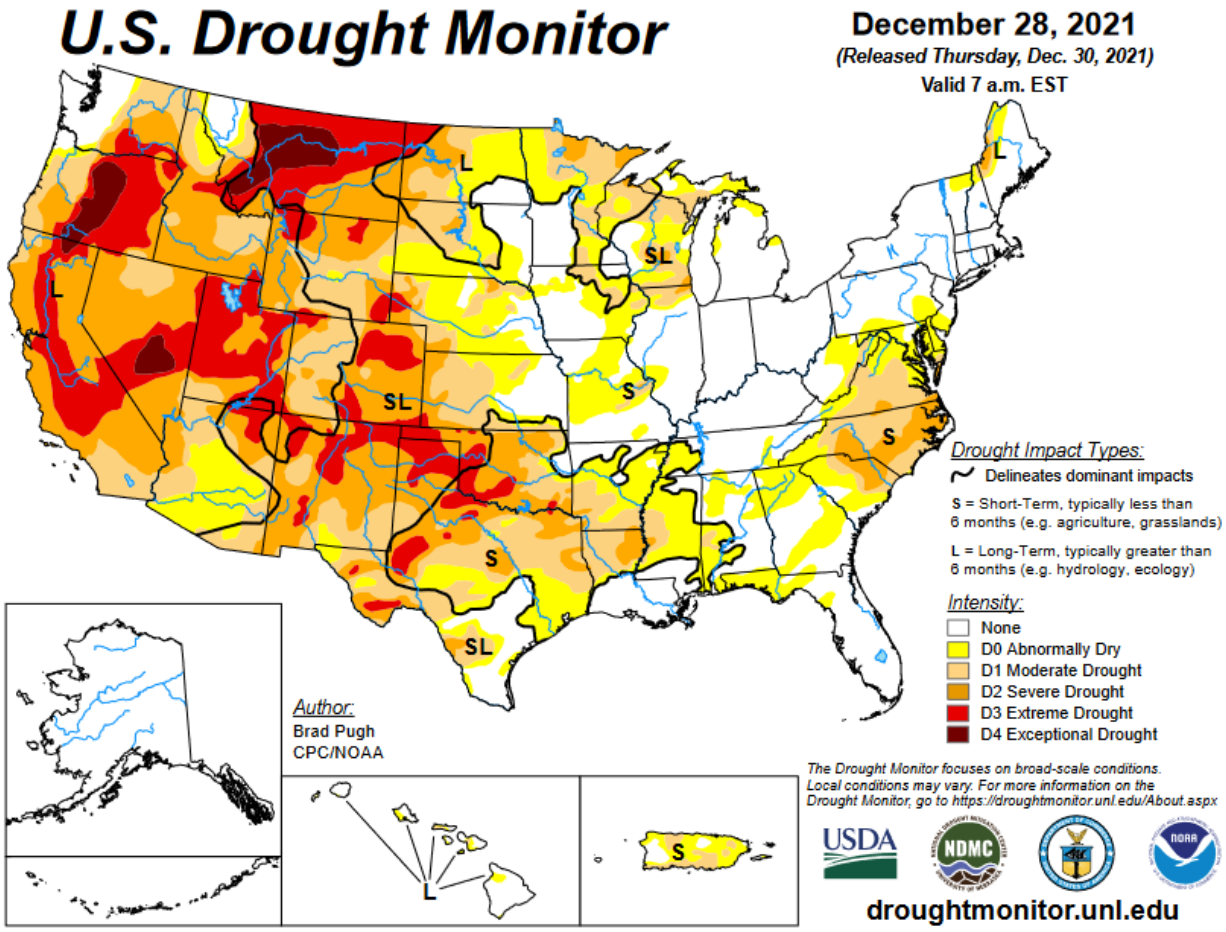

Figure 1. National Drought Mitigation Center U.S. Drought Monitor for December 28, 2021.

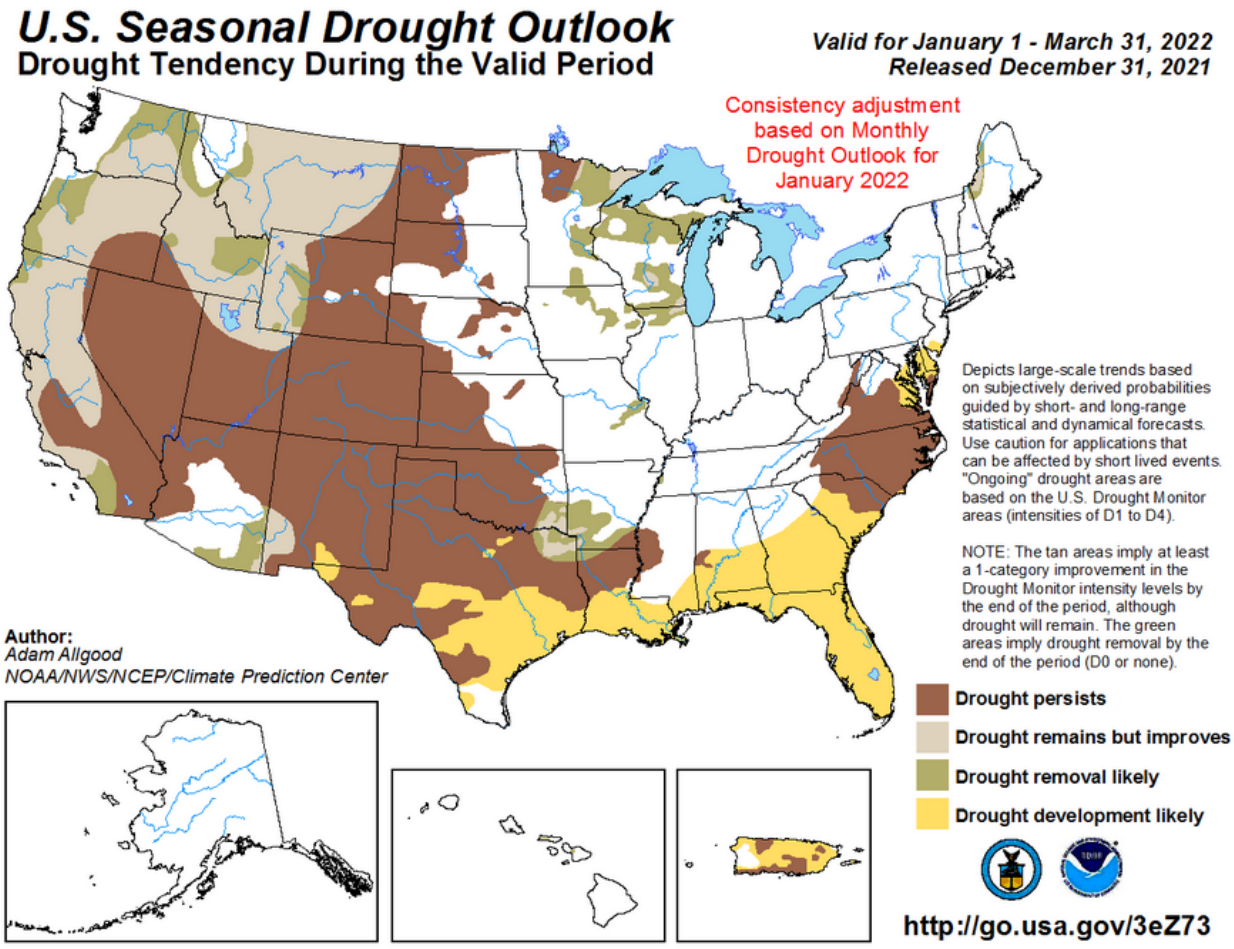

Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center images available at http://www.hprcc.unl.edu/. The December precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. December precipitation was varied across the upper Basin, and well below normal in the lower Basin. Heavy precipitation, exceeding 150 percent of normal, occurred in large areas of Montana, North Dakota, southern South Dakota, and Wyoming.

Precipitation as a percent of normal for the October-November-December period was also varied over the upper Basin, with well-above-normal areas in North and South Dakota, and below-normal areas in Montana (**Figure 4**).

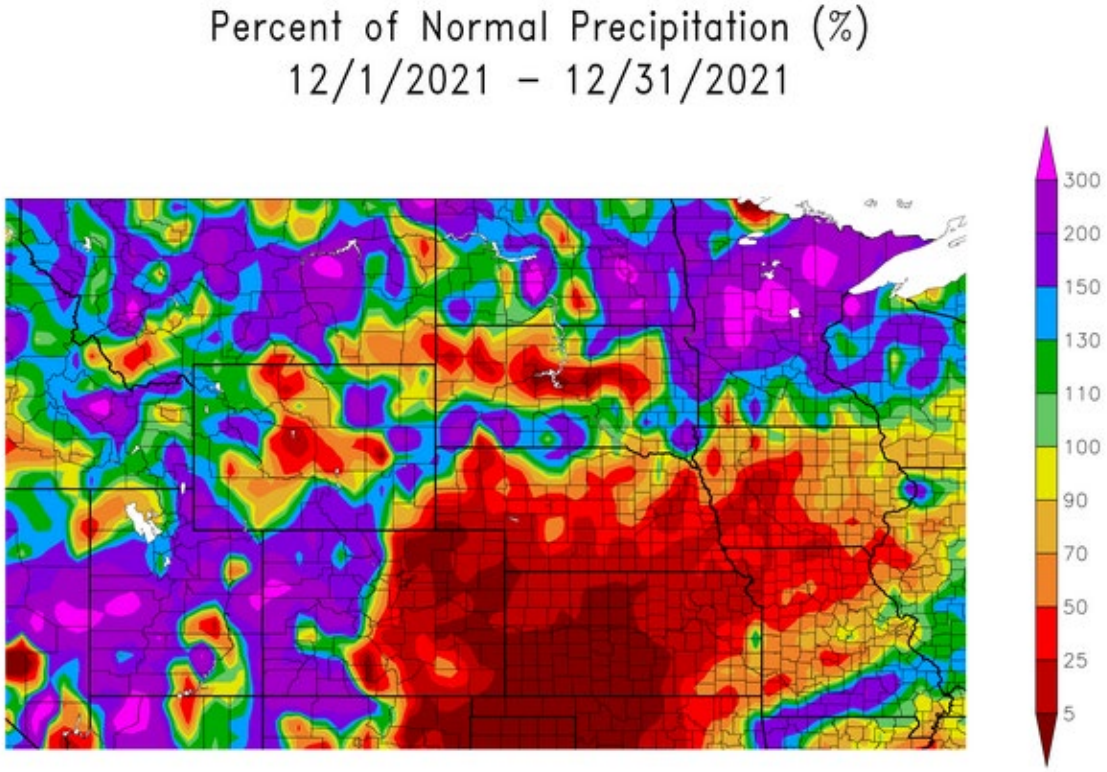

Figure 3. December 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

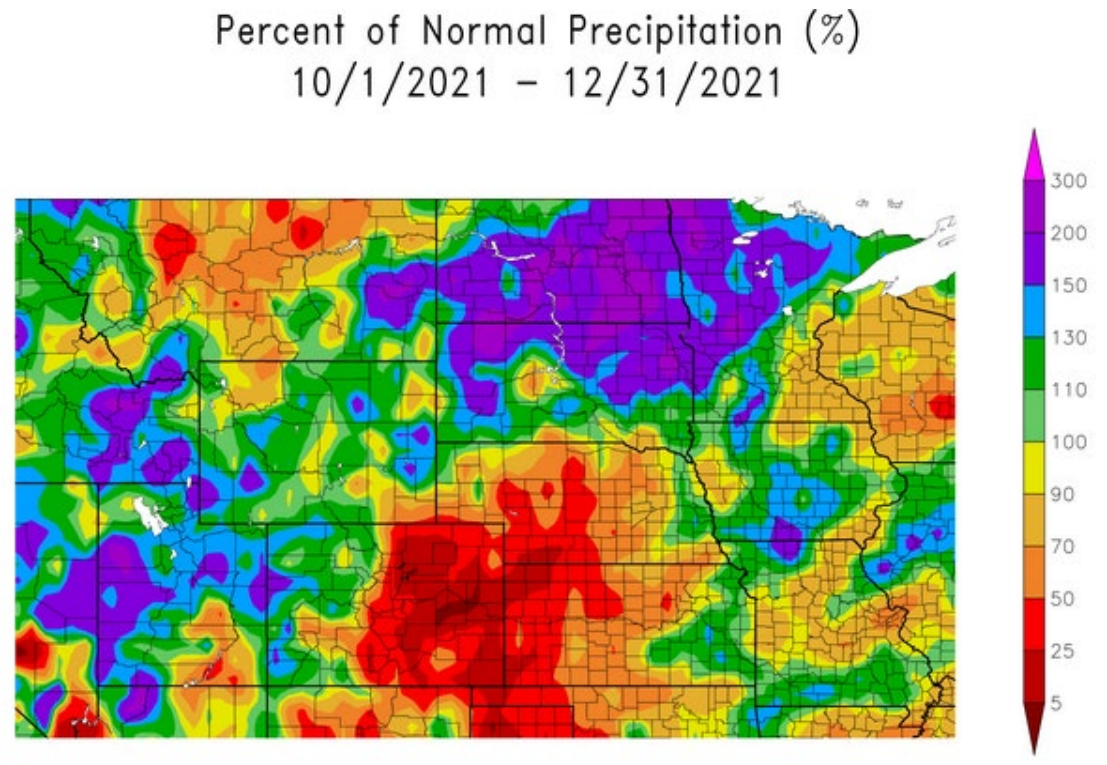

Figure 4. October, November, December 2021 Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

December temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures over most of the Basin. December temperatures in northern Montana and northern North Dakota were 2 to greater than 10 degrees F below normal. Temperatures across the rest of the Basin ranged from 2 to greater than 10 degrees F above normal. These warmer-than-normal temperatures limited the formation of river ice and allowed Missouri River tributaries to flow freely in December. The warmer temperatures also inhibited the formation of plains snowpack by causing winter precipitation to fall as rain, and by melting shallow snowpack several days after accumulation. October-November-December temperature departures are shown in **Figure 6**. The three-month average departures were generally 2 to 8 degrees F above normal across the entire Basin.

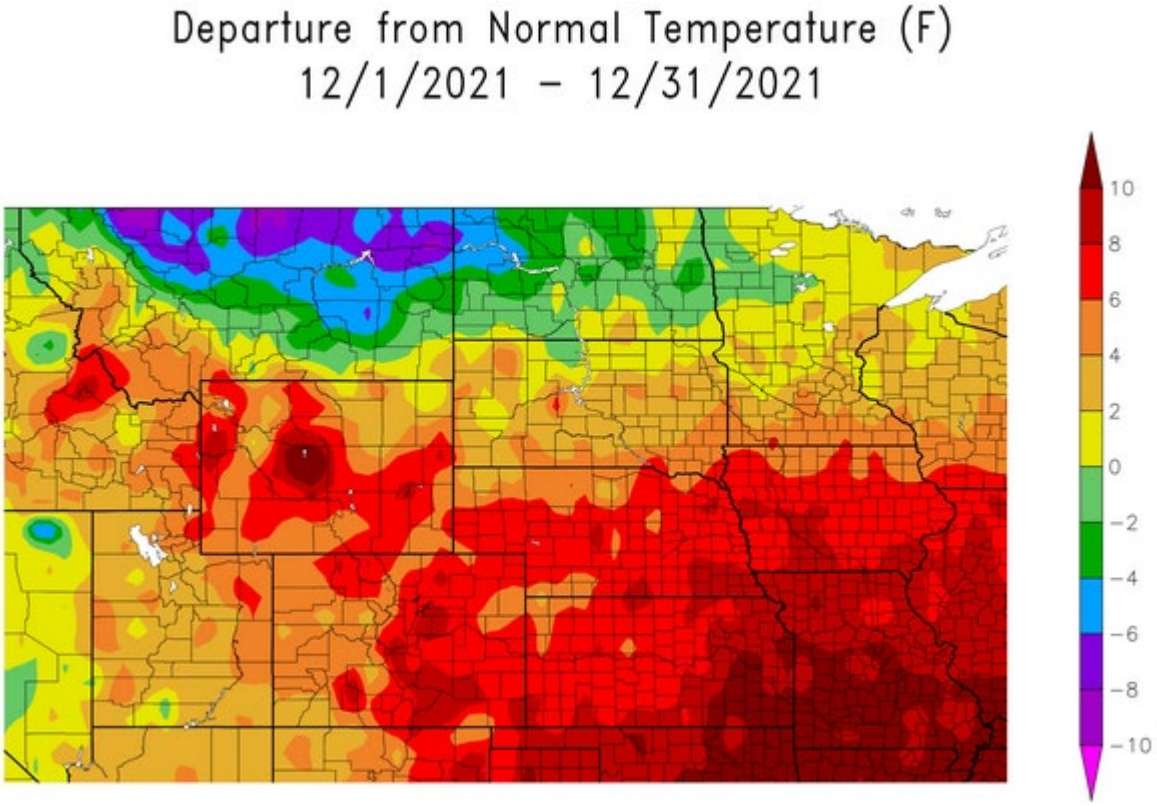

Figure 5. December 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

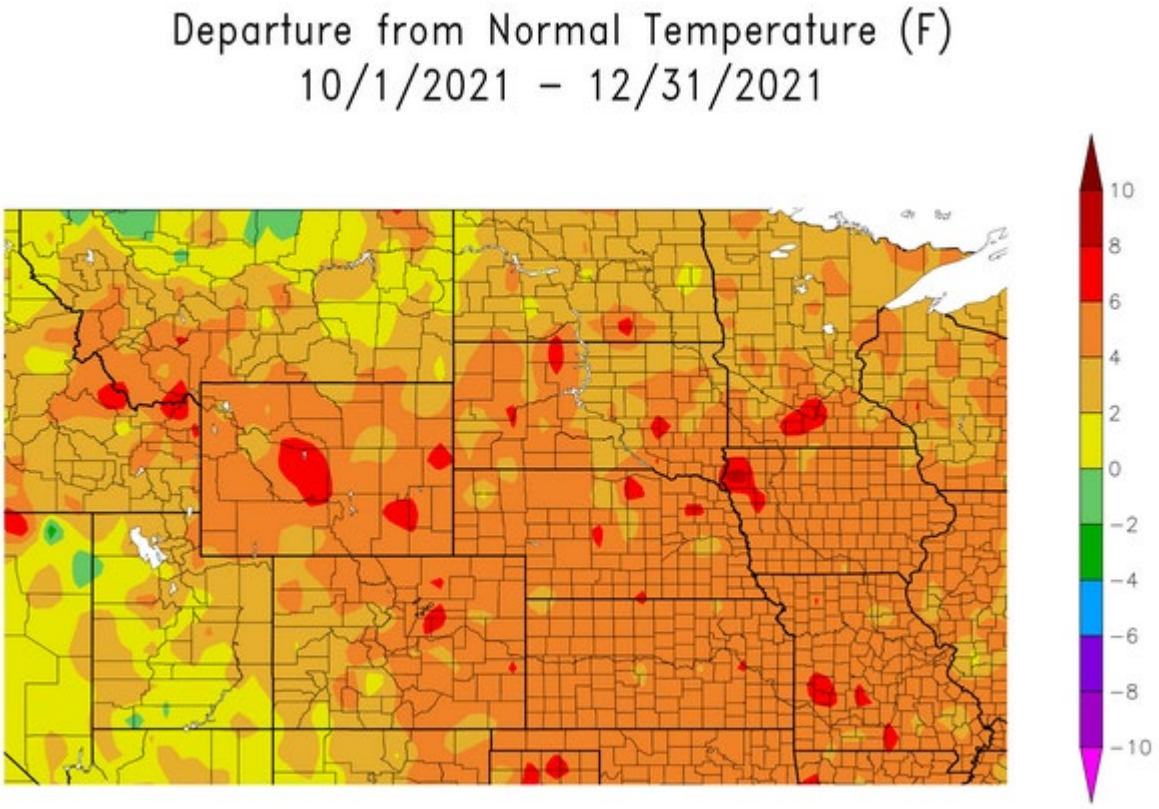

Figure 6. October-November-December 2021 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture anomalies and soil moisture percentiles from the Climate Prediction Center (CPC) at the beginning of January 2022 are shown in **Figure 7**, along with a comparison of soil moisture last year at this time in January of 2021. Soil moisture is drier than normal across much of the Basin, similar to conditions in 2021. The soil moisture percentiles rank low; between the 1st and 30th percentiles in Montana and Colorado. The 1st percentile indicates that soil moisture is at its driest for this time of year, compared to long-term soil moisture simulations. Generally, when soil moisture is low during the winter, the potential for high March-April runoff is lower. However, soil moisture in North and South Dakota has improved from what it was in January of 2021. Soil moisture is above normal in southeastern North Dakota and northeastern South Dakota.

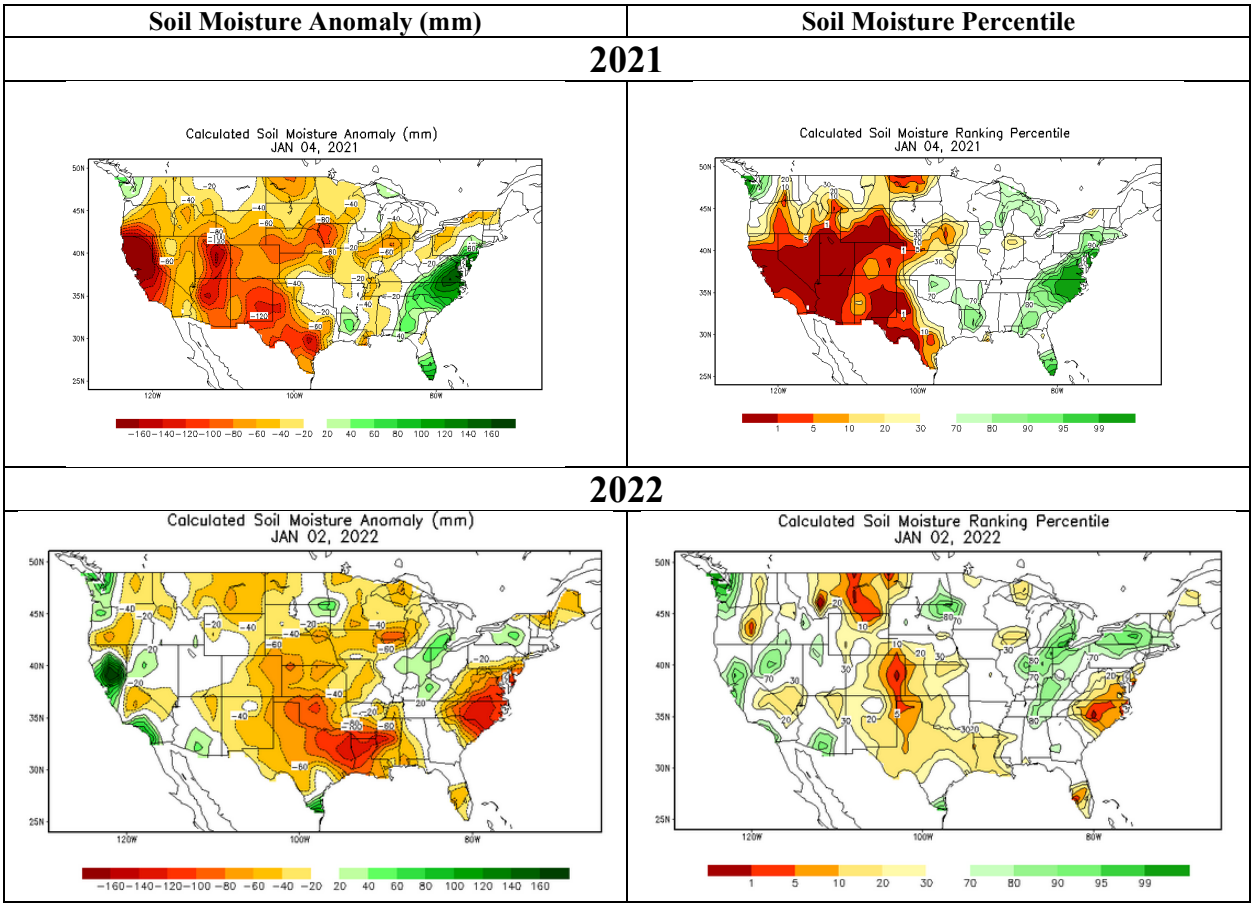

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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 this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from January 3, shown in **Figure 8**, indicates trace

amounts of snow water equivalent (SWE) in areas of every state in the Basin. There is a small area of 1 to 3 inches of SWE in North Dakota. January of 2021 was very similar, with only trace amounts of measurable SWE. The amount of runoff received in March and April will depend greatly on precipitation over the next few months.

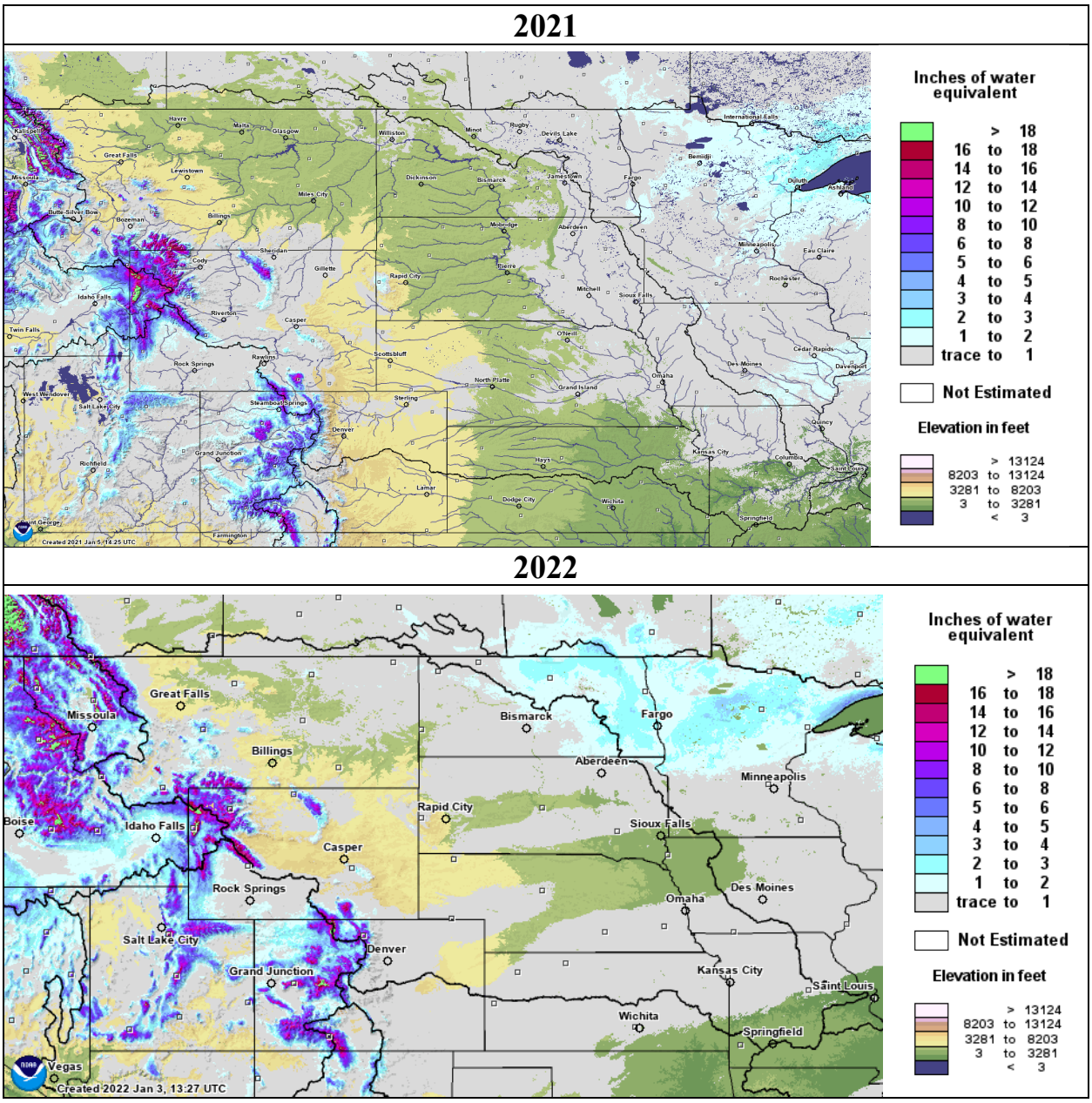

Figure 8. January 5, 2021 NOHRSC modeled plains snow water equivalent (top) and January 3, 2022 snow water equivalent (bottom). Source: NOAA National Operational Hydrologic Remote Sensing Center.
http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. May, June, and July runoff in the Fort Peck and Garrison reaches has very little correlation to the January 1 snowpack, because less than half of the mountain snowpack has accumulated on January 1. A majority of the mountain snowfall typically occurs from January 1 to mid-April, when snowpack typically peaks, therefore, later measurements of mountain snowpack are better runoff indicators.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2020 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

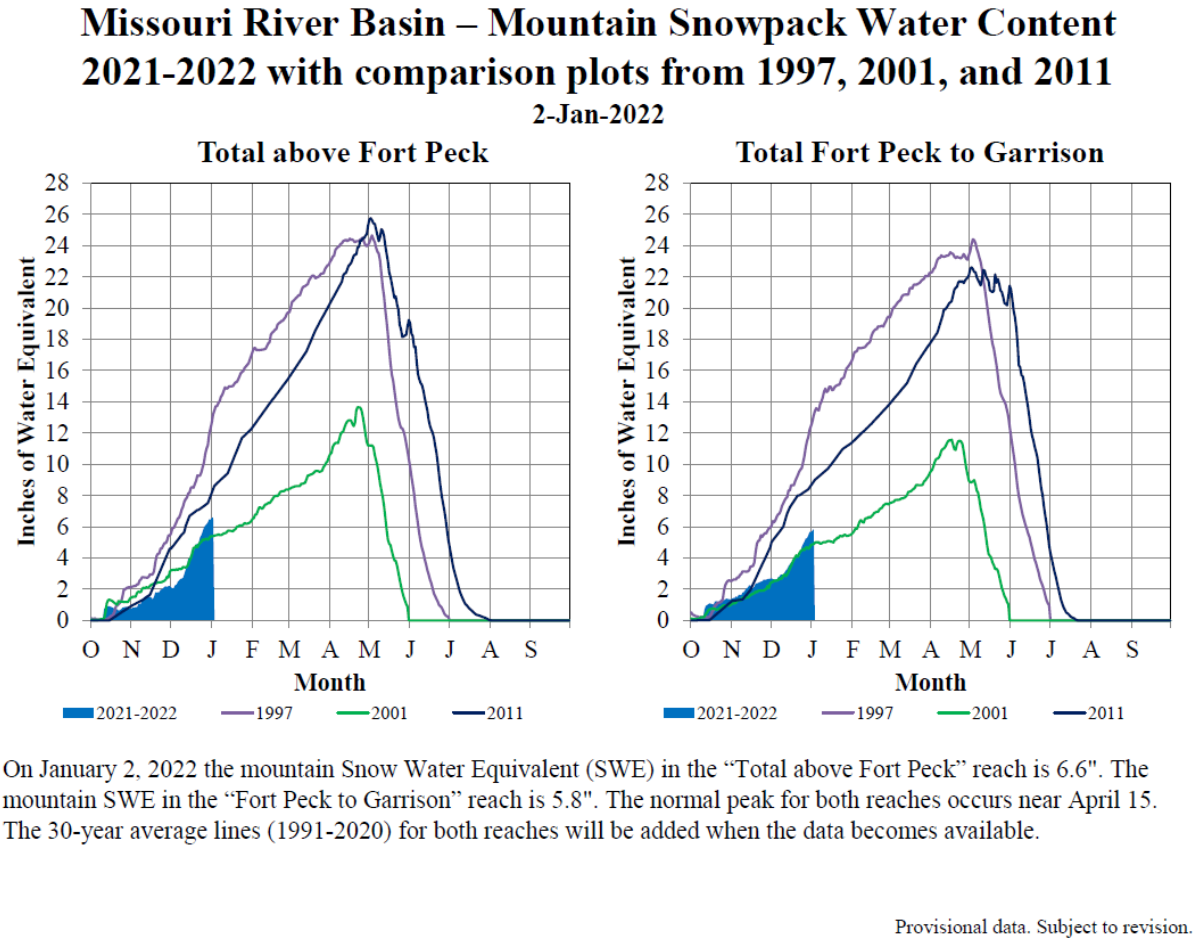

Figure 9. Mountain snowpack water content on January 2, 2022 compared to historic conditions. Corps of Engineers - Missouri River Basin Water Management.

As of January 2, 2022, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 6.6 inches, which is 87% of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 5.8 inches, which is 86% of average based on the 1981-2010 average SWE for the Garrison reach. Typically, by January 1, 44% of the total accumulation has occurred, and it typically peaks around April 15.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

The latest ENSO Outlook indicates that La Nina conditions are present and will likely remain during the Northern Hemisphere winter, but there is potential for a transition to ENSO neutral during the spring. During La Nina conditions there are increased chances for below-normal temperatures in the upper Basin and increased chances for an above-normal mountain snowpack.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at http://www.cpc.ncep.noaa.gov/.

The CPC temperature outlook through January 17 (**Figure 10**) indicates increased chances for above-normal temperatures over the Basin. The precipitation outlook indicates an increase in the chances for below-normal precipitation over the Basin.

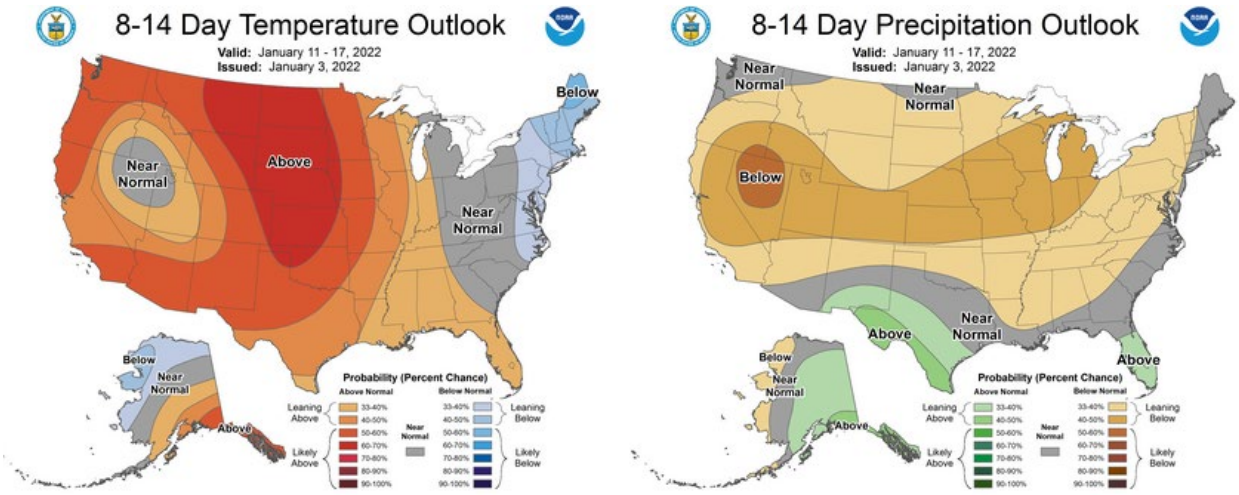

Figure 10. CPC 8-14 Day temperature and precipitation outlooks through January 17, 2022.

The January CPC outlooks in **Figure 11** indicate increased chances for below-normal temperatures over Montana, North and South Dakota, and Nebraska. With regard to precipitation, there is a slight increase in chances for above-normal precipitation in Montana and Wyoming.

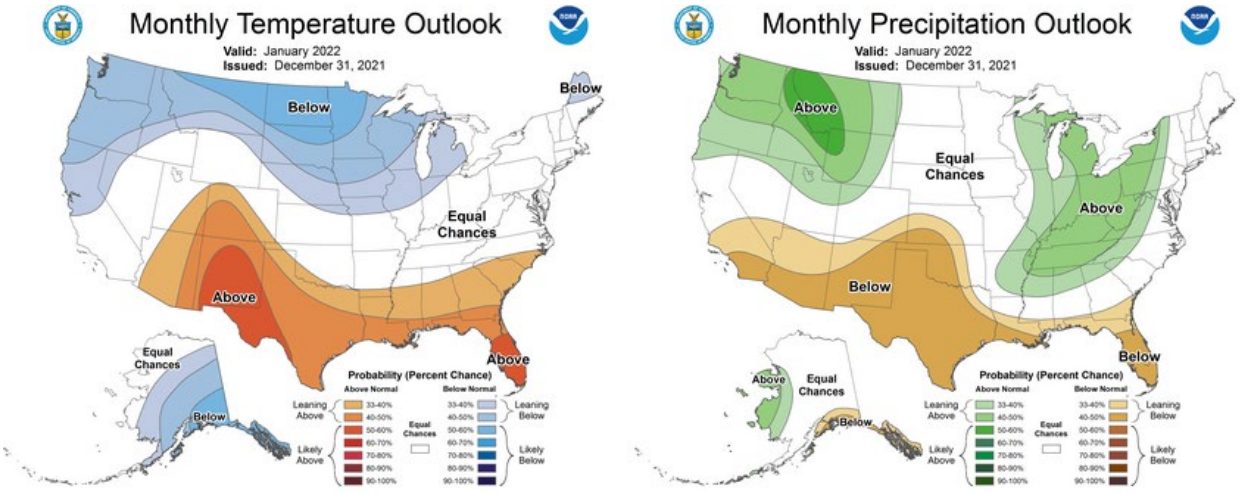

Figure 11. CPC January 2022 temperature and precipitation outlooks.

Three-month temperature and precipitation outlooks for four, three-month periods in 2021 are shown below in **Figure 12-Figure 15**. During the January-February-March 2021 period (**Figure 12**), the CPC indicates increased chances for below-normal temperatures in Montana and above-normal temperatures in Kansas and Missouri. Equal chances for above-normal, normal, and below-normal temperatures are indicated in most other areas of the Missouri Basin. With regard to precipitation, there is an increased probability for above-normal precipitation in Montana.

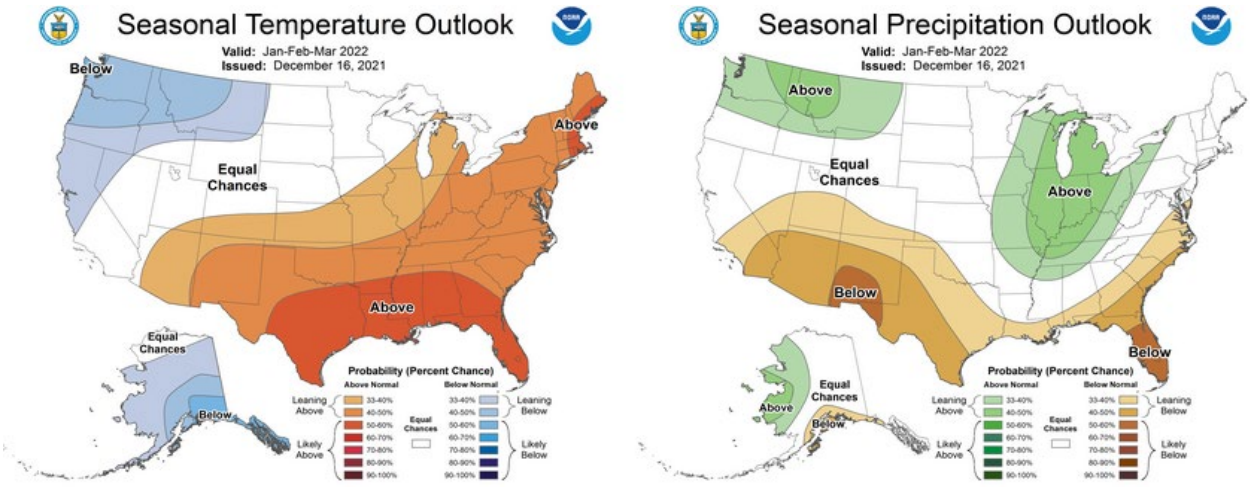

Figure 12. CPC January-February-March 2022 temperature and precipitation outlooks.

During the April-May-June 2021 forecast period (**Figure 13**), there are increased chances for above-normal temperatures in the lower Basin and equal chances for temperatures in the upper Basin. There are increased chances for below-normal precipitation in Wyoming and Colorado, and slight increases in above-normal precipitation in Iowa and Missouri. During July-August-September (**Figure 14**), below-normal precipitation chances transition to the north into Wyoming, Montana, and North Dakota, with equal chances elsewhere. With regards to temperature, there's an increased chance of above-normal temperatures across most of the Basin. During October-November-December, there are equal chances for above-, below-, and normal temperatures across all of the Basin, and increased chances for above-normal precipitation centered over Nebraska and Iowa (**Figure 15**). As previously noted, though, there is limited confidence in climate outlooks beyond the winter and early spring, therefore, the climate outlooks will likely change as the calendar progresses.

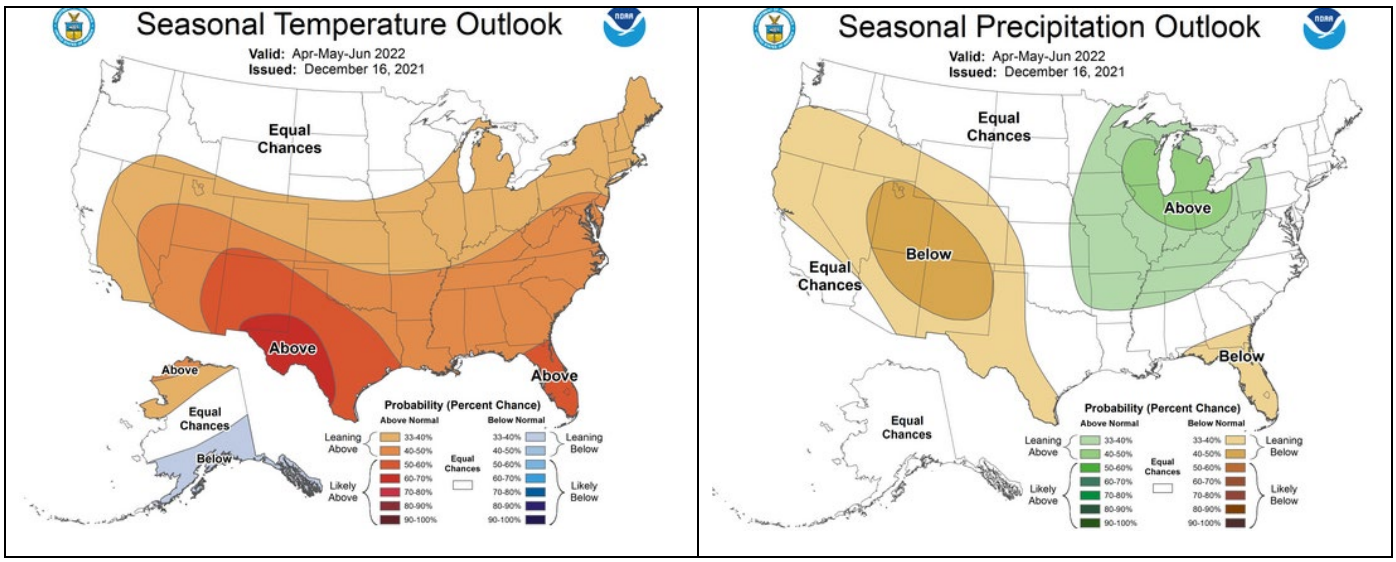

Figure 13. CPC April-May-June 2022 temperature and precipitation outlooks.

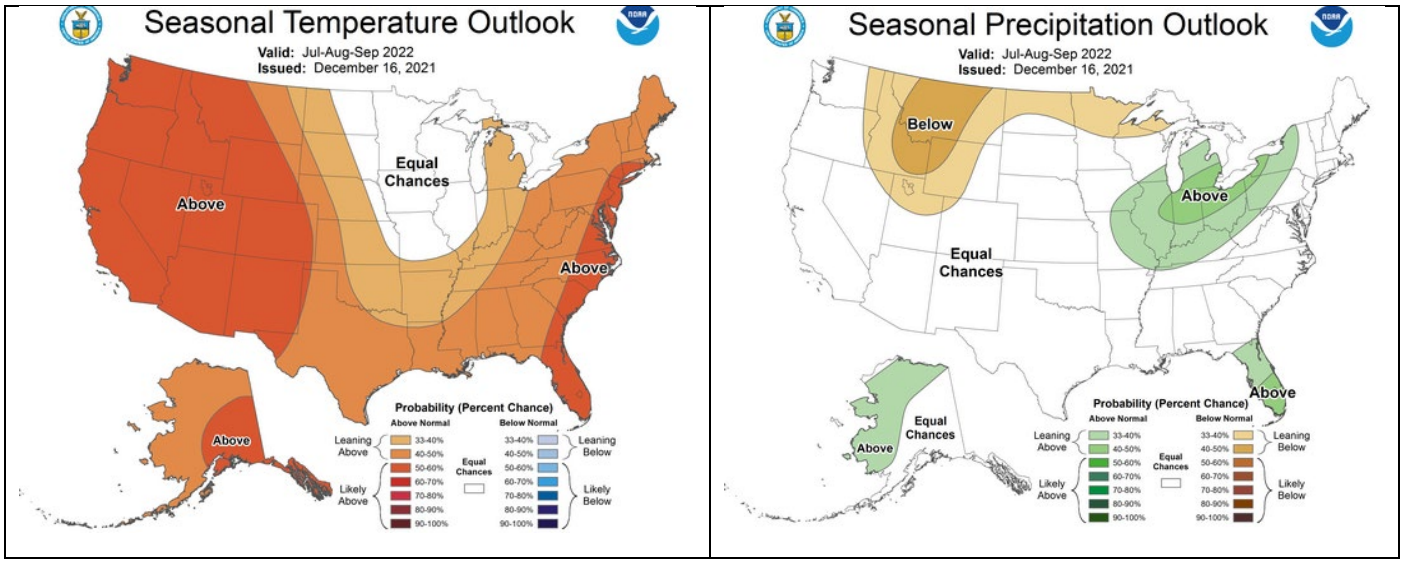

Figure 14. July-August-September 2022 temperature and precipitation outlooks.

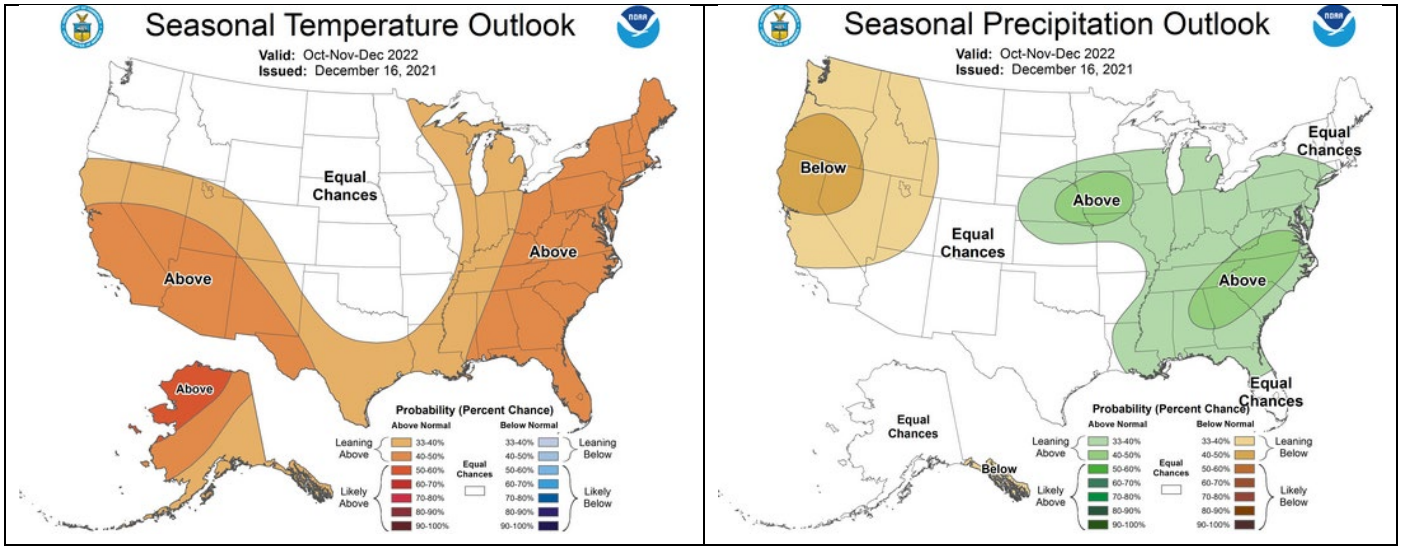

Figure 15. October-November-December 2022 temperature and precipitation outlooks.

Summary

Given the soil moisture conditions, moderate streamflow, minimal plains snowpack and cooler-than-normal forecasted temperatures, we expect runoff to decrease from the near-normal levels in December to below average by the end of February. March-April runoff potential is low due to the dry soil moisture conditions in the western portion of the Basin and minimal snow cover, but it will depend greatly on the accumulation of plains snowpack over the next 2 to 3 months. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the below-normal mountain snowpack and dry soil moisture conditions. In summary, the 2022 calendar year runoff forecast is **21.7 MAF (84% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: January 06, 2022 02:58:34 PM
   - Based on January 01, 2022 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Hebgen Lake Inflow (2)	APR-JUL	370	106	490	420	320	250	350
	APR-SEP	465	102	605	520	410	325	455

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	57	98	69	62	52	45	58
	APR-SEP	71	95	86	77	65	56	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	550	115	745	630	470	355	480
	APR-SEP	565	120	810	680	510	380	470
Bull Lake Ck nr Lenore (2)	APR-JUL	155	110	200	174	136	108	141
	APR-SEP	186	111	240	210	164	132	168
Boysen Reservoir Inflow (2)	APR-JUL	780	107	1210	955	605	350	730
	APR-SEP	850	108	1310	1040	665	390	785
Greybull R at Meeteetse	APR-JUL	145	103	215	172	118	77	141
	APR-SEP	197	99	275	230	166	121	199
Shell Ck nr Shell	APR-JUL	52	88	69	59	45	34	59
	APR-SEP	63	89	83	71	55	44	71
Bighorn R at Kane (2)	APR-JUL	1000	100	1620	1250	750	380	1000
	APR-SEP	1090	105	1760	1360	820	415	1040
NF Shoshone R at Wapiti	APR-JUL	480	107	625	540	420	335	450
	APR-SEP	530	103	685	595	470	375	515
SF Shoshone R nr Valley	APR-JUL	230	102	295	260	205	168	225
	APR-SEP	265	102	340	295	235	192	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	685	102	925	780	590	445	670
	APR-SEP	745	102	1000	850	640	490	730
Bighorn R nr St. Xavier (2)	APR-JUL	1540	96	2290	1840	1240	785	1610
	APR-SEP	1640	95	2460	1970	1310	815	1720
Tongue R nr Dayton (2)	APR-JUL	78	89	108	90	66	48	88
	APR-SEP	89	87	121	102	77	58	102
Tongue River Reservoir Inflow (2)	APR-JUL	175	80	275	215	135	76	220
	APR-SEP	193	77	295	235	151	89	250
NF Powder R nr Hazelton	APR-JUL	7.4	72	10.4	8.6	6.2	4.4	10.3
	APR-SEP	8.0	72	11.1	9.2	6.7	4.9	11.1
Powder R at Moorhead	APR-JUL	137	72	255	185	89	18.4	191
	APR-SEP	149	73	275	199	99	26	205

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAR-JUL	5.3	82	9.3	6.9	3.7	1.29	6.5
	APR-JUL	4.3	81	7.9	5.7	2.8	0.63	5.3
Pactola Reservoir Inflow (2)	MAR-JUL	18.8	67	37	26	11.5	0.79	28
	APR-JUL	16.2	65	33	23	9.3	0.100	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	250	125	385	305	195	113	200
	APR-SEP	275	125	420	335	215	130	220
Encampment R nr Encampment (2)	APR-JUL	177	131	250	205	148	105	135
	APR-SEP	188	133	265	220	158	113	141

Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	61	124	81	69	53	41	49
	APR-SEP	64	125	85	72	56	43	51
Seminoe Reservoir Inflow (2)	APR-JUL	825	125	1260	1000	645	385	660
	APR-SEP	885	124	1340	1070	700	425	715
Sweetwater R nr Alcova	APR-JUL	47	104	88	64	30	5.8	45
	APR-SEP	50	102	94	68	32	6.3	49
La Prele Ck nr Douglas	APR-JUL	17.6	84	33	24	11.3	2.1	21
	APR-SEP	17.7	91	34	24	11.2	1.68	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	915	123	1510	1160	675	320	745
	APR-SEP	950	125	1560	1200	700	335	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	940	126	1550	1190	690	325	745
	APR-SEP	955	123	1590	1210	700	325	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	145	124	205	170	120	83	117
	APR-SEP	158	125	225	185	131	92	126
Little Laramie R nr Filmore	APR-JUL	68	128	94	79	57	42	53
	APR-SEP	74	132	102	85	63	46	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
February 2022 Calendar Year Runoff Forecast
February 2, 2022

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

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

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Observed Runoff

January runoff was 0.9 MAF, 111% of average. Runoff was slightly above average due to the above-normal temperatures in the upper Basin. Runoff was above average in all reaches except Fort Peck and Oahe.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **21.7 MAF, 84% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **18.5 MAF**, **80% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 11 months, expected inflow could range from the 29.8 MAF upper basic forecast to the 14.4 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for January 25, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 86% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 17% of the Basin, mostly in Montana. The Monthly Drought Outlook in **Figure 2**, which extends through the end of February, indicates drought conditions are likely to persist everywhere except northern Montana, with some development possible in the rest of Nebraska and north-central Kansas.

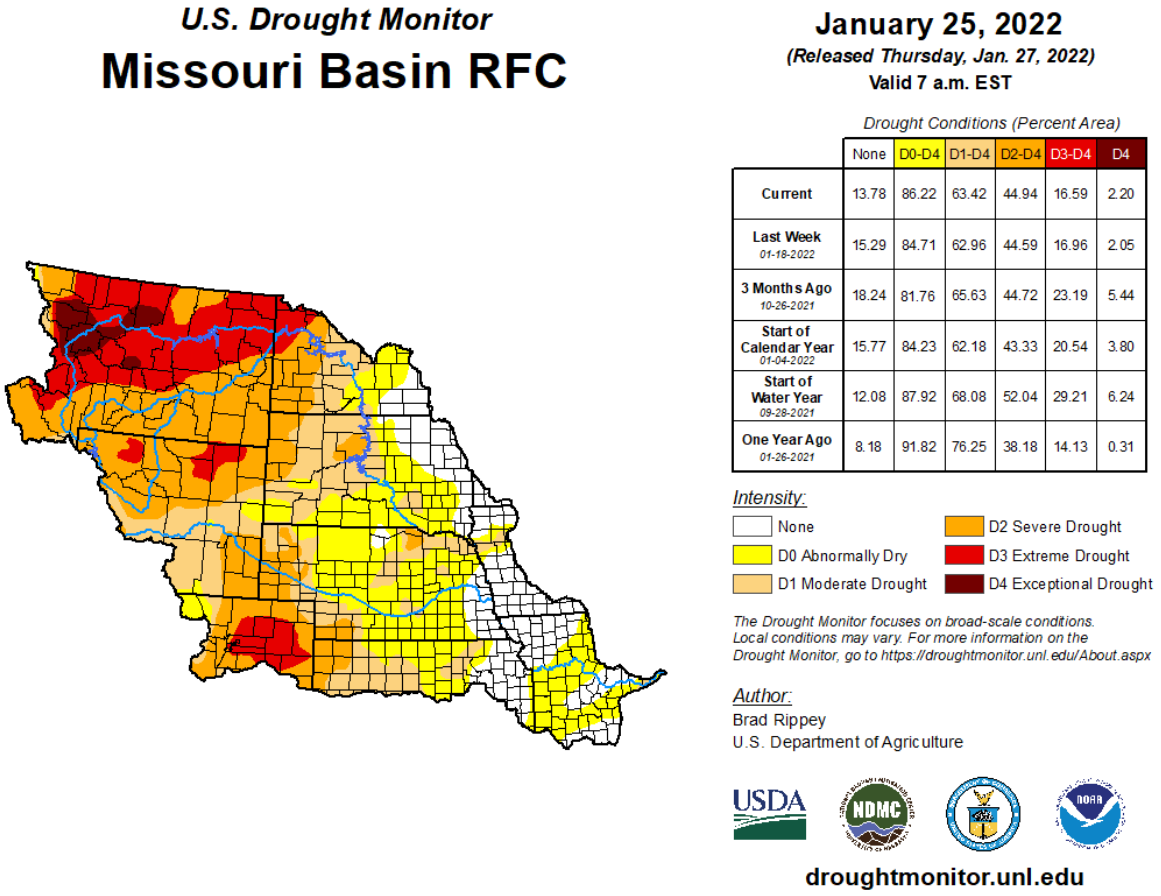


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

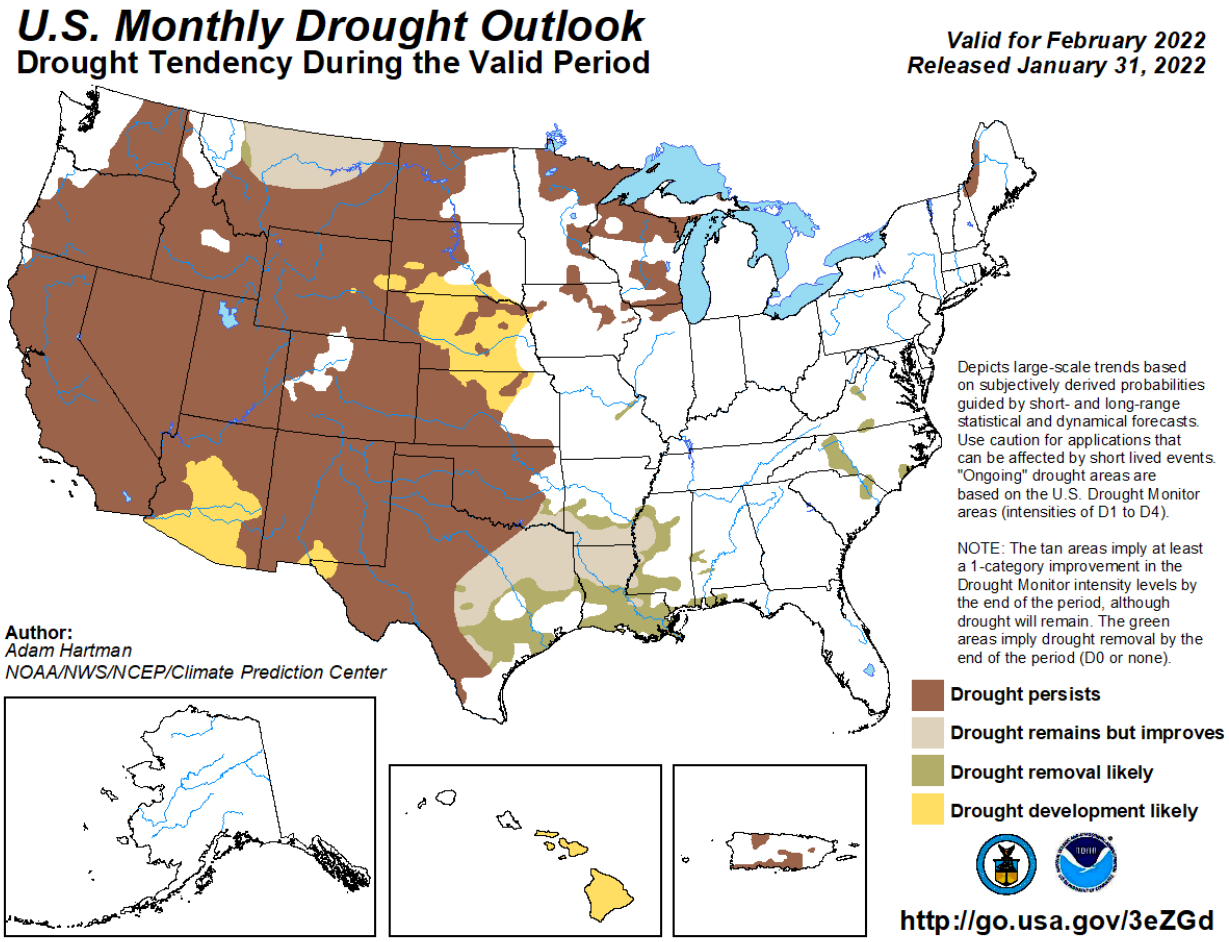


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The January precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. January precipitation was 5% to 70% of normal across most of the Basin. Central and eastern North Dakota, southeastern Wyoming, eastern Colorado and parts of western Nebraska and Kansas saw above normal precipitation.

Precipitation as a percent of normal for the November 2021 – January 2022 period was below normal (**Figure 4**). A small portion of southeastern Wyoming and north-central Colorado saw near normal precipitation, and north-central North Dakota saw near to above-average precipitation.

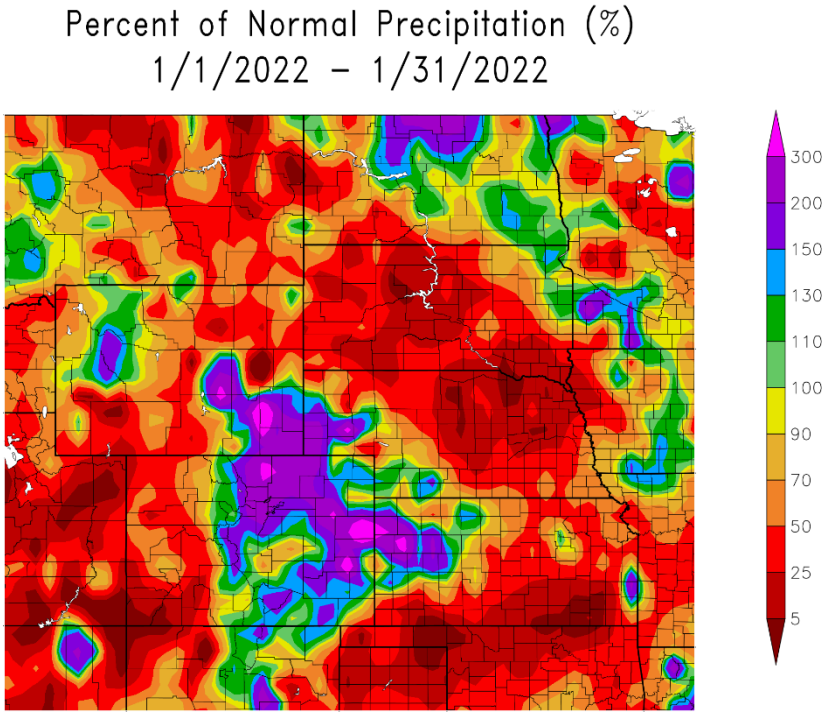


Figure 3. HPRCC January 2022 Percent of Normal Precipitation.

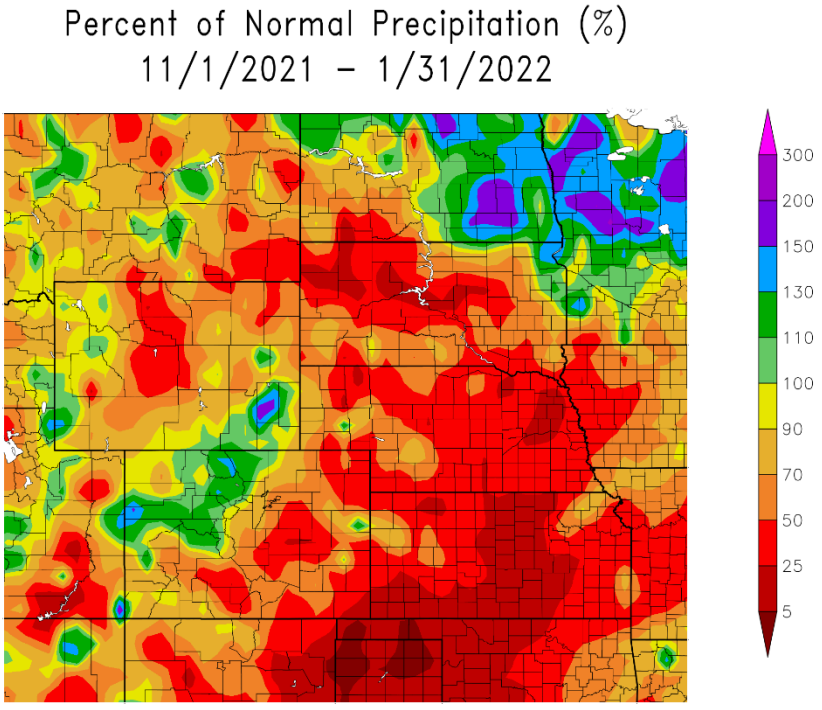


Figure 4. HPRCC November 2021 through January 2022 Percent of Normal Precipitation.

Temperature

January temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures over most of the upper Basin and near normal temperatures in most of the lower Basin. The warmer temperatures inhibited the accumulation of plains snowpack by melting shallow snowpack days after accumulation. November-December-January temperature departures are shown in **Figure 6**. The three-month average departures were generally 2 to 6 degrees F above normal across the entire Basin.

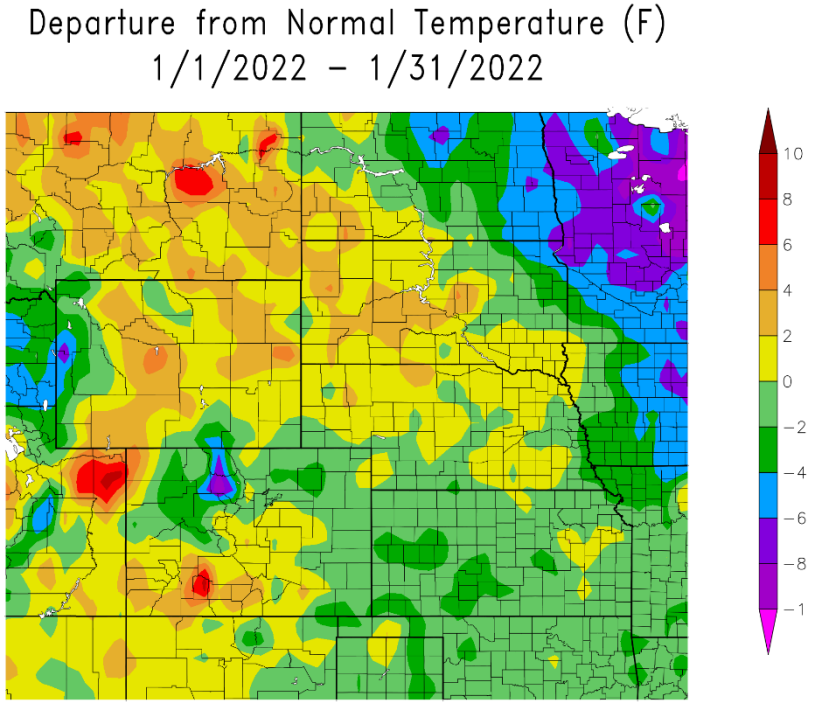


Figure 5. HPRCC January 2022 Departure from Normal Temperature.

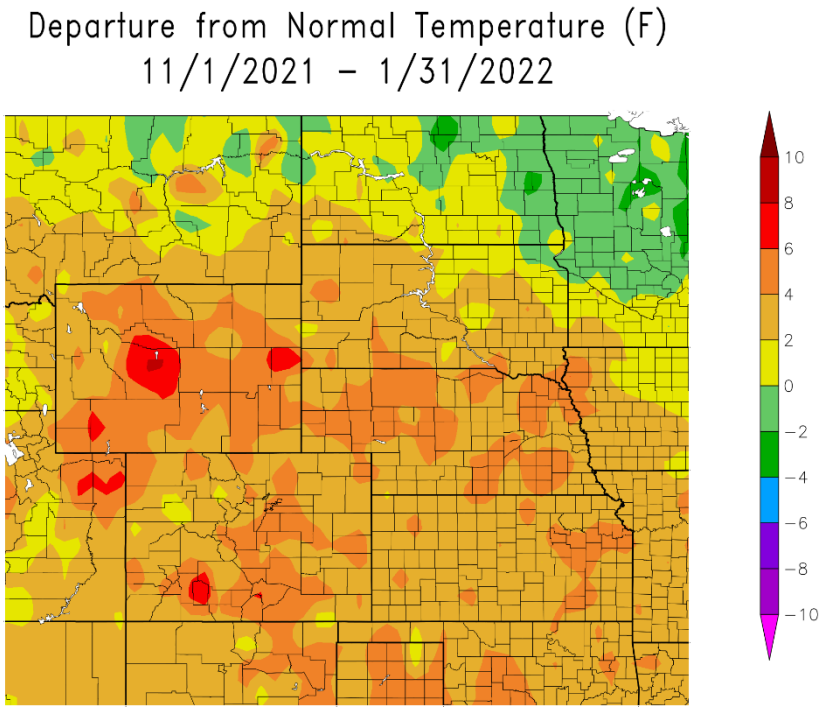


Figure 6. HPRCC November 2021 through January 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture is drier than normal across the western and lower portions of the Basin. Soil moisture percentiles in Montana rank from the 1st to the 10th percentile for much of the state. Only a small pocket of above-normal soil moisture exists in southeastern North Dakota and northeastern South Dakota. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**

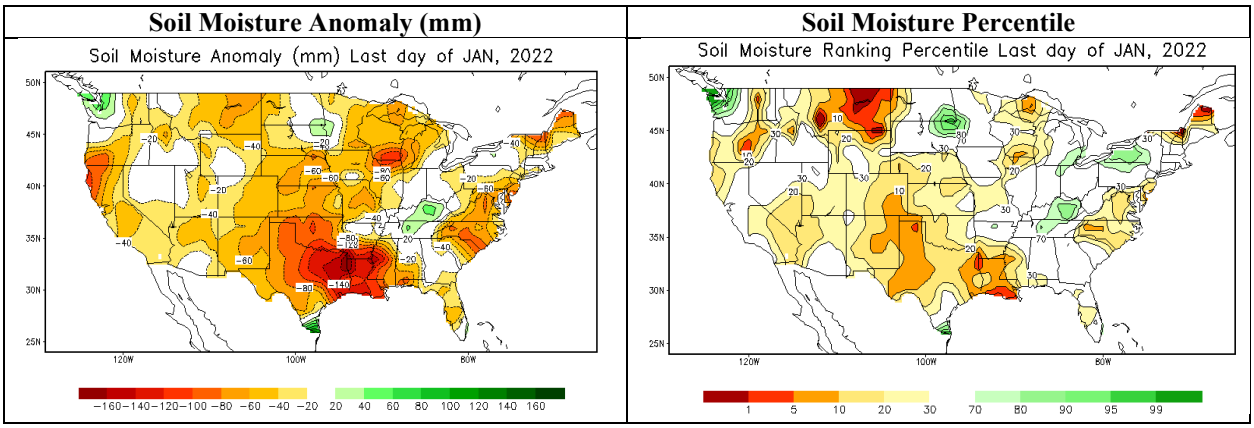


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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 this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC), modeled snow assessment from February 2, shown in **Figure 8**, indicates very little snow water equivalent (SWE) in the plains areas of the Basin. Central and eastern North Dakota is the only area with measurable accumulation, with 1 to 4 inches of modeled SWE. The amount of runoff received in March and April will depend greatly on precipitation over the next few months.

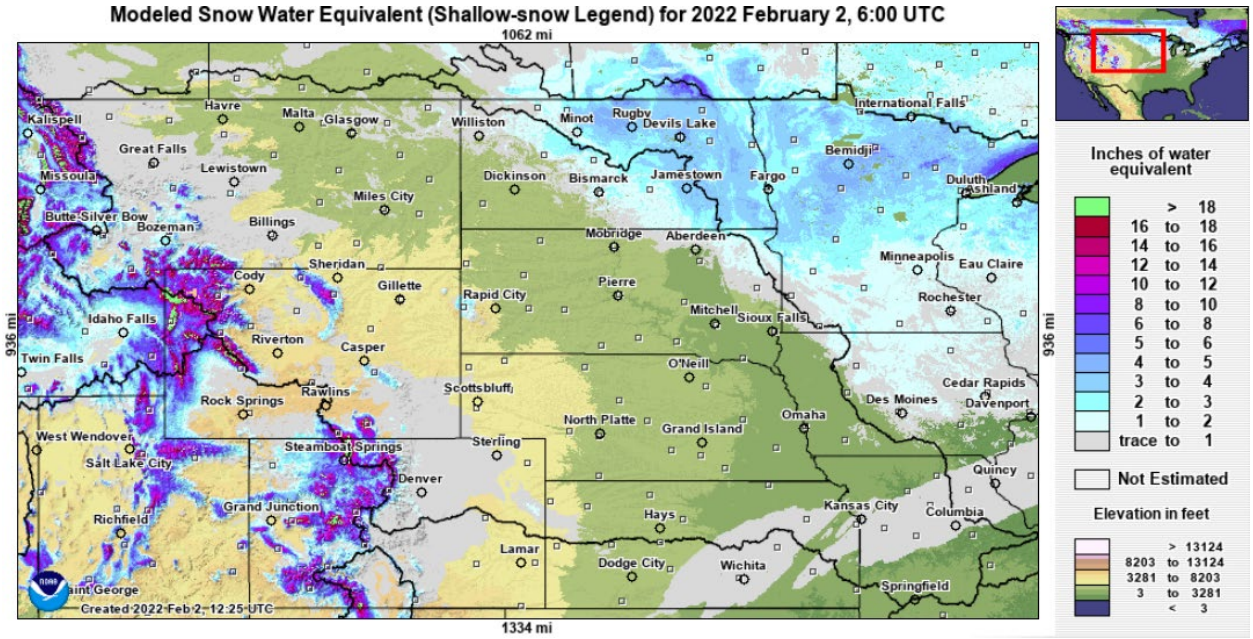


Figure 8. NOAA National Operational Hydrologic Remote Sensing Center modeled plains snow water equivalent.
http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. On average, 64% of the mountain snowpack has accumulated by February 1. A majority of the mountain snowfall typically occurs from January 1 to mid-April, when snowpack typically peaks, therefore, later measurements of mountain snowpack are better runoff indicators.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

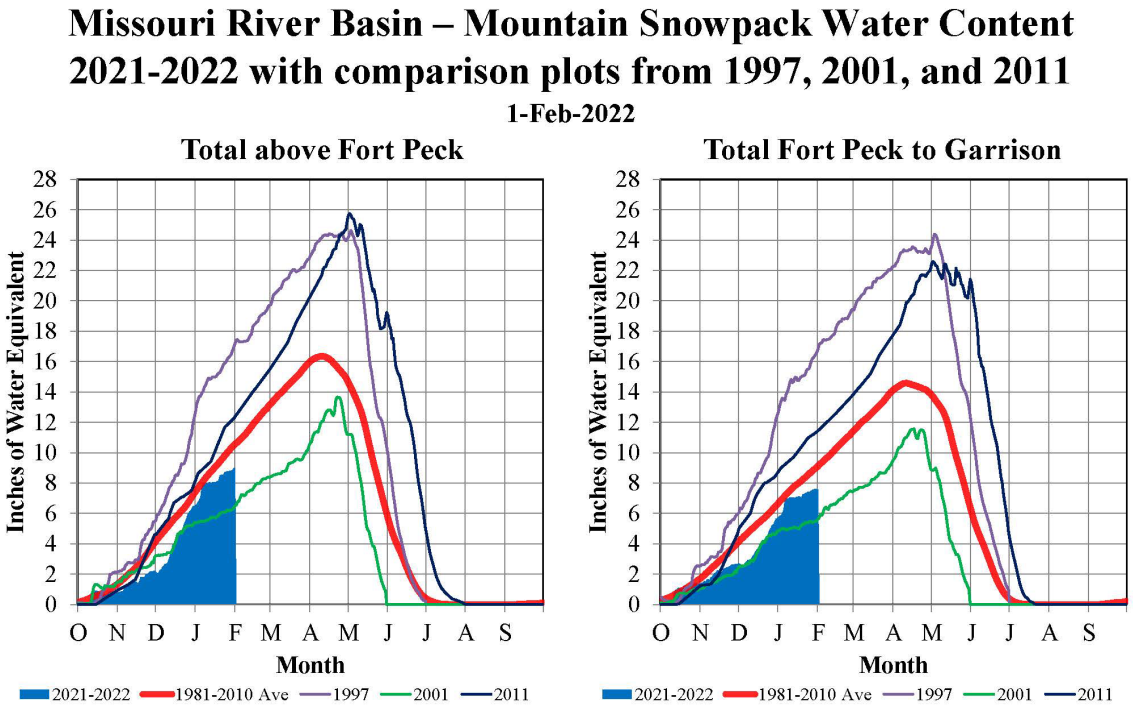


Figure 9. Mountain snowpack water content on February 1, 2022 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of February 1, 2022, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 9.0 inches, which is 85% of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 7.5 inches, which is 83% of average based on the 1981-2010 average SWE for the Garrison reach.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically

favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 67% chance of continuing during March-May 2022, and there is a 51% chance of transitioning to ENSO-neutral conditions during April-June 2022.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The February CPC temperature outlook (**Figure 10**) indicates increased chances for below-normal temperatures over the northern Basin and into the Dakotas. The precipitation outlook indicates increased chances for above-normal precipitation over the northern Basin.

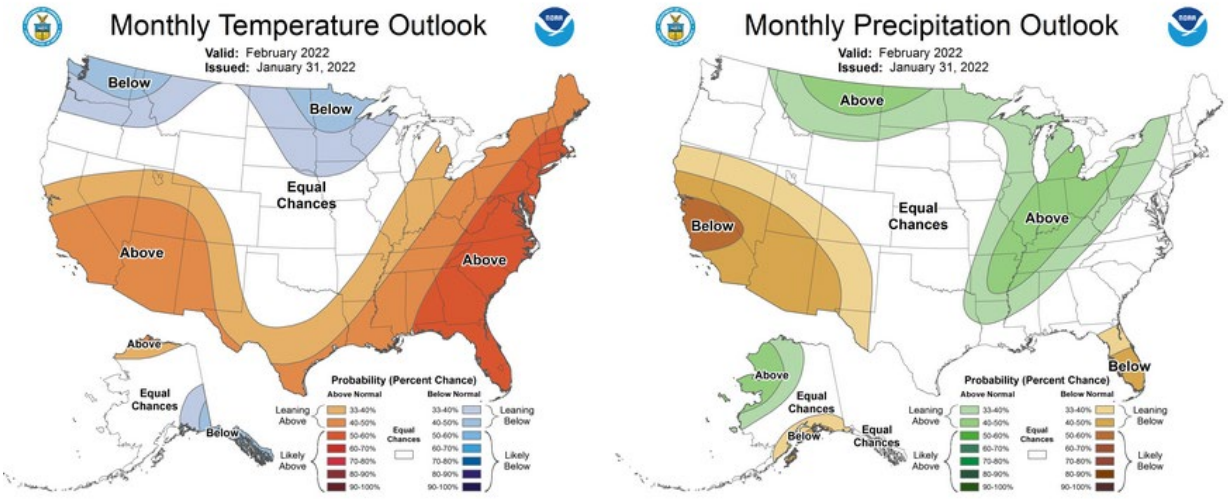


Figure 10. NOAA CPC One-Month Temperature and Precipitation Outlooks (February).

Three-month temperature and precipitation outlooks for February through April 2022 are shown below in **Figure 11**. The three-month temperature outlook indicates equal chances for above-normal, normal, or below-normal temperatures for the upper Basin except for Montana, which has increased chances of below-normal temperatures. The lower Basin has increased chances of above-normal temperatures. The three-month precipitation outlook indicates equal chances of above-normal, normal, and below-normal precipitation for most of the Basin, with increased chances of below-normal precipitation in Nebraska and western Kansas into Colorado.

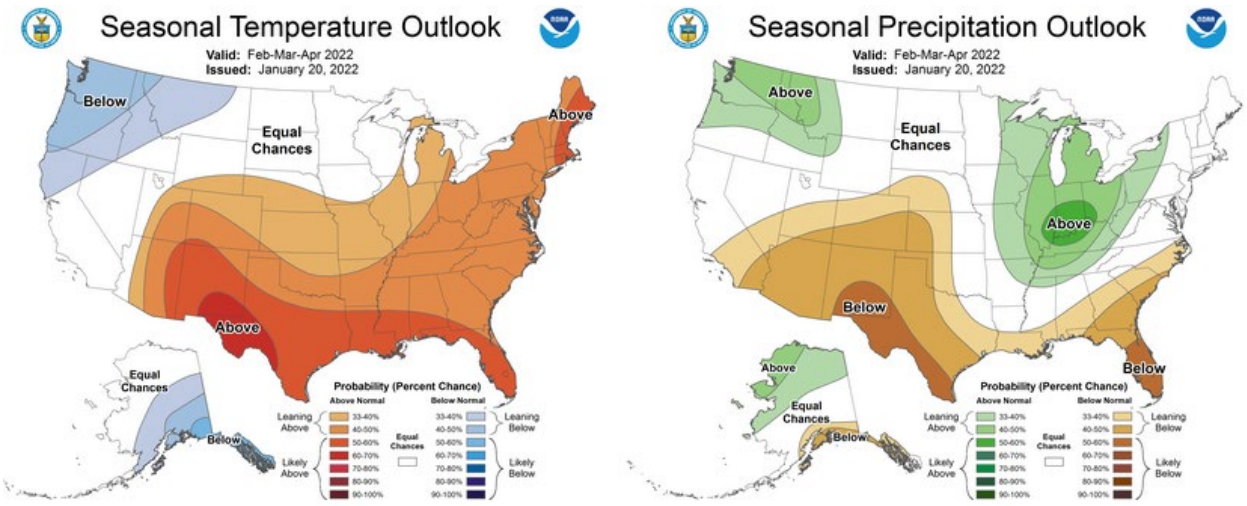


Figure 11. CPC February-March-April 2022 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be near normal in February. March and April runoff potential is low due to the dry soil moisture conditions in the western portion of the Basin and minimal snow cover, but it will depend greatly on the accumulation of plains snowpack over the next couple months. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the below-normal mountain snowpack and dry soil moisture conditions. In summary, the 2022 calendar year runoff forecast is **21.7 MAF (84% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: February 04, 2022 08:25:23 AM
   - Based on February 01, 2022 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Hebgen Lake Inflow (2)	APR-JUL	315	90	405	350	280	225	350
	APR-SEP	400	88	505	445	355	295	455

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	57	98	69	62	52	45	58
	APR-SEP	71	95	86	77	65	56	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	540	113	725	615	465	355	480
	APR-SEP	565	120	765	645	485	365	470
Bull Lake Ck nr Lenore (2)	APR-JUL	158	112	200	176	140	114	141
	APR-SEP	190	113	240	210	170	140	168
Boysen Reservoir Inflow (2)	APR-JUL	800	110	1220	970	630	375	730
	APR-SEP	850	108	1300	1030	670	400	785
Greybull R at Meeteetse	APR-JUL	145	103	210	172	118	79	141
	APR-SEP	193	97	265	225	163	120	199
Shell Ck nr Shell	APR-JUL	50	85	67	57	43	33	59
	APR-SEP	61	86	79	68	54	43	71
Bighorn R at Kane (2)	APR-JUL	1010	101	1620	1260	765	400	1000
	APR-SEP	1090	105	1750	1360	825	435	1040
NF Shoshone R at Wapiti	APR-JUL	435	97	570	490	380	300	450
	APR-SEP	480	93	625	540	420	335	515
SF Shoshone R nr Valley	APR-JUL	215	96	275	240	191	155	225
	APR-SEP	245	94	315	275	215	176	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	605	90	835	700	510	375	670
	APR-SEP	650	89	895	750	550	405	730
Bighorn R nr St. Xavier (2)	APR-JUL	1480	92	2230	1780	1170	730	1610
	APR-SEP	1560	91	2370	1890	1230	740	1720
Tongue R nr Dayton (2)	APR-JUL	76	86	105	88	65	47	88
	APR-SEP	88	86	118	100	75	57	102
Tongue River Reservoir Inflow (2)	APR-JUL	167	76	265	205	127	68	220
	APR-SEP	187	75	290	230	145	83	250
NF Powder R nr Hazelton	APR-JUL	7.2	70	9.9	8.3	6.1	4.5	10.3
	APR-SEP	7.8	70	10.6	8.9	6.7	5.0	11.1
Powder R at Moorhead	APR-JUL	128	67	245	176	80	9.7	191
	APR-SEP	139	68	260	188	89	16.7	205

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAR-JUL	4.6	71	8.3	6.1	3.1	0.93	6.5
	APR-JUL	3.7	70	7.1	5.1	2.3	0.31	5.3
Pactola Reservoir Inflow (2)	MAR-JUL	16.8	60	33	23	10.2	0.52	28
	APR-JUL	14.5	58	30	21	8.2	0.020	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	240	120	360	290	191	119	200
	APR-SEP	265	120	395	315	215	136	220
Encampment R nr Encampment (2)	APR-JUL	149	110	210	173	125	89	135
	APR-SEP	157	111	220	182	132	95	141

Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	55	112	73	62	48	37	49
	APR-SEP	57	112	76	65	49	38	51
Seminoe Reservoir Inflow (2)	APR-JUL	760	115	1160	920	600	365	660
	APR-SEP	815	114	1230	985	645	400	715
Sweetwater R nr Alcova	APR-JUL	49	109	88	65	33	10.2	45
	APR-SEP	52	106	93	69	35	10.9	49
La Prele Ck nr Douglas	APR-JUL	17.8	85	33	24	11.5	2.2	21
	APR-SEP	16.6	85	33	23	10.0	0.38	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	855	115	1400	1080	630	305	745
	APR-SEP	880	116	1450	1110	650	315	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	860	115	1430	1090	630	290	745
	APR-SEP	885	114	1470	1120	650	300	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	137	117	196	161	113	78	117
	APR-SEP	150	119	215	175	125	87	126
Little Laramie R nr Filmore	APR-JUL	62	117	86	71	52	38	53
	APR-SEP	66	118	92	77	56	41	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
March 2022 Calendar Year Runoff Forecast
March 2, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

February runoff was 0.9 MAF, 78% of average. Runoff was below normal due to colder-than-normal temperatures and less-than-normal precipitation across most of the Basin.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **20.4 MAF, 79% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **17.5 MAF**, **75% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 10 months, expected inflow could range from the 27.9 MAF upper basic forecast to the 13.8 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for February 22, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 89% of the Basin, with Extreme (D3) or Exceptional (D4) Drought present in 17% of the Basin, mostly in Montana. The Monthly Drought Outlook in **Figure 2**, which extends through the end of May, indicates drought conditions are likely to persist everywhere in the Basin.

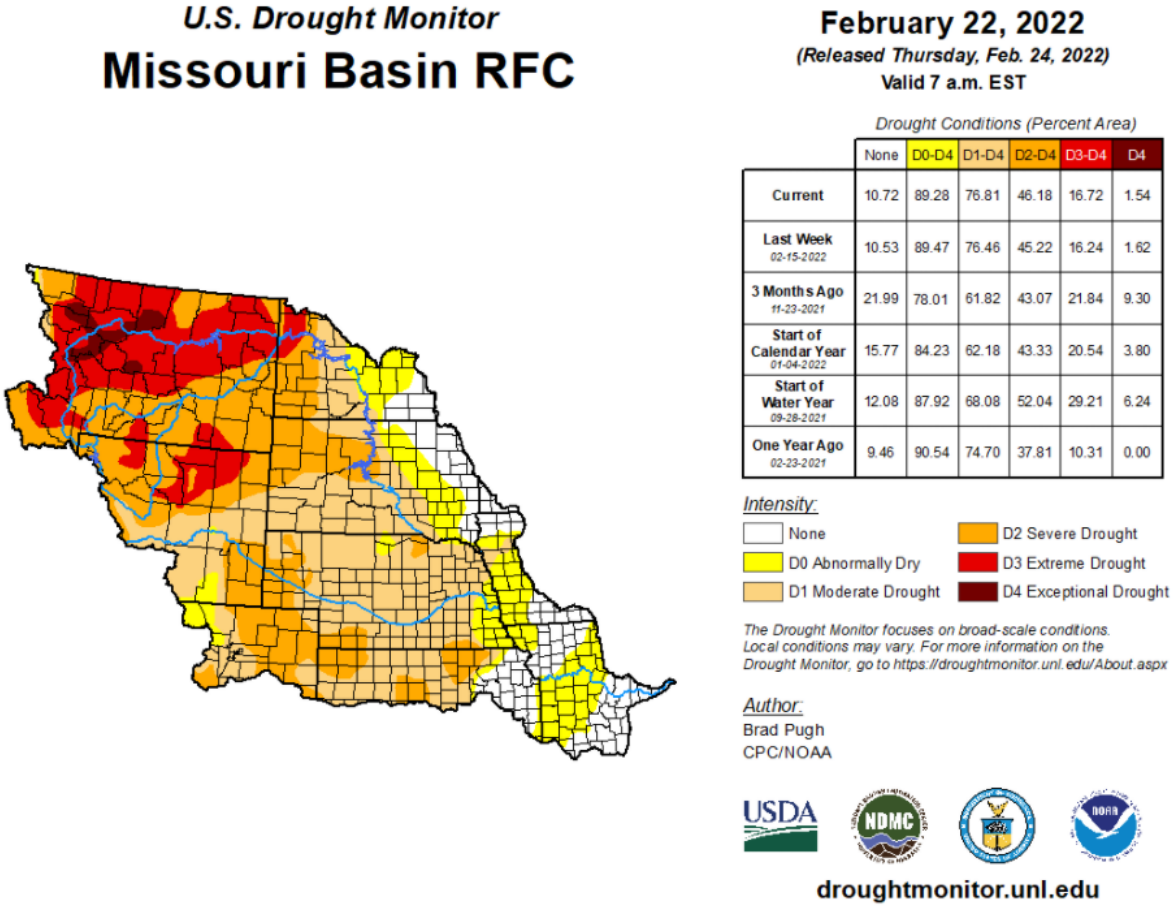
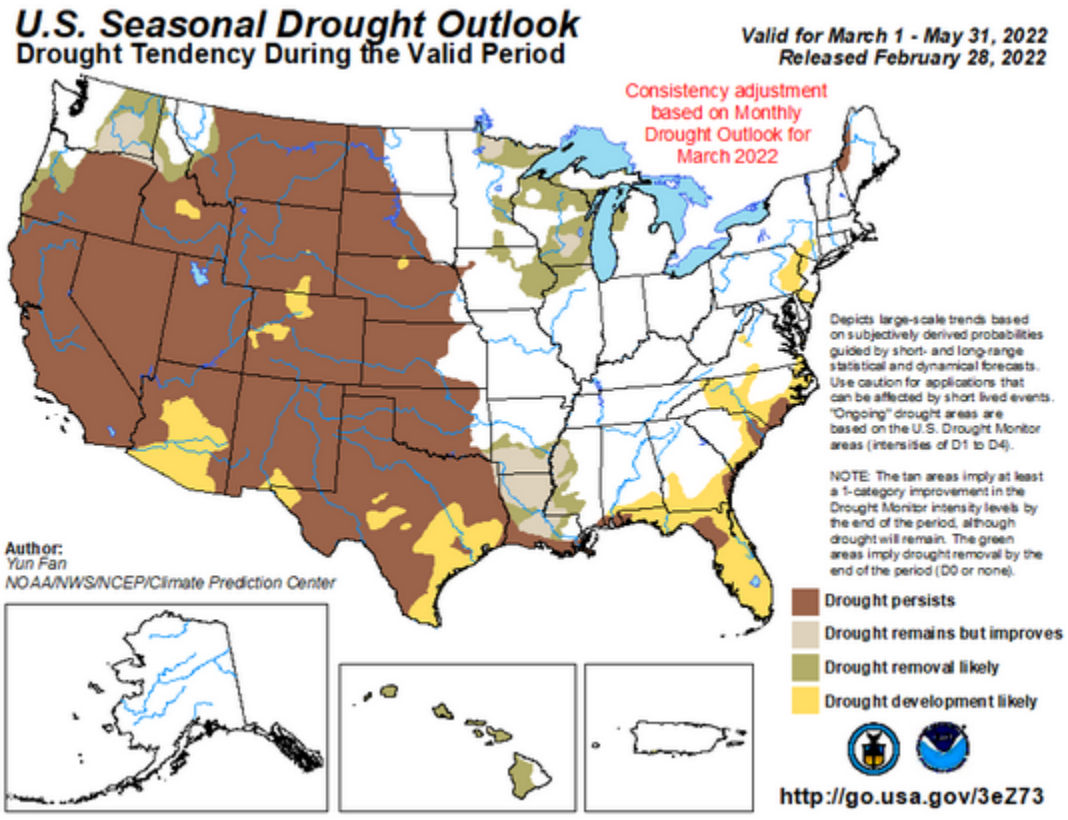


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.



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Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The February precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. February precipitation was less than 2% to 75% of normal across most of the Basin. A stretch through central Montana, Wyoming, and Colorado saw slightly above normal precipitation.

Precipitation as a percent of normal for the December 2021 – February 2022 period was below normal for most areas (**Figure 4**). Portions of Montana, Wyoming, Colorado, and North Dakota saw above normal precipitation.

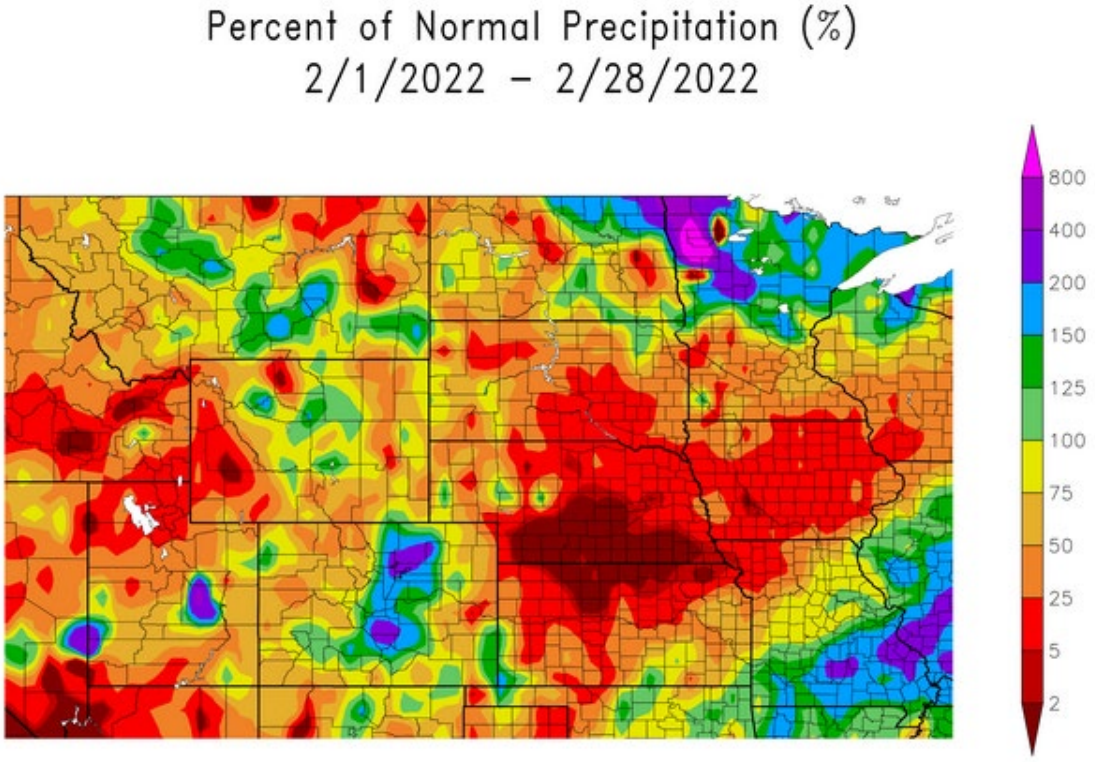


Figure 3. HPRCC February 2022 Percent of Normal Precipitation.

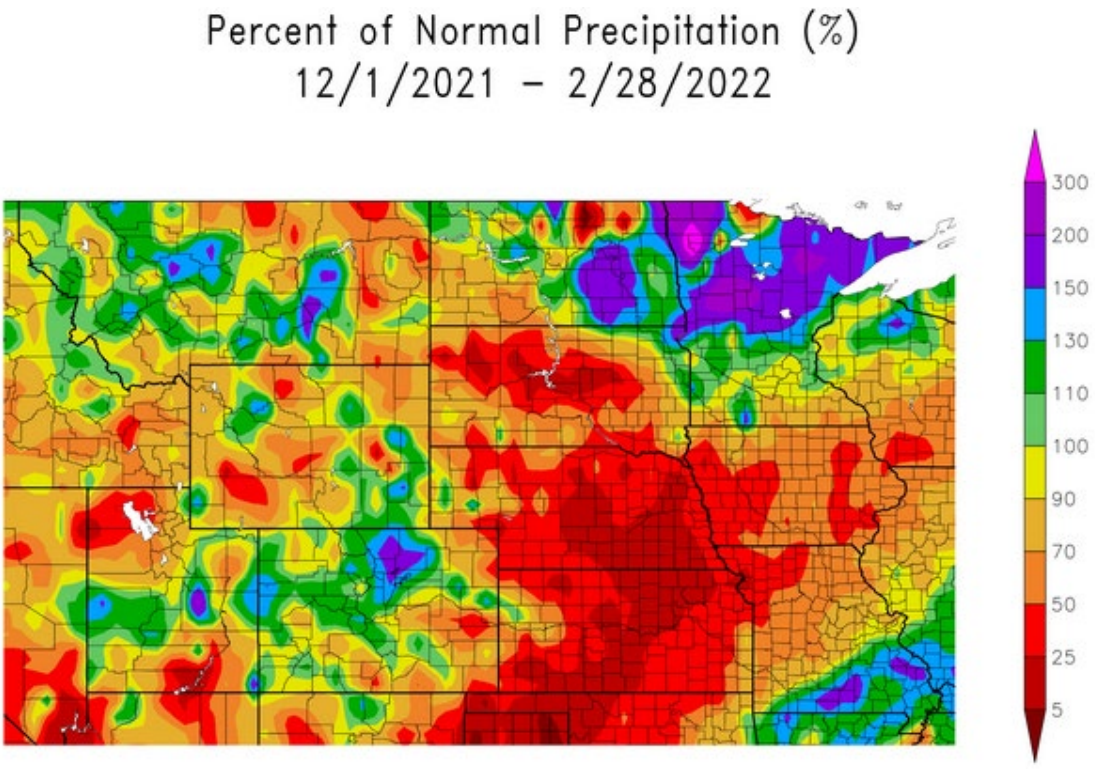
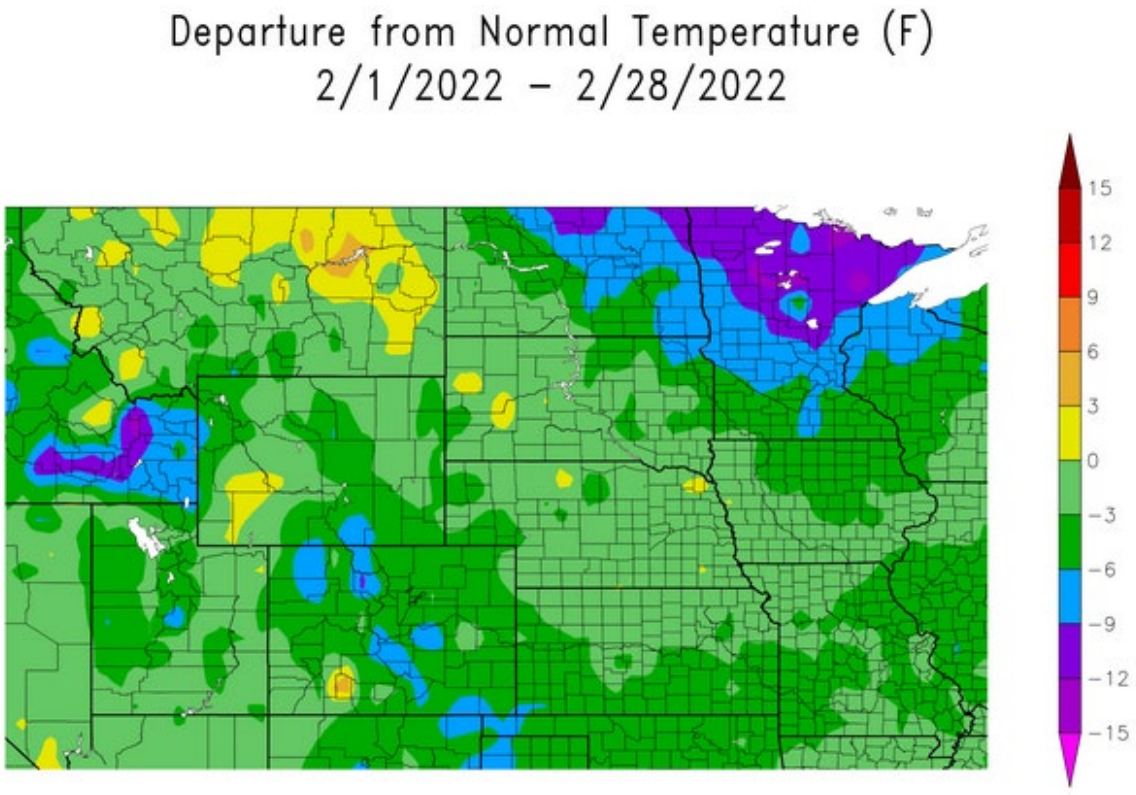


Figure 4. HPRCC December 2021 through February 2022 Percent of Normal Precipitation.

Temperature

February temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate slightly cooler-than-normal temperatures over most of the upper Basin. Most areas were 0 to 6 degrees F below normal, with an area of central Montana that was 0 to 3 degrees F above normal. December-January-February temperature departures are shown in **Figure 6**. The three-month average departures were generally 2 to 4 degrees F above normal across the entire Basin, except for Montana and North Dakota. Temperatures there were 0 to 6 degrees F below normal.



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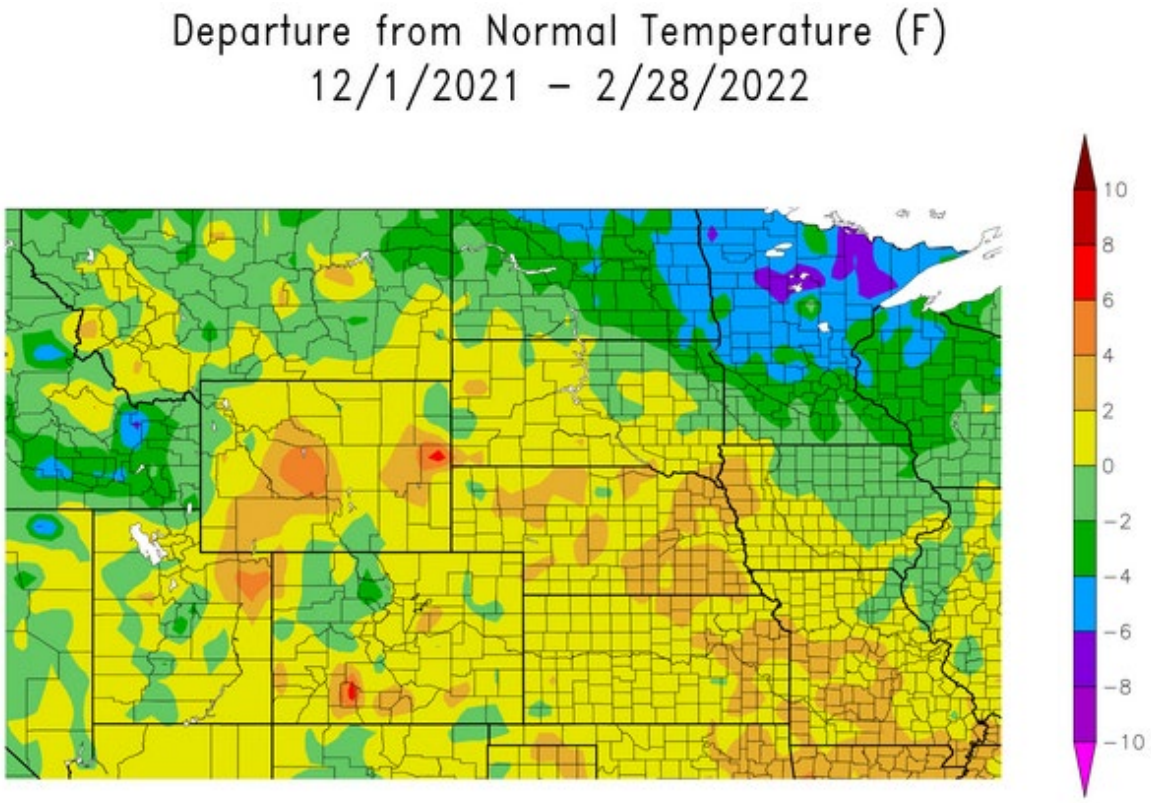

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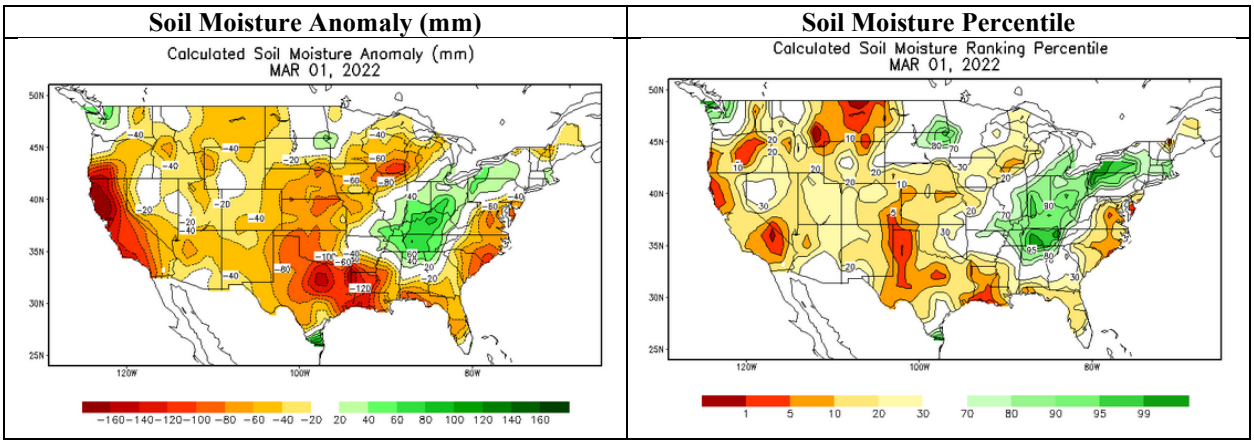
Soil moisture conditions remain dry in Montana, Wyoming, Colorado, and western North Dakota, ranking between the 1st and 30th percentiles. Soil conditions are near normal in the rest of the upper Basin except for a pocket of above-normal soil moisture in southeastern North Dakota and northeastern South Dakota. This is shown in soil moisture estimates from the Climate Prediction Center (CPC) in **Figure 7**. Both the soil moisture anomalies and the soil moisture percentiles are shown in **Figure 7**



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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 is 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 this time of year, plains snowpack provides some indication of March-April runoff; however, as the snowpack reaches its ultimate peak accumulation, better forecasts of future runoff can be made.

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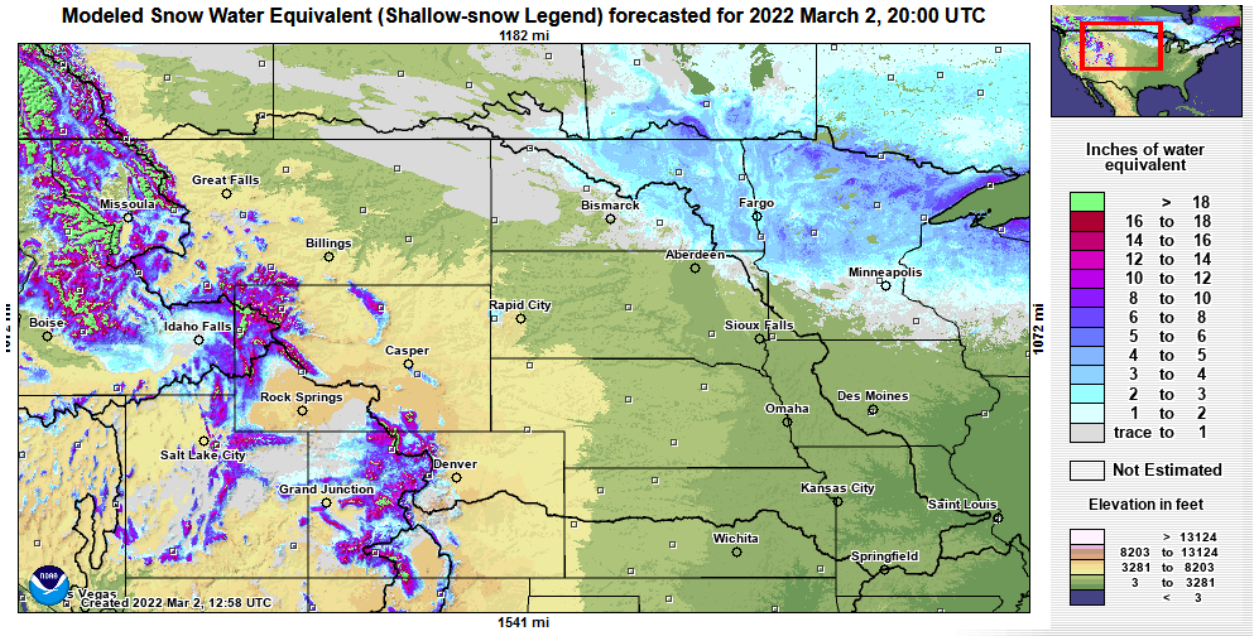


Figure 8. NOAA National Operational Hydrologic Remote Sensing Center modeled plains snow water equivalent.
http://www.nohrsc.nws.gov/interactive/html/map.html

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. On average, 79% of the mountain snowpack has accumulated by March 1. Mountain snowpack typically peaks in mid-April.

Figure 9 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

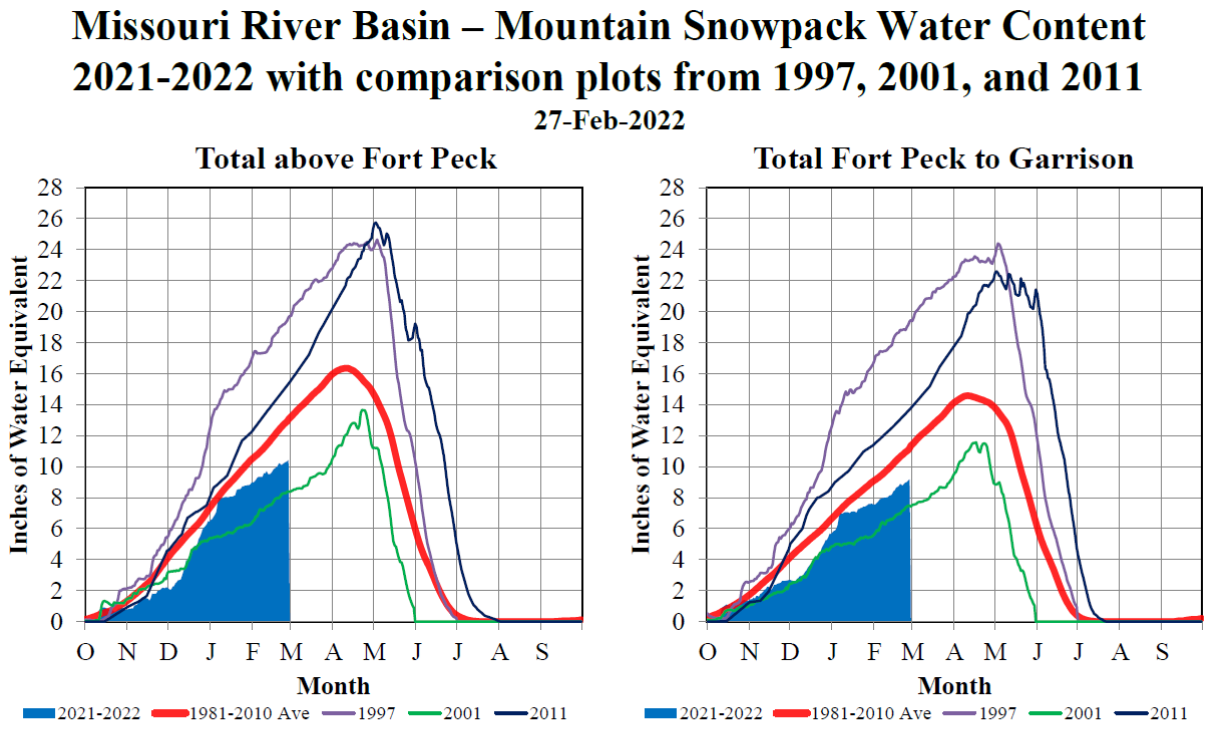


Figure 9. Mountain snowpack water content on February 27, 2022 compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of February 27, 2022, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 10.4 inches, which is 80% of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 9.2 inches, which is 82% of average based on the 1981-2010 average SWE for the Garrison reach.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 77% chance of continuing during March-May 2022, and there is a 56% chance of transitioning to ENSO-neutral conditions during May-July 2022.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The March CPC temperature outlook (**Figure 10**) indicates increased chances for below-normal temperatures across the upper Basin and increased chances for above-normal precipitation in Montana and northwestern Wyoming, with equal chances of above-normal, normal, or below-normal precipitation for the rest of the Basin.

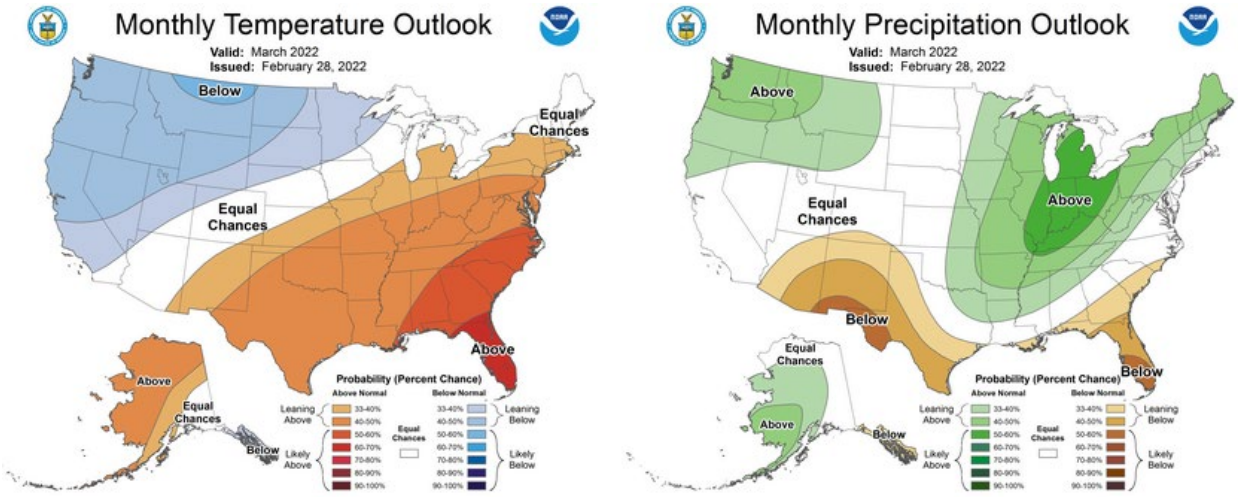


Figure 10. NOAA CPC One-Month Temperature and Precipitation Outlooks (March).

Three-month temperature and precipitation outlooks for April through December 2022 are shown below in **Figures 11** through **13**. The three-month temperature outlooks indicate equal chances for above-normal, normal, or below-normal temperatures for Montana and North Dakota in April, expanding to the entire Basin by the end of December. The precipitation outlooks

indicate either increased chances for below-normal precipitation, or equal chances through the remainder of the year in the upper Basin.

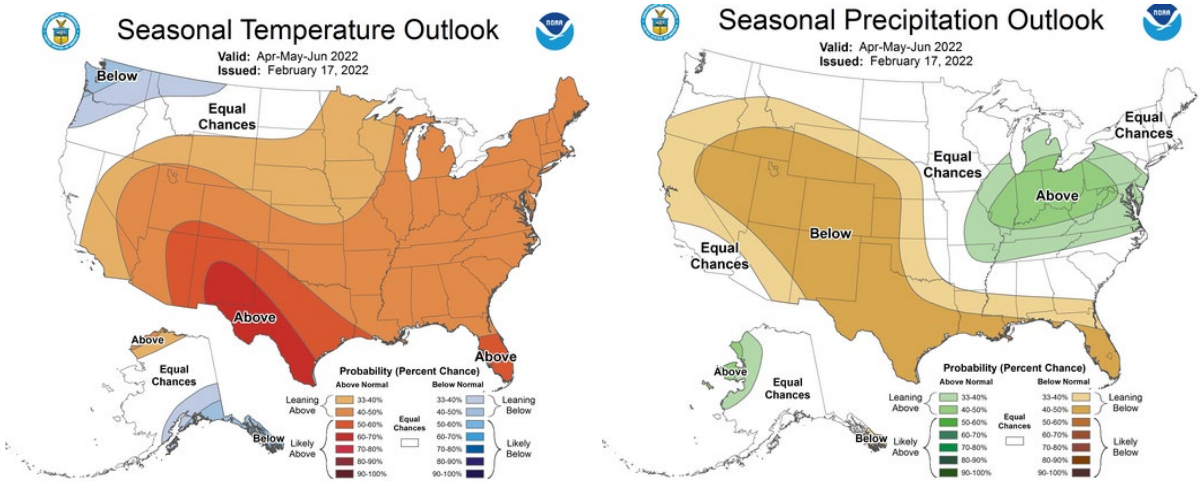


Figure 11. CPC April-May-June 2022 temperature and precipitation outlooks.

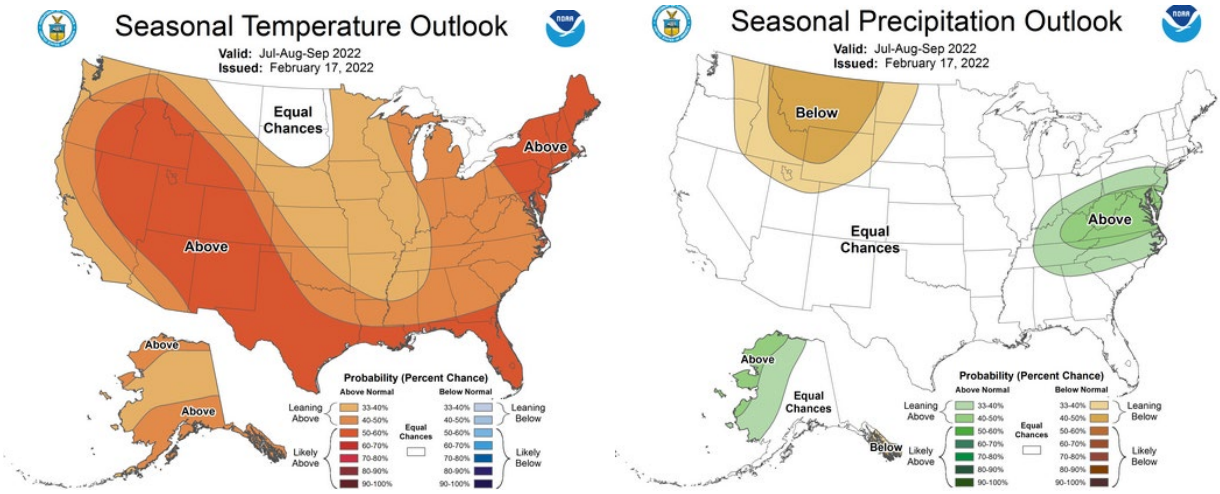


Figure 12. CPC July-August-September 2022 temperature and precipitation outlooks.

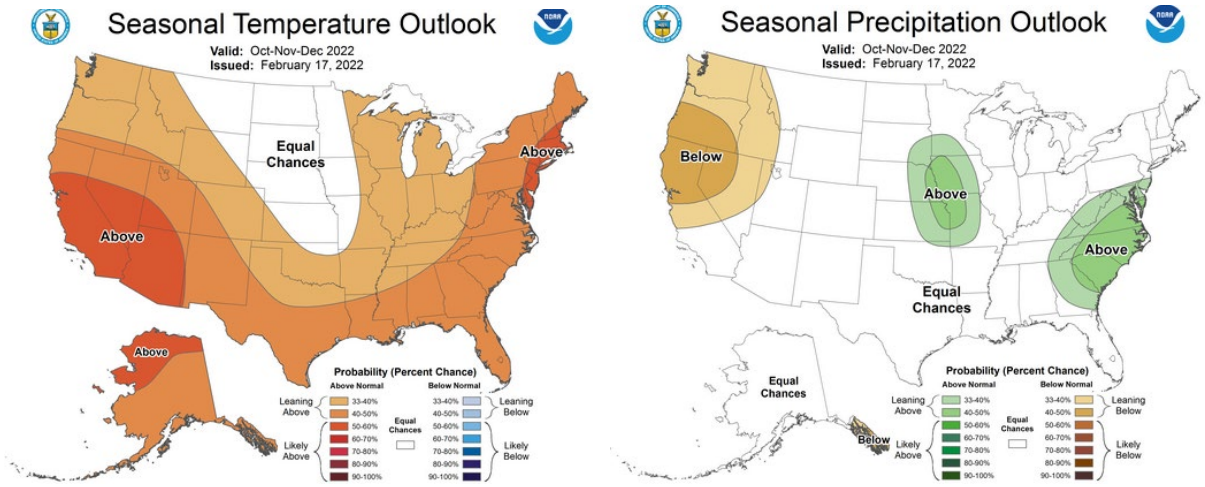


Figure 13. CPC October-November-December 2022 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal for the remainder of the year. March and April runoff potential is low due to the dry soil moisture conditions in the western portion of the Basin and minimal snow cover, but it will depend greatly on the accumulation of plains snowpack over the next month. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the below-normal mountain snowpack and dry soil moisture conditions. During May, June, and July in the other reaches, as well as the remainder of the year in all reaches, we expect runoff to be below normal, but this could vary based on precipitation events in the spring, summer, and fall. In summary, the 2022 calendar year runoff forecast is **20.4 MAF (79% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: March 04, 2022 11:41:33 AM
   - Based on March 01, 2022 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	APR-JUL	101	102	123	110	92	79	99
	APR-SEP	115	99	139	125	105	91	116
St. Mary R at Intl Boundary (2)	APR-JUL	470	104	590	520	420	350	450
	APR-SEP	530	104	660	585	475	400	510
Lima Reservoir Inflow (2)	APR-JUL	55	87	91	69	41	19.4	63
	APR-SEP	58	79	97	74	42	18.9	73
Clark Canyon Inflow (2)	APR-JUL	47	75	105	71	23	0.63	63
	APR-SEP	58	83	121	83	33	0.70	70
Jefferson R nr Three Forks (2)	APR-JUL	520	72	945	695	350	97	720
	APR-SEP	550	78	980	725	375	122	705
Hebgen Lake Inflow (2)	APR-JUL	275	79	360	310	240	190	350
	APR-SEP	360	79	460	400	320	260	455
Ennis Lake Inflow (2)	APR-JUL	510	83	660	570	450	360	615
	APR-SEP	640	85	815	710	570	465	750
Missouri R at Toston (2)	APR-JUL	1350	76	2020	1620	1080	680	1780
	APR-SEP	1500	76	2240	1800	1200	765	1970
Smith R bl Eagle Ck (2)	APR-JUL	69	64	120	89	48	17.7	108
	APR-SEP	74	65	130	97	52	18.7	114
Gibson Reservoir Inflow (2)	APR-JUL	395	105	505	440	350	285	375
	APR-SEP	425	102	545	475	375	305	415
Marias R nr Shelby (2)	APR-JUL	360	109	530	430	290	191	330
	APR-SEP	365	107	545	435	295	186	340

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	53	91	63	57	49	43	58
	APR-SEP	67	89	80	72	62	54	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	505	105	660	570	440	350	480
	APR-SEP	515	110	685	585	445	345	470
Bull Lake Ck nr Lenore (2)	APR-JUL	145	103	184	161	128	105	141
	APR-SEP	175	104	220	193	156	129	168
Boysen Reservoir Inflow (2)	APR-JUL	735	101	1120	890	580	350	730
	APR-SEP	775	99	1180	940	610	370	785
Greybull R at Meeteetse	APR-JUL	142	101	210	169	115	76	141
	APR-SEP	189	95	265	220	159	115	199
Shell Ck nr Shell	APR-JUL	49	83	65	55	42	32	59
	APR-SEP	60	85	78	67	52	41	71
Bighorn R at Kane (2)	APR-JUL	975	98	1560	1210	740	395	1000
	APR-SEP	1020	98	1650	1280	775	405	1040
NF Shoshone R at Wapiti	APR-JUL	405	90	530	455	355	280	450
	APR-SEP	450	87	585	505	395	315	515
SF Shoshone R nr Valley	APR-JUL	210	93	265	235	187	153	225
	APR-SEP	240	92	305	265	215	174	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	580	87	785	665	495	375	670
	APR-SEP	635	87	860	725	545	410	730
Bighorn R nr St. Xavier (2)	APR-JUL	1420	88	2140	1710	1130	705	1610
	APR-SEP	1470	85	2260	1790	1150	685	1720
Little Bighorn R nr Hardin	APR-JUL	86	84	139	107	64	32	102
	APR-SEP	97	80	156	121	73	38	121
Tongue R nr Dayton (2)	APR-JUL	78	89	109	90	66	47	88
	APR-SEP	90	88	123	103	77	57	102
Tongue River Reservoir Inflow (2)	APR-JUL	174	79	280	215	132	70	220
	APR-SEP	195	78	305	240	150	85	250
NF Powder R nr Hazelton	APR-JUL	7.2	70	10.3	8.5	5.9	4.1	10.3
	APR-SEP	7.8	70	11.0	9.1	6.5	4.6	11.1

Powder R at Moorhead	APR-JUL	126	66	255	178	75	1.91	191
	APR-SEP	136	66	270	190	83	3.6	205
Powder R nr Locate	APR-JUL	146	65	290	205	89	3.8	225
	APR-SEP	156	65	305	215	95	4.8	240

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAR-JUL	4.8	74	8.1	6.2	3.4	1.46	6.5
	APR-JUL	4.0	75	7.1	5.2	2.8	0.93	5.3
Pactola Reservoir Inflow (2)	MAR-JUL	17.3	62	31	23	11.8	3.7	28
	APR-JUL	14.5	58	27	19.8	9.3	1.67	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	200	100	315	245	153	83	200
	APR-SEP	220	100	345	270	169	94	220
Encampment R nr Encampment (2)	APR-JUL	128	95	189	153	103	67	135
	APR-SEP	137	97	200	163	111	73	141
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	47	96	64	54	40	30	49
	APR-SEP	50	98	68	57	43	32	51
Seminoe Reservoir Inflow (2)	APR-JUL	645	98	1040	805	485	250	660
	APR-SEP	705	99	1120	870	535	290	715
Sweetwater R nr Alcova	APR-JUL	40	89	76	55	25	4.1	45
	APR-SEP	44	90	82	59	29	5.8	49
La Prele Ck nr Douglas	APR-JUL	18.1	86	35	25	11.5	1.67	21
	APR-SEP	17.2	88	34	24	10.4	0.29	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	710	95	1260	935	485	157	745
	APR-SEP	745	98	1310	975	515	174	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	710	95	1290	945	480	139	745
	APR-SEP	745	96	1330	985	505	157	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	121	103	177	144	98	65	117
	APR-SEP	131	104	191	155	107	71	126
Little Laramie R nr Filmore	APR-JUL	50	94	72	59	41	27	53
	APR-SEP	53	95	77	63	44	30	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
April 2022 Calendar Year Runoff Forecast
April 4, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

March runoff was 1.5 MAF, 48% of average. Runoff was well below normal due to dry soil conditions and well below-normal precipitation across the basin.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **17.8 MAF, 69% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **15.5 MAF**, **67% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 9 months, expected inflow could range from the 23.4 MAF upper basic forecast to the 12.8 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for March 29, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 85% of the Basin, with Extreme (D3) Drought present in 19% of the Basin, mostly in Montana. The Monthly Drought Outlook in **Figure 2**, which extends through the end of June, indicates drought conditions are likely to persist everywhere in the Basin.

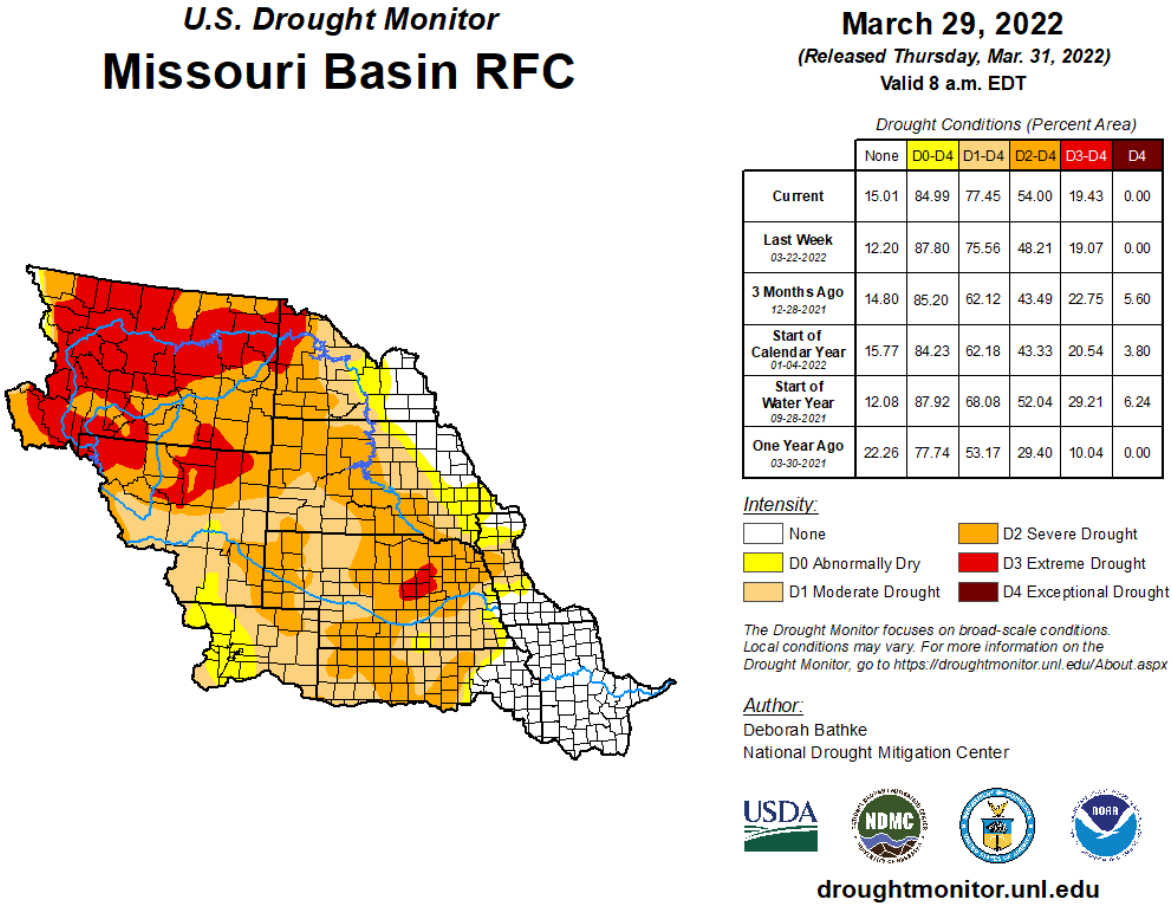


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

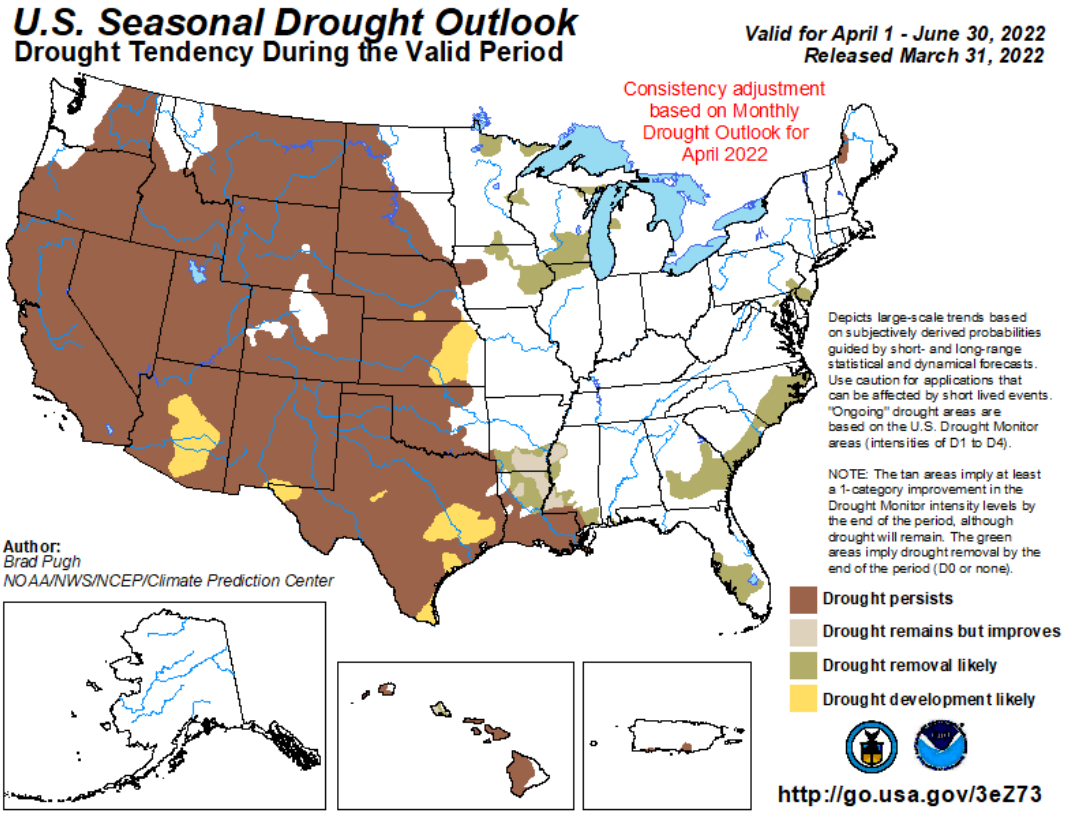


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The March precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. March precipitation was less than 5% to 70% of normal across most of the Basin. Normal to above-normal precipitation was observed in the lower basin south of Omaha, NE.

Precipitation as a percent of normal for the January – March 2022 period was below normal for most of the Basin (**Figure 4**), except for a small area in Colorado and southeastern Wyoming.

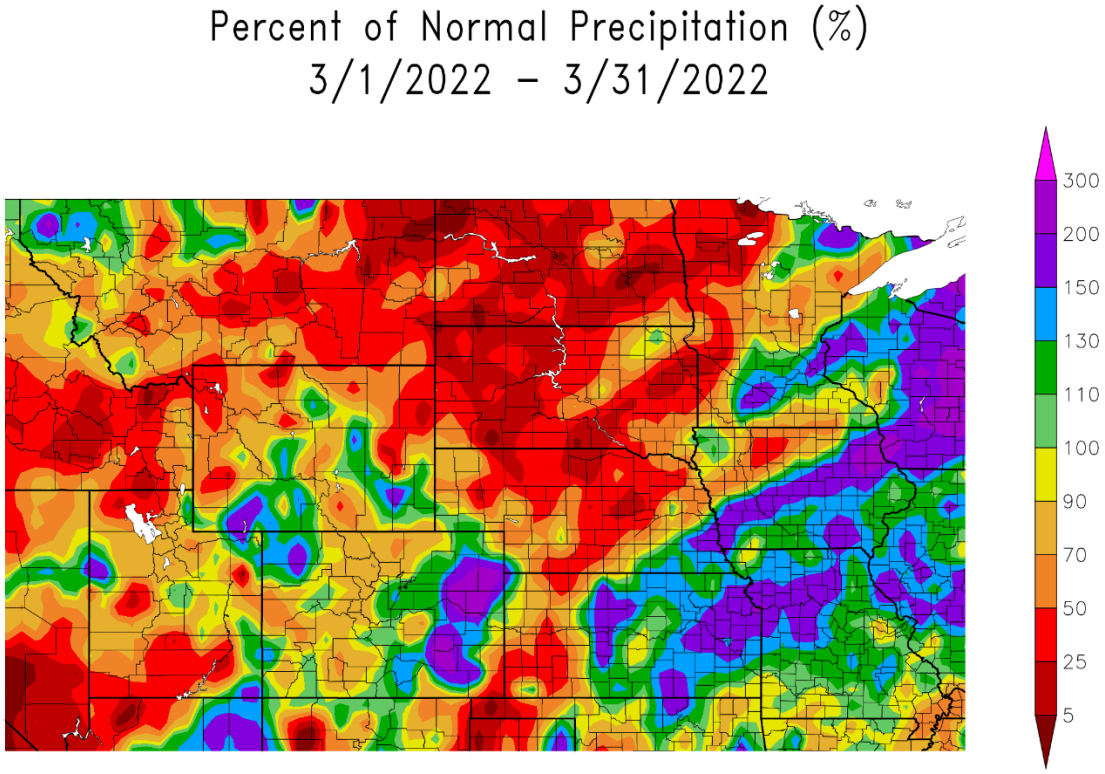


Figure 3. HPRCC March 2022 Percent of Normal Precipitation.

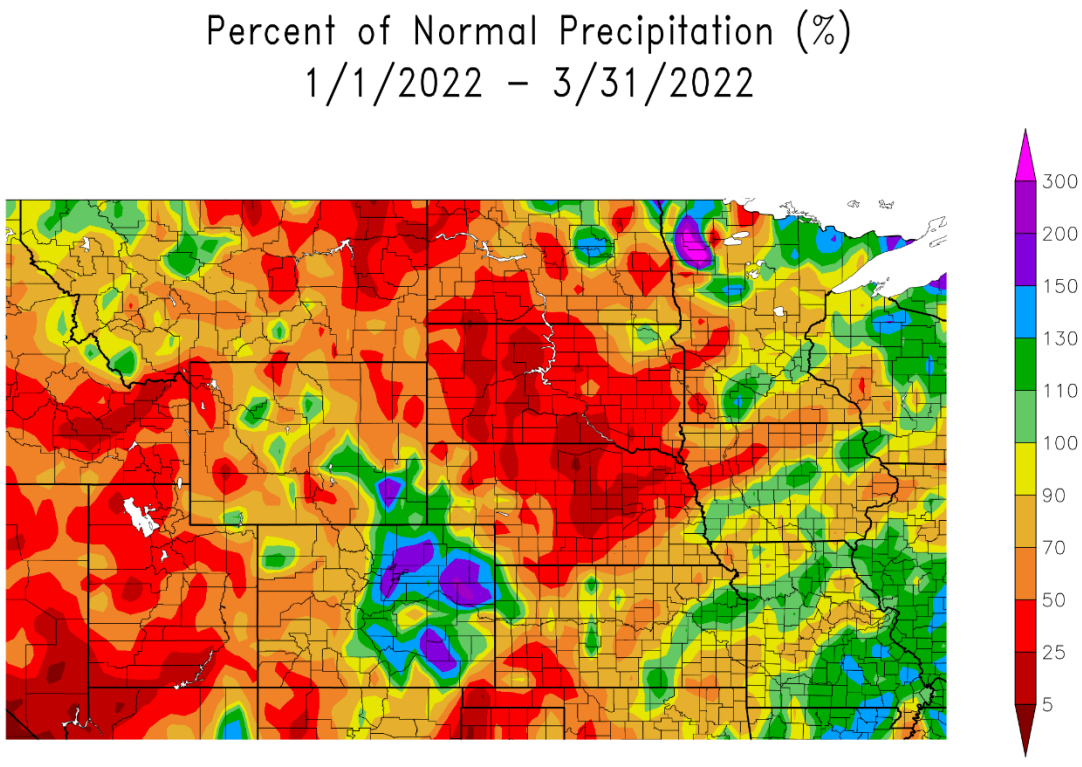


Figure 4. HPRCC January through March 2022 Percent of Normal Precipitation.

Temperature

March temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate normal to slightly above-normal temperatures in Montana, parts of the Dakotas, and into eastern Nebraska and Iowa and Missouri. Normal to slightly below-normal temperatures were observed in the rest of the Basin. January – March 2022 temperature departures are shown in **Figure 6**. The same trend is present over the last quarter, with Montana and western South Dakota observing slightly warmer than normal temperatures, while the rest of the basin saw slightly cooler than normal temperatures.

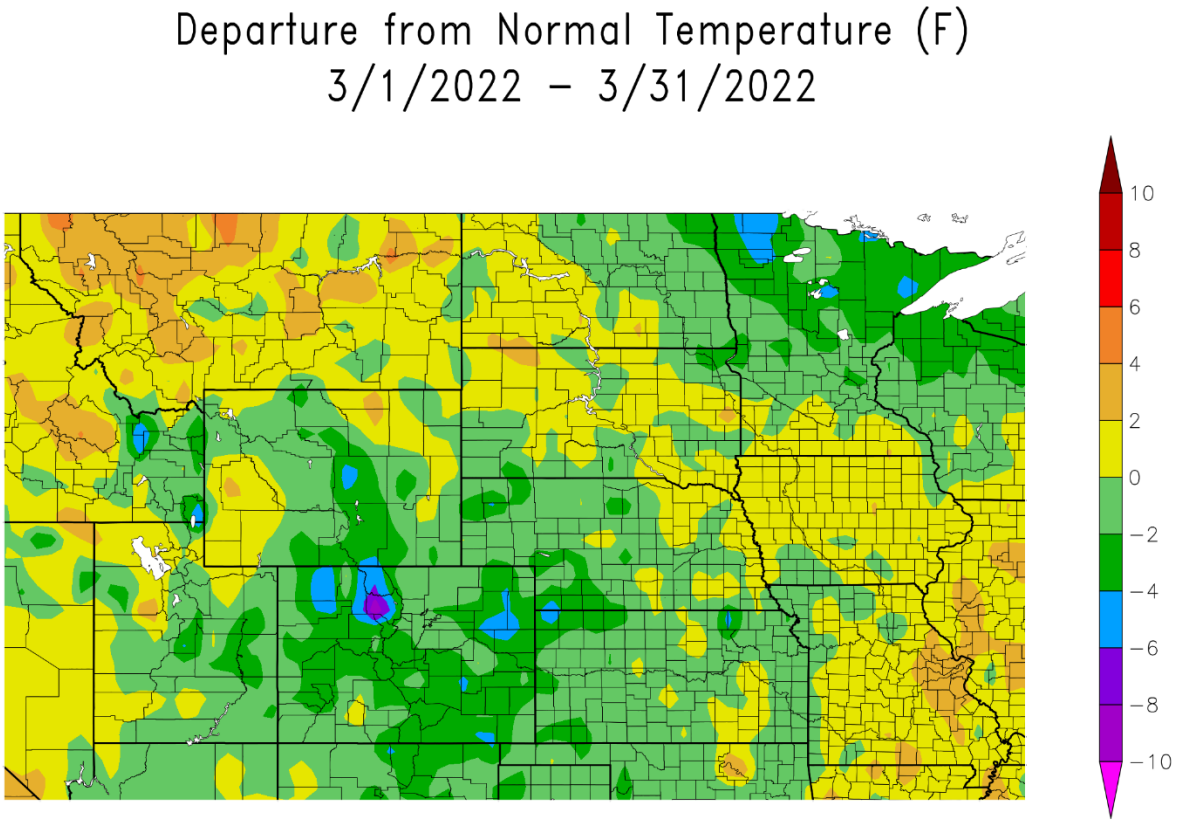


Figure 5. HPRCC February 2022 Departure from Normal Temperature.

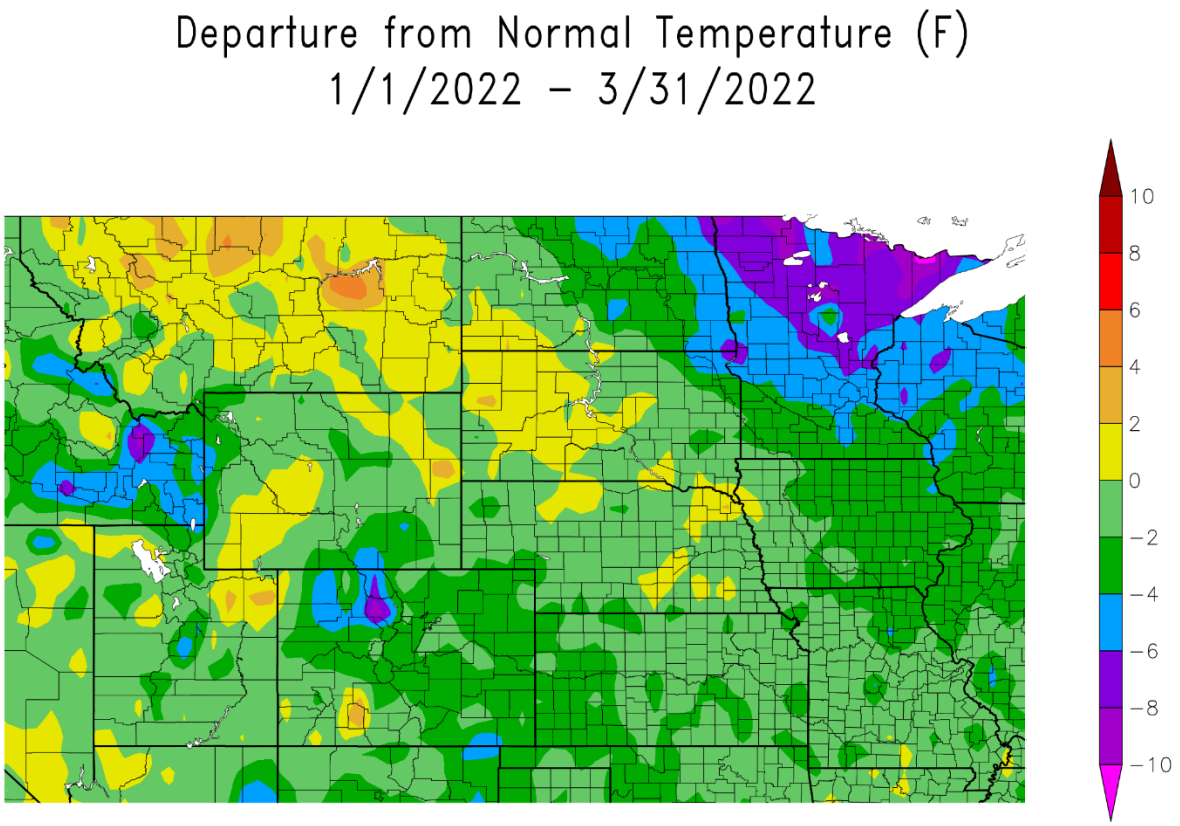


Figure 6. HPRCC January through March 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry in much of the Basin except for eastern North Dakota, northeastern South Dakota, and Missouri. A pocket of above-normal soil moisture is observed in northeastern South Dakota into southeastern North Dakota. Soil moisture rankings are in the 1st to 5th percentile for much of Montana, the driest area in the Basin. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

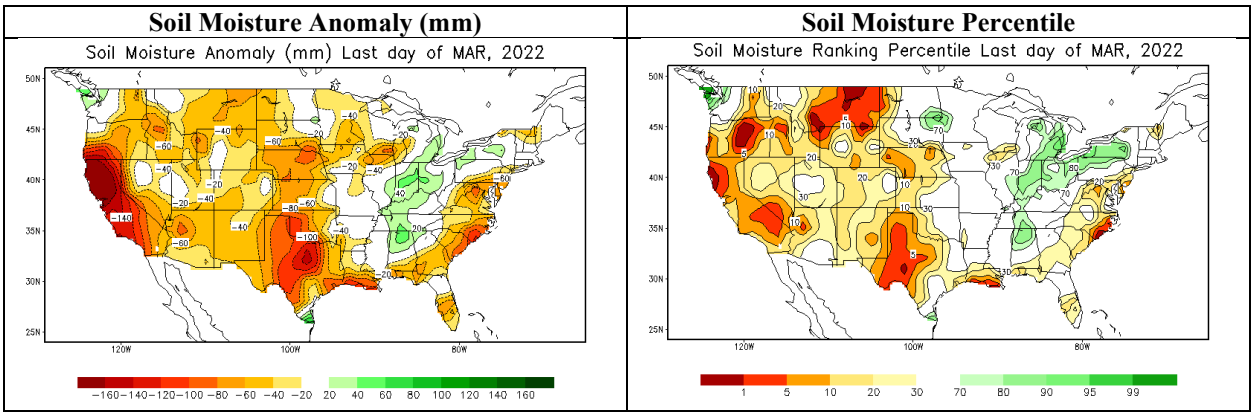


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) modeled snow assessment from April 1 indicates plains snowmelt in the Basin is non-existent.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. On average, 97% of the mountain snowpack has accumulated by April 1. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

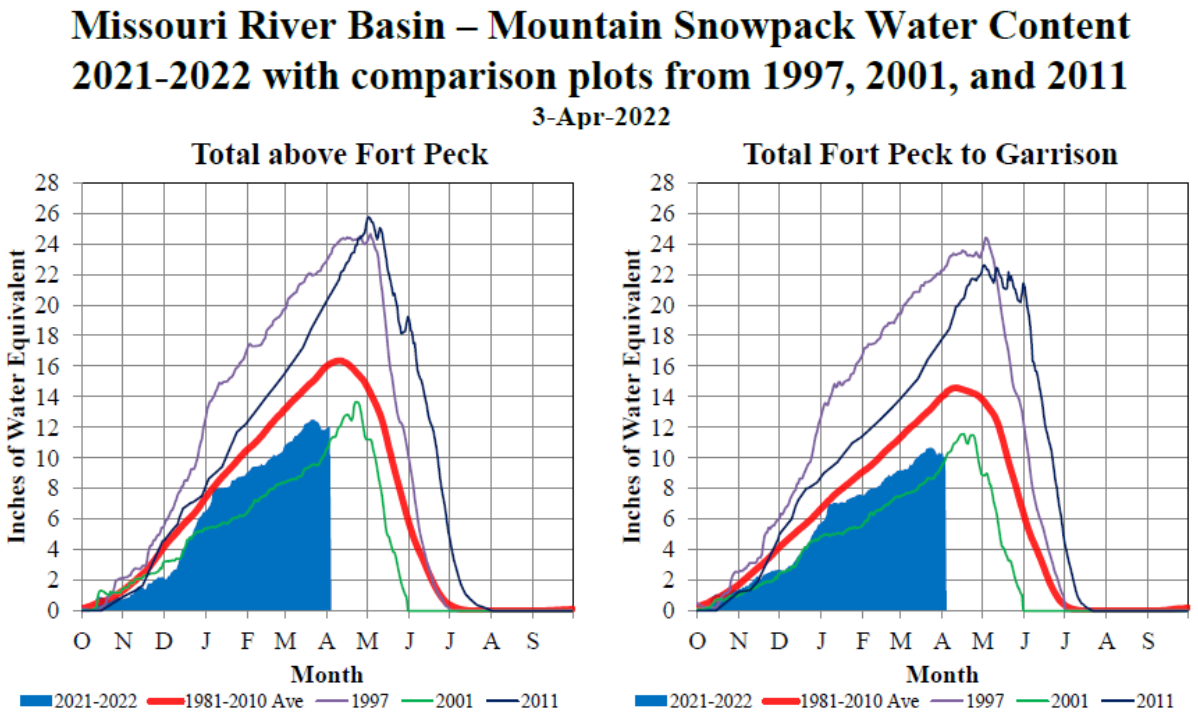


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

As of April 3, 2022, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 12.0 inches, which is 75 of average based on the 1981-2010 average SWE for the Fort Peck reach. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 10.1 inches, which is 71% of average based on the 1981-2010 average SWE for the Garrison reach.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 53% chance of continuing during June through August 2022, and there is a 40-50% chance of continuing La Niña or transitioning to ENSO-neutral conditions after August.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The April CPC temperature outlook (**Figure 9**) indicates equal chances for above-normal, normal, or below-normal temperatures across the upper Basin and increased chances for above-normal temperatures in the lower Basin. The outlook indicates equal chances of above-normal, normal, or below-normal precipitation.

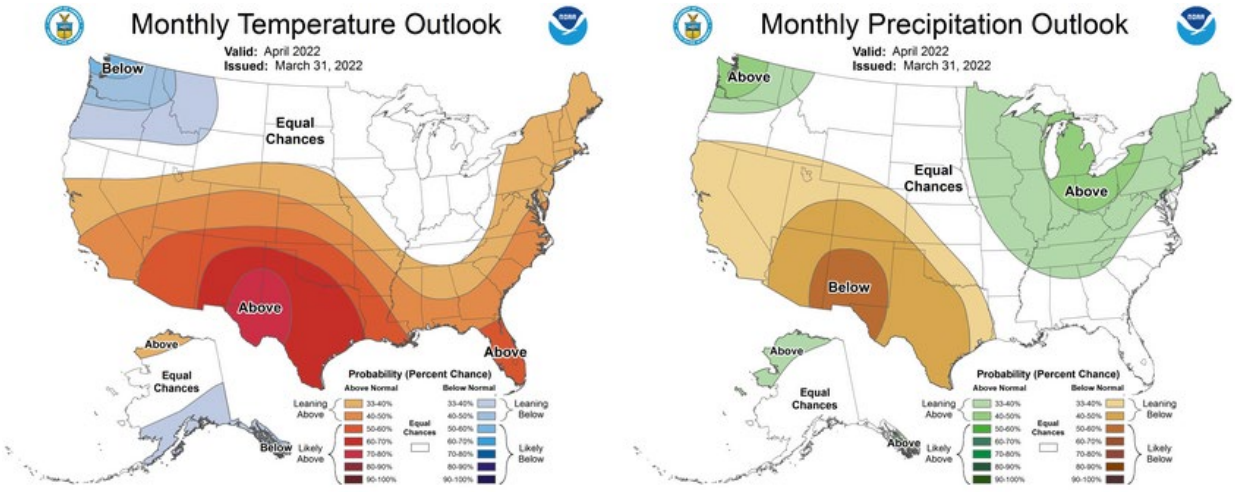


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (April).

Three-month temperature and precipitation outlooks for April through December 2022 are shown below in **Figure 10** through **12**. The three-month temperature outlooks indicate warmer-than-normal temperatures for the Basin until winter, when no indicators are present. The precipitation outlooks indicate below-normal precipitation for the Basin until winter, when no indicators are present.

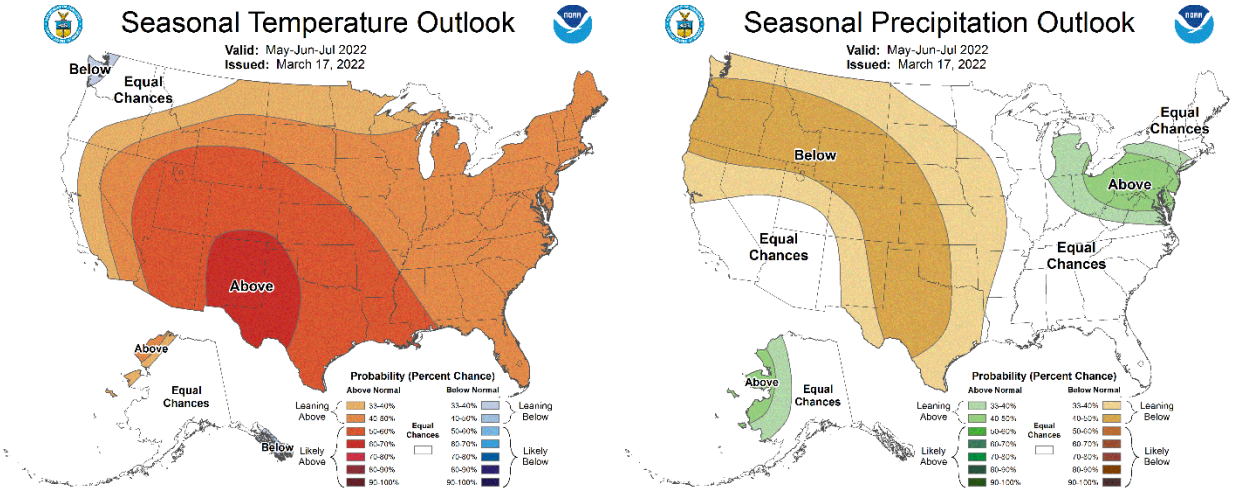


Figure 10. CPC May-June-July 2022 temperature and precipitation outlooks.

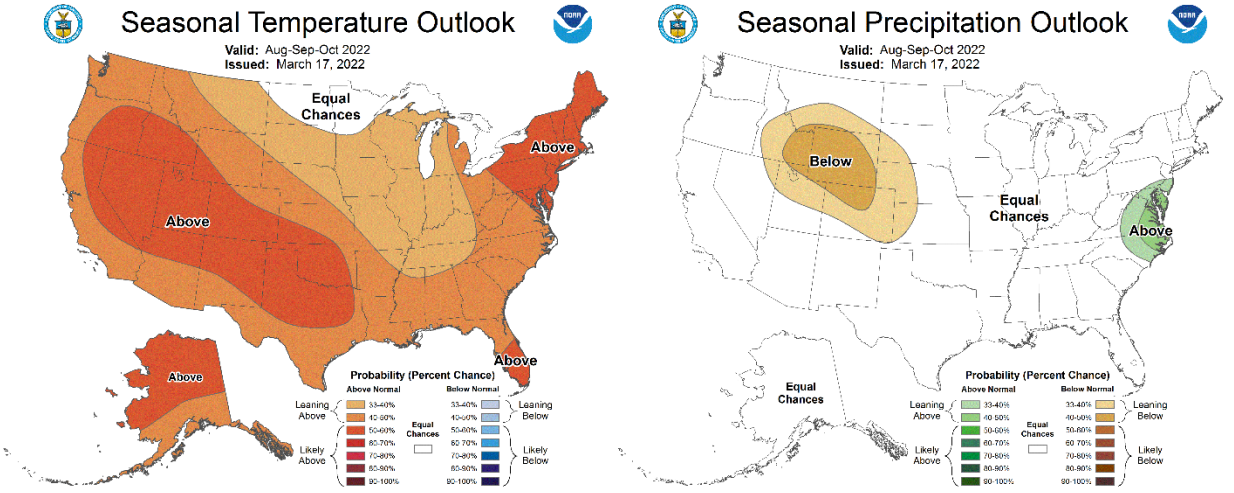


Figure 11. CPC August-September-October 2022 temperature and precipitation outlooks.

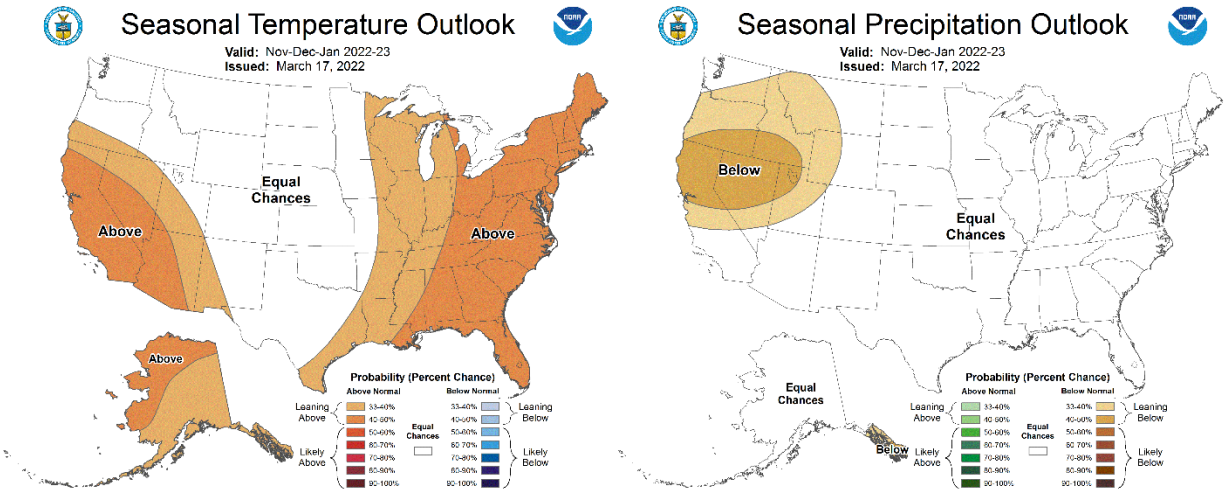


Figure 12. CPC November-December-January 2022-2023 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal for the remainder of the year. April runoff potential is low due to the dry soil moisture conditions and a lack of plains snowpack. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the below-normal mountain snowpack and dry soil moisture conditions. During May, June, and July in the other reaches, as well as the remainder of the year in all reaches, we expect runoff to be below normal, but this could vary based on precipitation events in the spring, summer, and fall. In summary, the 2022 calendar year runoff forecast is **17.8 MAF (69% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: April 05, 2022 02:26:36 PM
   - Based on April 01, 2022 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	APR-JUL	104	105	123	112	96	85	99
	APR-SEP	117	101	139	126	108	95	116
St. Mary R at Intl Boundary (2)	APR-JUL	475	106	580	520	430	370	450
	APR-SEP	540	106	660	590	490	420	510
Lima Reservoir Inflow (2)	APR-JUL	39	62	67	50	28	10.9	63
	APR-SEP	50	68	80	62	38	19.7	73
Clark Canyon Inflow (2)	APR-JUL	25	40	74	45	11.3	0.63	63
	APR-SEP	36	51	91	58	13.7	0.70	70
Jefferson R nr Three Forks (2)	APR-JUL	355	49	690	490	215	15.8	720
	APR-SEP	375	53	740	520	225	8.7	705
Hebgen Lake Inflow (2)	APR-JUL	245	70	315	275	215	173	350
	APR-SEP	325	71	410	360	290	240	455
Ennis Lake Inflow (2)	APR-JUL	460	75	580	510	410	340	615
	APR-SEP	580	77	725	640	520	435	750
Missouri R at Toston (2)	APR-JUL	1100	62	1710	1350	860	495	1780
	APR-SEP	1260	64	1930	1530	980	580	1970
Smith R bl Eagle Ck (2)	APR-JUL	57	53	108	78	36	6.1	108
	APR-SEP	62	54	117	84	40	6.8	114
Gibson Reservoir Inflow (2)	APR-JUL	395	105	485	430	360	305	375
	APR-SEP	430	104	530	470	390	330	415
Marias R nr Shelby (2)	APR-JUL	355	108	515	420	290	193	330
	APR-SEP	360	106	535	430	290	185	340

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	APR-JUL	49	84	58	53	45	40	58
	APR-SEP	62	83	74	67	57	50	75
Wind R Ab Bull Lake Ck (2)	APR-JUL	430	90	580	490	370	280	480
	APR-SEP	445	95	610	510	380	280	470
Bull Lake Ck nr Lenore (2)	APR-JUL	127	90	163	142	112	91	141
	APR-SEP	153	91	195	170	136	111	168
Boysen Reservoir Inflow (2)	APR-JUL	565	77	915	705	425	220	730
	APR-SEP	590	75	955	735	440	220	785
Greybull R at Meeteetse	APR-JUL	130	92	195	156	104	65	141
	APR-SEP	175	88	250	205	145	101	199
Shell Ck nr Shell	APR-JUL	46	78	61	52	40	31	59
	APR-SEP	57	80	74	64	50	40	71
Bighorn R at Kane (2)	APR-JUL	755	76	1300	975	540	215	1000
	APR-SEP	785	75	1360	1020	550	205	1040
NF Shoshone R at Wapiti	APR-JUL	360	80	465	400	320	255	450
	APR-SEP	405	79	515	450	360	295	515
SF Shoshone R nr Valley	APR-JUL	184	82	235	205	163	133	225
	APR-SEP	215	83	275	240	191	156	260
Buffalo Bill Reservoir Inflow (2)	APR-JUL	510	76	685	580	440	335	670
	APR-SEP	560	77	750	635	485	370	730
Bighorn R nr St. Xavier (2)	APR-JUL	1130	70	1800	1400	855	450	1610
	APR-SEP	1150	67	1900	1460	850	405	1720
Little Bighorn R nr Hardin	APR-JUL	76	75	125	96	56	27	102
	APR-SEP	87	72	142	109	65	32	121
Tongue R nr Dayton (2)	APR-JUL	74	84	100	85	63	48	88
	APR-SEP	85	83	114	97	73	56	102
Tongue River Reservoir Inflow (2)	APR-JUL	163	74	250	199	127	75	220
	APR-SEP	180	72	275	220	142	86	250
NF Powder R nr Hazelton	APR-JUL	7.3	71	10.4	8.5	6.1	4.2	10.3
	APR-SEP	7.9	71	11.1	9.2	6.6	4.7	11.1

Powder R at Moorhead	APR-JUL	123	64	245	173	72	1.91	191
	APR-SEP	132	64	260	183	81	5.0	205
Powder R nr Locate	APR-JUL	143	64	280	198	89	8.6	225
	APR-SEP	151	63	290	210	95	11.1	240

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	APR-JUL	2.8	53	5.9	4.0	1.56	0.050	5.3
Pactola Reservoir Inflow (2)	APR-JUL	7.5	30	21	13.1	1.85	0.25	25

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	APR-JUL	190	95	290	230	149	89	200
	APR-SEP	205	93	315	250	160	94	220
Encampment R nr Encampment (2)	APR-JUL	107	79	159	128	86	55	135
	APR-SEP	113	80	167	135	91	59	141
Rock Ck ab King Canyon Cnl nr Arlington	APR-JUL	43	88	57	49	37	28	49
	APR-SEP	45	88	60	51	39	30	51
Seminoe Reservoir Inflow (2)	APR-JUL	560	85	895	695	425	230	660
	APR-SEP	600	84	945	740	455	250	715
Sweetwater R nr Alcova	APR-JUL	33	73	63	45	21	2.5	45
	APR-SEP	36	73	68	49	23	3.1	49
La Prele Ck nr Douglas	APR-JUL	20	95	33	25	14.9	7.4	21
	APR-SEP	19.1	98	32	24	13.8	6.1	19.5
North Platte R bl Glendo Reservoir (2)	APR-JUL	600	81	1080	795	410	128	745
	APR-SEP	615	81	1100	810	415	125	760
North Platte R bl Guernsey Reservoir (2)	APR-JUL	600	81	1090	800	400	104	745
	APR-SEP	610	79	1120	815	405	105	775
Laramie R and Pioneer Cnl nr Woods Lg (2)	APR-JUL	117	100	165	137	97	69	117
	APR-SEP	126	100	178	147	105	74	126
Little Laramie R nr Filmore	APR-JUL	43	81	62	51	36	24	53
	APR-SEP	46	82	66	54	38	26	56

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
May 2022 Calendar Year Runoff Forecast
May 4, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

April runoff was 1.5 MAF, 51% of average, and 0.2 MAF less than forecasted last month. Runoff was well below normal due to dry soil conditions and below-normal precipitation across most of Basin.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **17.8 MAF, 69% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **16.1 MAF**, **69% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 8 months, expected inflow could range from the 22.7 MAF upper basic forecast to the 13.5 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for April 26, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 84% of the Basin, with Extreme (D3) Drought present in 19% of the Basin, mostly in Montana. The updated Seasonal Drought Outlook extending through the end of July in **Figure 2** does show conditions improving for a large area of the Basin, and drought removal likely for western South Dakota.

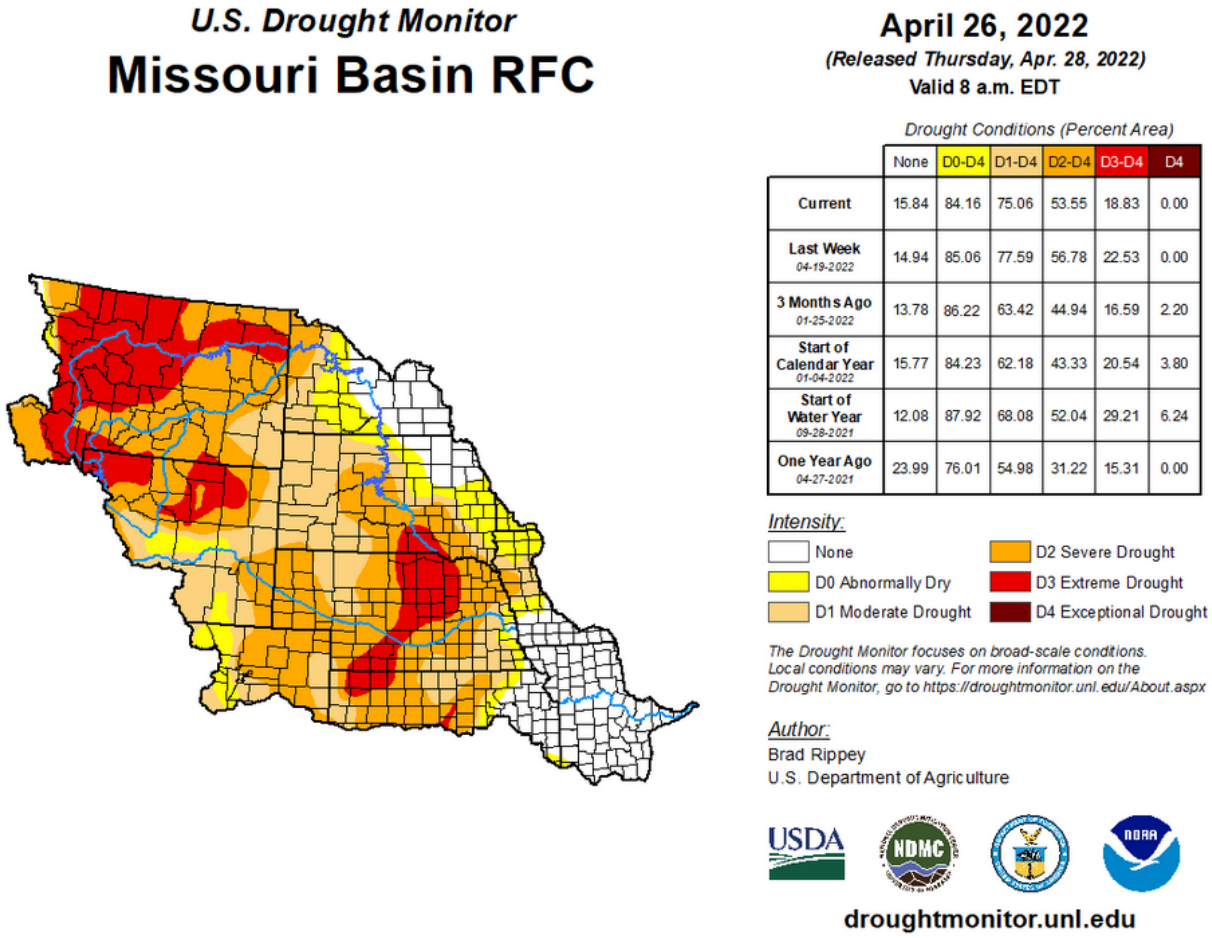


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

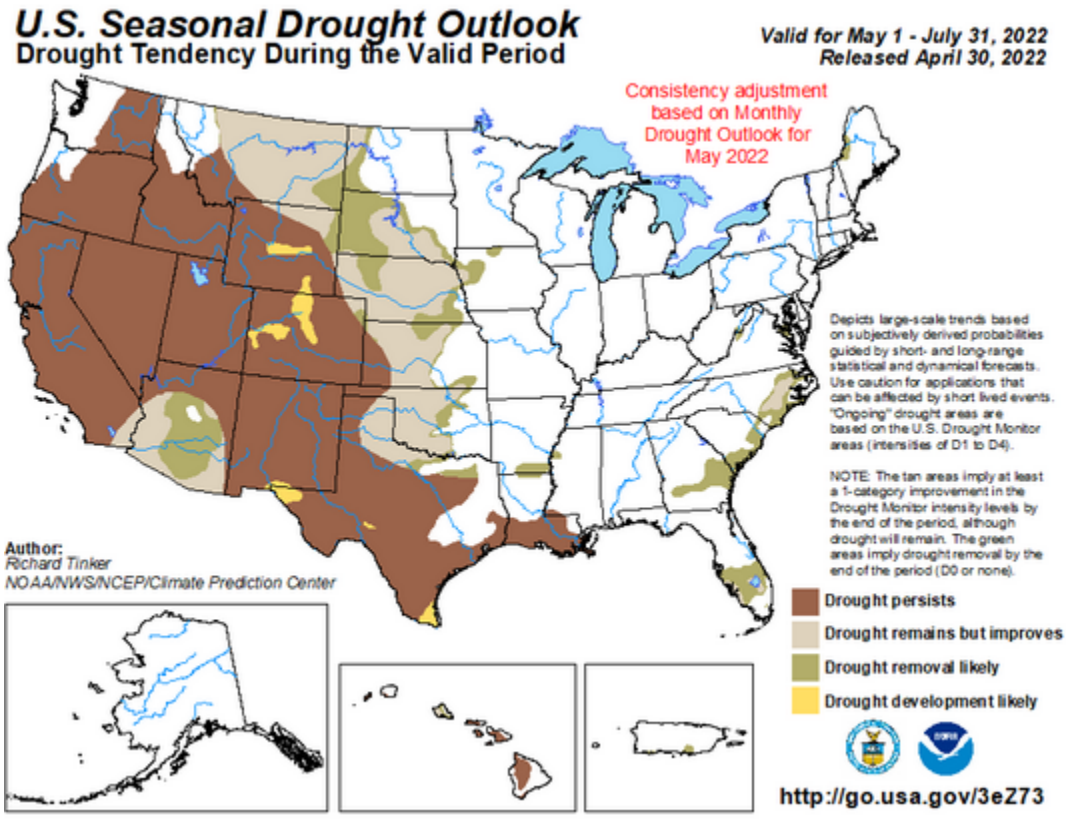


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The April precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. April precipitation was less than 5% to 75% of normal across most of the Basin. Normal to 400% of normal precipitation was observed in North Dakota, southeastern Montana, and a small area of northern South Dakota.

Precipitation as a percent of normal for the February – April 2022 period was below normal to normal for most of the Basin (**Figure 4**), except for North Dakota, southeastern Montana, and a small area of northern South Dakota.

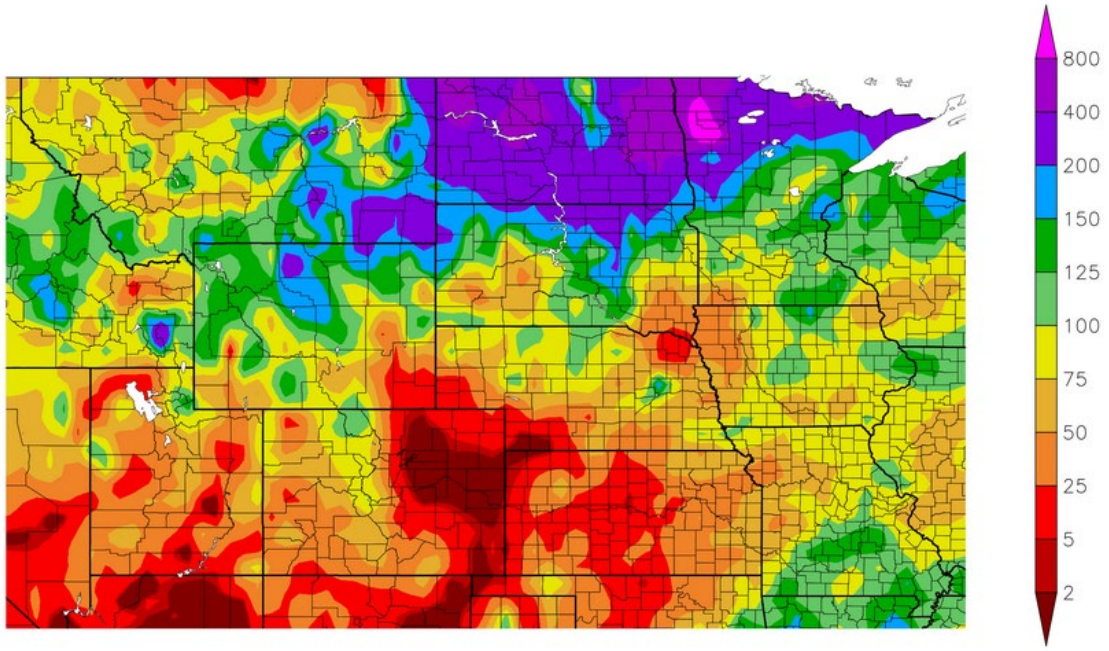


Figure 3. HPRCC April 2022 Percent of Normal Precipitation.

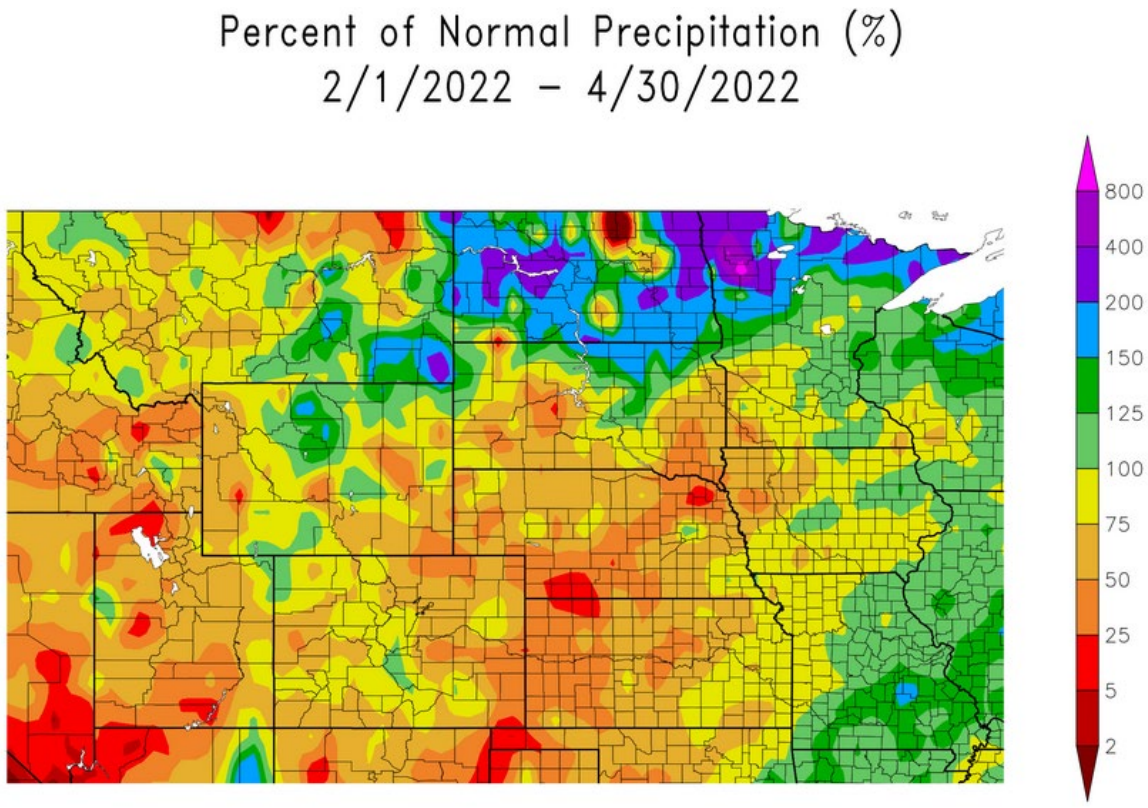


Figure 4. HPRCC February through April 2022 Percent of Normal Precipitation.

Temperature

April temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate normal to slightly above-normal temperatures in the lower Basin, while temperatures were as low as 10 degrees below normal in the upper Basin. February – April 2022 temperature departures are shown in **Figure 6**. Temperatures over the past three months have generally been near normal, with the exception of North Dakota, which has been 2 to 8 degrees below normal.

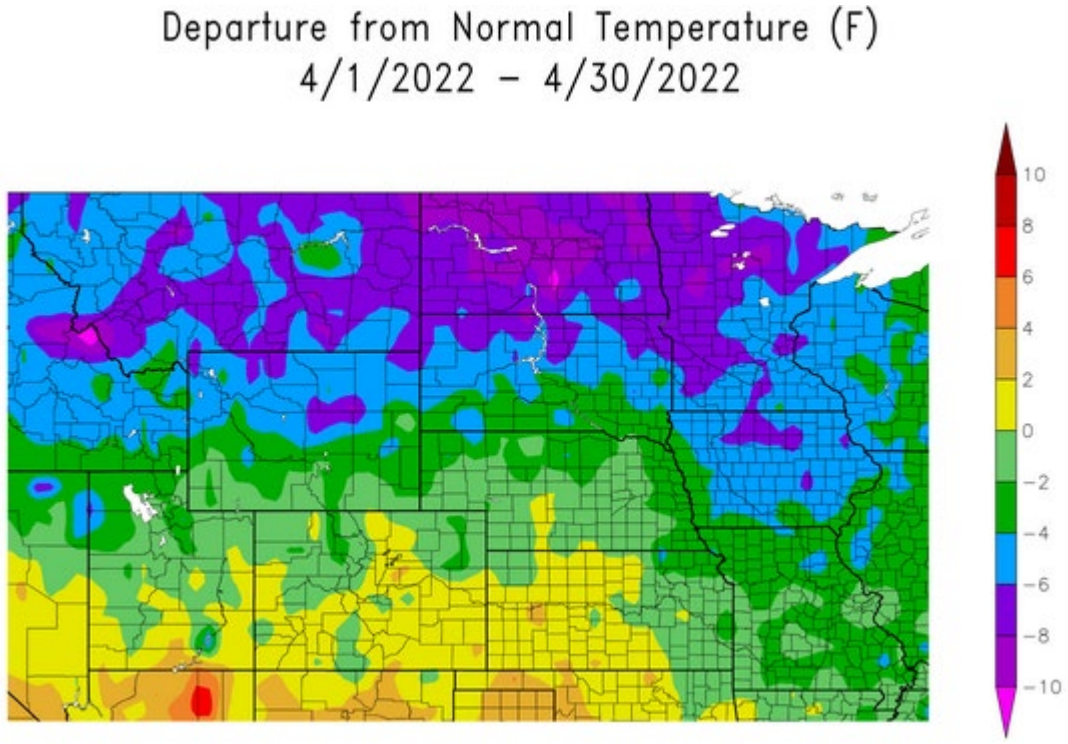


Figure 5. HPRCC April 2022 Departure from Normal Temperature.

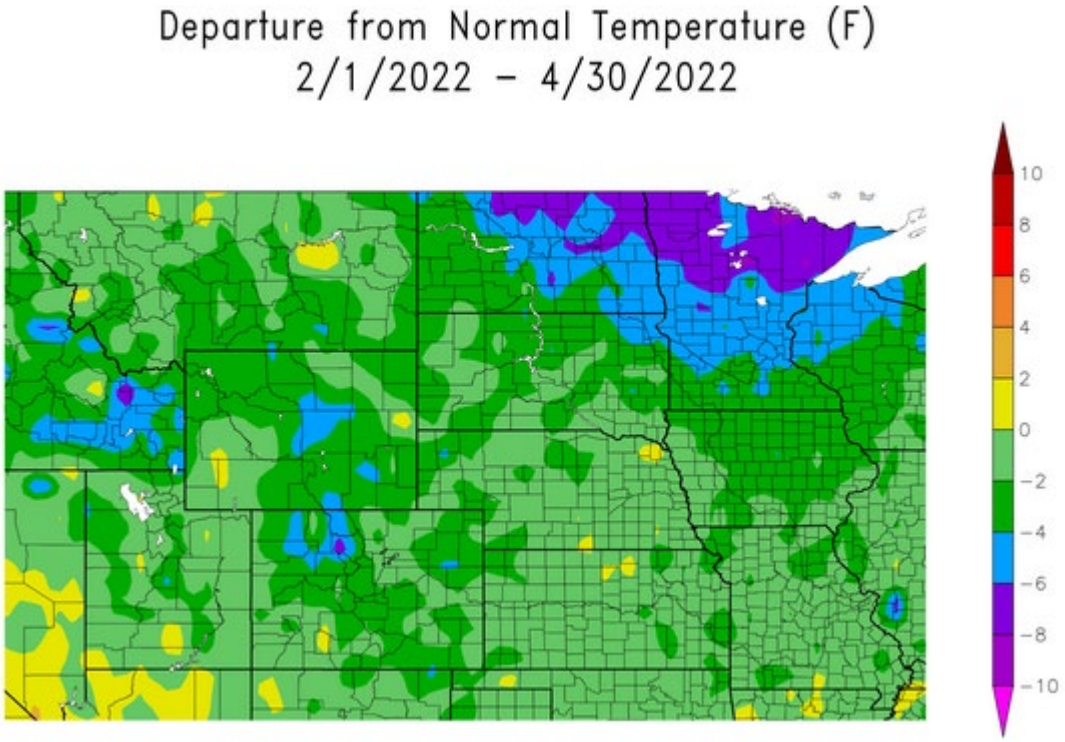


Figure 6. HPRCC February through April 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry in much of the Basin except for North Dakota, northern South Dakota, and Missouri. Soil moisture rankings are in the 1st to 5th percentile for much of Montana, the driest area in the Basin. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

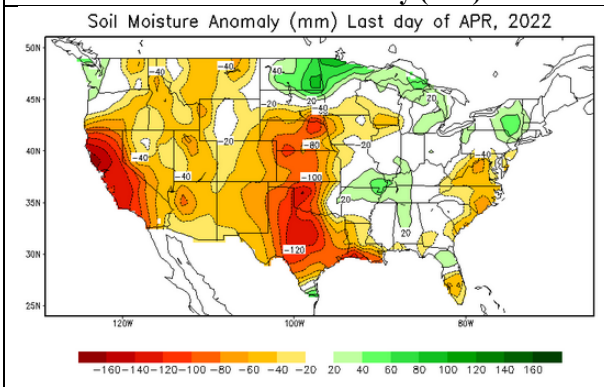
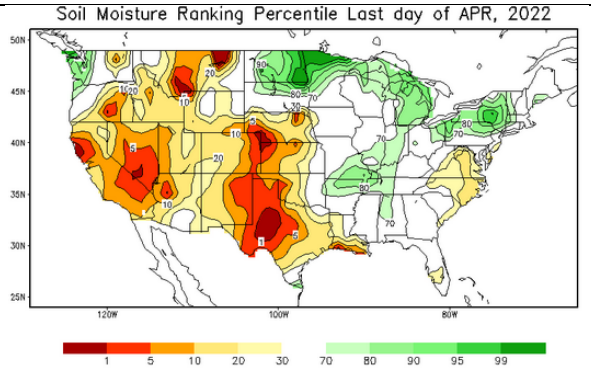
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
	

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

We continue to see plains snowfall in some areas of the Basin. However, the snow melts soon after it falls without a significant increase in runoff due to the dry soil conditions. The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) modeled snow assessment from May 4 indicates plains snowpack in the Basin is non-existent.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1981-2010 basin average SWE (bold red line), a recent low SWE year in 2001 (green line), and two historic high SWE years occurring in 1997 (purple) and 2011 (dark blue).

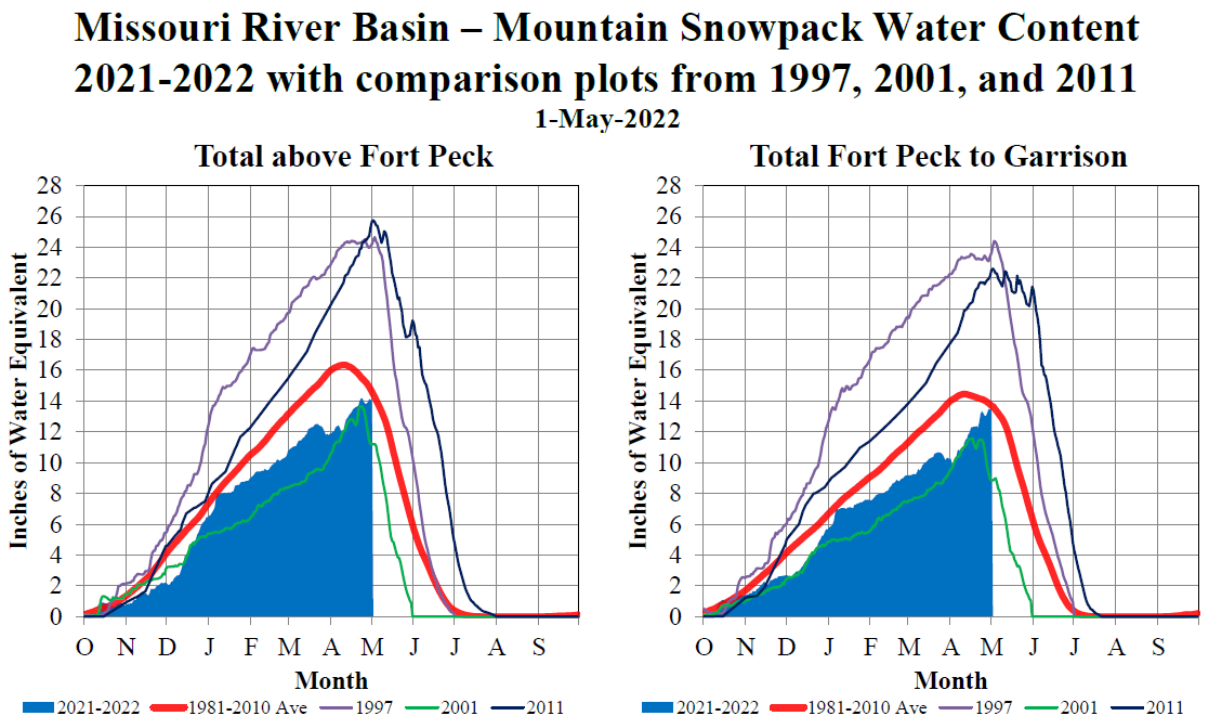


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack appeared to have peaked in late April but recent storms and cooler temperatures have resulted in additional snowpack accumulation. As of May 1, 2022, the Corps of Engineers computed an average mountain SWE in the Fort Peck reservoir reach of 14.1 inches, which is 86% of the normal April 15 peak. In the reservoir reach between Fort Peck Dam and Garrison Dam, the Corps computed an average mountain SWE of 13.6 inches, which is 94% of the normal April 15 peak. The late season mountain snowpack has increased runoff projections for May, June, and July slightly in the Fort Peck and Garrison reaches.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 59% chance of continuing during June through August 2022, and there is a 50-55% chance of continuing La Niña through the fall.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The May CPC outlooks (**Figure 9**) indicate increased chances for cooler and wetter than normal conditions across most of the Basin

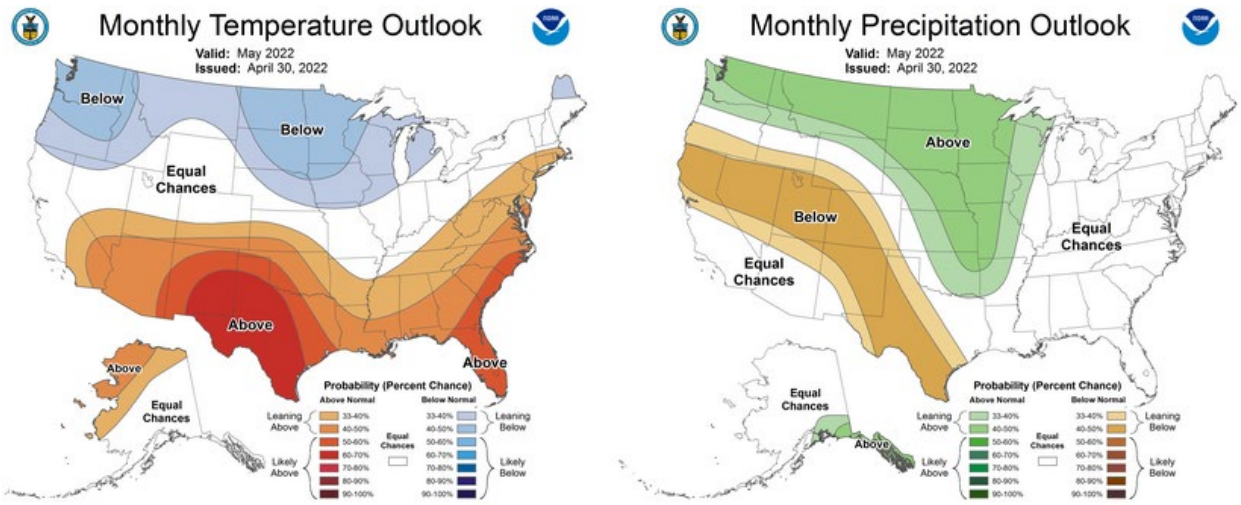


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (May).

Three-month temperature and precipitation outlooks for May through December 2022 are shown below in **Figure 10** through **Figure 12**. During June, July, and August, the outlooks are indicating increased chances for warmer than normal and drier than normal conditions across the entire Basin. The September-October-November outlooks indicate warmer-than-normal temperatures and below normal precipitation chances for the mountains, with equal chances elsewhere across the Basin. From December 2022 through February 2023, the outlooks are indicating equal chances across the entire Basin.

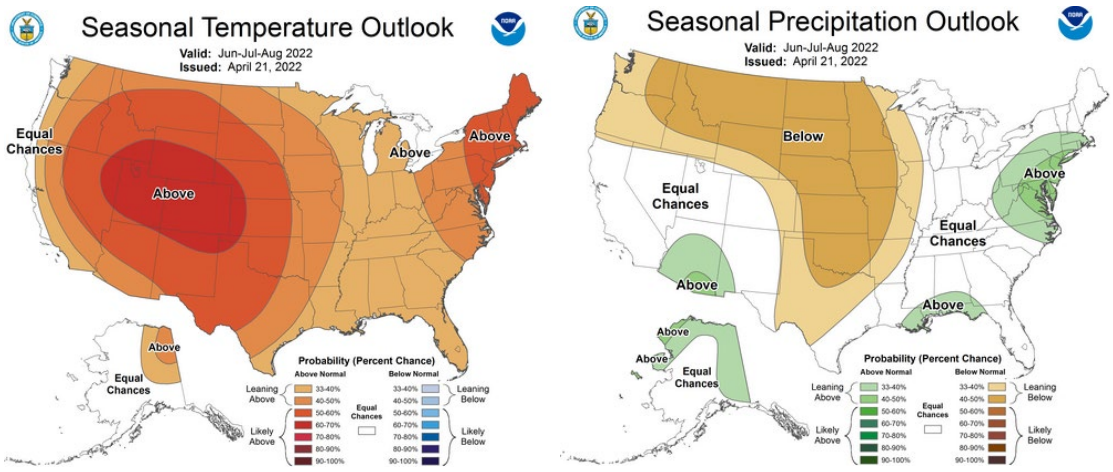


Figure 10. CPC June-July-August 2022 temperature and precipitation outlooks.

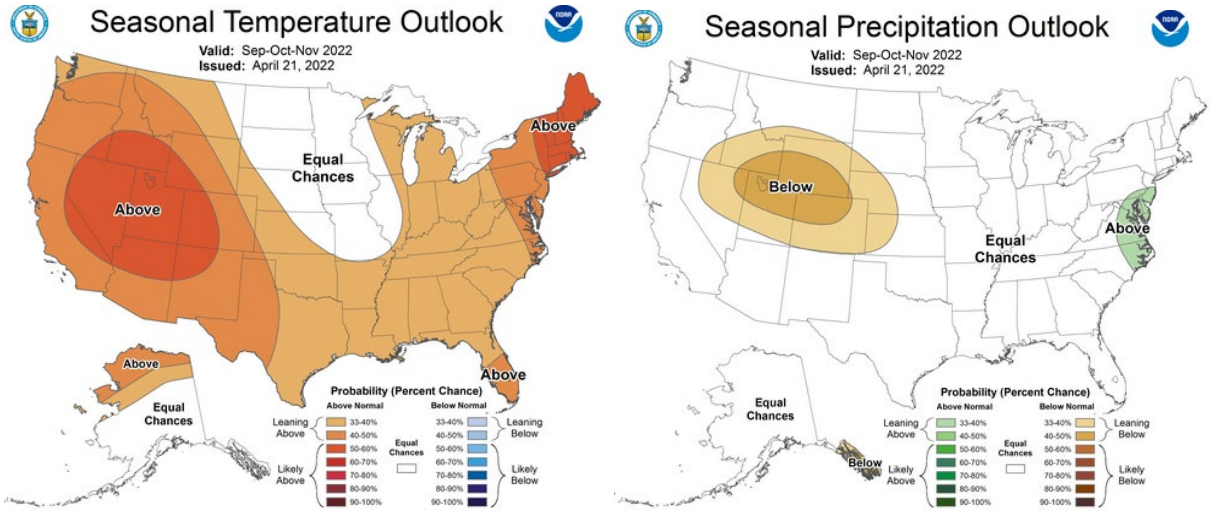


Figure 11. CPC September-October-November 2022 temperature and precipitation outlooks.

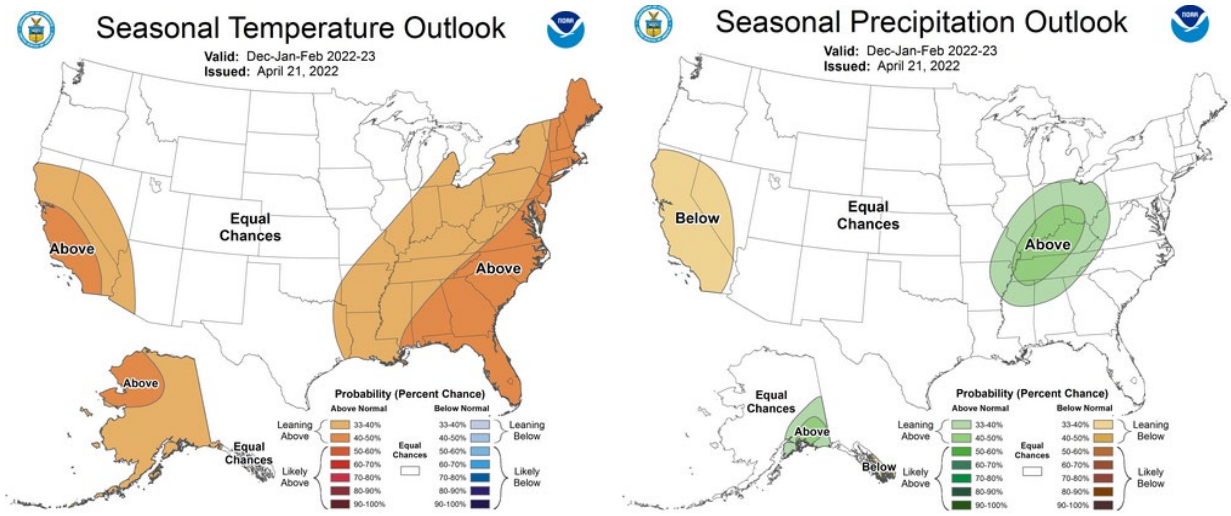


Figure 12. CPC December-January-February 2022-2023 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal for the remainder of the year. During May, June and July, Fort Peck and Garrison runoff is forecast to be below average due to the slightly below-normal mountain snowpack and dry soil moisture conditions. During May, June, and July in the other reaches, as well as the remainder of the year in all reaches, we expect runoff to be below normal, but this could vary based on precipitation events in the spring, summer, and fall. In summary, the 2022 calendar year runoff forecast is **17.8 MAF (69% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: May 04, 2022 11:14:43 AM
   - Based on May 01, 2022 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	MAY-JUL	96	107	115	104	88	77	90
	MAY-SEP	111	106	132	119	103	90	105
St. Mary R at Intl Boundary (2)	MAY-JUL	460	111	565	505	415	355	415
	MAY-SEP	525	112	645	575	475	405	470
Lima Reservoir Inflow (2)	MAY-JUL	32	80	57	42	22	7.1	40
	MAY-SEP	37	74	64	48	26	9.9	50
Clark Canyon Inflow (2)	MAY-JUL	24	75	66	41	7.1	0.32	32
	MAY-SEP	32	86	79	51	13.1	0.37	37
Jefferson R nr Three Forks (2)	MAY-JUL	390	72	680	505	270	96	540
	MAY-SEP	420	75	730	545	295	111	560
Hebgen Lake Inflow (2)	MAY-JUL	250	88	325	280	220	176	285
	MAY-SEP	335	87	425	370	300	245	385
Ennis Lake Inflow (2)	MAY-JUL	450	87	565	495	405	335	515
	MAY-SEP	575	88	715	630	520	435	655
Missouri R at Toston (2)	MAY-JUL	1120	74	1710	1360	880	525	1520
	MAY-SEP	1330	78	1970	1590	1070	690	1700
Smith R bl Eagle Ck (2)	MAY-JUL	56	70	102	75	37	9.9	80
	MAY-SEP	63	72	114	83	43	12.4	87
Gibson Reservoir Inflow (2)	MAY-JUL	390	116	455	415	365	325	335
	MAY-SEP	430	115	505	460	400	355	375
Marias R nr Shelby (2)	MAY-JUL	335	118	480	395	275	189	285
	MAY-SEP	345	119	505	410	280	187	290

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	MAY-JUL	53	93	61	56	50	45	57
	MAY-SEP	67	91	77	71	63	57	74
Wind R Ab Bull Lake Ck (2)	MAY-JUL	465	103	570	505	425	360	450
	MAY-SEP	475	108	590	520	430	360	440
Bull Lake Ck nr Lenore (2)	MAY-JUL	139	103	165	149	128	113	135
	MAY-SEP	168	103	199	181	156	138	163
Boysen Reservoir Inflow (2)	MAY-JUL	645	95	885	745	545	405	680
	MAY-SEP	680	94	925	780	580	435	725
Greybull R at Meeteetse	MAY-JUL	145	106	198	166	124	92	137
	MAY-SEP	194	102	255	220	170	134	190
Shell Ck nr Shell	MAY-JUL	53	95	69	59	47	37	56
	MAY-SEP	65	96	82	72	58	48	68
Bighorn R at Kane (2)	MAY-JUL	900	97	1320	1070	730	485	925
	MAY-SEP	945	99	1380	1120	770	515	955
NF Shoshone R at Wapiti	MAY-JUL	400	94	490	435	365	310	425
	MAY-SEP	445	92	545	485	405	345	485
SF Shoshone R nr Valley	MAY-JUL	200	95	245	220	181	154	210
	MAY-SEP	230	92	280	250	210	178	250
Buffalo Bill Reservoir Inflow (2)	MAY-JUL	580	94	725	640	525	435	620
	MAY-SEP	635	93	795	700	570	480	680
Bighorn R nr St. Xavier (2)	MAY-JUL	1340	91	1870	1550	1120	800	1480
	MAY-SEP	1380	86	1960	1620	1150	810	1610
Little Bighorn R nr Hardin	MAY-JUL	93	103	136	110	75	50	90
	MAY-SEP	107	99	155	126	87	58	108
Tongue R nr Dayton (2)	MAY-JUL	83	100	107	93	73	59	83
	MAY-SEP	96	100	122	106	85	69	96
Tongue River Reservoir Inflow (2)	MAY-JUL	190	95	270	225	157	109	200
	MAY-SEP	215	96	300	250	180	129	225
NF Powder R nr Hazelton	MAY-JUL	8.4	88	11.6	9.7	7.1	5.2	9.6
	MAY-SEP	9.1	87	12.5	10.5	7.7	5.7	10.5

Powder R at Moorhead	MAY-JUL	145	90	265	193	97	26	161
	MAY-SEP	159	92	280	210	110	38	173
Powder R nr Locate	MAY-JUL	157	85	285	210	105	29	184
	MAY-SEP	172	86	305	225	118	38	199

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	MAY-JUL	2.5	66	5.4	3.7	1.35	0.040	3.8
Pactola Reservoir Inflow (2)	MAY-JUL	9.5	49	23	15.0	4.0	0.20	19.5

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	MAY-JUL	172	101	250	205	140	93	170
	MAY-SEP	190	97	275	225	155	104	196
Encampment R nr Encampment (2)	MAY-JUL	103	86	143	119	87	63	120
	MAY-SEP	110	89	152	127	93	68	124
Rock Ck ab King Canyon Cnl nr Arlington	MAY-JUL	45	96	56	49	40	33	47
	MAY-SEP	47	94	59	52	42	35	50
Seminoe Reservoir Inflow (2)	MAY-JUL	530	92	760	625	440	305	575
	MAY-SEP	575	92	810	670	480	340	625
Sweetwater R nr Alcova	MAY-JUL	33	89	56	42	24	10.4	37
	MAY-SEP	36	88	61	46	26	11.5	41
La Prele Ck nr Douglas	MAY-JUL	14.1	105	23	17.6	10.6	5.4	13.4
	MAY-SEP	14.1	109	22	17.5	10.7	5.8	12.9
North Platte R bl Glendo Reservoir (2)	MAY-JUL	555	87	855	675	430	250	635
	MAY-SEP	570	86	880	695	445	260	660
North Platte R bl Guernsey Reservoir (2)	MAY-JUL	575	93	890	705	445	260	620
	MAY-SEP	590	91	905	715	460	270	650
Laramie R and Pioneer Cnl nr Woods Lg (2)	MAY-JUL	111	100	147	125	97	75	111
	MAY-SEP	122	102	160	137	107	84	120
Little Laramie R nr Filmore	MAY-JUL	44	90	60	50	38	28	49
	MAY-SEP	47	89	63	54	40	31	53

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
June 2022 Calendar Year Runoff Forecast
June 6, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

May runoff was 2.7 MAF, 79% of average, and 0.4 MAF more than forecasted last month. Runoff was below average due to cooler-than-normal temperatures slowing snowmelt, below-normal precipitation, and dry soil conditions in western portions of the Basin.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **18.3 MAF, 71% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **16.4 MAF**, **70% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 7 months, expected inflow could range from the 22.2 MAF upper basic forecast to the 14.8 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for May 31, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 76% of the Basin, with Extreme (D3) Drought present in 6% of the Basin, mostly in Montana. The updated Seasonal Drought Outlook extending through the end of August in **Figure 2** shows existing drought conditions persisting and potential drought development into Iowa, though the monthly drought outlook indicates drought improvement is likely in parts of the Basin.

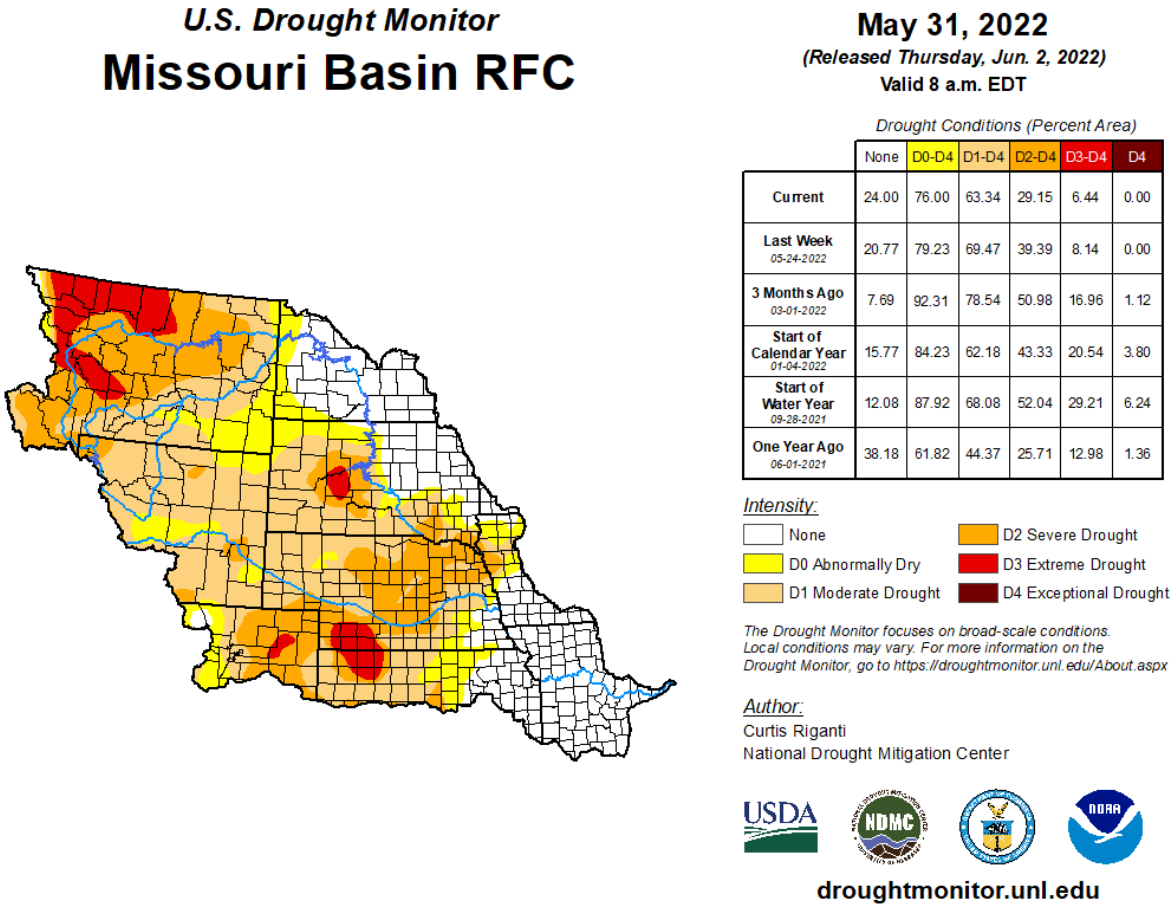


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

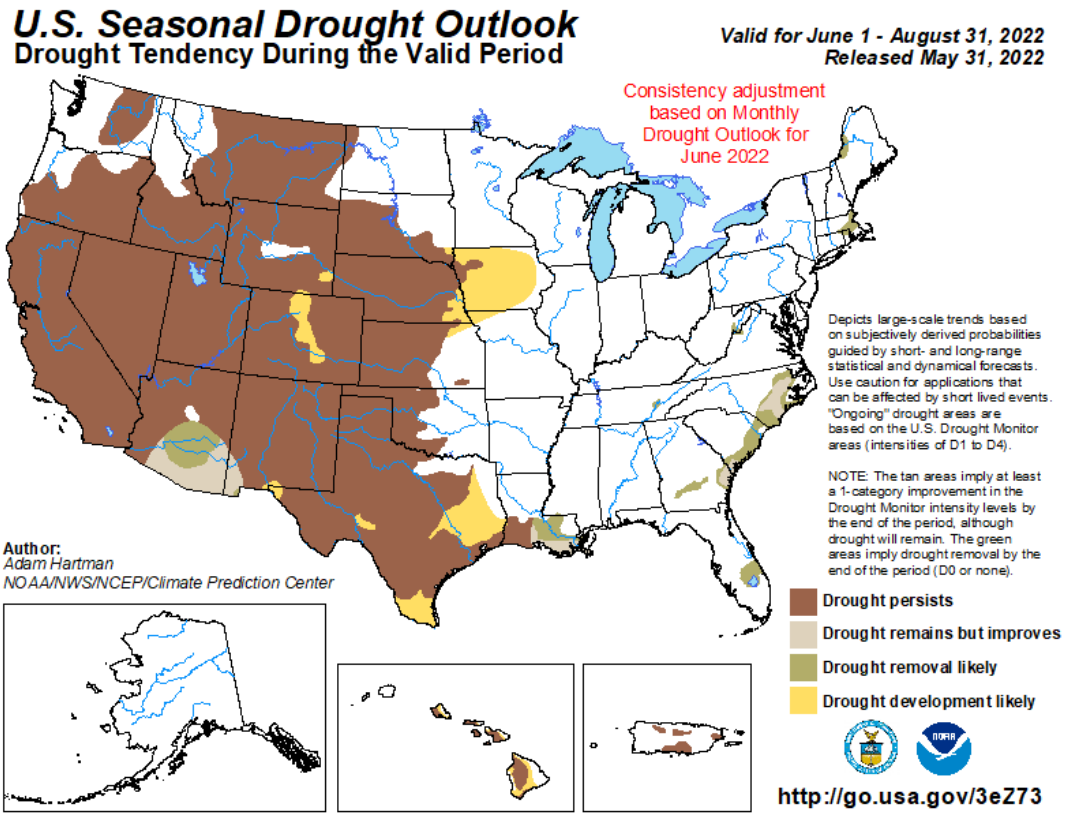


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The May precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. May precipitation was below normal for much of the upper Basin except for western and eastern North Dakota and eastern South Dakota, which all saw 150% to over 300% of normal precipitation. Montana saw 5-50% of normal precipitation over much of the state. The lower Basin in Kansas and Missouri also saw above-normal precipitation.

Precipitation as a percent of normal for the March through May 2022 period was below normal to normal for most of the Basin (**Figure 4**), except for North Dakota.

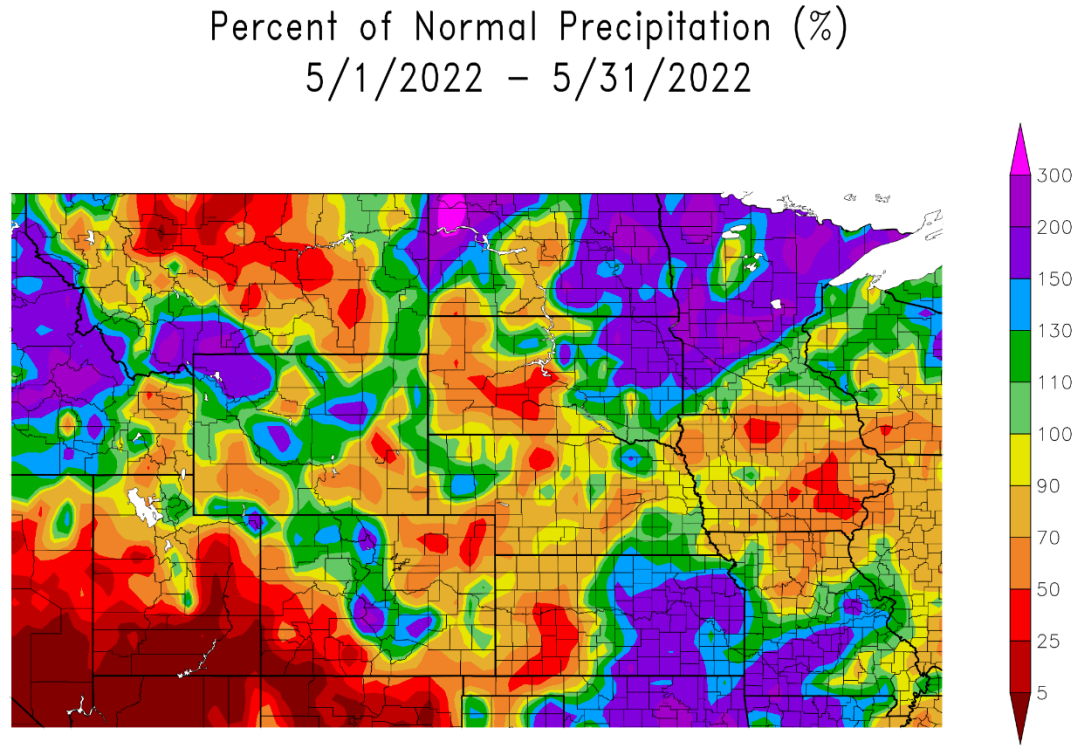


Figure 3. HPRCC May 2022 Percent of Normal Precipitation.

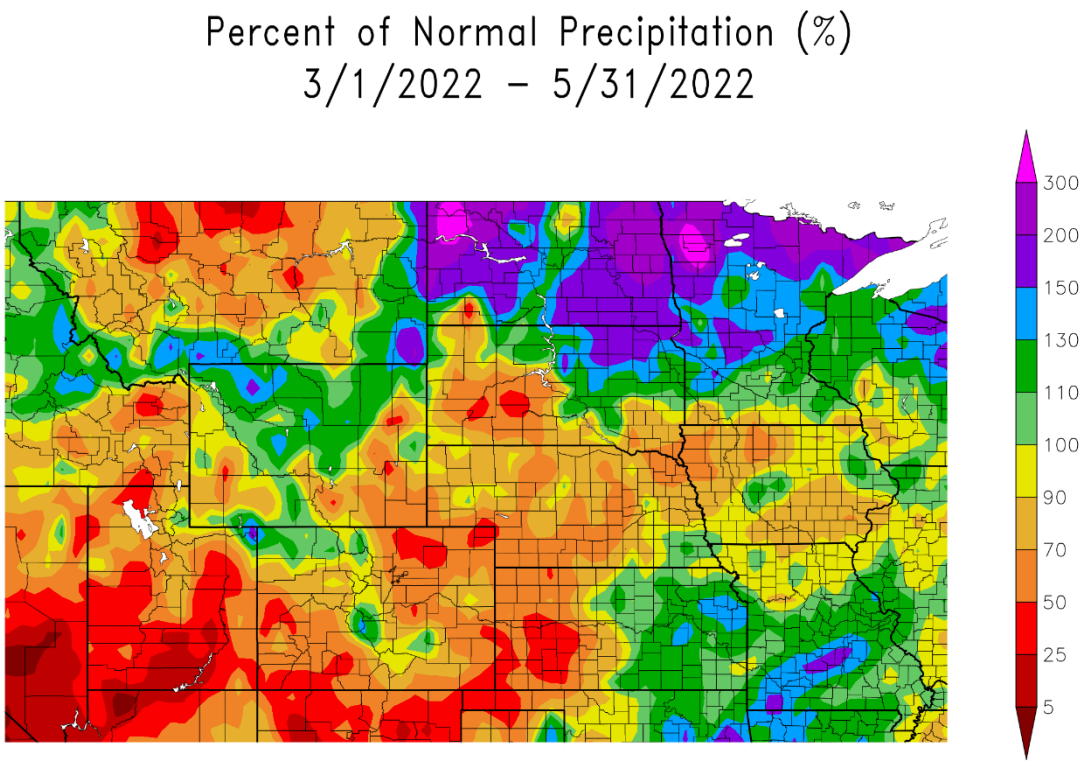


Figure 4. HPRCC March through May 2022 Percent of Normal Precipitation.

Temperature

May temperature departures in degrees Fahrenheit (deg F) in **Figure 5** indicate normal to above-normal temperatures in the areas of the Basin which saw above-normal precipitation, in North Dakota, eastern South Dakota, and the lower basin in Kansas and Missouri. Normal to below-normal temperatures were observed in Montana, western South Dakota, central North Dakota, and portions of the lower Basin.

March through May 2022 temperature departures are shown in **Figure 6**. Temperatures over the past three months have generally been slightly below normal in Montana, western South Dakota, Nebraska, Iowa, and western Kansas, and slightly above normal in the rest of the Basin.

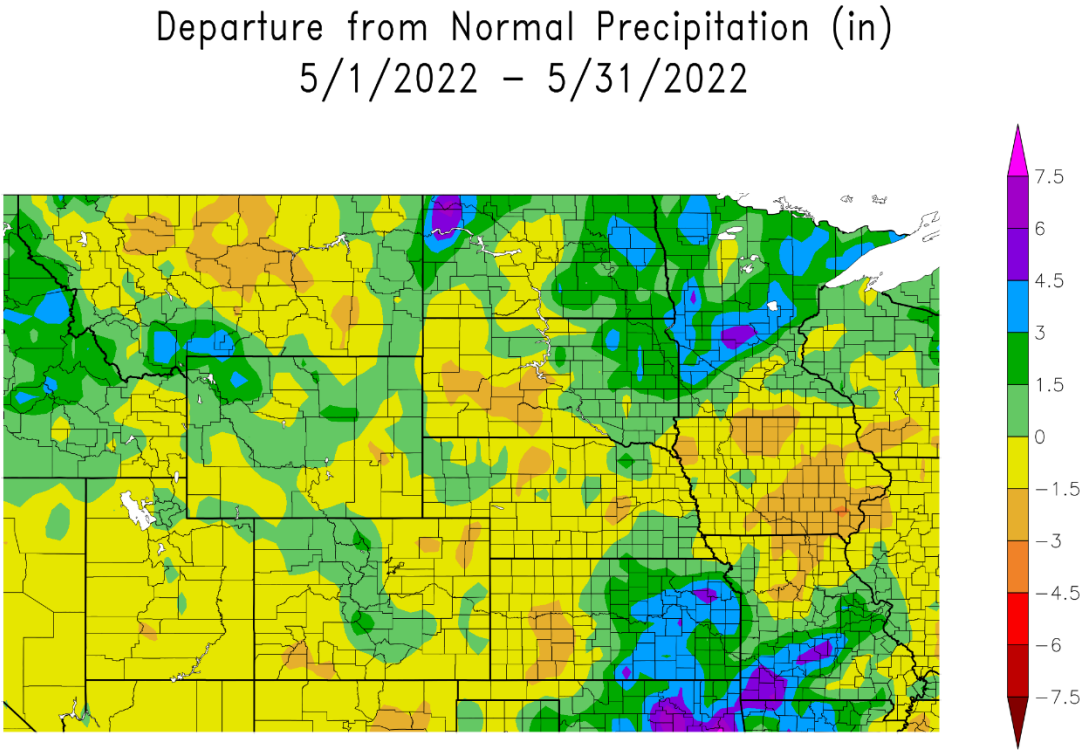


Figure 5. HPRCC May 2022 Departure from Normal Temperature.

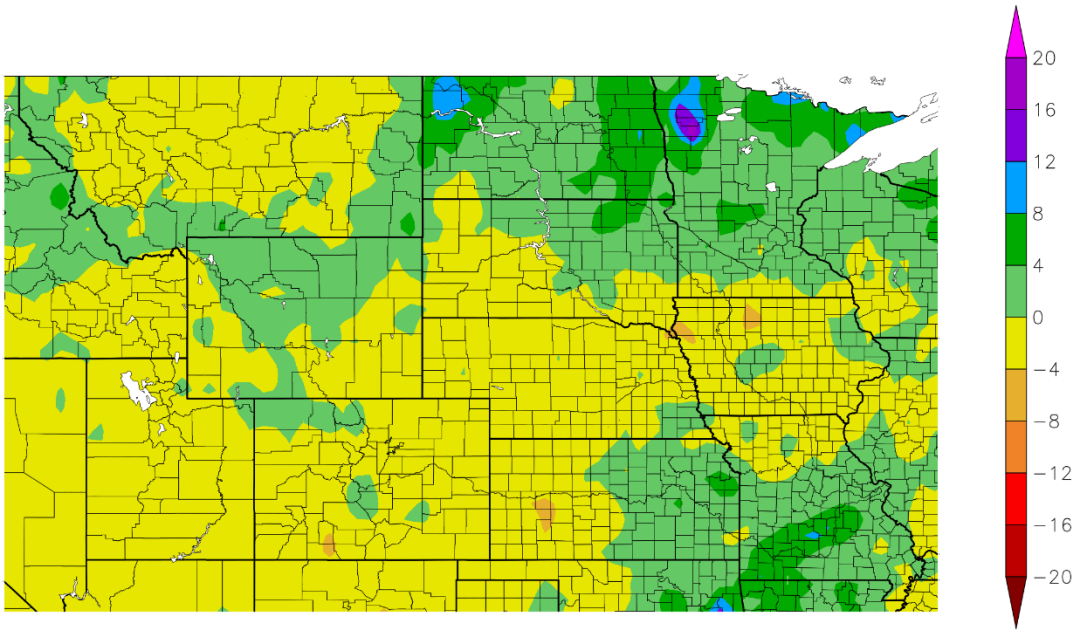


Figure 6. HPRCC March through May 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry in much of the upper Basin except for North Dakota. Soil moisture conditions are also dry in Nebraska, Iowa, and western Kansas, but more normal and, in some areas, slightly above normal in eastern Kansas and Missouri. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

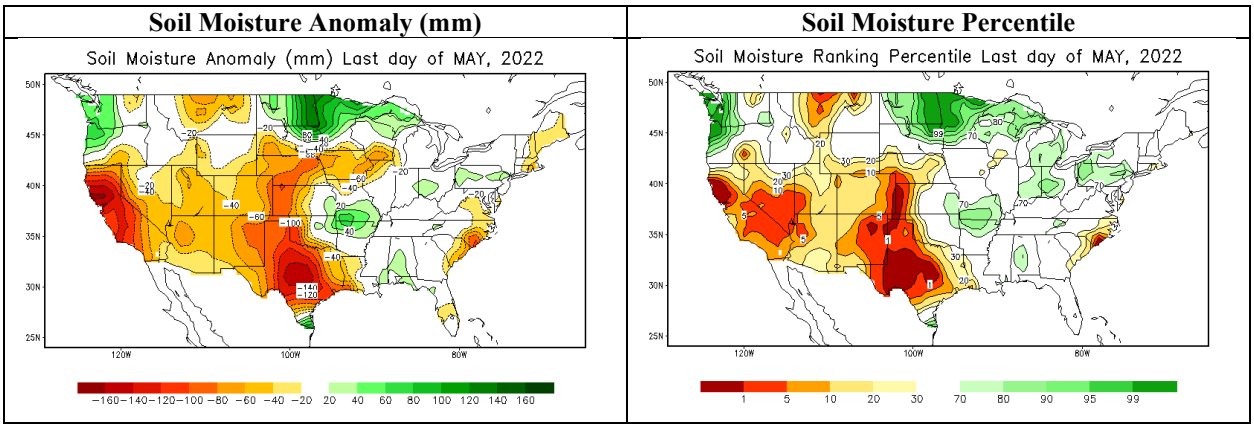


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

A few sporadic light plains snowfall events have occurred in May in the western areas of the Basin. However, the snow melts soon after it falls without a significant increase in runoff due to the dry soil conditions. The National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) modeled snow assessment from June 6 indicates plains snowpack in the Basin is non-existent.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

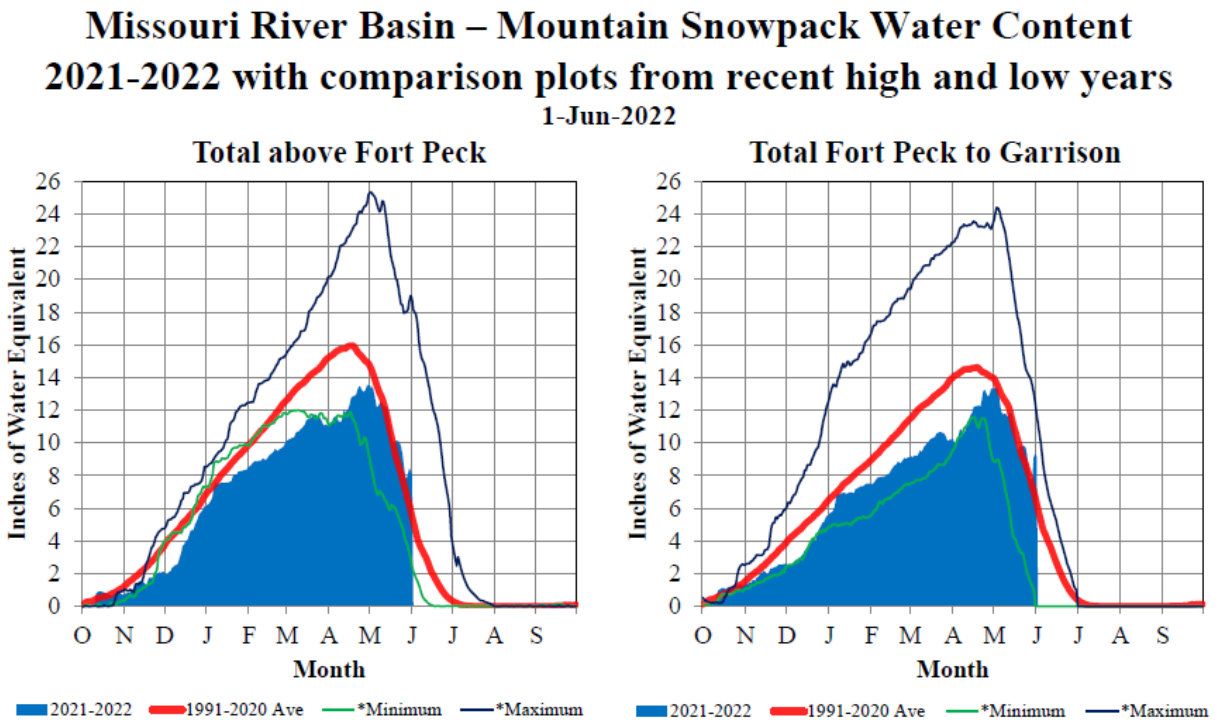


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack peaked in the Fort Peck reach on April 29 at 13.5" of SWE and 85% of the normal peak. The mountain snowpack peaked in the Garrison reach on May 3 at 13.4" of SWE and 92% of the normal peak. As of June 1, 60% of the annual peak remains above Fort Peck, and 68% of the annual peak remains above Garrison. The later-than-normal peak snowpack and additional late-season snowpack additions have slightly increased runoff projections for June and July in the Fort Peck and Garrison reaches.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña). During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 58% chance of continuing during August through October 2022, and there is a 61% chance of continuing La Niña through the fall and early winter.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The June CPC outlooks (**Figure 9**) indicate increased chances for cooler-than-normal temperatures across much of the Basin. An increased chance of above-normal precipitation is indicated in western Montana and in the lower Basin in Kansas and Missouri, while equal chances for above-normal, normal, or below-normal precipitation exist in the rest of the Basin.

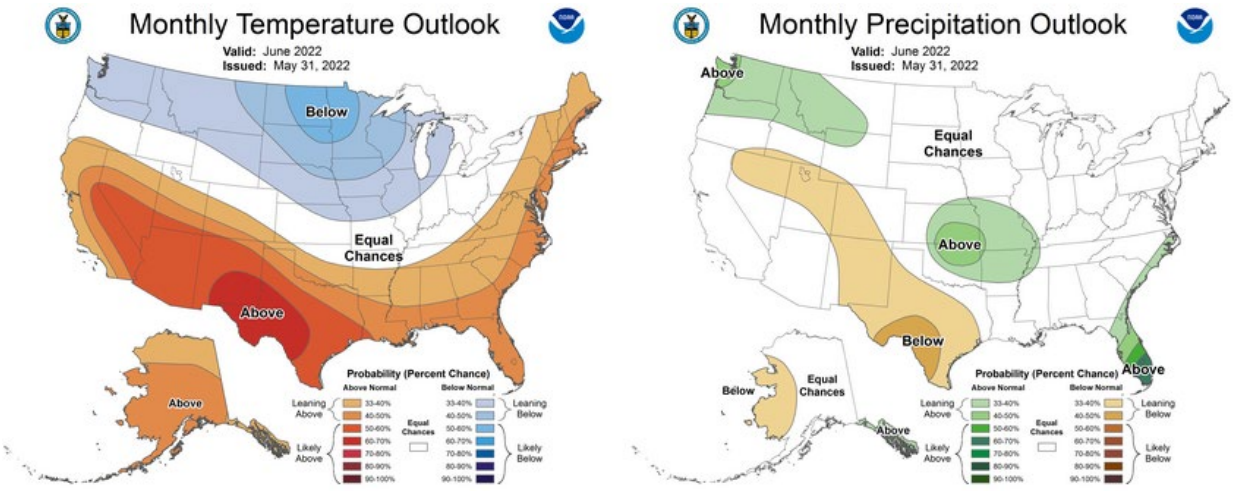


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (June).

Three-month temperature and precipitation outlooks for July through December 2022 are shown below in **Figure 10** and **Figure 11**. During July through September, the outlooks indicate increased chances for warmer-than-normal and drier-than-normal conditions across the entire Basin. The October through December outlooks indicate above-normal temperatures over most of the Basin except for Montana and North Dakota, where equal chances for above-normal,

normal, or below-normal temperatures exist. Equal chances for precipitation are indicated over most of the Basin for the October through December period.

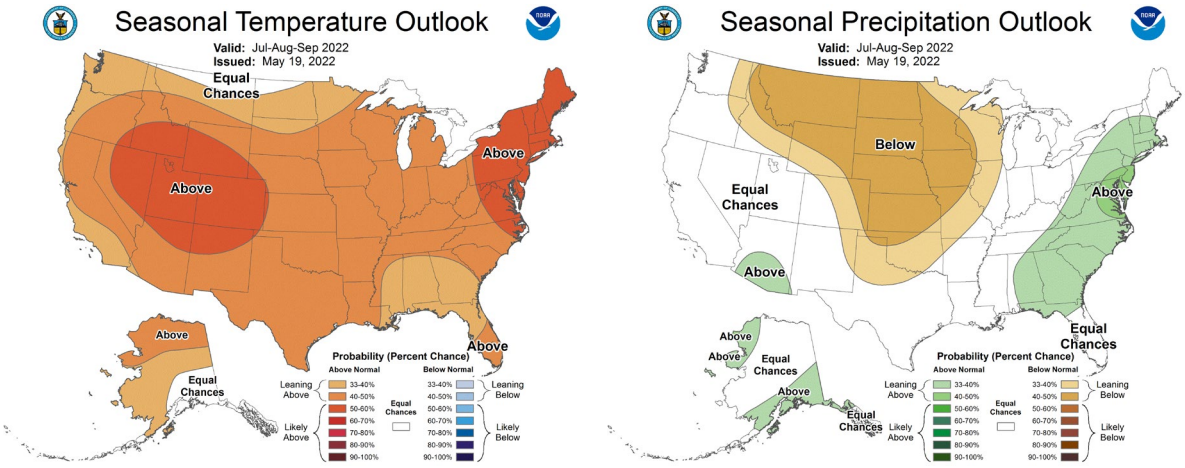


Figure 10. CPC July-August-September 2022 temperature and precipitation outlooks.

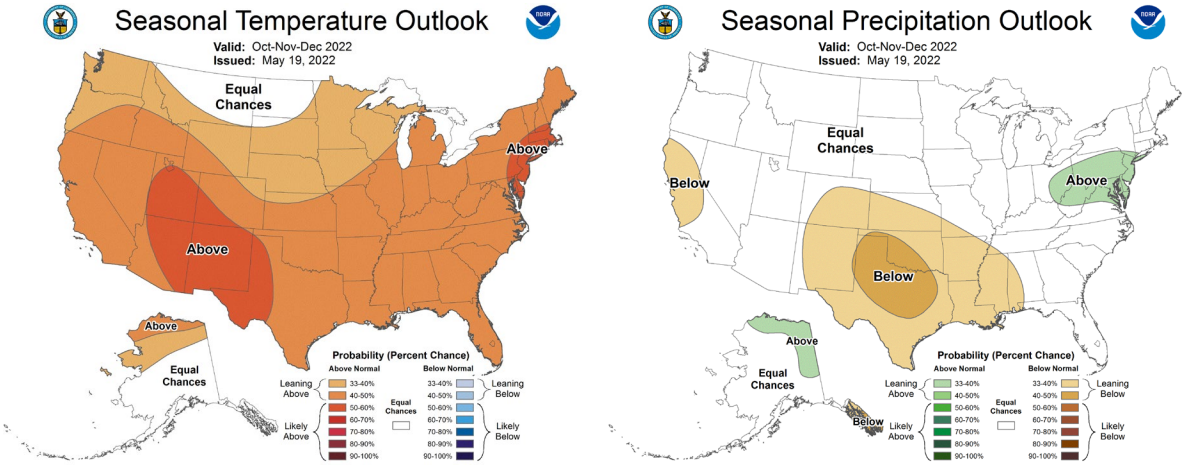


Figure 11. CPC October-November-December 2022 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal for the remainder of the year. During June and July, Fort Peck and Garrison runoff is forecast to be below average due to the slightly below-normal mountain snowpack and dry soil moisture conditions. During June and July in the other reaches, as well as the remainder of the year in all reaches, we expect runoff to be below normal or near normal, but this could vary based on precipitation events in the summer and fall. In summary, the 2022 calendar year runoff forecast is **18.3 MAF (71% of average)**.

Water Supply Forecasts

USDA NRCS National Water & Climate Center
 * - DATA CURRENT AS OF: June 03, 2022 02:58:28 PM
   - Based on June 01, 2022 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Lake Sherburne Inflow (2)	JUN-JUL	72	138	89	79	65	55	52
	JUN-SEP	87	132	107	95	79	67	66
St. Mary R at Intl Boundary (2)	JUN-JUL	365	140	460	405	325	265	260
	JUN-SEP	435	132	545	480	390	325	330
Lima Reservoir Inflow (2)	JUN-JUL	35	135	52	42	28	17.8	26
	JUN-SEP	45	129	65	53	37	25	35
Clark Canyon Inflow (2)	JUN-JUL	29	299	59	41	16.8	0.48	9.7
	JUN-SEP	43	228	80	58	28	6.0	18.9
Jefferson R nr Three Forks (2)	JUN-JUL	420	142	575	465	315	205	295
	JUN-SEP	465	145	685	555	375	245	320
Hebgen Lake Inflow (2)	JUN-JUL	174	112	215	191	158	133	155
	JUN-SEP	255	102	310	275	230	197	250
Ennis Lake Inflow (2)	JUN-JUL	375	121	465	415	340	285	310
	JUN-SEP	530	116	645	580	485	420	455
Missouri R at Toston (2)	JUN-JUL	1090	117	1440	1230	945	735	935
	JUN-SEP	1360	120	1790	1530	1180	920	1130
Smith R bl Eagle Ck (2)	JUN-JUL	47	104	88	64	30	5.8	45
	JUN-SEP	55	106	100	73	37	10.2	52
Gibson Reservoir Inflow (2)	JUN-JUL	230	131	290	255	205	169	176
	JUN-SEP	270	120	345	300	240	199	225
Marias R nr Shelby (2)	JUN-JUL	162	106	265	205	119	56	153
	JUN-SEP	155	115	275	205	106	33	135

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Mystic Lake Inflow (2)	JUN-JUL	53	110	60	56	50	46	48
	JUN-SEP	70	108	80	74	66	60	65
Wind R Ab Bull Lake Ck (2)	JUN-JUL	400	114	485	430	365	310	350
	JUN-SEP	430	119	545	475	385	315	360
Bull Lake Ck nr Lenore (2)	JUN-JUL	124	120	144	132	116	104	103
	JUN-SEP	156	120	183	167	145	129	130
Boysen Reservoir Inflow (2)	JUN-JUL	535	118	690	600	475	380	455
	JUN-SEP	580	120	775	660	500	385	485
Greybull R at Meeteetse	JUN-JUL	129	126	169	145	113	90	102
	JUN-SEP	179	117	225	199	160	131	153
Shell Ck nr Shell	JUN-JUL	41	121	51	45	37	31	34
	JUN-SEP	55	117	67	60	50	43	47
Bighorn R at Kane (2)	JUN-JUL	755	112	1010	860	650	495	675
	JUN-SEP	815	110	1130	940	690	505	740
NF Shoshone R at Wapiti	JUN-JUL	375	119	440	400	350	310	315
	JUN-SEP	435	118	505	465	405	360	370
SF Shoshone R nr Valley	JUN-JUL	187	117	225	205	171	148	160
	JUN-SEP	225	116	270	240	205	180	194
Buffalo Bill Reservoir Inflow (2)	JUN-JUL	570	124	675	610	525	460	460
	JUN-SEP	645	124	765	690	595	525	520
Bighorn R nr St. Xavier (2)	JUN-JUL	1190	113	1550	1340	1050	835	1050
	JUN-SEP	1270	114	1700	1450	1100	840	1110
Little Bighorn R nr Hardin	JUN-JUL	69	125	97	80	58	41	55
	JUN-SEP	84	124	117	98	70	51	68
Tongue R nr Dayton (2)	JUN-JUL	65	135	78	70	60	52	48
	JUN-SEP	79	127	95	85	73	63	62
Tongue River Reservoir Inflow (2)	JUN-JUL	160	130	205	179	142	115	123
	JUN-SEP	188	131	245	210	167	134	144
NF Powder R nr Hazelton	JUN-JUL	4.5	102	6.7	5.4	3.6	2.3	4.4
	JUN-SEP	5.2	98	7.6	6.2	4.2	2.8	5.3

Powder R at Moorhead	JUN-JUL	109	124	180	138	80	38	88
	JUN-SEP	125	118	200	155	94	49	106
Powder R nr Locate	JUN-JUL	123	124	210	158	88	37	99
	JUN-SEP	141	117	235	179	102	45	121

PRELIMINARY RAPID VALLEY UNIT FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
Deerfield Reservoir Inflow (2)	JUN-JUL	1.78	74	3.2	2.3	1.22	0.40	2.4
Pactola Reservoir Inflow (2)	JUN-JUL	6.2	60	15.9	10.1	2.3	1.10	10.3

PRELIMINARY PLATTE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of med	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr med
North Platte R nr Northgate (2)	JUN-JUL	121	99	169	140	101	72	122
	JUN-SEP	141	99	192	162	120	90	143
Encampment R nr Encampment (2)	JUN-JUL	63	95	82	71	55	44	66
	JUN-SEP	71	97	92	79	63	50	73
Rock Ck ab King Canyon Cnl nr Arlington	JUN-JUL	30	100	36	33	28	24	30
	JUN-SEP	32	97	39	35	30	26	33
Seminoe Reservoir Inflow (2)	JUN-JUL	345	97	465	395	300	230	355
	JUN-SEP	395	99	515	440	345	270	400
Sweetwater R nr Alcova	JUN-JUL	23	100	33	27	18.8	12.7	23
	JUN-SEP	26	100	38	31	21	13.5	26
La Prele Ck nr Douglas	JUN-JUL	3.0	111	6.6	4.5	1.53	0.030	2.7
	JUN-SEP	4.3	113	8.0	5.8	2.8	0.55	3.8
North Platte R bl Glendo Reservoir (2)	JUN-JUL	325	89	465	380	270	188	365
	JUN-SEP	345	88	495	405	290	200	390
North Platte R bl Guernsey Reservoir (2)	JUN-JUL	320	90	460	375	260	175	355
	JUN-SEP	335	88	485	395	275	187	380
Laramie R and Pioneer Cnl nr Woods Lg (2)	JUN-JUL	69	96	88	77	61	50	72
	JUN-SEP	80	99	100	88	72	60	81
Little Laramie R nr Filmore	JUN-JUL	32	91	40	35	29	24	35
	JUN-SEP	36	92	44	39	32	27	39

Max (10%), 30%, 50%, 70% and Min (90%) chance that actual volume will exceed forecast.
Medians are for the 1991-2020 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

Upper Missouri River Basin
July 2022 Calendar Year Runoff Forecast
July 6, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

June runoff was 5.2 MAF, 94% of average and 1.5 MAF more than forecasted last month. Precipitation during June was only slightly above normal in areas of the upper Basin, but a heavy rainstorm over the Yellowstone River coinciding with the mountain snowpack melt resulted in flooding along the Yellowstone River and around a 6-foot rise in Garrison.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **20.0 MAF, 78% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **17.8 MAF**, **76% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 6 months, expected inflow could range from the 22.3 MAF upper basic forecast to the 17.9 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for June 28, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 62% of the Basin, with Extreme Drought (D3) present in 4% of the Basin, mostly in Montana. The updated Seasonal Drought Outlook extending through the end of September in **Figure 2** shows existing drought conditions persisting and potential drought development into Iowa.

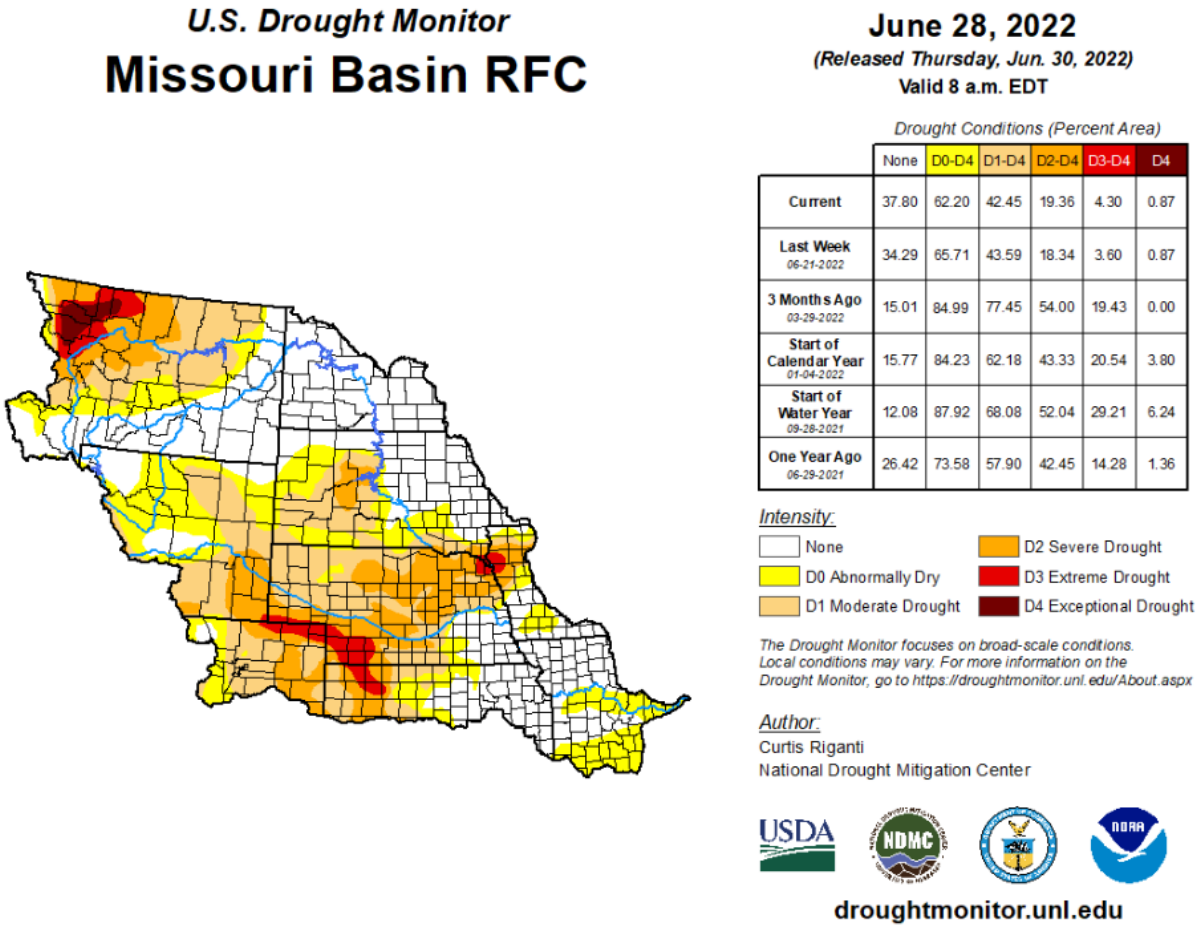


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

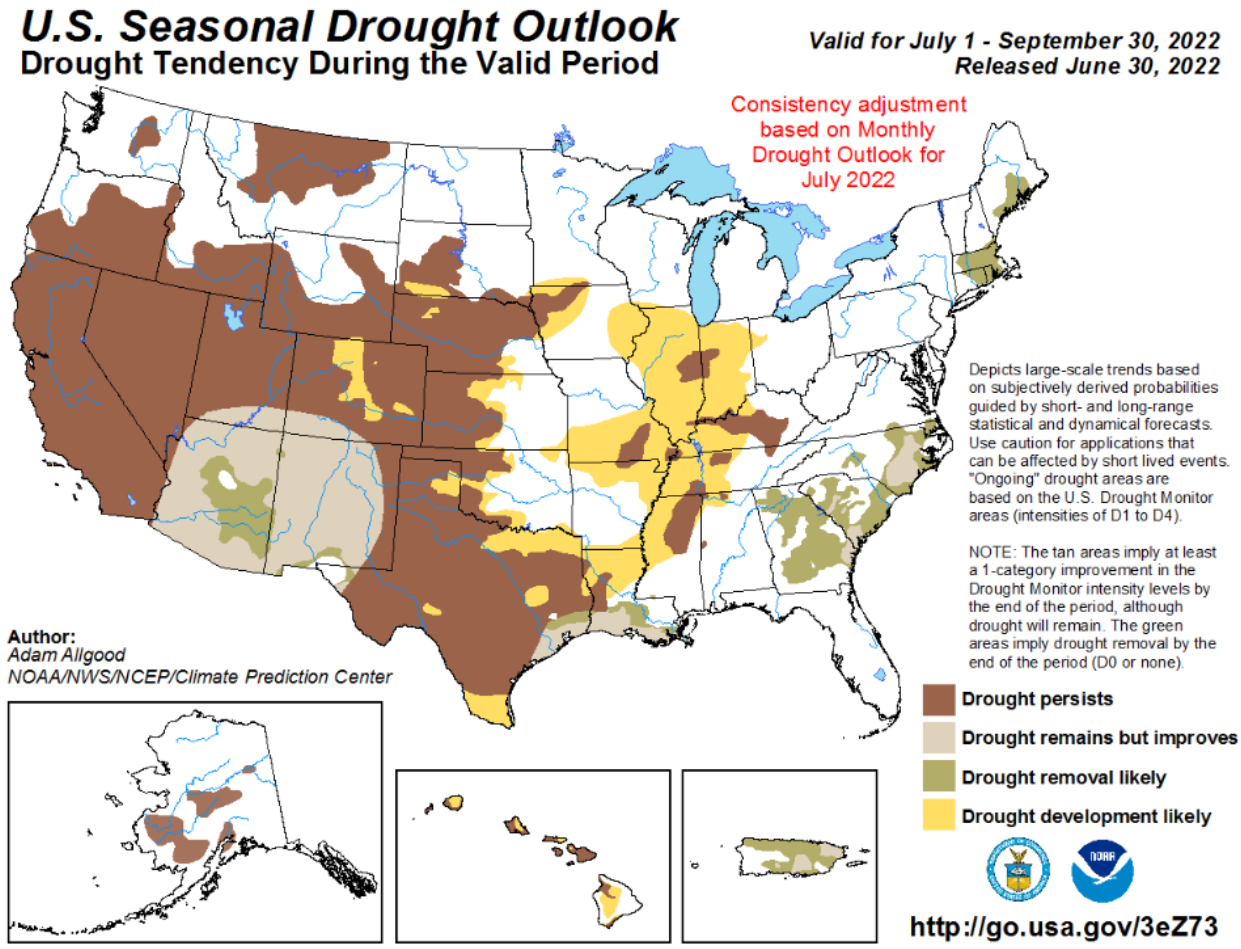


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The June precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. June precipitation was below normal for much of the Basin, with areas of near normal or slightly above normal precipitation in parts of Montana, the western Dakotas, and parts of eastern Kansas.

Precipitation as a percent of normal for the April through June 2022 period was below normal to normal for most of the Basin (**Figure 4**), except for North Dakota and parts of southern Montana and northern Wyoming.

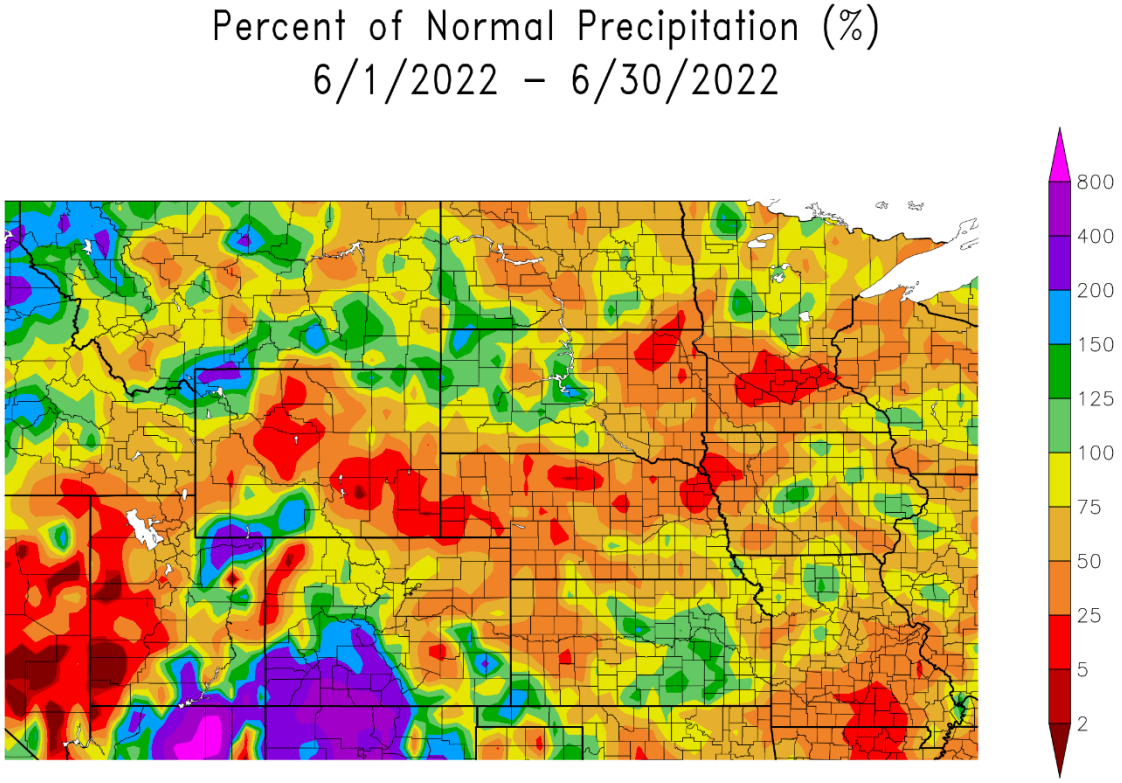


Figure 3. HPRCC June 2022 Percent of Normal Precipitation.

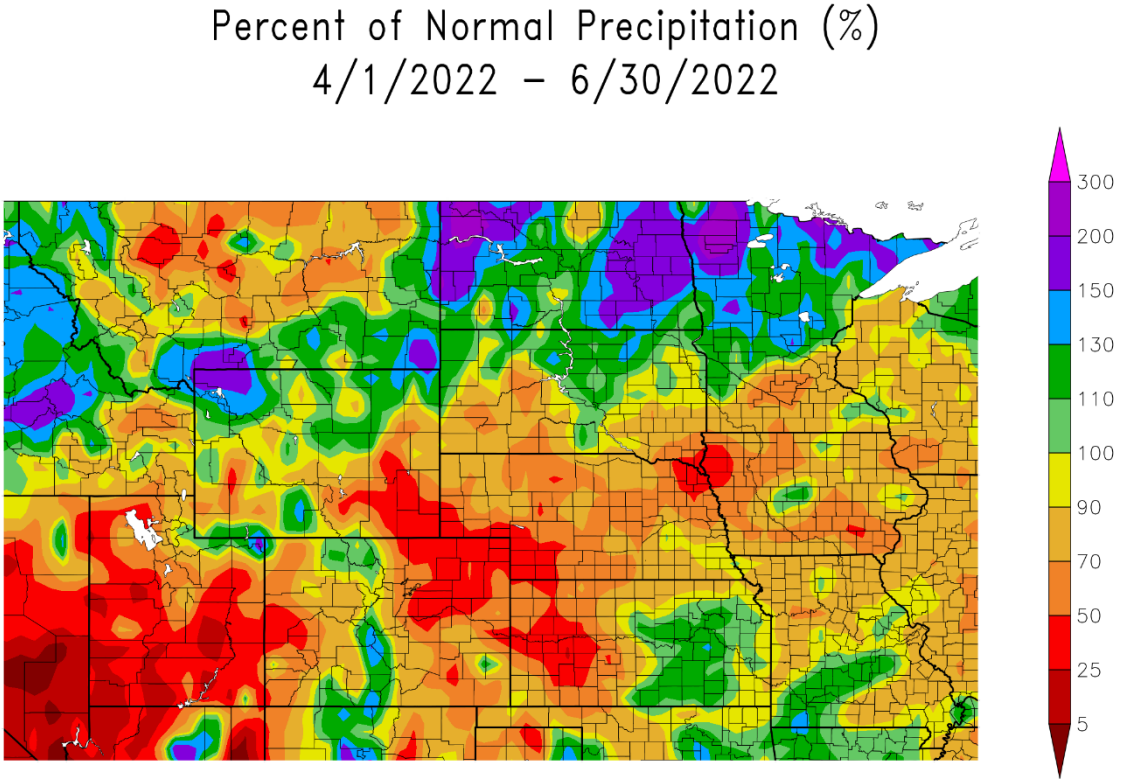


Figure 4. HPRCC April through June 2022 Percent of Normal Precipitation.

Temperature

June temperature departures from normal in degrees Fahrenheit (deg F) in **Figure 5** indicate slightly lower-than-normal temperatures in the western side of the Basin, with slightly warmer-than-normal temperatures in the eastern and lower Basin.

April through June 2022 temperature departures are shown in **Figure 6**. Temperatures over the past three months have generally been slightly below normal in the upper basin and slightly above normal in the lower Basin.

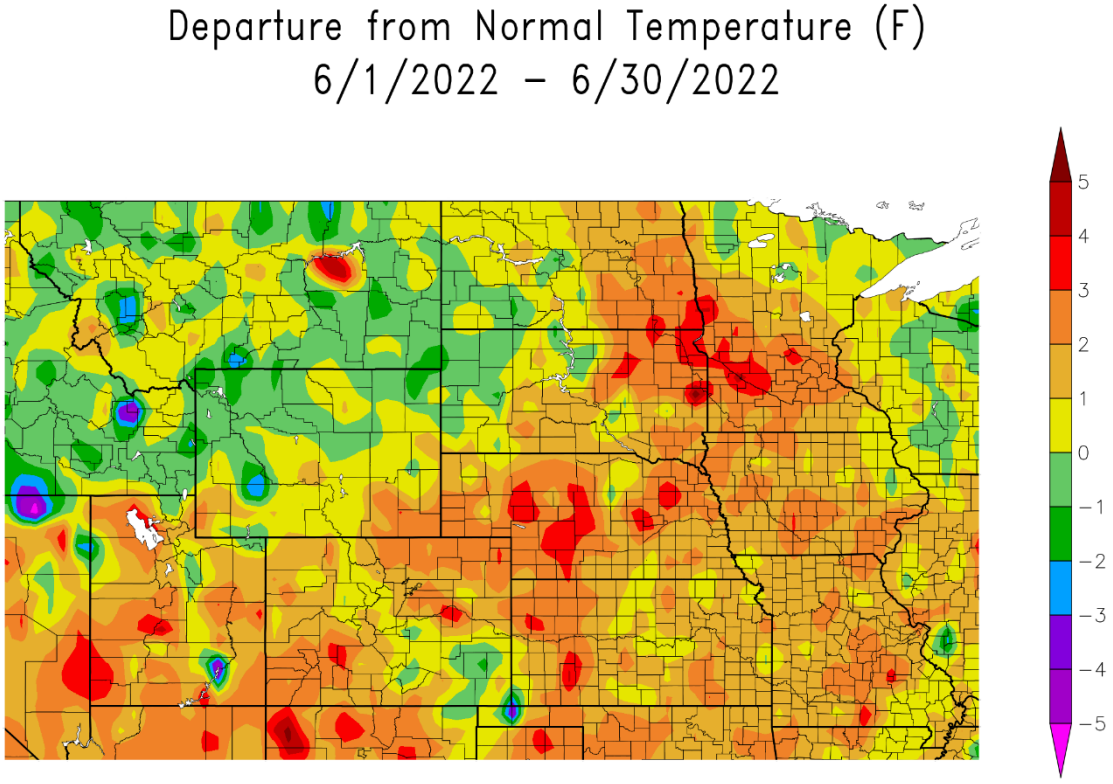


Figure 5. HPRCC June 2022 Departure from Normal Temperature.

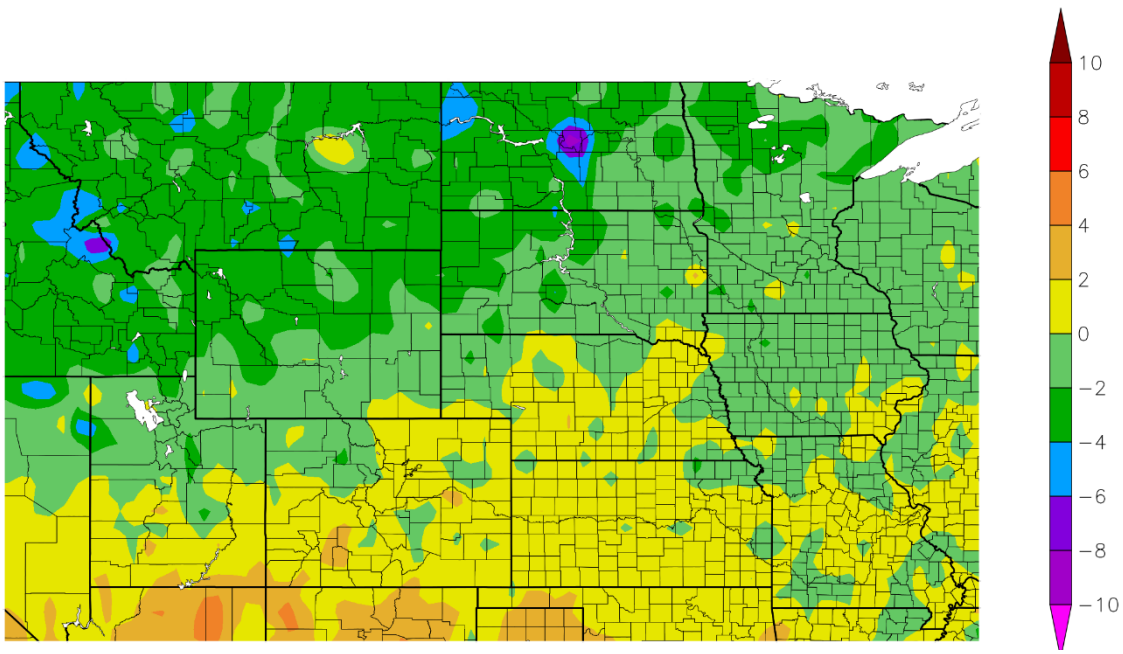


Figure 6. HPRCC April through June 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry in Montana, parts of Wyoming, Nebraska, western Iowa, and western Kansas, with near-normal conditions present in much of the rest of the Basin. Soil moisture is above normal in eastern North Dakota and northeastern South Dakota. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

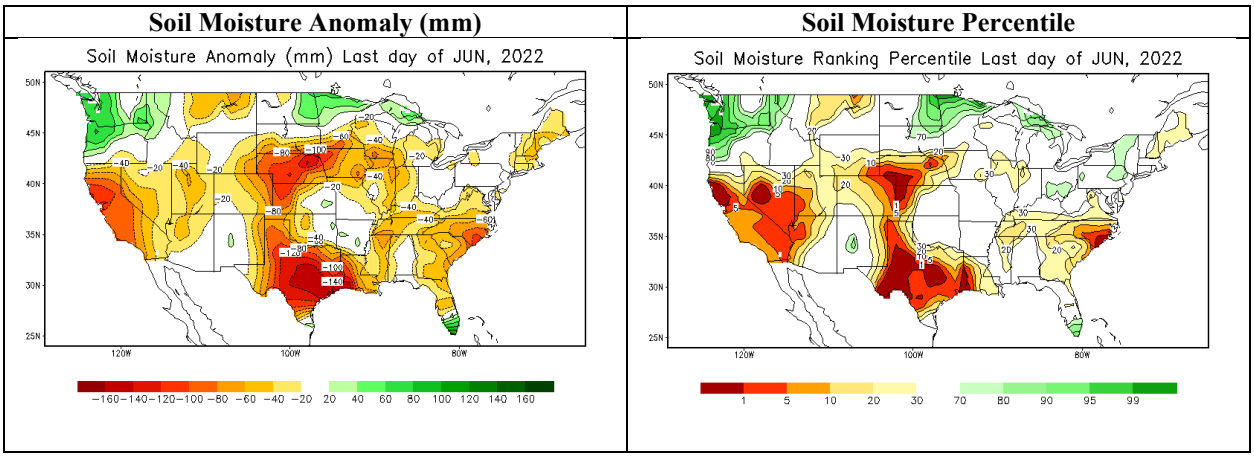


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

Plains snowpack in the basin has been nonexistent since May, so was not factored into the July 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

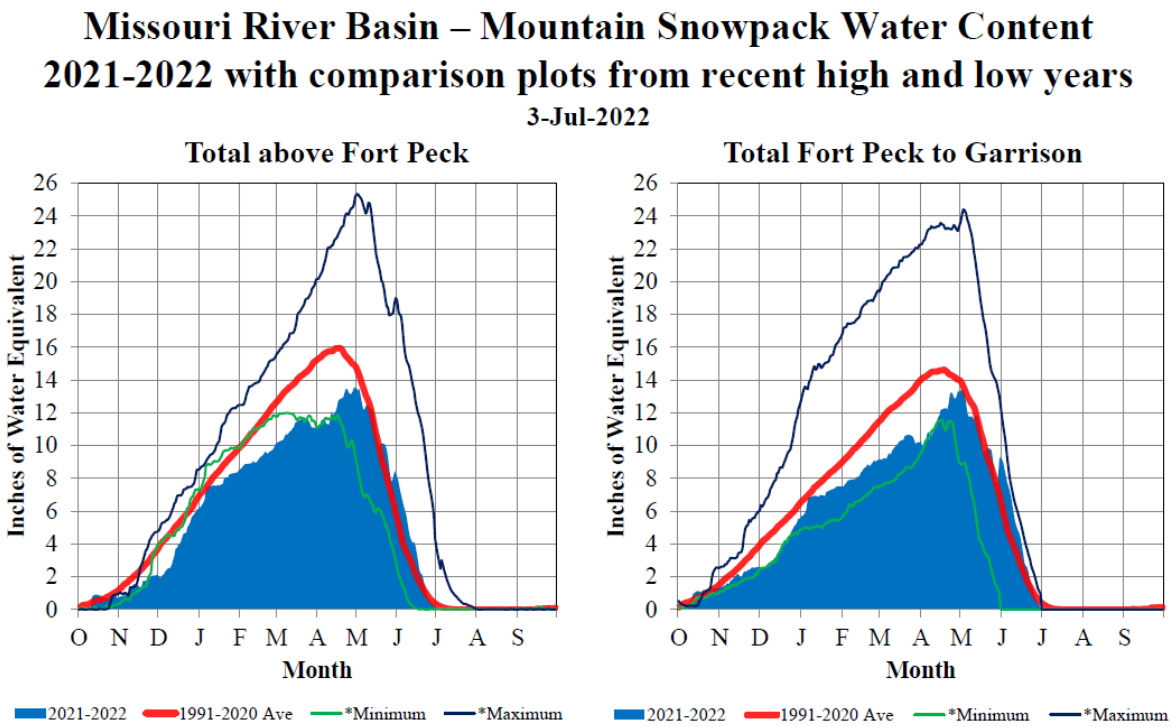


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack peaked in the Fort Peck reach on April 29 at 13.5" of SWE and 85% of the normal peak. The mountain snowpack peaked in the Garrison reach on May 3 at 13.4" of SWE and 92% of the normal peak. As of July 3, all mountain snowpack has melted in both reaches.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña).

During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 52% chance of continuing during July through September 2022, and there is a 58-59% chance of continuing La Niña through the fall and early winter.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The July CPC outlooks (**Figure 9**) indicate increased chances for warmer-than-normal temperatures across the entire Basin. An increased chance of below-normal precipitation is indicated in the lower Basin, while equal chances for above-normal, normal, or below-normal precipitation exist in the upper Basin.

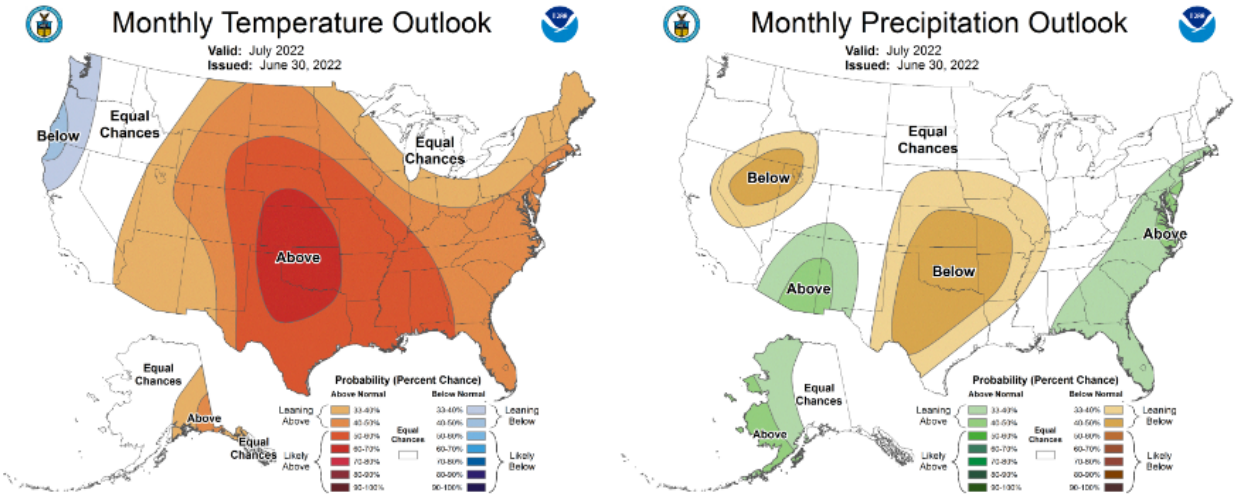


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (July).

Three-month temperature and precipitation outlooks for August 2022 through January 2023 are shown below in **Figure 10** and **Figure 11**. During August through October, the outlooks indicate increased chances for warmer-than-normal and drier-than-normal conditions across the lower Basin, with equal chances in Montana, North Dakota, and northeastern South Dakota. The November 2022 through January 2023 outlooks indicate above-normal temperatures over most of the Basin except for Iowa, where equal chances for above-normal, normal, or below-normal temperatures exist. Equal chances for precipitation are indicated over most of the Basin for the November through January period.

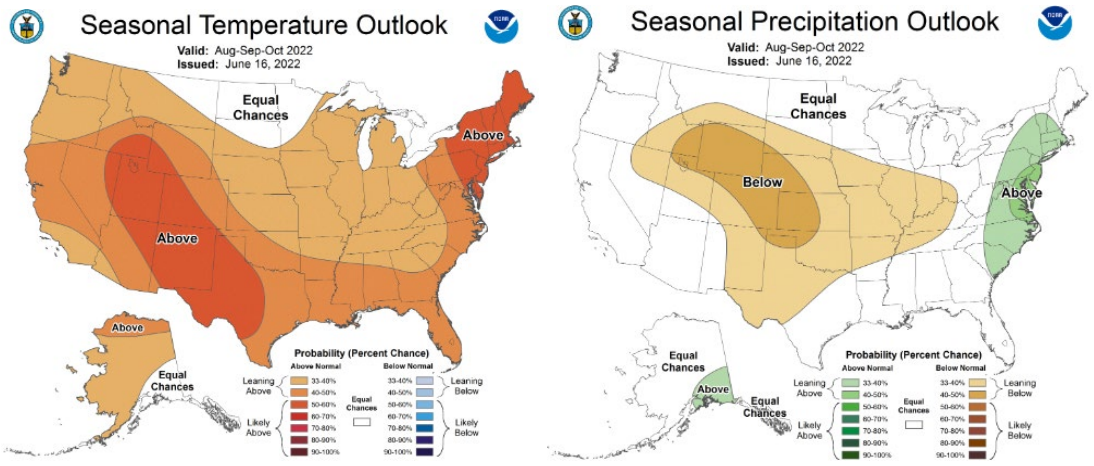


Figure 10. CPC August-September-October 2022 temperature and precipitation outlooks.

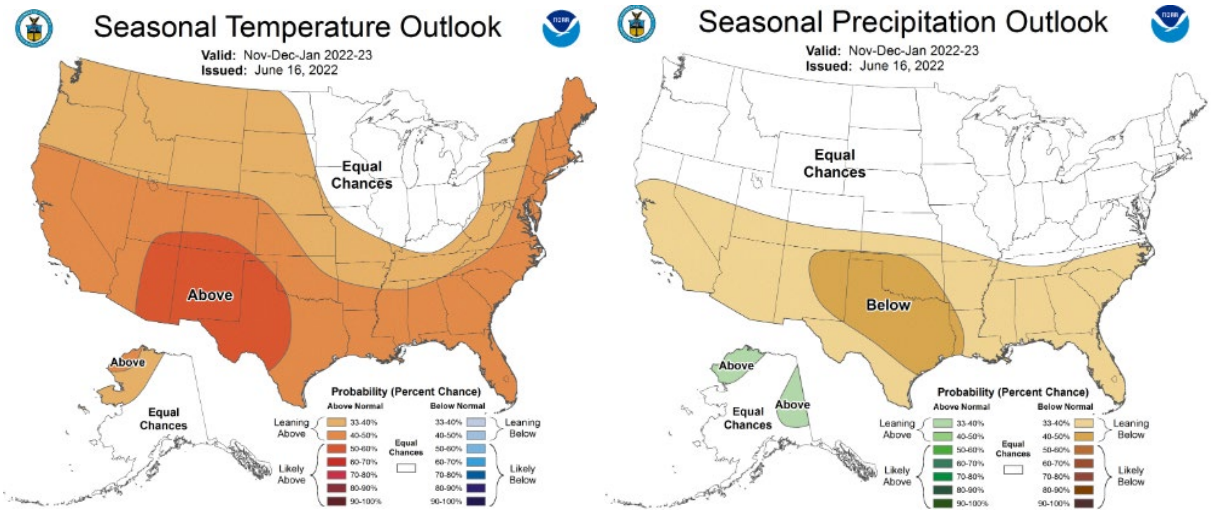


Figure 11. CPC November-December 2022-January 2023 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal for the remainder of the year. During July, Fort Peck and Garrison runoff is forecast to be below average due to the slightly below-normal mountain snowpack which is melted already, and the dry soil moisture conditions. During July in the other reaches, as well as the remainder of the year in all reaches, we expect runoff to be below normal to near normal, but this could vary based on precipitation events in the summer and fall. In summary, the 2022 calendar year runoff forecast is **20.0 MAF (78% of average)**.

Upper Missouri River Basin
August 2022 Calendar Year Runoff Forecast
August 2, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

July runoff was 3.2 MAF, 98% of average and 0.7 MAF more than forecasted last month. Precipitation during July was very mixed in the Basin. Pockets of near to above-normal precipitation were observed in Montana, western North Dakota, eastern and central South Dakota, central Nebraska into northeastern Kansas, and northern Missouri. Below-normal precipitation was observed elsewhere in the Basin.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **20.6 MAF, 80% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **18.4 MAF**, **79% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 5 months, expected inflow could range from the 21.9 MAF upper basic forecast to the 19.5 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for July 26, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 62% of the Basin, with Extreme Drought (D3) present in 6% of the Basin. The updated Seasonal Drought Outlook extending through the end of October in **Figure 2** shows existing drought conditions persisting and potential drought development over the rest of the lower Basin.

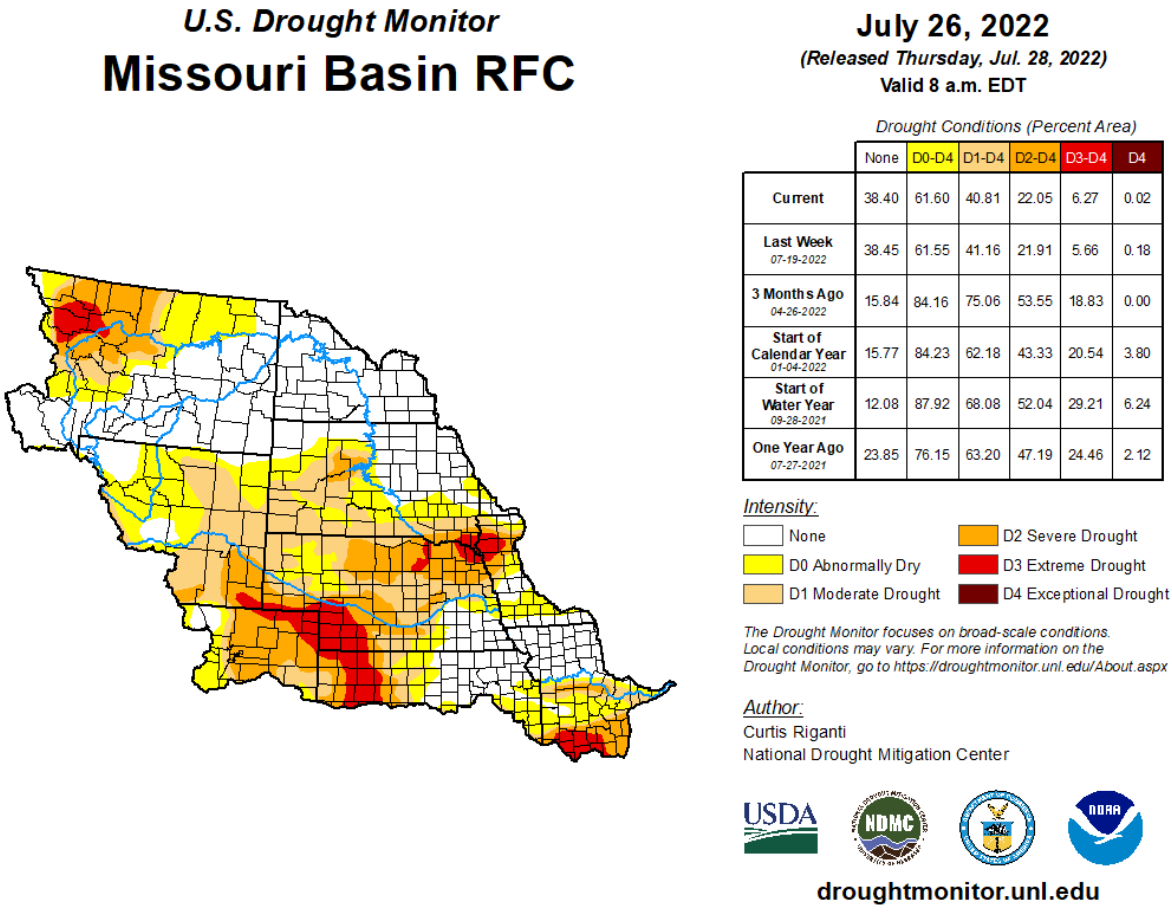


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

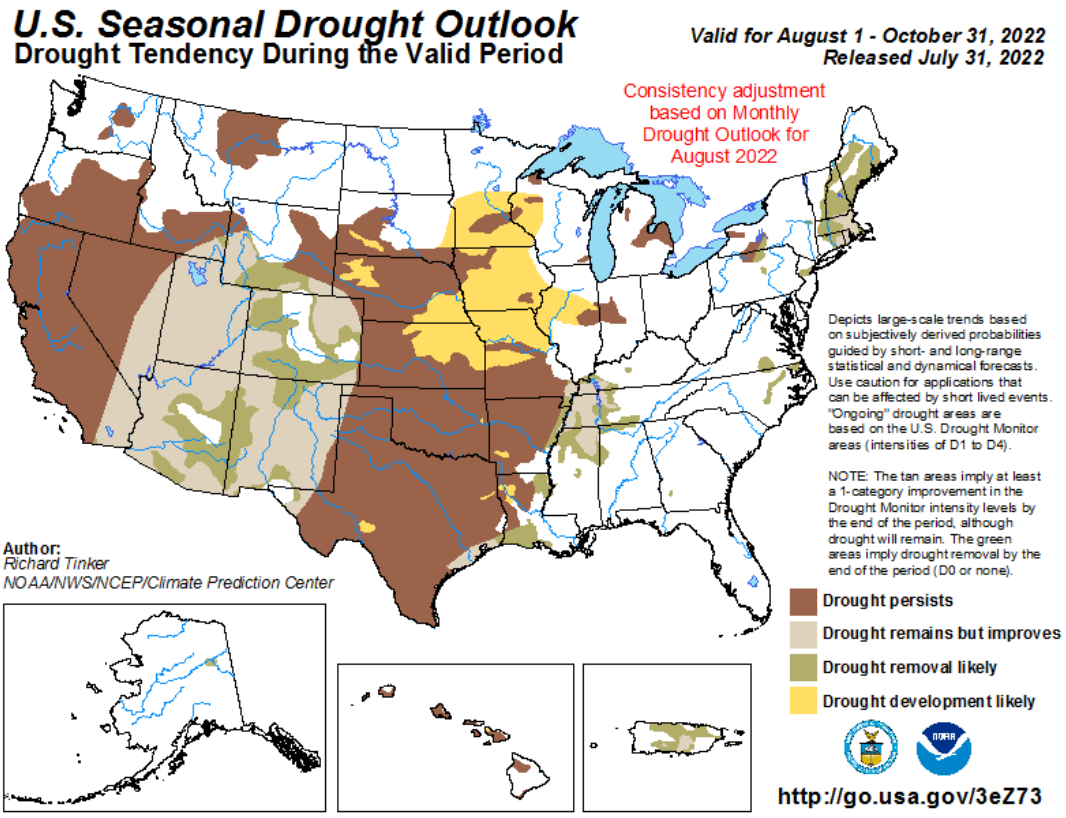


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The July precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. July precipitation was mixed in the Basin, with areas of normal to above-normal precipitation in Montana, western North Dakota, eastern and central South Dakota, central Nebraska into northeastern Kansas, and northern Missouri. Below-normal precipitation was observed elsewhere in the Basin.

Precipitation as a percent of normal for the May through July 2022 period was below normal for most of the Basin (**Figure 4**), except for pockets of normal to above-normal precipitation scattered in the upper Basin and in eastern Kansas and northern Missouri.

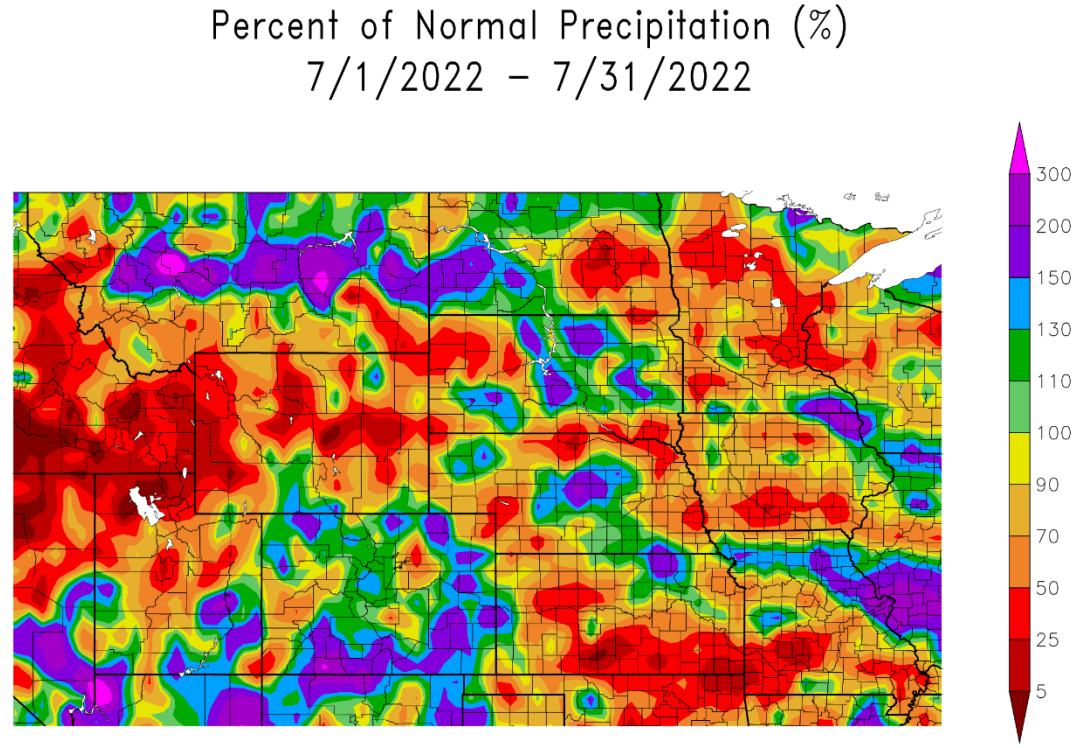


Figure 3. HPRCC July 2022 Percent of Normal Precipitation.

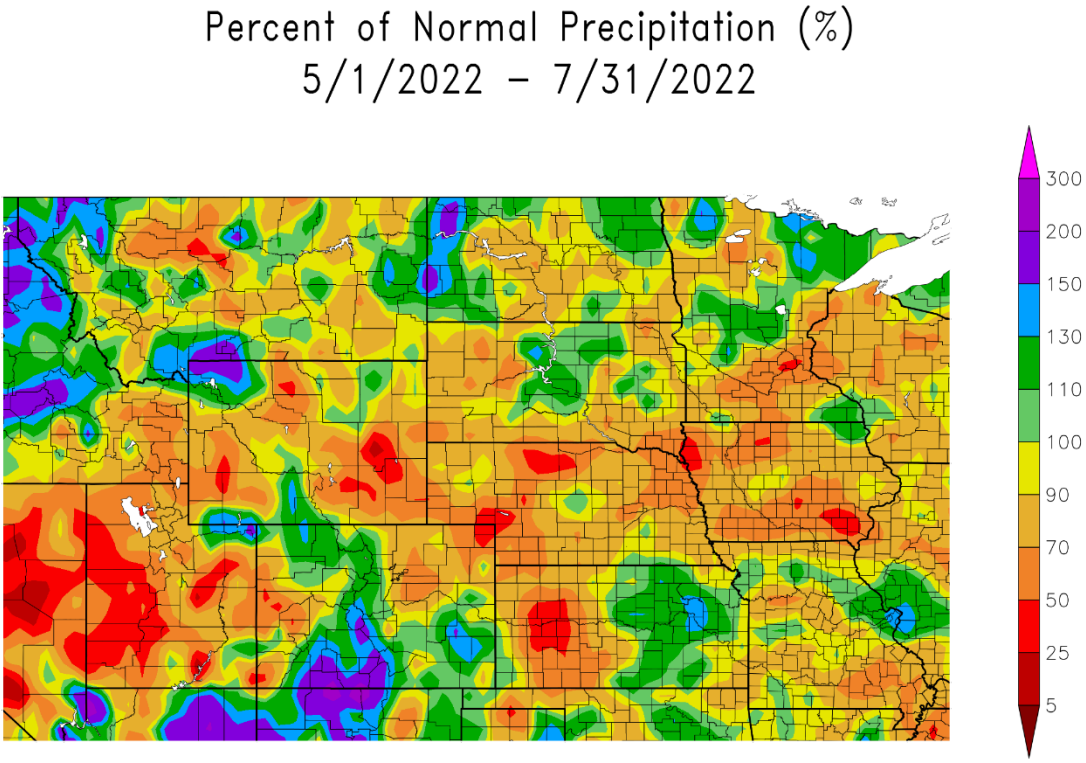


Figure 4. HPRCC May through July 2022 Percent of Normal Precipitation.

Temperature

July temperature departures from normal in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures for most of the Basin, except for a small strip of near to below-normal temperatures along the Kansas-Nebraska border and into northern Missouri.

May through July 2022 temperature departures are shown in **Figure 6**. Temperatures over the past three months have been mostly near normal, with slightly cooler temperatures in the west and slightly warmer temperatures in the east and south.

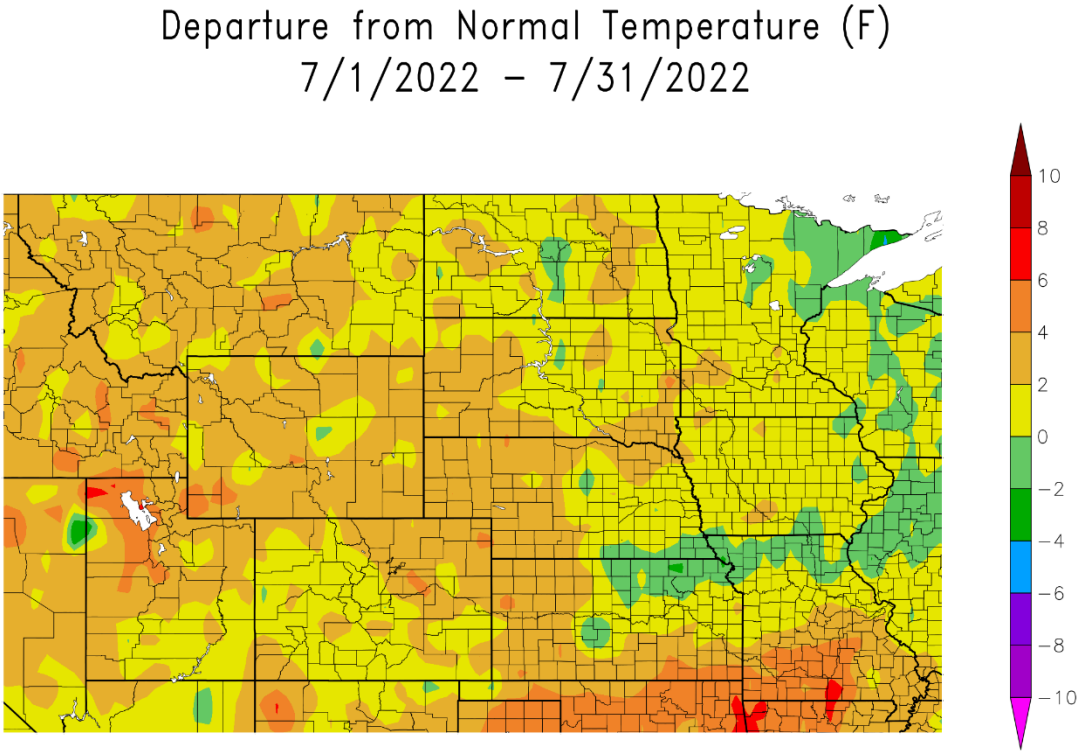


Figure 5. HPRCC July 2022 Departure from Normal Temperature.

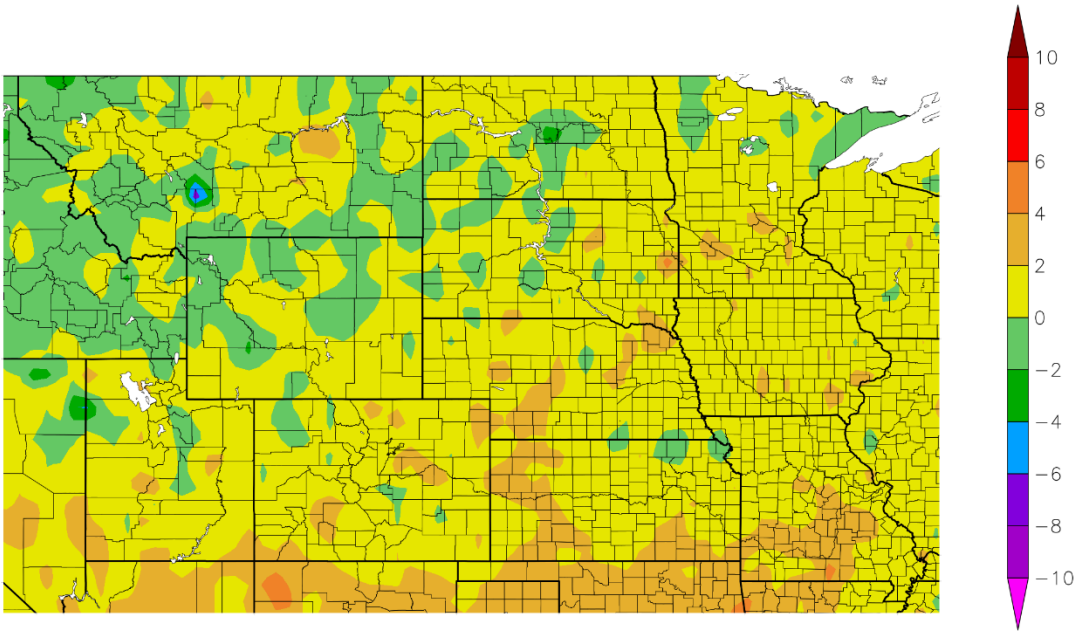


Figure 6. HPRCC May through July 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry in the lower Basin, with drier conditions creeping northward into southern South Dakota over the past month. Continued drier-than-normal soil conditions are observed in Wyoming and parts of Montana. A small area of above-normal soil moisture conditions exists in western North Dakota and central Missouri. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

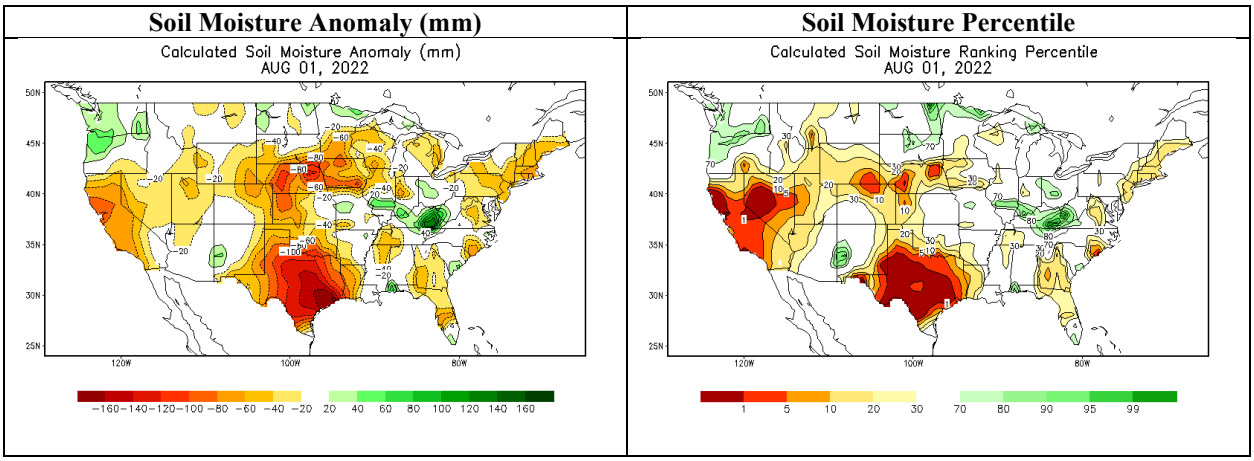


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

Plains snowpack in the basin has been nonexistent since May, so was not factored into the August 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

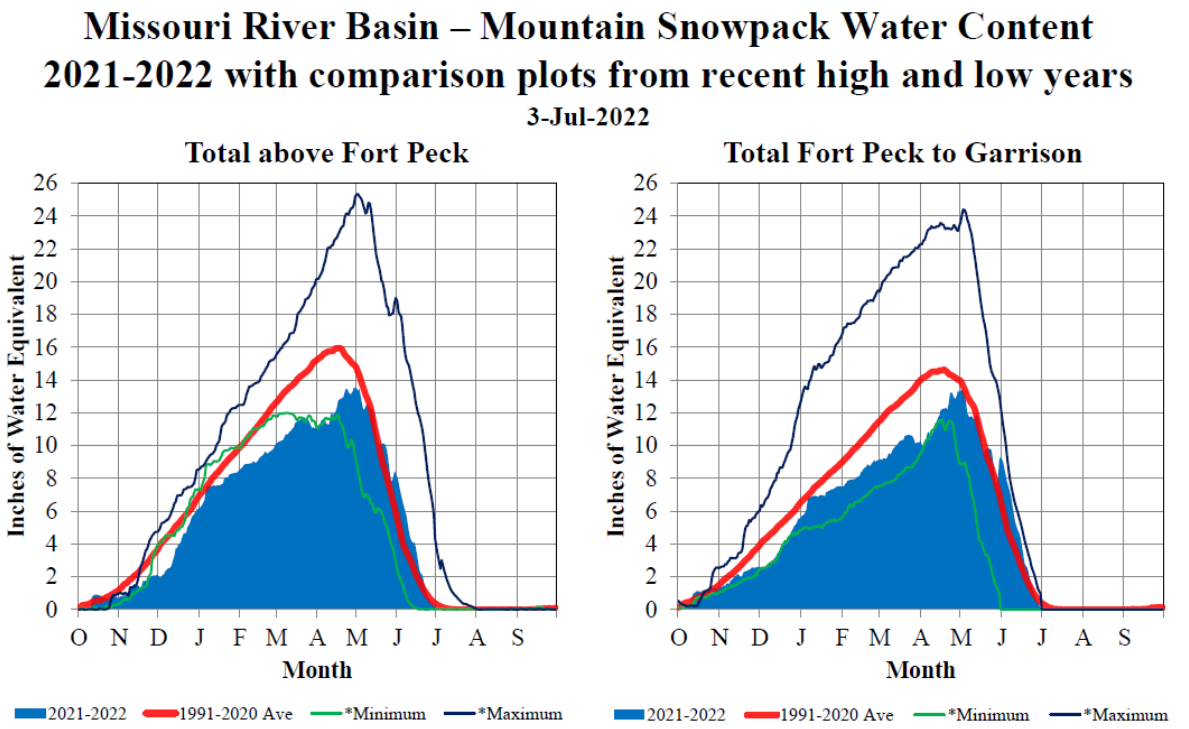


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack peaked in the Fort Peck reach on April 29 at 13.5" of SWE and 85% of the normal peak. The mountain snowpack peaked in the Garrison reach on May 3 at 13.4" of SWE and 92% of the normal peak. All mountain snowpack had melted in both reaches by July 3.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña).

During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have a 60% chance of continuing during July through September 2022, and there is a 62-66% chance of continuing La Niña through the fall and early winter.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The August CPC outlooks (**Figure 9**) indicate increased chances for warmer-than-normal temperatures and below-normal precipitation across the entire Basin.

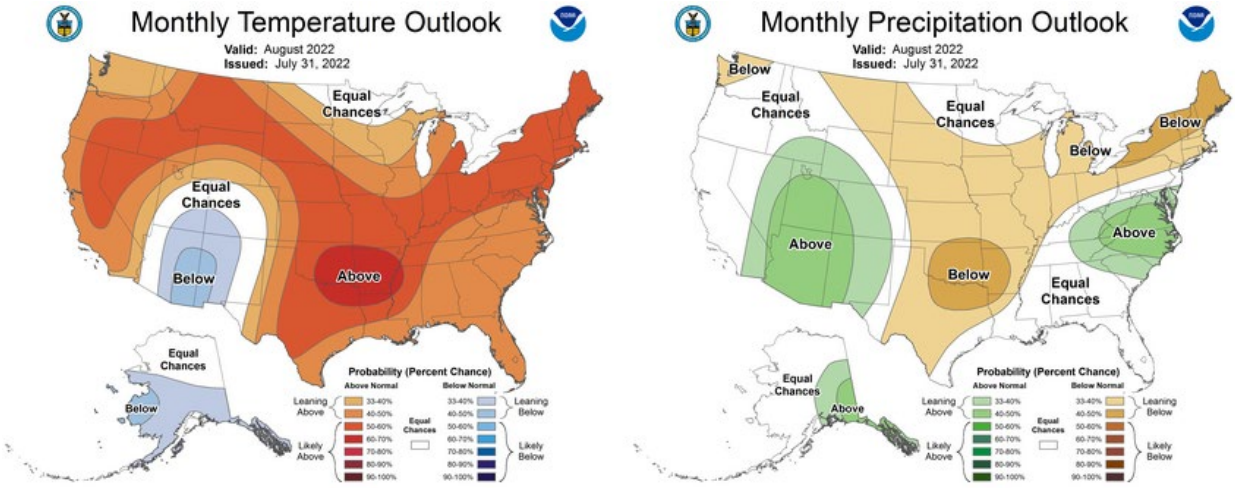


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (August).

Three-month temperature and precipitation outlooks for September 2022 through February 2023 are shown below in **Figure 10** and **Figure 11**. During September through November, the temperature outlook indicates increased chances for warmer-than-normal temperatures in the lower Basin and into Wyoming, with equal chances for above-normal, normal, or below-normal temperatures in the rest of the Basin. The precipitation outlook indicates equal chances for above-normal, normal, or below-normal precipitation in Montana and North Dakota, with increased chances for below-normal precipitation in the rest of the Basin. The December 2022 through February 2023 outlooks indicate equal chances for above-normal, normal, and below-normal temperature and precipitation across the Basin.

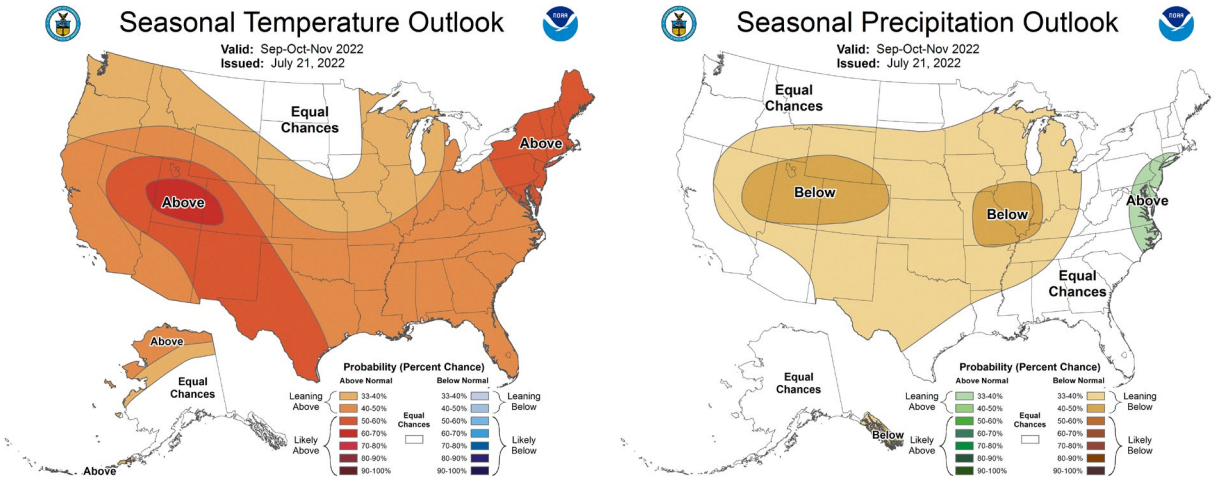


Figure 10. CPC August-September-October 2022 temperature and precipitation outlooks.

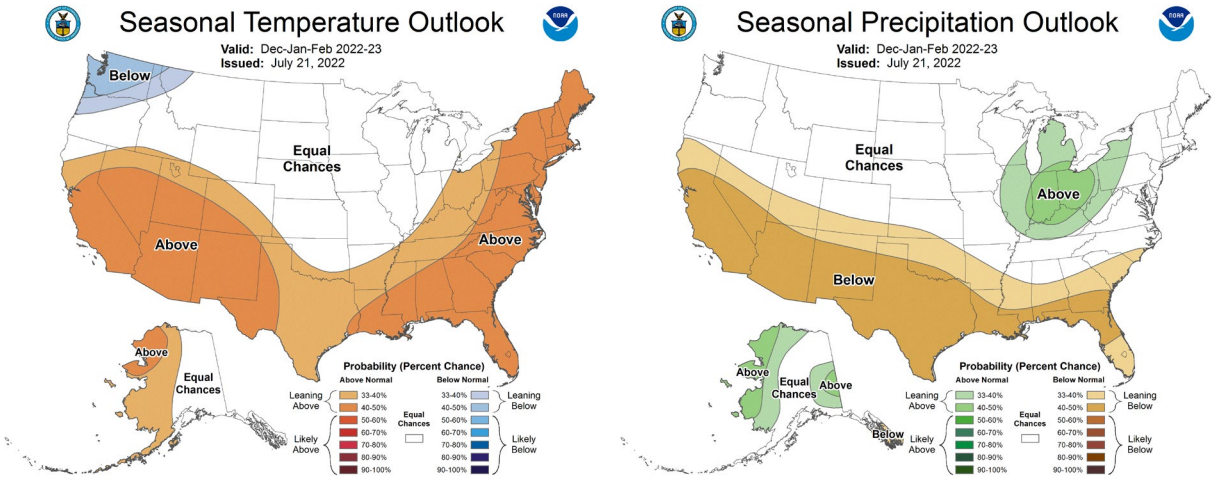


Figure 11. CPC November-December 2022-January 2023 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal in all reaches for the remainder of the year, but this could vary based on precipitation events in the late summer and fall. In summary, the 2022 calendar year runoff forecast is **20.6 MAF (80% of average)**.

Upper Missouri River Basin
September 2022 Calendar Year Runoff Forecast
September 2, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

August runoff was 0.9 MAF, 62% of average above Sioux City, and 0.6 MAF or 49% of average above Gavins Point. Runoff in the upper four reaches was well below normal, ranging from 10 to 49 percent of average. Precipitation during August was below normal for most of the Basin, except for Wyoming and localized areas of Colorado, central Montana, and western South Dakota.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **20.2 MAF, 78% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **17.8 MAF**, **76% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 4 months, expected inflow could range from the 21.0 MAF upper basic forecast to the 19.4 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for August 30, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 74% of the Basin, with Extreme Drought (D3) present in 7% of the Basin. The updated Seasonal Drought Outlook extending through the end of November in **Figure 2** shows existing drought conditions persisting and potential additional drought development.

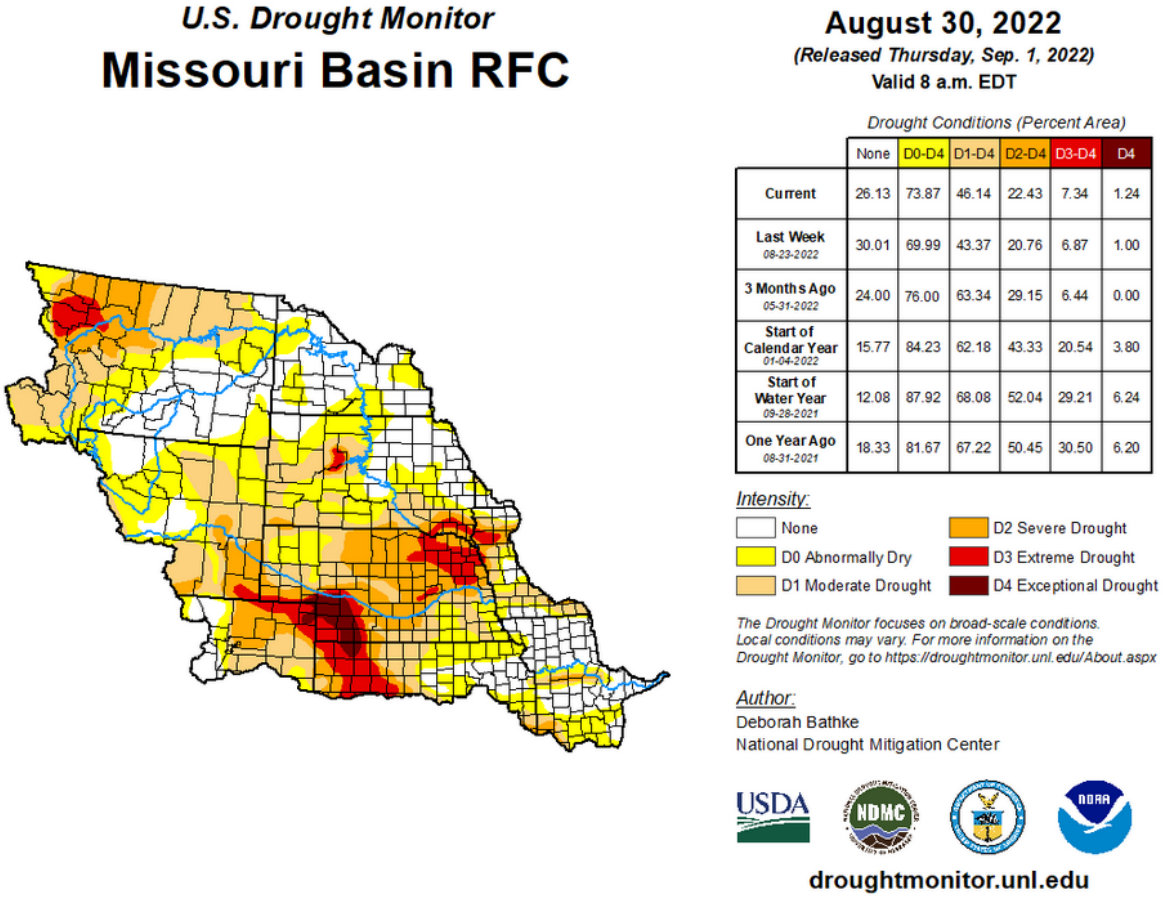


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

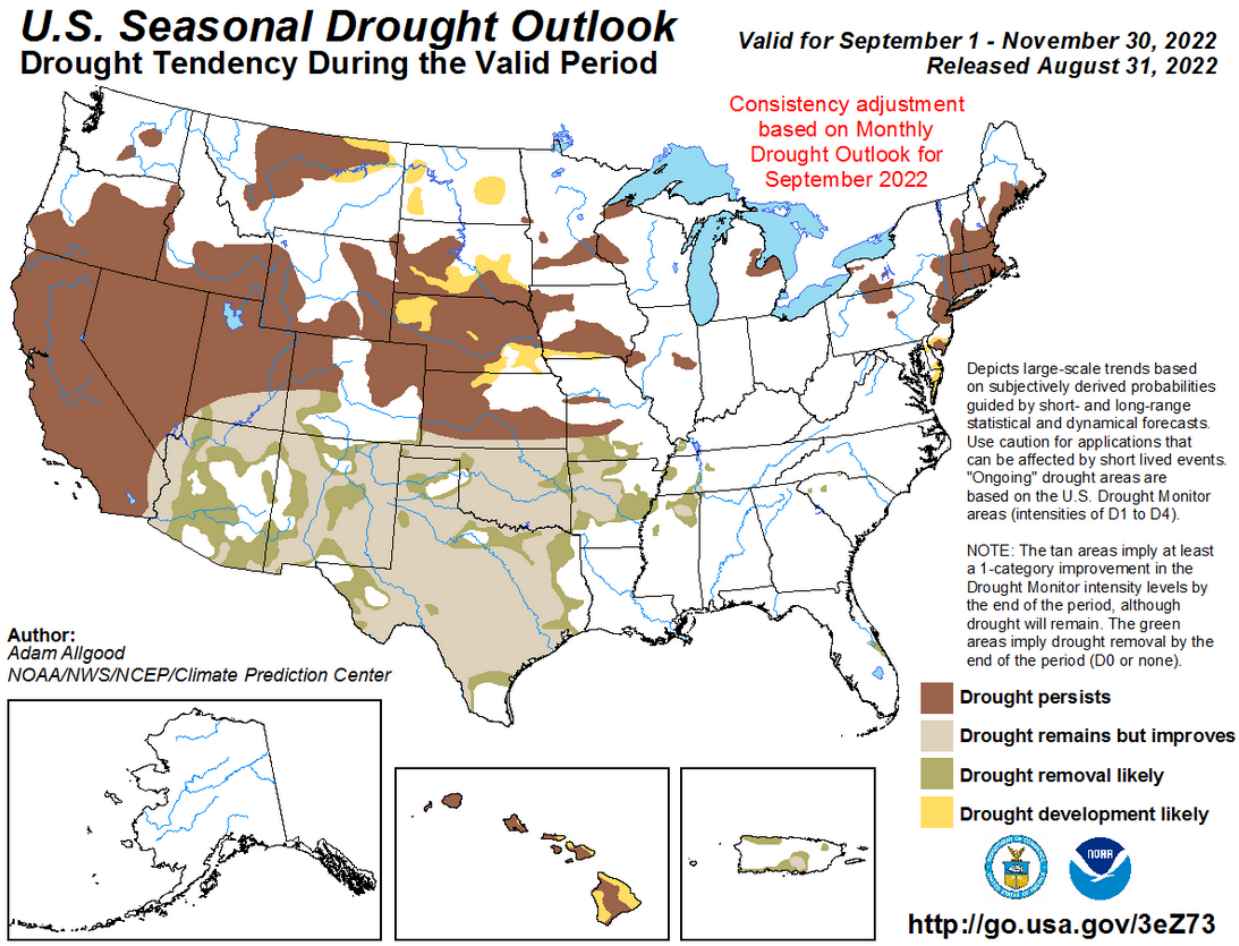


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The August precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. August precipitation was below normal across much of the Basin. Wyoming and isolated areas of central Colorado, central Montana, and western South Dakota saw slightly above normal precipitation in August. Areas of Montana and Nebraska saw as little as two percent of normal precipitation.

Precipitation as a percent of normal for the June through August 2022 period was below normal for most of the Basin (**Figure 4**), except for pockets of normal to above-normal precipitation scattered in the upper Basin and in Missouri.

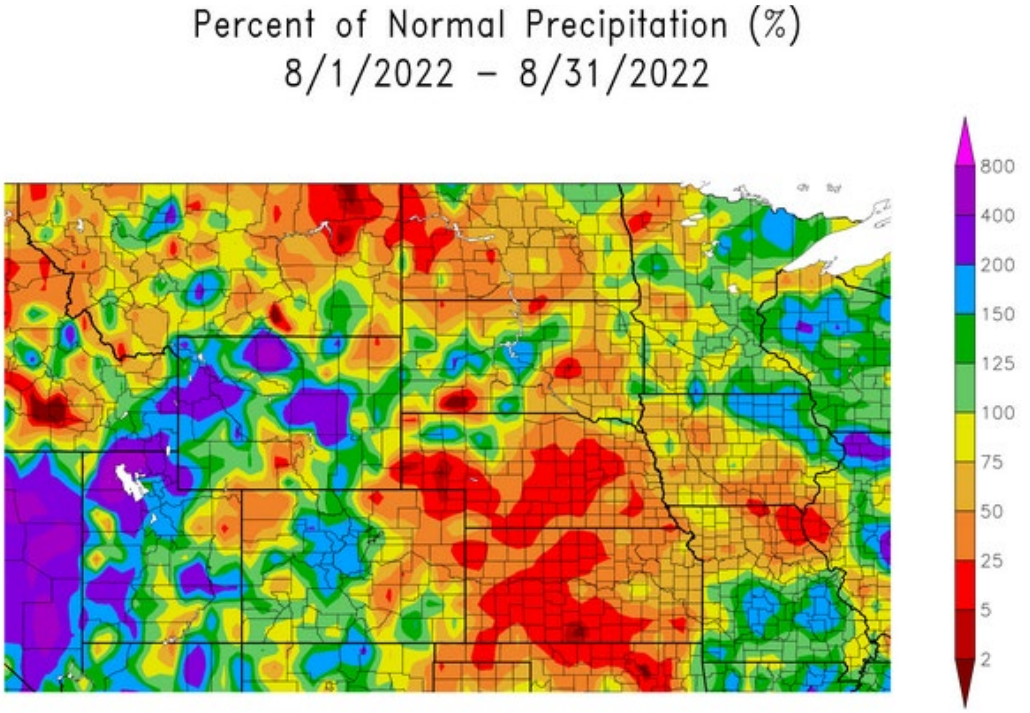


Figure 3. HPRCC August 2022 Percent of Normal Precipitation.

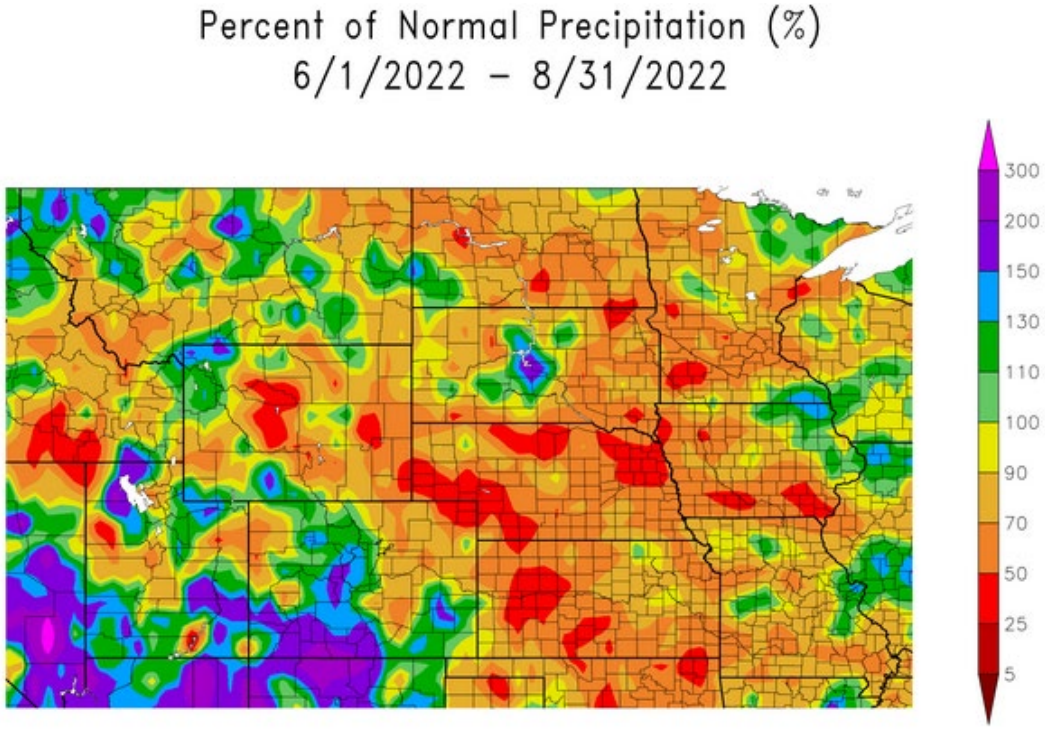


Figure 4. HPRCC June through August 2022 Percent of Normal Precipitation.

Temperature

August temperature departures from normal in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures for most of the Basin, ranging up to 6 degrees above normal over large areas of Montana.

June through August 2022 temperature departures are shown in **Figure 6**. Temperatures over the past three months have also been warmer than normal, with many areas up to 4 degrees above normal.

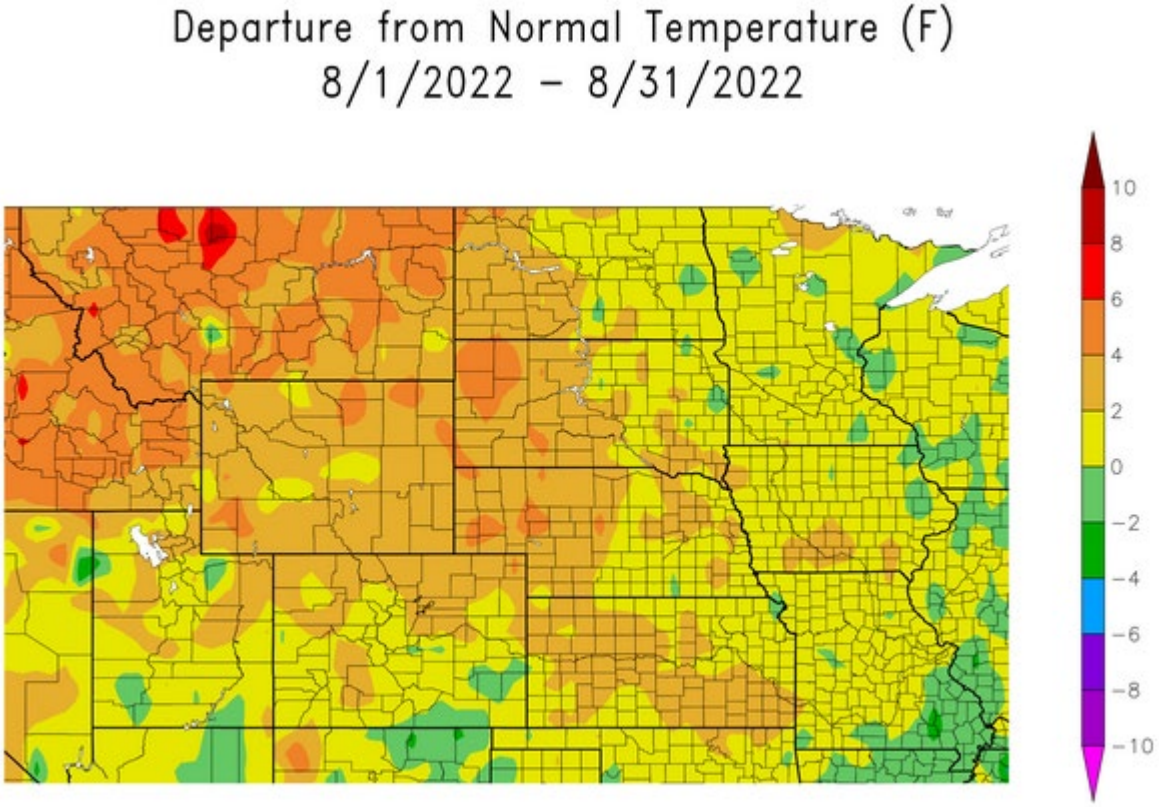


Figure 5. HPRCC August 2022 Departure from Normal Temperature.

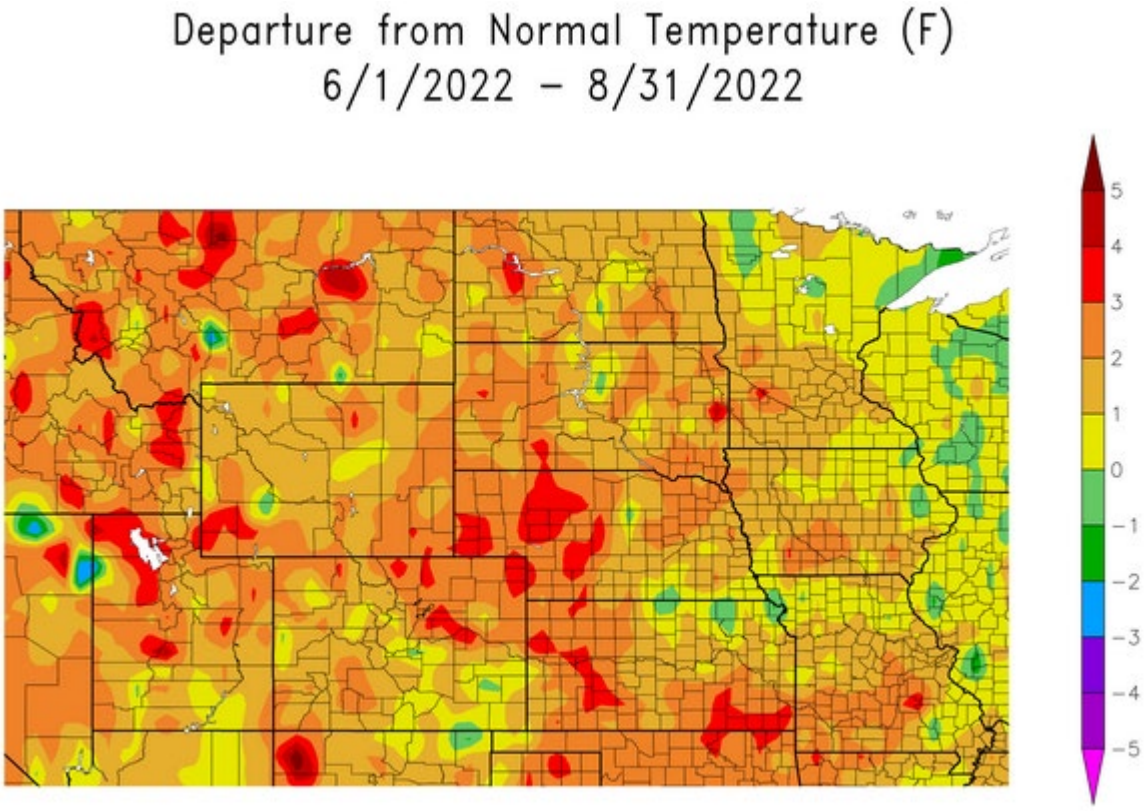


Figure 6. HPRCC June through August 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry across most of the Basin, except for large areas of Wyoming and South Dakota, which are near normal. Large areas of northern Montana and southwestern Nebraska are extremely dry, ranking below the first percentile. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

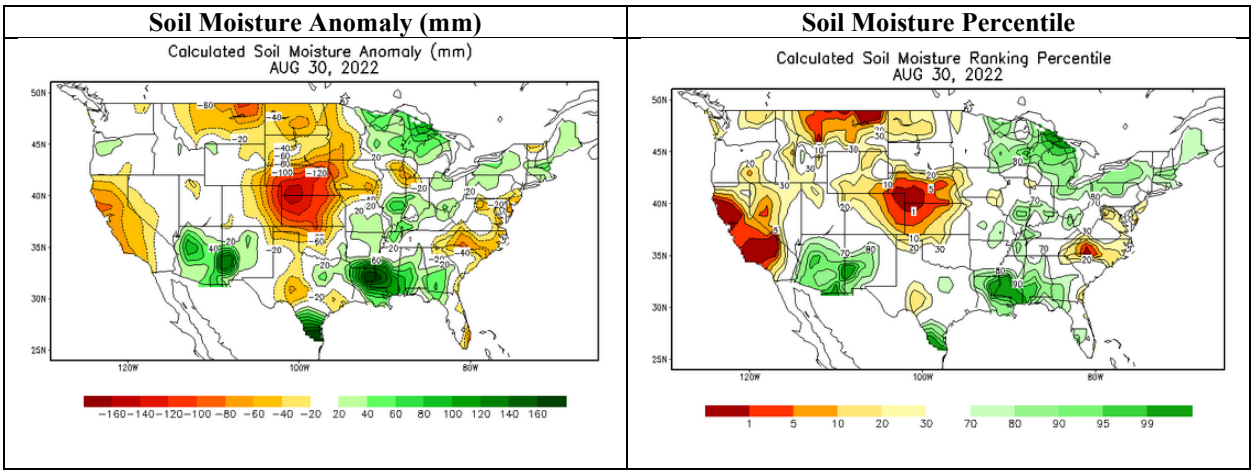


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

Plains snowpack in the basin has been nonexistent since May, so it was not factored into the September 1 forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

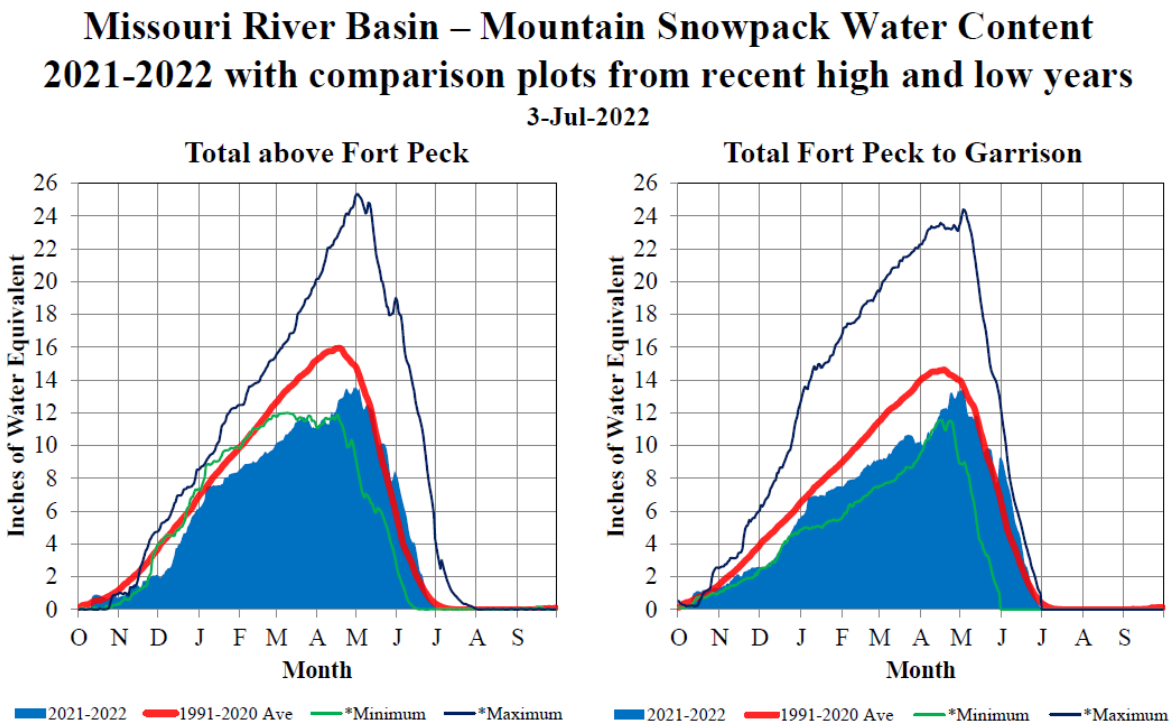


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack peaked in the Fort Peck reach on April 29 at 13.5" of SWE and 85% of the normal peak. The mountain snowpack peaked in the Garrison reach on May 3 at 13.4" of SWE and 92% of the normal peak. All mountain snowpack had melted in both reaches by July 3 and was not factored into this September 1 forecast.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña).

During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions have an 86% chance of continuing through the summer and early fall, with a 60% chance of continuing La Niña through December to February 2022-23.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The September CPC outlooks (**Figure 9**) indicate increased chances for warmer-than-normal temperatures and below-normal precipitation across the entire Basin.

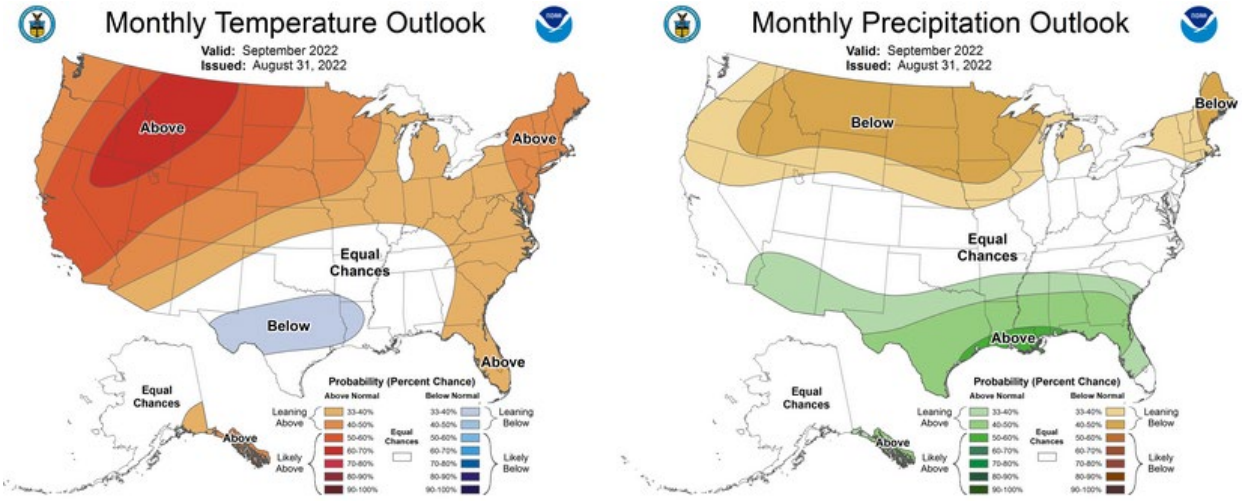


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (September).

Three-month temperature and precipitation outlooks for October through December are shown below in **Figure 10**. During October through December, the temperature outlook indicates increased chances for warmer-than-normal temperatures in the lower Basin and into Wyoming, with equal chances for above-normal, normal, or below-normal temperatures in the rest of the upper Basin. The precipitation outlook indicates equal chances for above-normal, normal, or below-normal precipitation in the upper Basin, with increased chances for below-normal precipitation in the lower Basin.

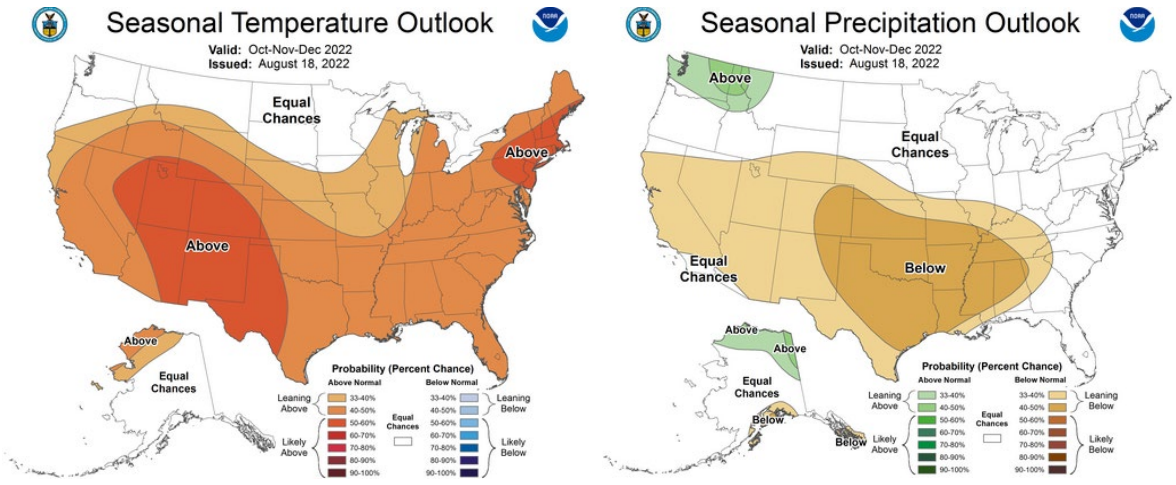


Figure 10. CPC October-November-December 2022 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal in the reaches above Gavins Point for the remainder of the year, but this could vary based on precipitation events in the late summer and fall. In summary, the 2022 calendar year runoff forecast is **20.2 MAF (78% of average)**.

Upper Missouri River Basin
October 2022 Calendar Year Runoff Forecast
October 5, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

September runoff was 0.6 MAF, 47% of average above Sioux City, and 0.5 MAF or 44% of average above Gavins Point. Runoff was below normal in all reaches except for the Gavins Point reach, which was near normal. Precipitation during September was below normal for most of the Basin, except for localized areas in western Montana, Wyoming, and portions of Nebraska and Kansas.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **19.5 MAF, 76% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **17.2 MAF**, **74% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 3 months, expected inflow could range from the 20.1 MAF upper basic forecast to the 19.0 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for September 27, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 92% of the Basin, with Extreme Drought (D3) present in 2% of the Basin. The updated Seasonal Drought Outlook extending through the end of December in **Figure 2** shows existing drought conditions persisting and potential expansion across most of the Basin. A small area in western Montana could see some drought improvement.

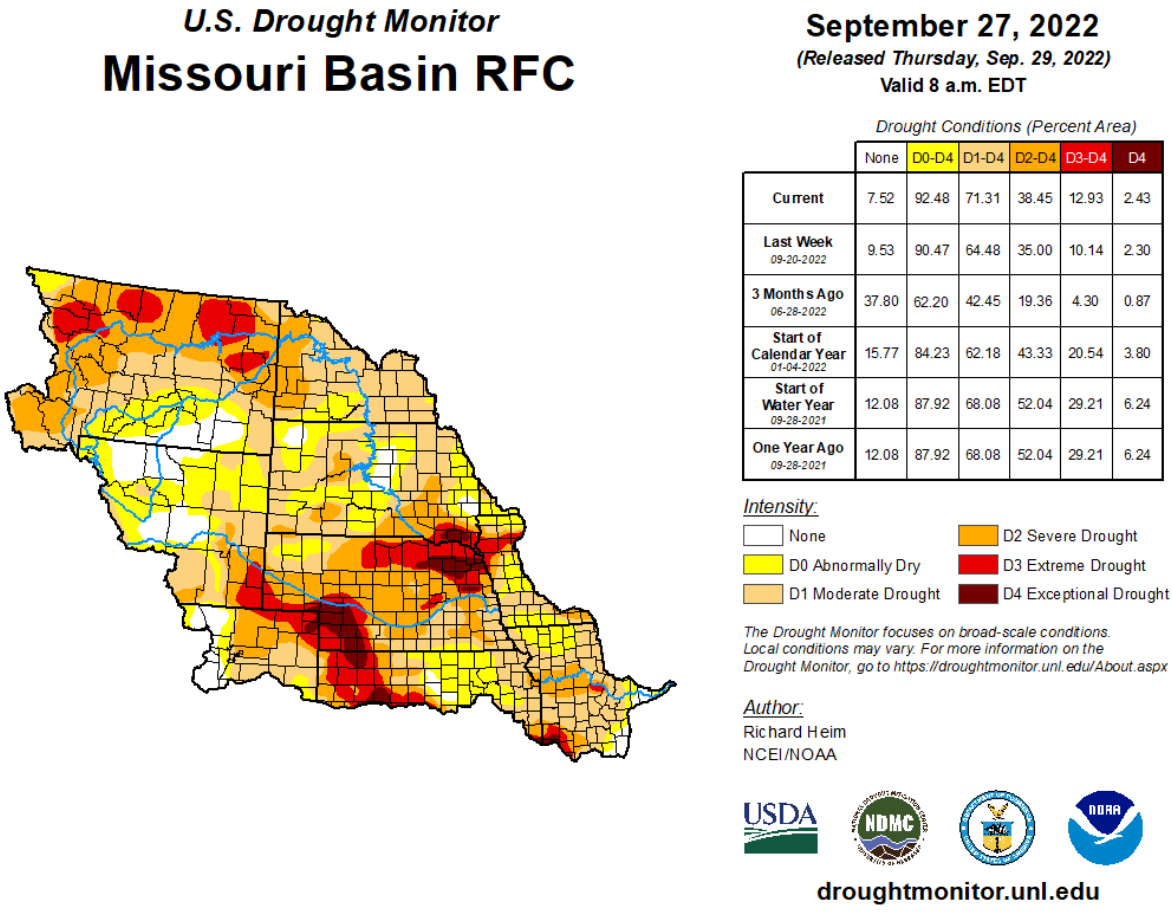


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

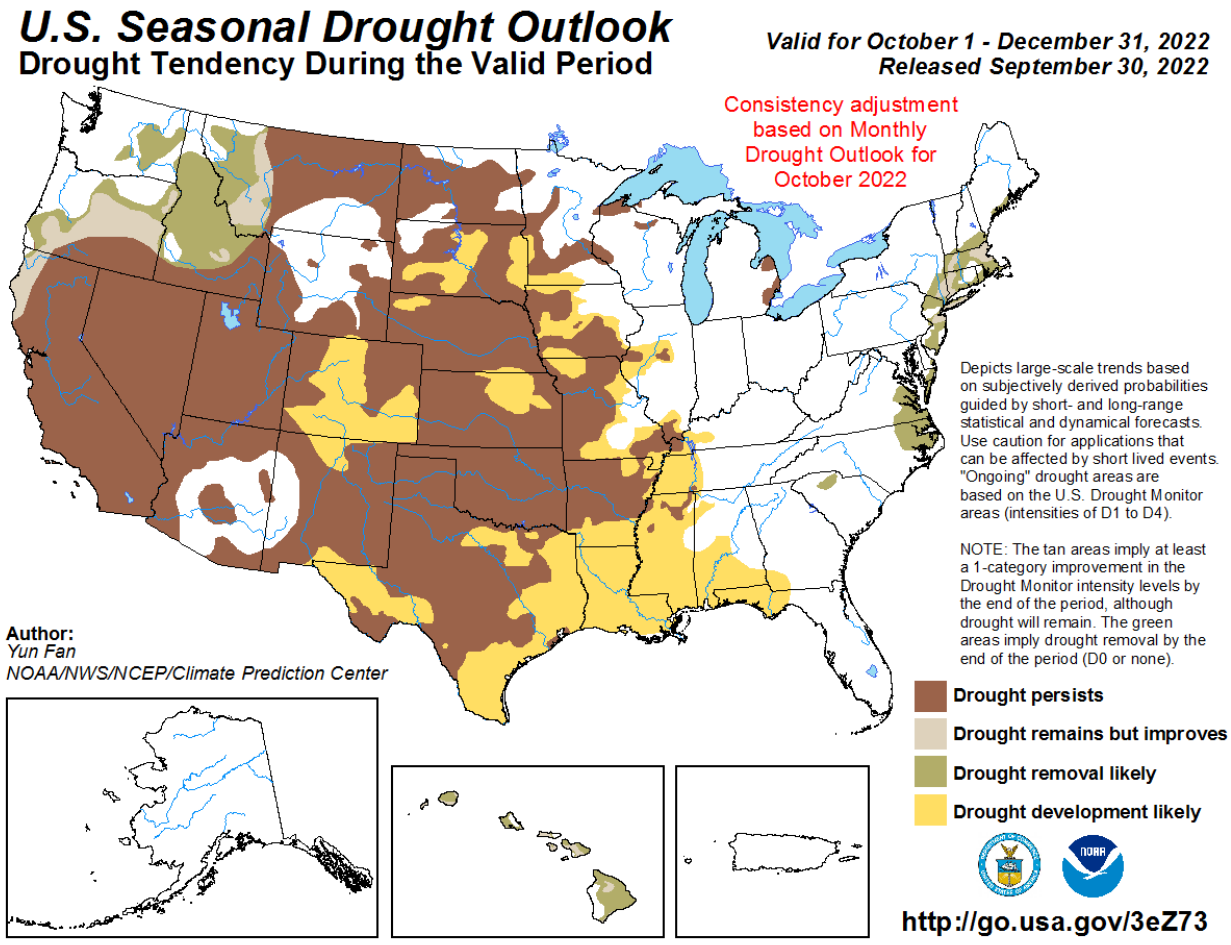


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The September precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. September precipitation was below normal across much of the Basin. Western Montana, Wyoming, and parts of southern Nebraska and central Kansas saw slightly above normal precipitation in September.

Precipitation as a percent of normal for the July through September 2022 period was below normal for most of the Basin (**Figure 4**), except for pockets of normal to above-normal precipitation scattered across Montana and Wyoming.

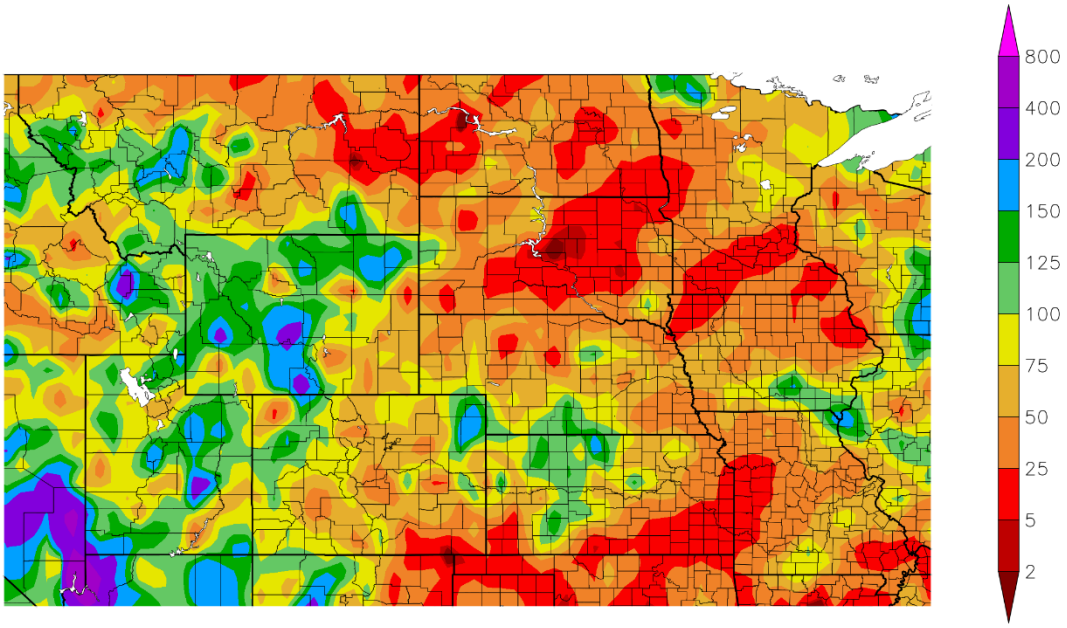


Figure 3. HPRCC September 2022 Percent of Normal Precipitation.

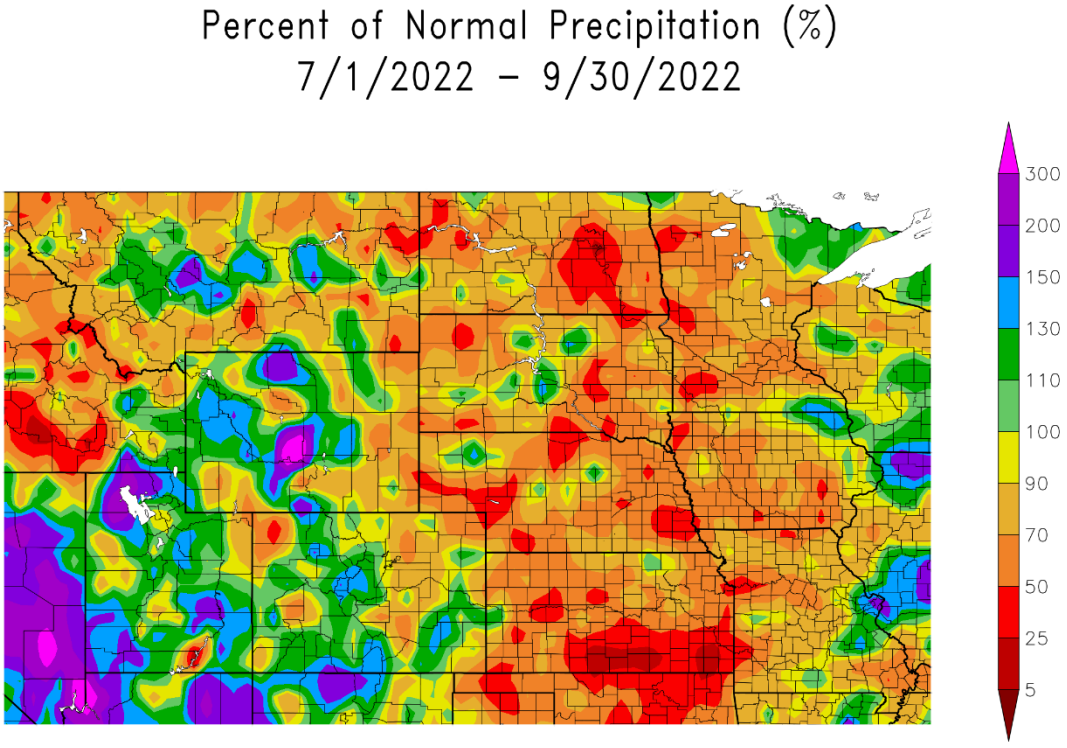


Figure 4. HPRCC July through September 2022 Percent of Normal Precipitation.

Temperature

September temperature departures from normal in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures the Basin, ranging from 2 to 6 degrees above normal over most of the Basin.

July through September 2022 temperature departures are shown in **Figure 6**. Temperatures over the past three months have also been warmer than normal, with widespread areas of up to 4 degrees above normal. Montana saw large areas of up to 6 degrees above normal over the past three months.

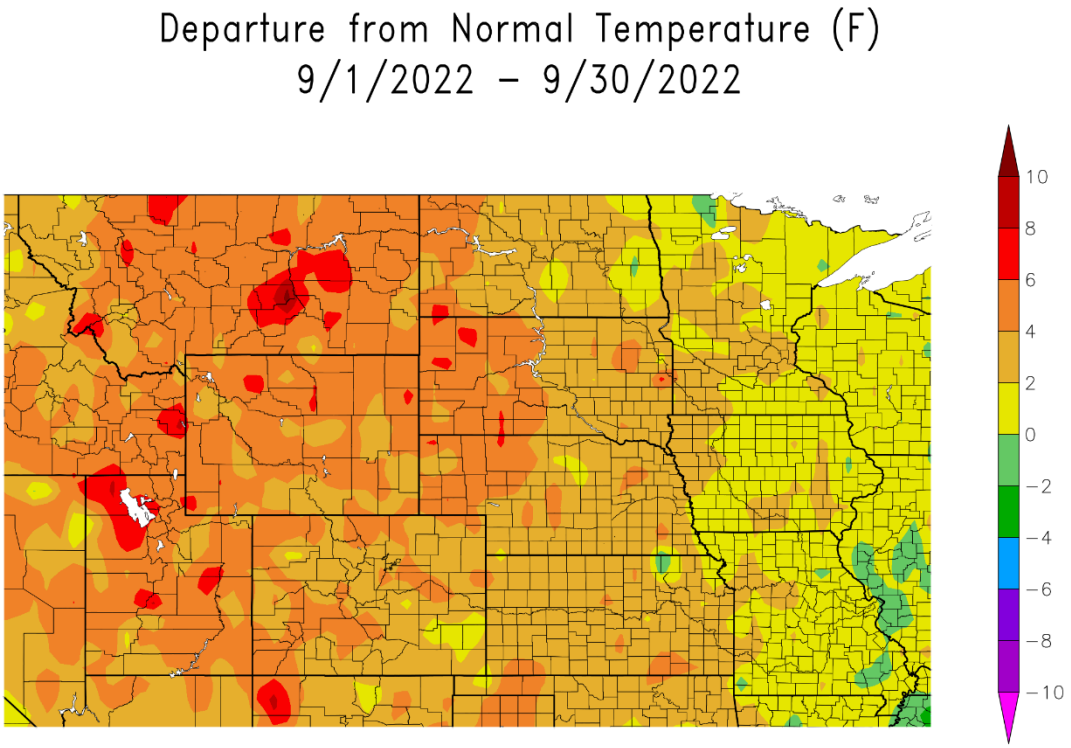


Figure 5. HPRCC September 2022 Departure from Normal Temperature.

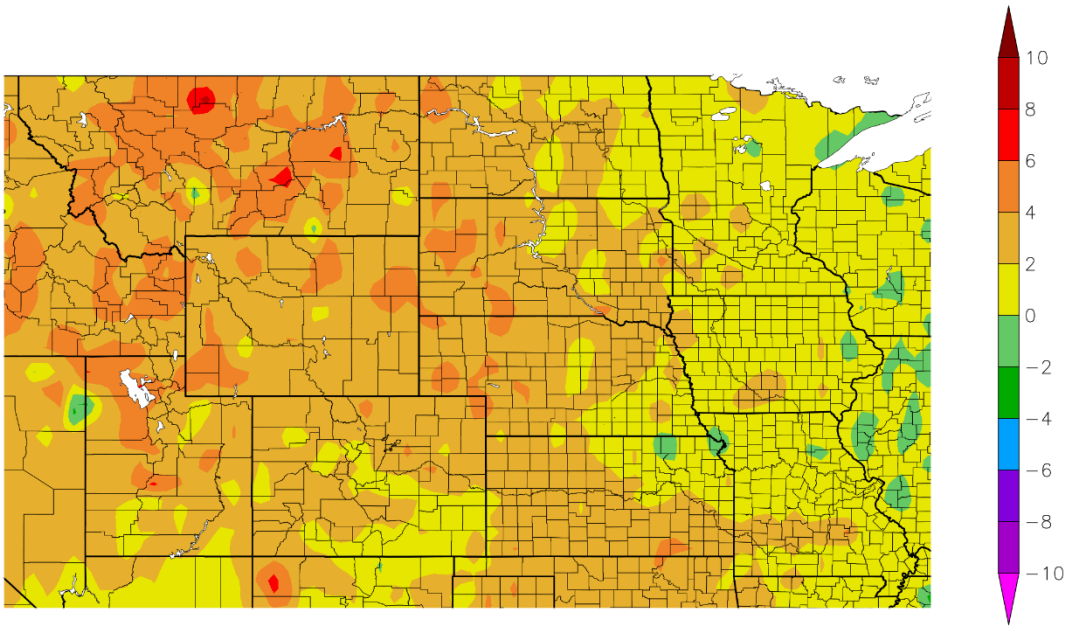


Figure 6. HPRCC July through September 2022 Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry across most of the Basin. Montana, the eastern Dakotas, and the lower Basin rank in the 30th percentile or lower. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

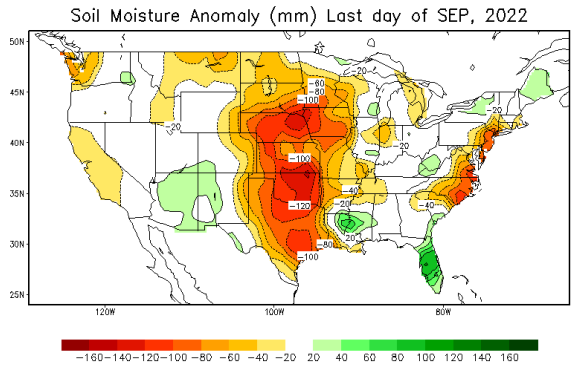
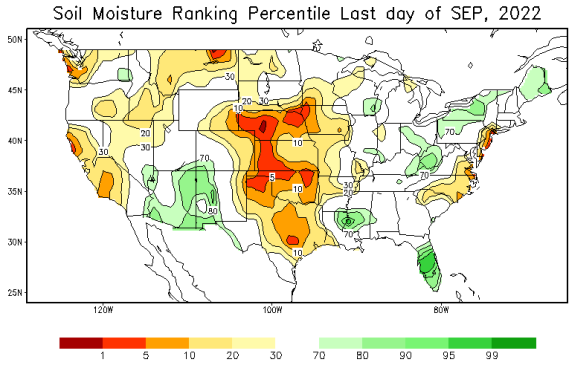
Soil Moisture Anomaly (mm)	Soil Moisture Percentile
	

Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

Plains snowpack in the basin has been nonexistent since May, so it was not factored into the forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

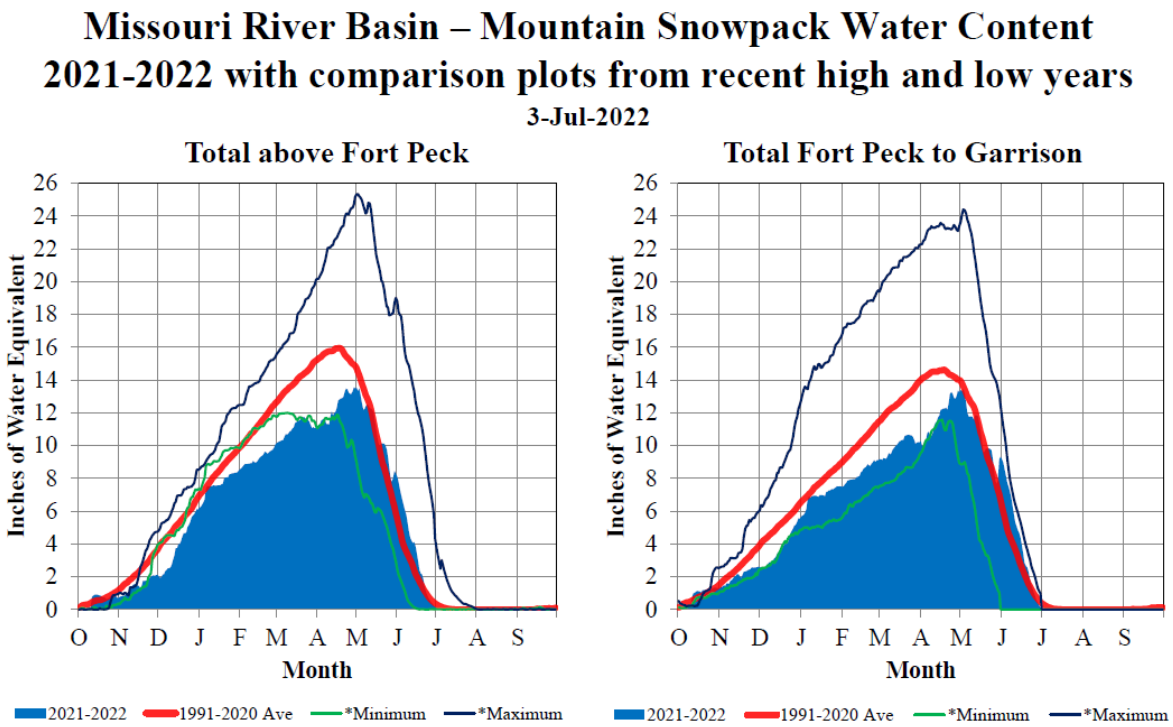


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack peaked in the Fort Peck reach on April 29 at 13.5" of SWE and 85% of the normal peak. The mountain snowpack peaked in the Garrison reach on May 3 at 13.4" of SWE and 92% of the normal peak. All mountain snowpack had melted in both reaches by July 3 and was not factored into this forecast.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña).

During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above-normal snowfall.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions are favored to continue through the 2022-23 winter.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The October CPC outlooks (**Figure 9**) indicate increased chances for warmer-than-normal temperatures across the entire Basin. Increased chances for below-normal precipitation exist on the eastern side of the Basin, while equal chances for below-normal, normal, or above-normal precipitation exist on the western side of the Basin.

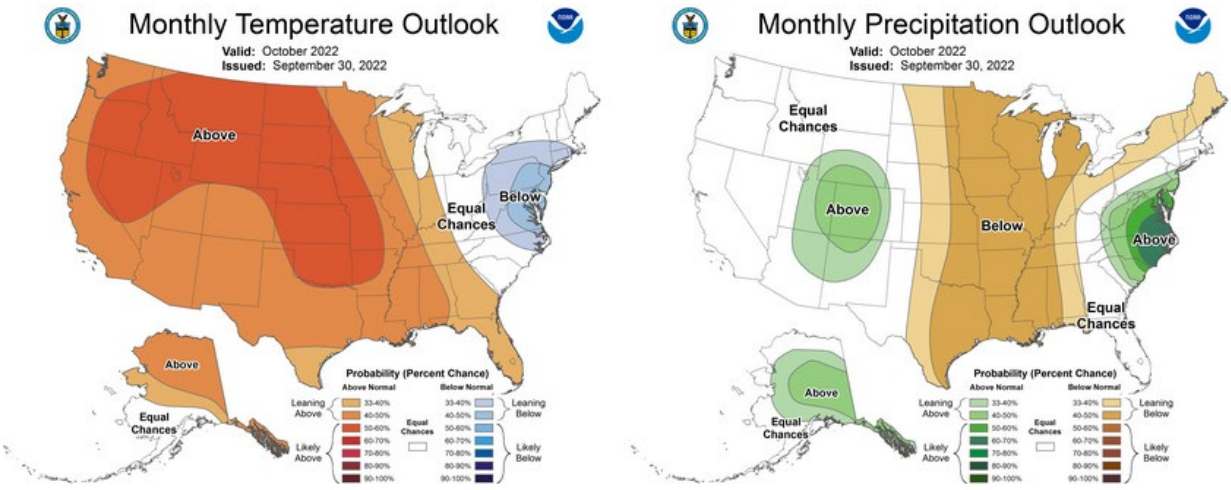


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (September).

Three-month temperature and precipitation outlooks for October through December are shown below in **Figure 10**. Over the next three months, increased chances for warmer and drier weather exist in the lower Basin, while equal chances for below-normal, normal, or above-normal temperature and precipitation exist in the upper Basin.

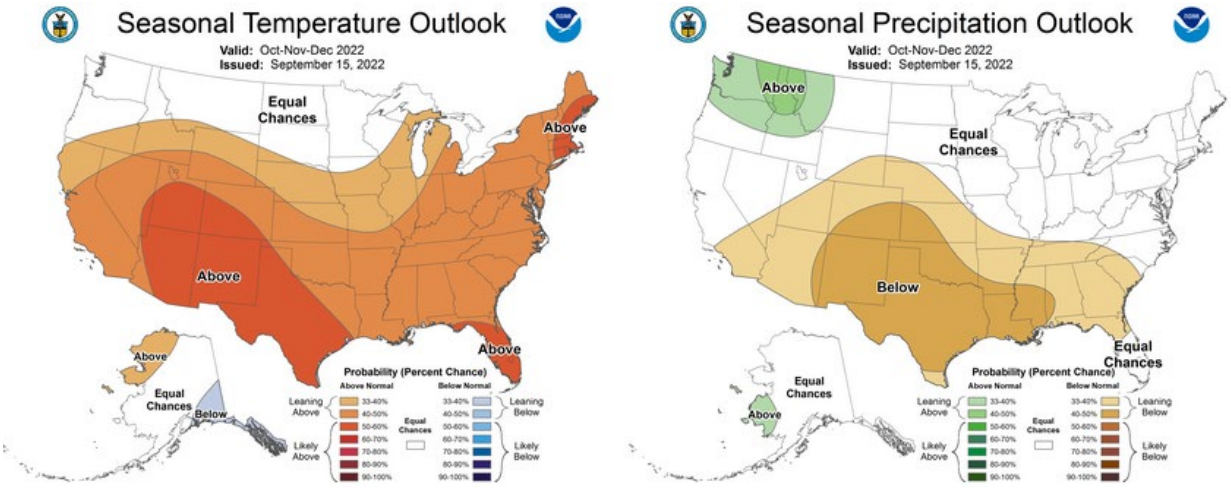


Figure 10. CPC October-November-December 2022 temperature and precipitation outlooks.

Summary

Given the above conditions, we expect runoff to be below normal in the reaches above Gavins Point for the remainder of the year, but this could vary based on precipitation events in the late summer and fall. In summary, the 2022 calendar year runoff forecast is **19.5 MAF (76% of average)**.

Upper Missouri River Basin
November 2022 Calendar Year Runoff Forecast
November 4, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

October runoff was 0.73 MAF, 60% of average above Sioux City, and 0.7 MAF or 63% of average above Gavins Point. Runoff was below normal in all reaches except for the Gavins Point reach, which was near normal. Precipitation during October was well below normal across much of the Basin, except for areas in Montana and northwest North Dakota.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **19.4 MAF, 76% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **17.2 MAF**, **74% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 2 months, expected inflow could range from the 19.8 MAF upper basic forecast to the 19.1 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for November 1, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 93% of the Basin, with Extreme Drought (D3) present in 3% of the Basin. The updated Seasonal Drought Outlook extending through the end of January 2023 in **Figure 2** shows existing drought conditions persisting across most of the Basin. The northern Rockies and parts of the lower Basin in Kansas and Missouri could see some improvement.

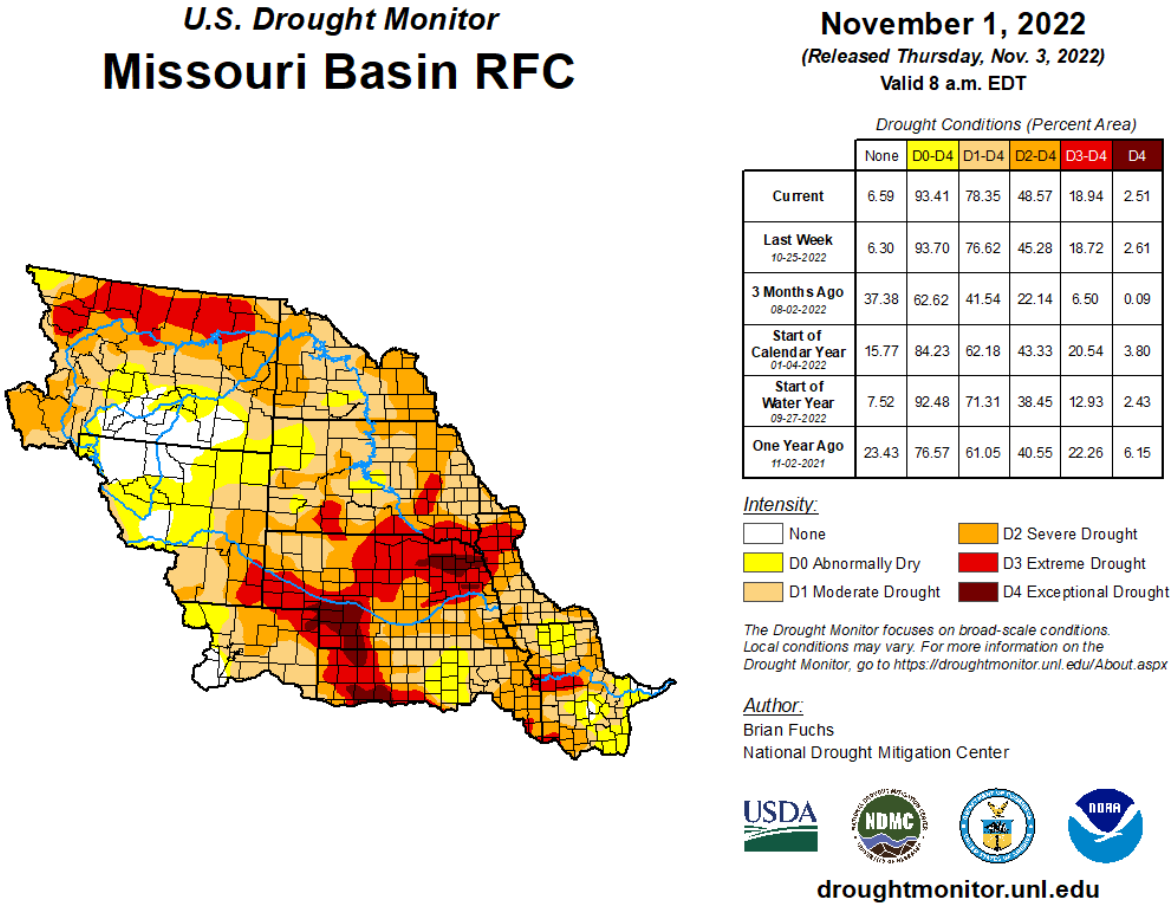


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

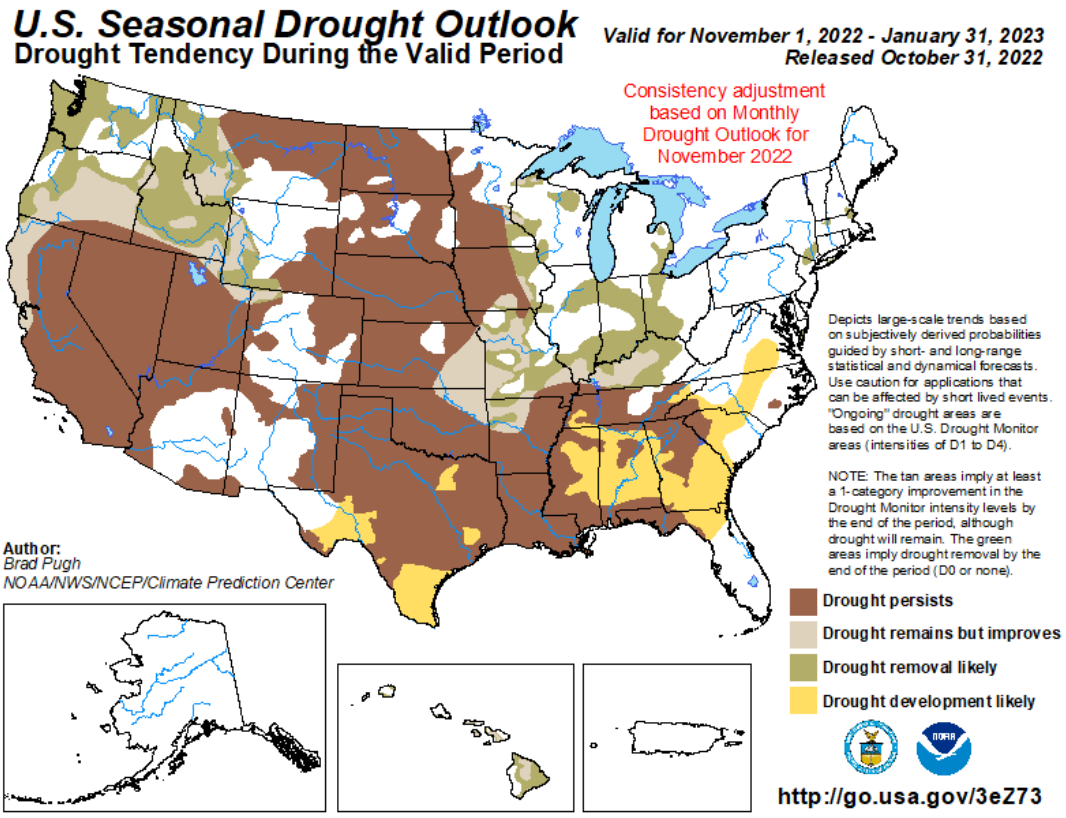


Figure 2. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The October precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. October precipitation was well below normal for most of the Basin except for Montana and northwestern North Dakota. Most of the Basin saw precipitation amounts of 5-50% of normal.

Precipitation as a percent of normal for the August through October period was also below normal for most of the Basin (**Figure 4**), except for pockets of normal to above-normal precipitation scattered across western Montana and Wyoming.

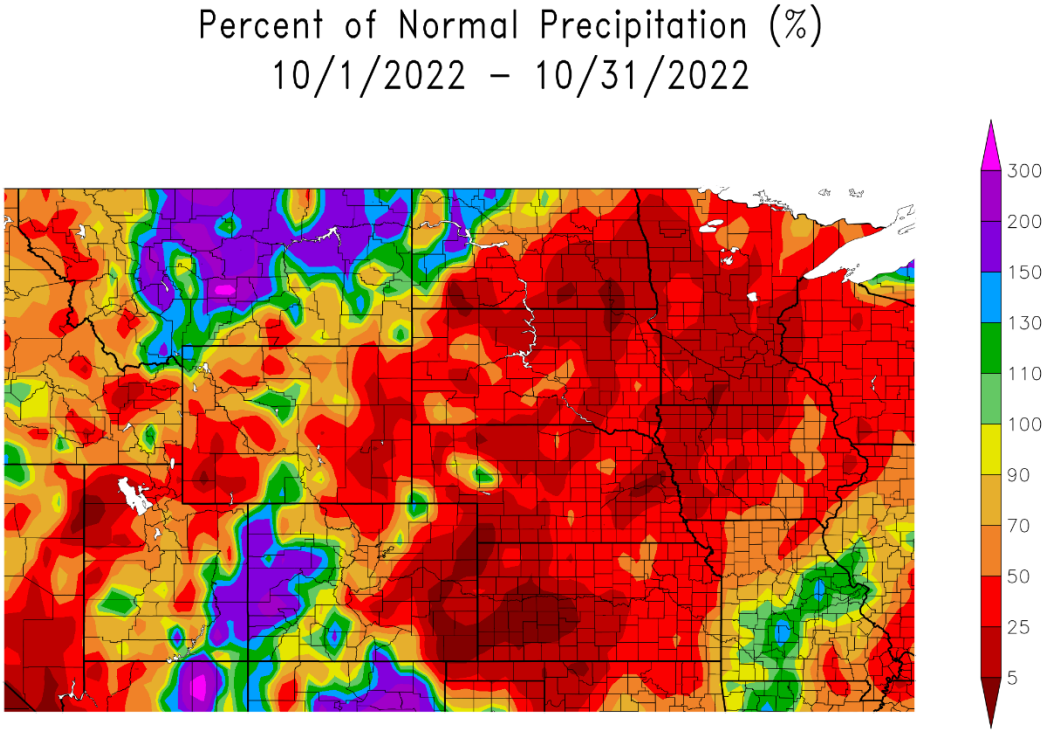


Figure 3. HPRCC October 2022 Percent of Normal Precipitation.

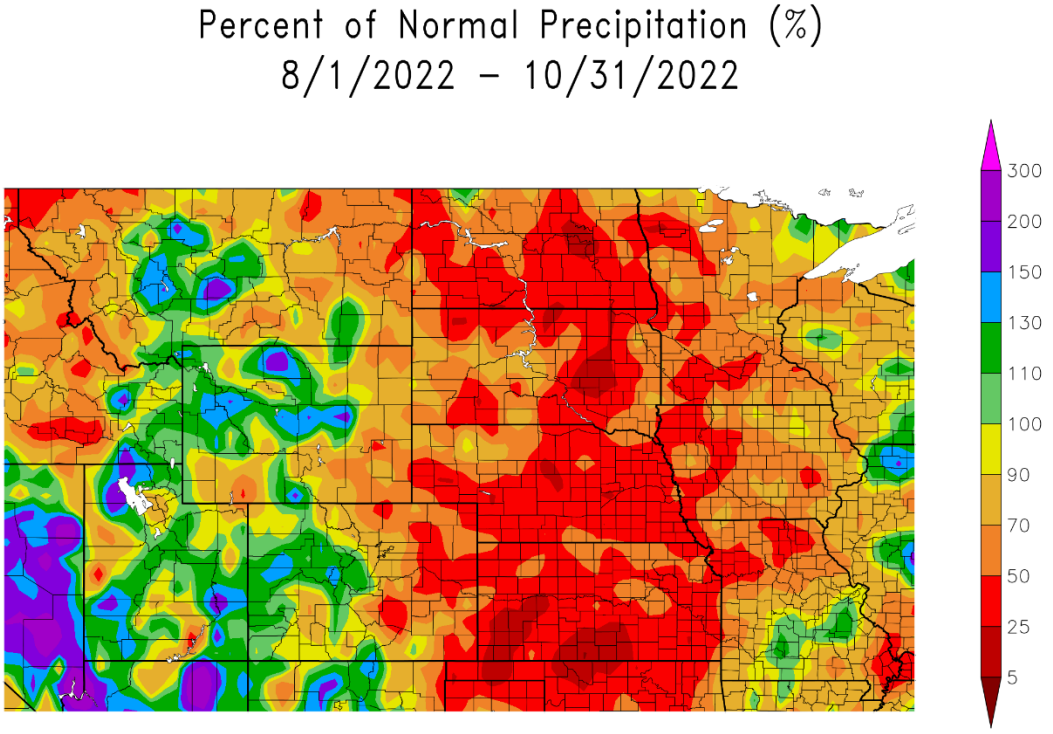


Figure 4. HPRCC August-October 2022 Percent of Normal Precipitation.

Temperature

October temperature departures from normal in degrees Fahrenheit (deg F) in **Figure 5** indicate warmer-than-normal temperatures across the upper Basin, ranging from 2 to 6 degrees above normal over most of the Basin, and isolated areas in Montana of up to 8 degrees above normal. More normal temperatures were observed in the lower Basin, ranging from 2 degrees below normal to 2 degrees above normal

August through October temperature departures are shown in **Figure 6**. Temperatures over the past three months have been up to 4 degrees above normal across much of the Basin. Montana and parts of the western Dakotas and Wyoming saw areas of up to 8 degrees above normal over the past three months.

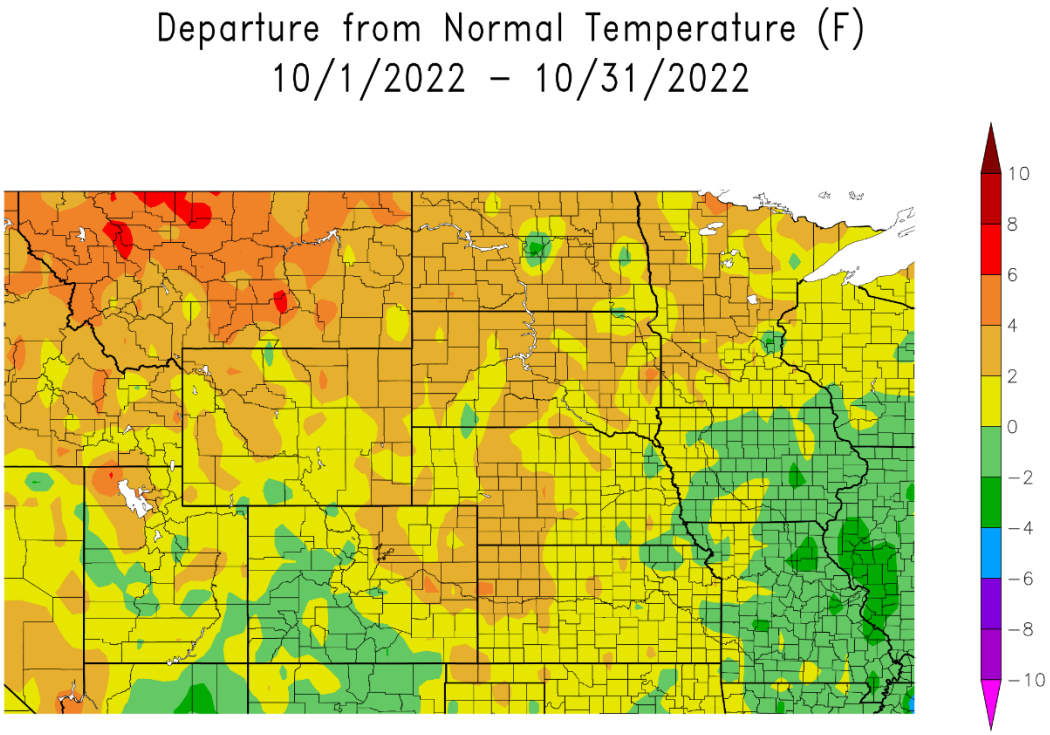


Figure 5. HPRCC October Departure from Normal Temperature.

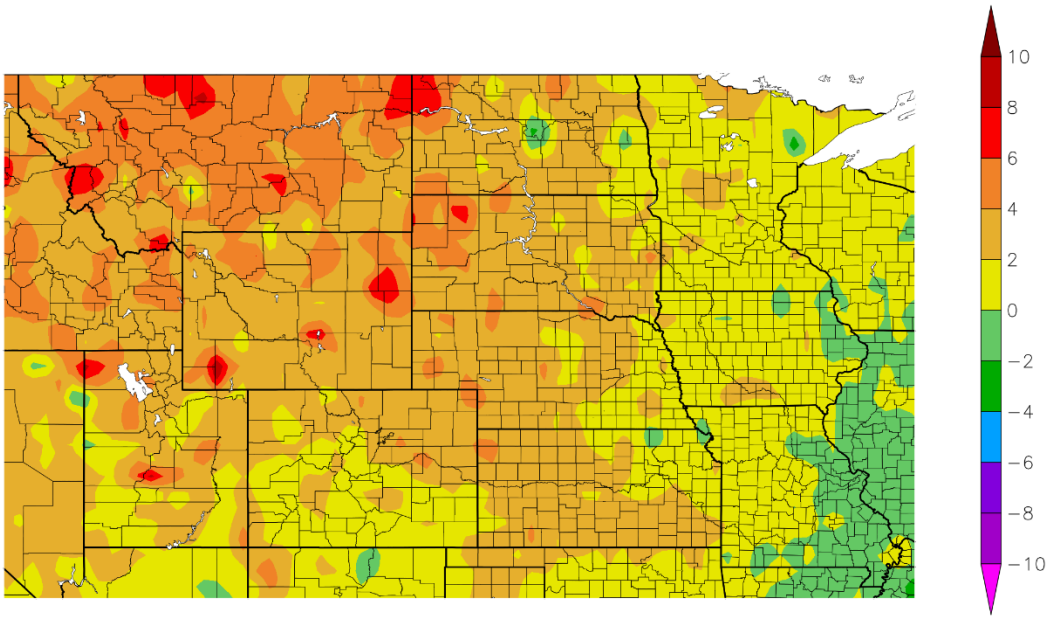


Figure 6. HPRCC August-October Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry across much of the Basin, especially in the lower Basin. Soil moisture in the lower Basin ranges from the 1st to the 10th percentile. Soil moistures are below the 30th percentile in the Dakotas and parts of Montana. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.

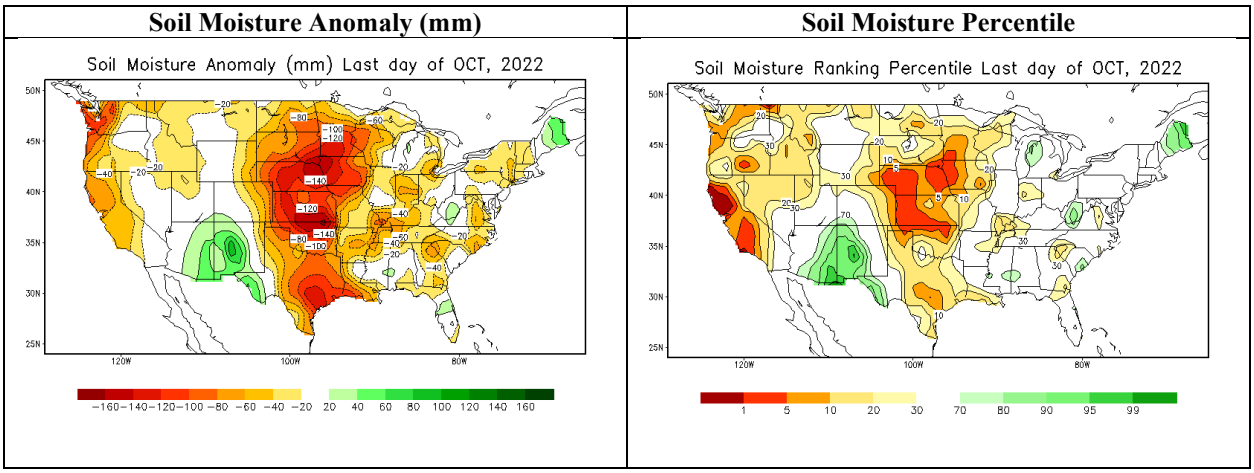


Figure 7. NOAA CPC Soil Moisture Anomaly (mm) and Soil Moisture Percentile. Source: NOAA NLDAS Drought Monitor Soil Moisture. https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml

Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the basin during the months of March and April. 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 is 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.

Plains snowpack in the basin has been nonexistent since May, so it was not factored into the forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

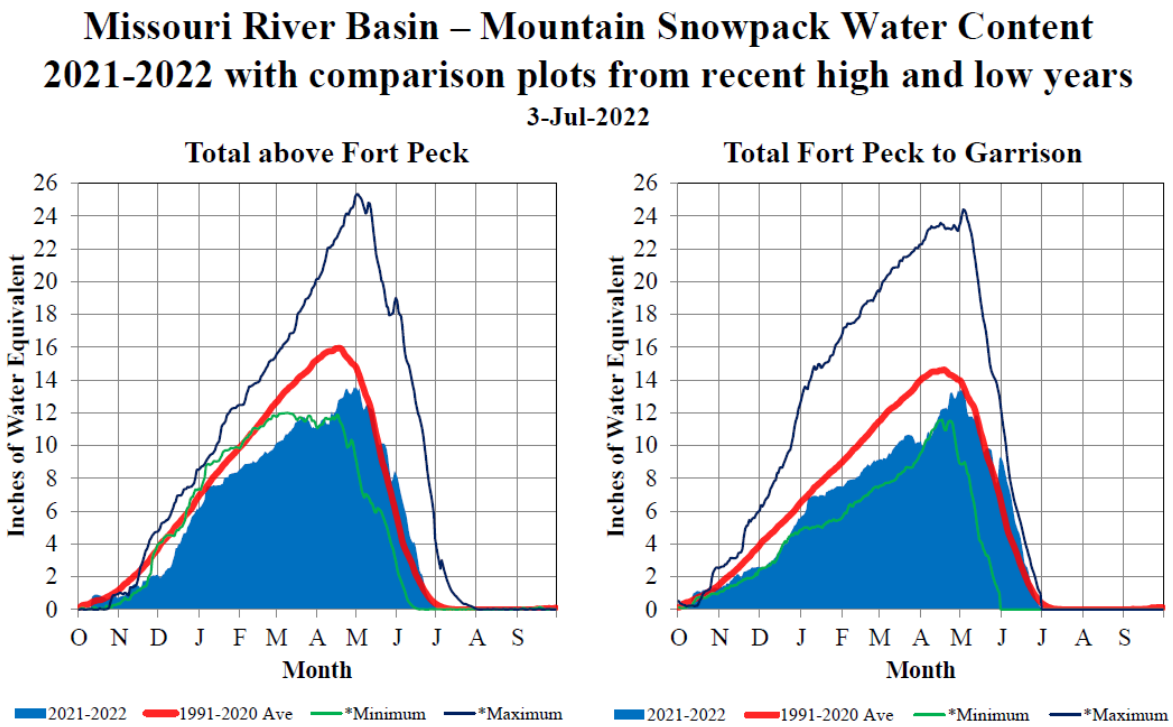


Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

The mountain snowpack peaked in the Fort Peck reach on April 29 at 13.5" of SWE and 85% of the normal peak. The mountain snowpack peaked in the Garrison reach on May 3 at 13.4" of SWE and 92% of the normal peak. All mountain snowpack had melted in both reaches by July 3 and was not factored into this forecast.

Climate Outlook

MRBWM participates in the monthly North Central U.S. Climate/Drought Outlook Webinar coordinated through NOAA, the regional climate centers, and the American Association of State Climatologists (AASC). These webinars provide updates on near-term climate outlooks and impacts including the ENSO climate pattern and its implications on winter temperature and precipitation patterns in the Missouri Basin.

ENSO (El Niño Southern Oscillation)

El Niño Southern Oscillation is an oscillation that occurs in the tropical Pacific Ocean and fluctuates between warm episodes (El Niño), neutral conditions, and cold episodes (La Niña).

During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above-normal snowfall across the northern Rockies.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions are favored to continue through February 2023.

Temperature and Precipitation Outlooks

The NOAA CPC outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The November CPC outlooks (**Figure 9**) indicate increased chances below-normal temperatures and above-normal precipitation in the northwestern parts of the Basin. Increased chances for warmer-than-normal temperatures are possible in the lower Basin.

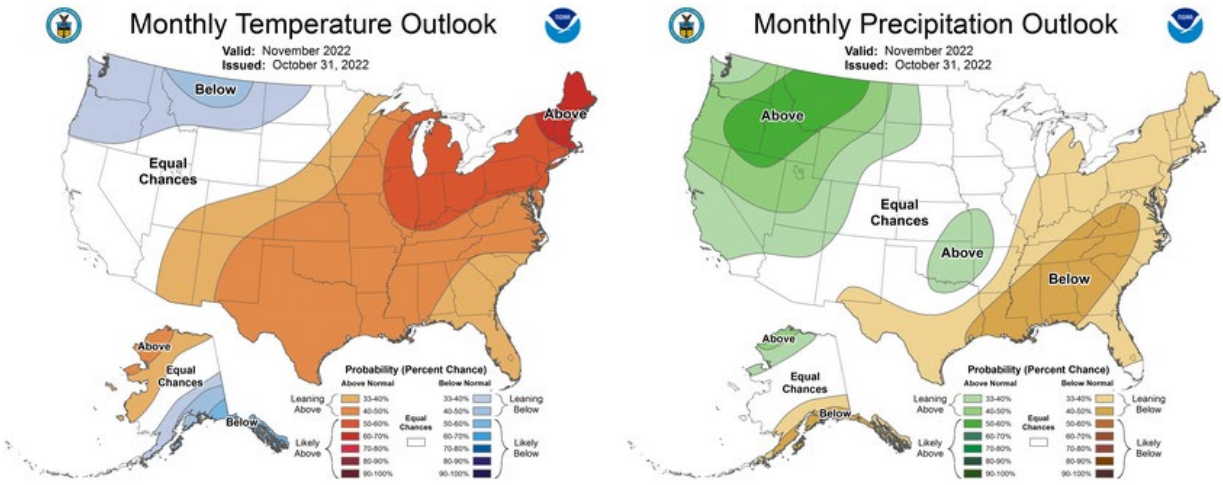


Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (October).

Three-month temperature and precipitation outlooks for November 2022 through January 2023 are shown below in **Figure 10**. Over the next three months, increased chances for above-normal precipitation exist in the northern Rockies, while equal chances for below-normal, normal, or above-normal precipitation are in the rest of the Basin. Warmer-than-normal temperatures are possible in the southwestern side of the Basin, while equal chances for below-normal, normal, or above-normal temperatures exist in the rest of the Basin.

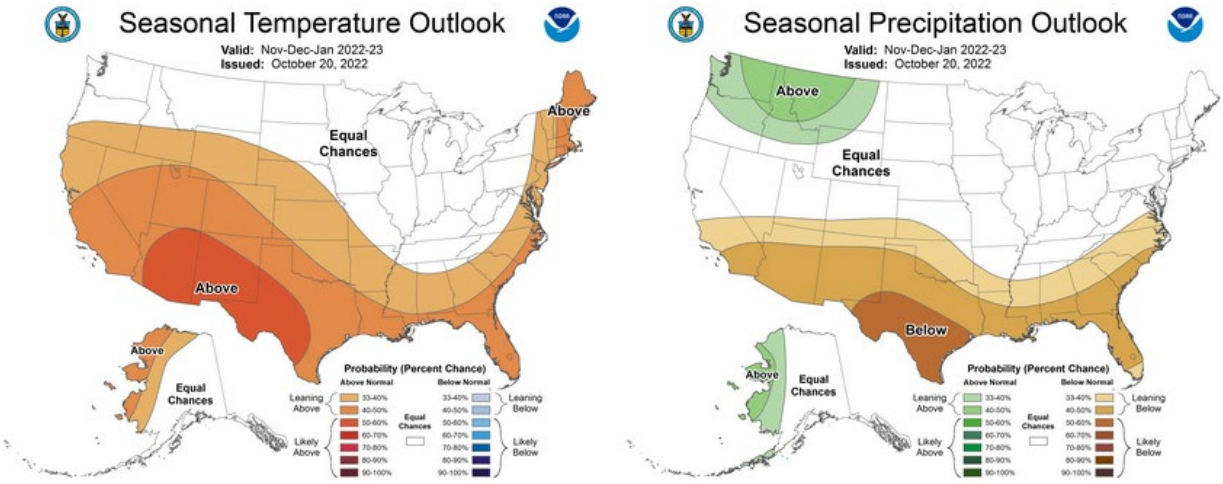


Figure 10. CPC Three-Month Temperature and Precipitation Outlooks (November 2022 through January 2023).

Summary

Given the above conditions, we expect runoff to be below normal in the reaches above Sioux City for the remainder of the year, but this could vary based on late-season precipitation events. In summary, the 2022 calendar year runoff forecast is **19.4 MAF (76% of average)**.

Upper Missouri River Basin
December 2022 Calendar Year Runoff Forecast
December 5, 2022

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. The Calendar Year Runoff Forecast is available at https://www.nwd-mr.usace.army.mil/rcc/reports/runoff.pdf. 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 Basin above Sioux City (upper Basin). 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.

Observed Runoff

November runoff was 0.54 MAF, 51% of average above Sioux City, and 0.47 MAF or 49% of average above Gavins Point. Runoff was below normal in all reaches. Precipitation during November was below normal for South Dakota, Nebraska, Iowa, and western Kansas, and above normal in eastern Kansas and northwestern Missouri. Precipitation was mixed across Montana, North Dakota, and Wyoming.

2022 Calendar Year Forecast Synopsis

The 2022 calendar year runoff forecast for the upper Missouri Basin above Sioux City, IA is **19.0 MAF, 74% of average**. The 2022 calendar year runoff forecast for the Missouri Basin above Gavins Point is **16.8 MAF**, **72% of average**.

Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next month, expected inflow could range from the 19.1 MAF upper basic forecast to the 18.9 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 wetter-than-expected or drier-than-expected conditions, respectively.

Current Conditions

Drought Analysis

The National Drought Mitigation Center's drought monitor for November 29, 2022 is shown in **Figure 1**. The drought monitor is available at https://droughtmonitor.unl.edu/. The U.S. Drought Monitor for the Missouri Basin (Basin) shows at least Abnormally Dry (D0) conditions are present in 90% of the Basin, with Extreme Drought (D3) or worse present in 19% of the Basin. The updated Monthly Drought Outlook extending through the end of December in **Figure 2** shows existing drought conditions persisting across most of the Basin.

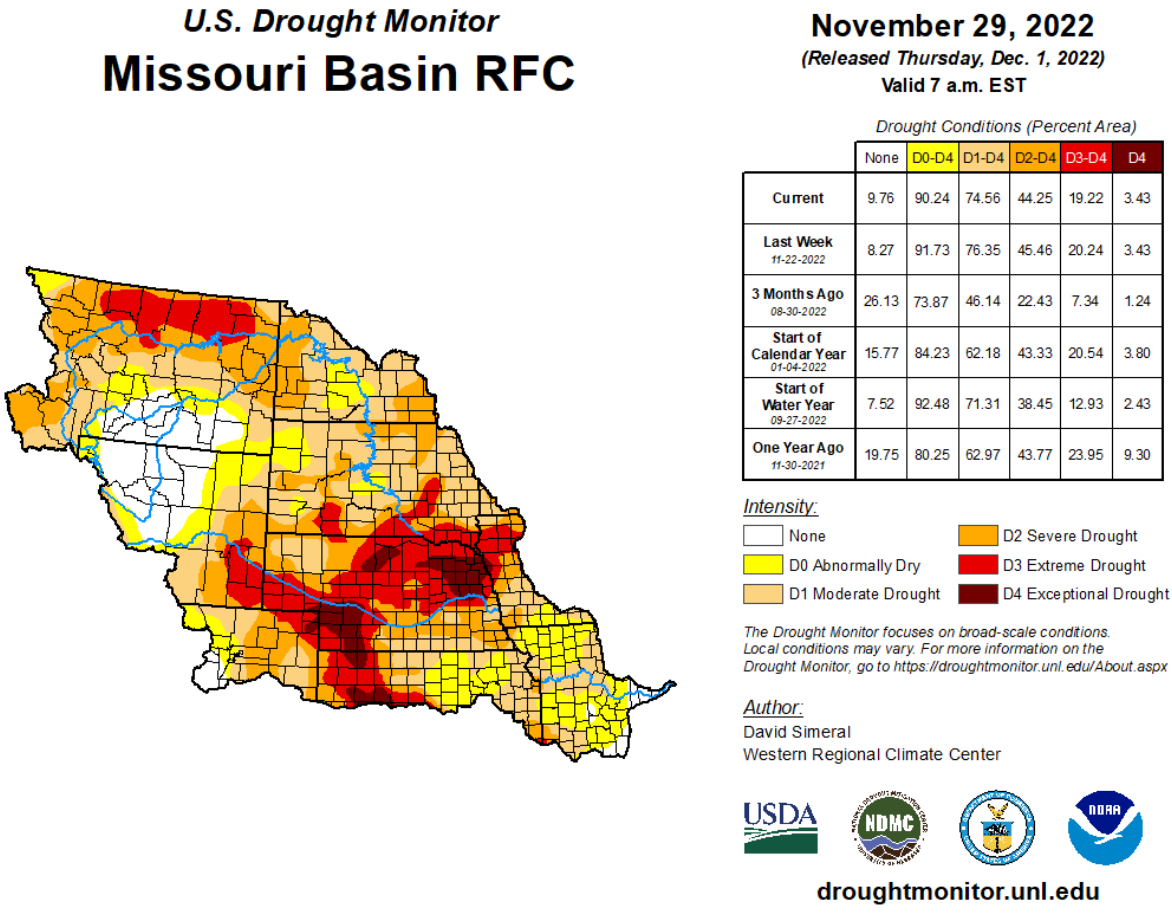


Figure 1. National Drought Mitigation Center U.S. Drought Monitor.

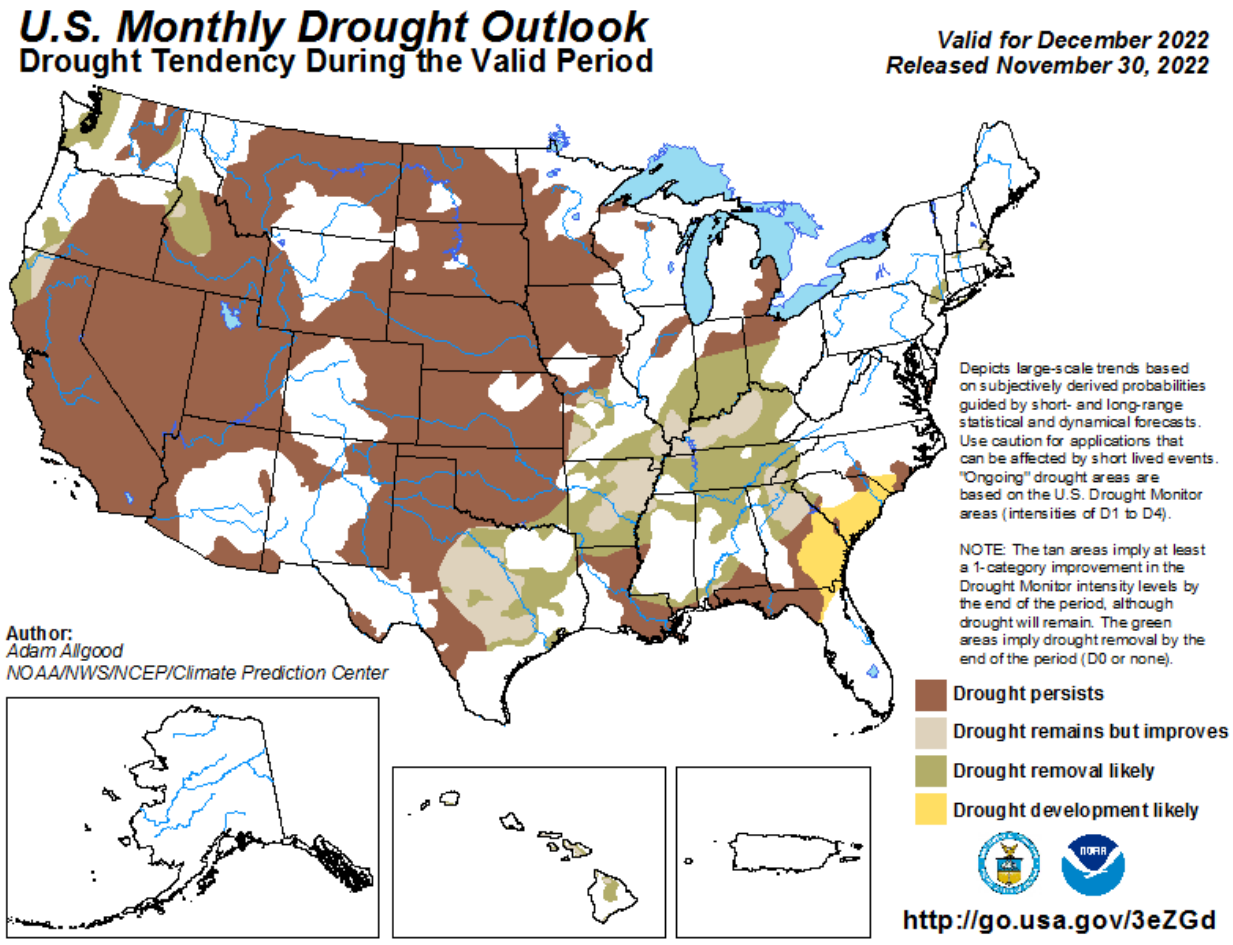


Figure 2. National Drought Mitigation Center U.S. Monthly Drought Outlook.

Precipitation

Monthly precipitation accumulations are shown using High Plains Regional Climate Center (HPRCC) images available at https://www.hprcc.unl.edu/. The November precipitation accumulations are shown in **Figure 3** as a percent of normal precipitation. November precipitation was below normal in southern South Dakota, Nebraska, Iowa, and western Kansas. Above-normal precipitation was observed in eastern Kansas and northwestern Missouri, and mixed precipitation occurred across Montana, North Dakota, Wyoming, and northern South Dakota.

Precipitation as a percent of normal for the September through November period was below normal for most of the Basin (**Figure 4**), except for pockets of normal to above-normal precipitation across western Montana and Wyoming.

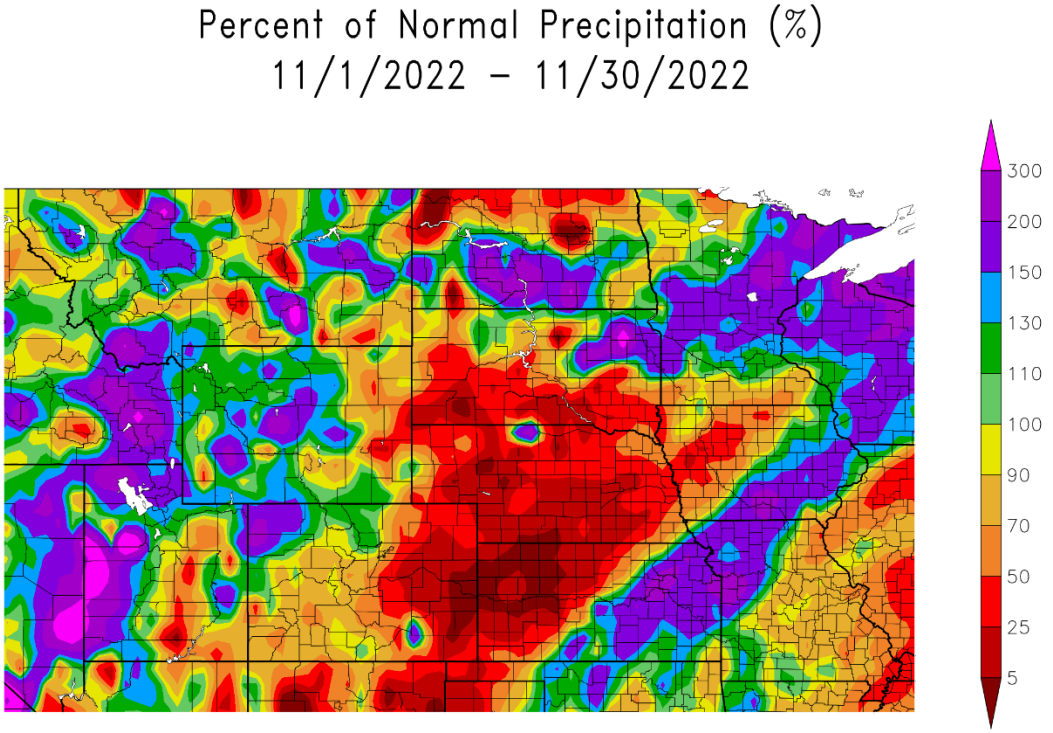


Figure 3. HPRCC November 2022 Percent of Normal Precipitation.

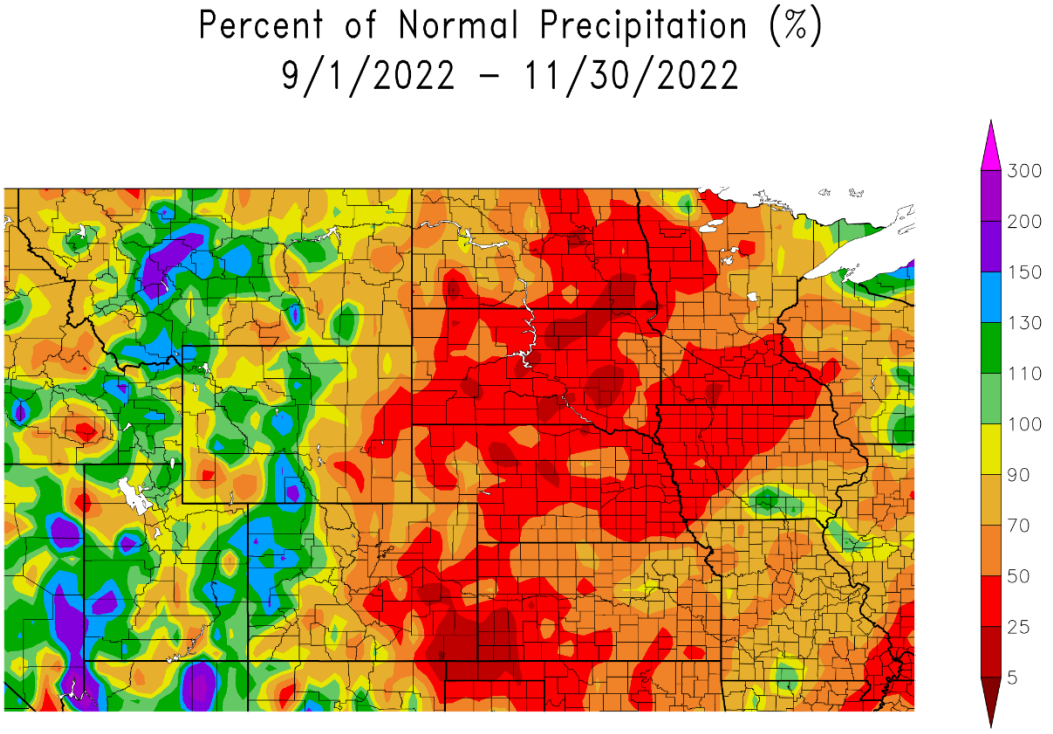


Figure 4. HPRCC September - November 2022 Percent of Normal Precipitation.

Temperature

November temperature departures from normal in degrees Fahrenheit (deg F) in **Figure 5** indicate cooler-than-normal temperatures across the Basin. Most of Montana and parts of southwestern and central North Dakota saw temperatures 6-9 degrees below normal, and isolated areas in Montana saw temperatures up to 12 degrees below normal.

September through November temperature departures are shown in **Figure 6**. Temperatures over the past three months normal to slightly above normal, with most of the Basin seeing temperatures up to 2 degrees above normal.

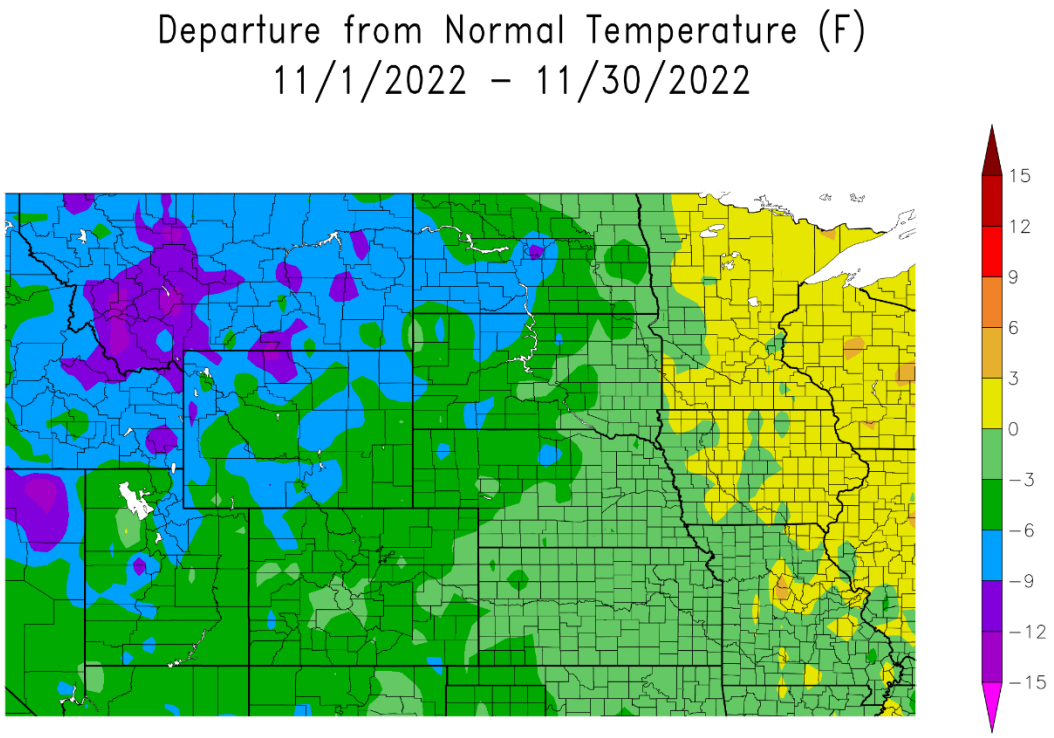


Figure 5. HPRCC November Departure from Normal Temperature.

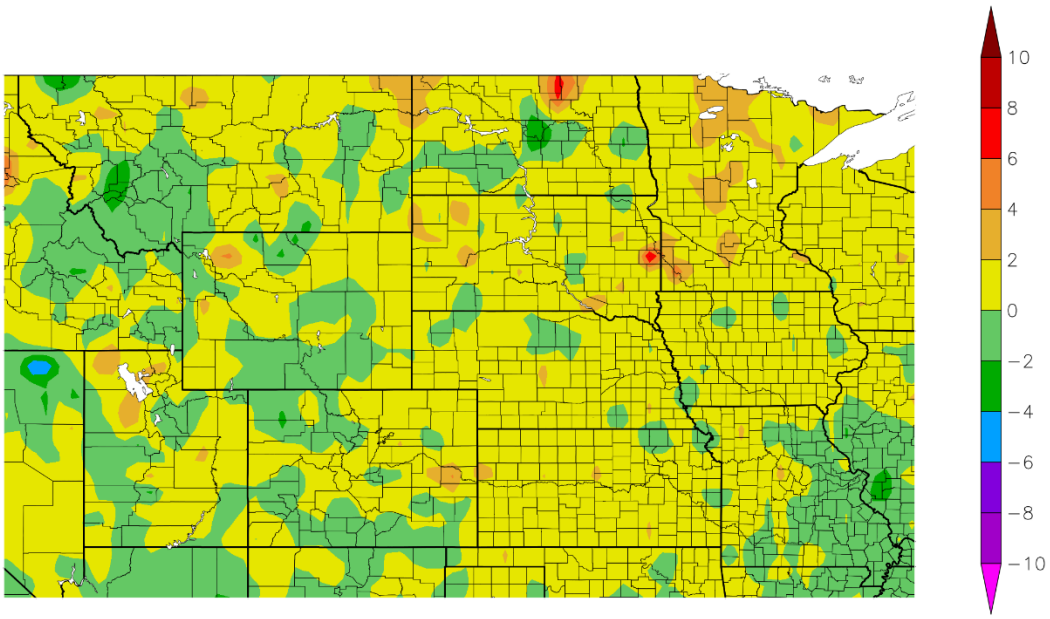
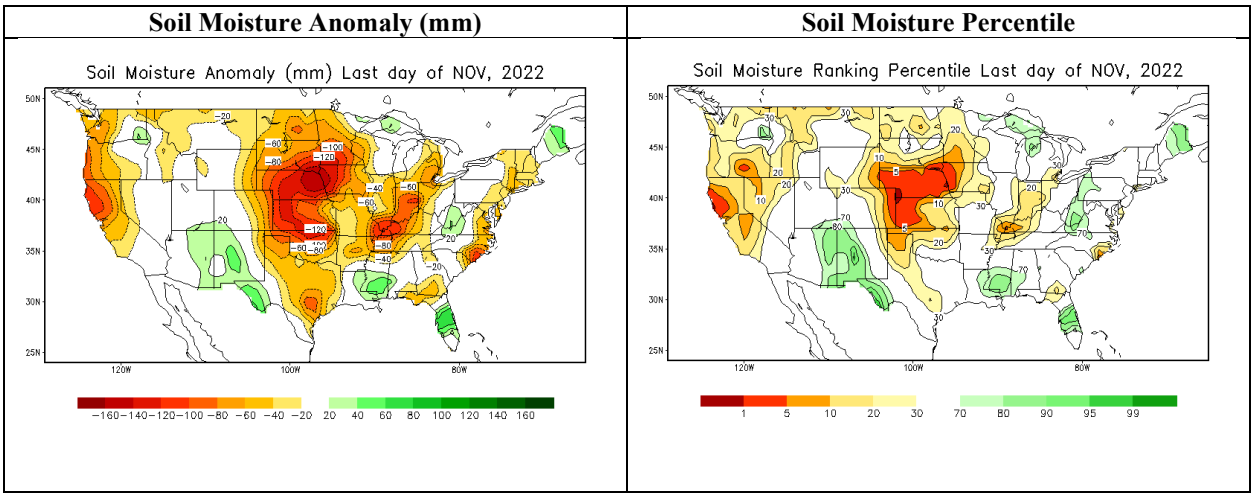


Figure 6. HPRCC September-November Departure from Normal Temperature.

Soil Moisture

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, but it can also be used as an indicator of future runoff. As the calendar year approaches winter, the soil moisture conditions will provide some insight into late winter and early spring runoff potential.

Soil moisture conditions remain dry across much of the Basin, especially in the Missouri Basin below Sioux City (lower Basin). Soil moisture in Nebraska, western Kansas, and western Iowa ranges from the 1st to the 5th percentile. Soil moistures are below the 30th percentile in much of the rest of the Basin, except for southern and central Montana, parts of the North Dakota-South Dakota border, and central Missouri. **Figure 7** shows both the soil moisture anomalies and the soil moisture percentiles.



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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 is 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.

Plains snowpack in the basin has been nonexistent since May, so it was not factored into the forecast.

Mountain Snowpack

Mountain snowpack is the primary factor used to predict May, June, and July runoff volumes in the Fort Peck and Fort Peck to Garrison mainstem reservoir reaches. Mountain snowpack typically peaks in mid-April.

Figure 8 includes time series plots of the average mountain SWE beginning on October 1, 2021 based on the NRCS SNOTEL data for the headwater basin above Fort Peck and the incremental basin from Fort Peck to Garrison. The current average SWE values (shaded blue area) are plotted against the 1991-2020 basin average SWE (bold red line), the historic low SWE during 1991-2020 (green line), and historic high SWE during 1991-2020 (dark blue).

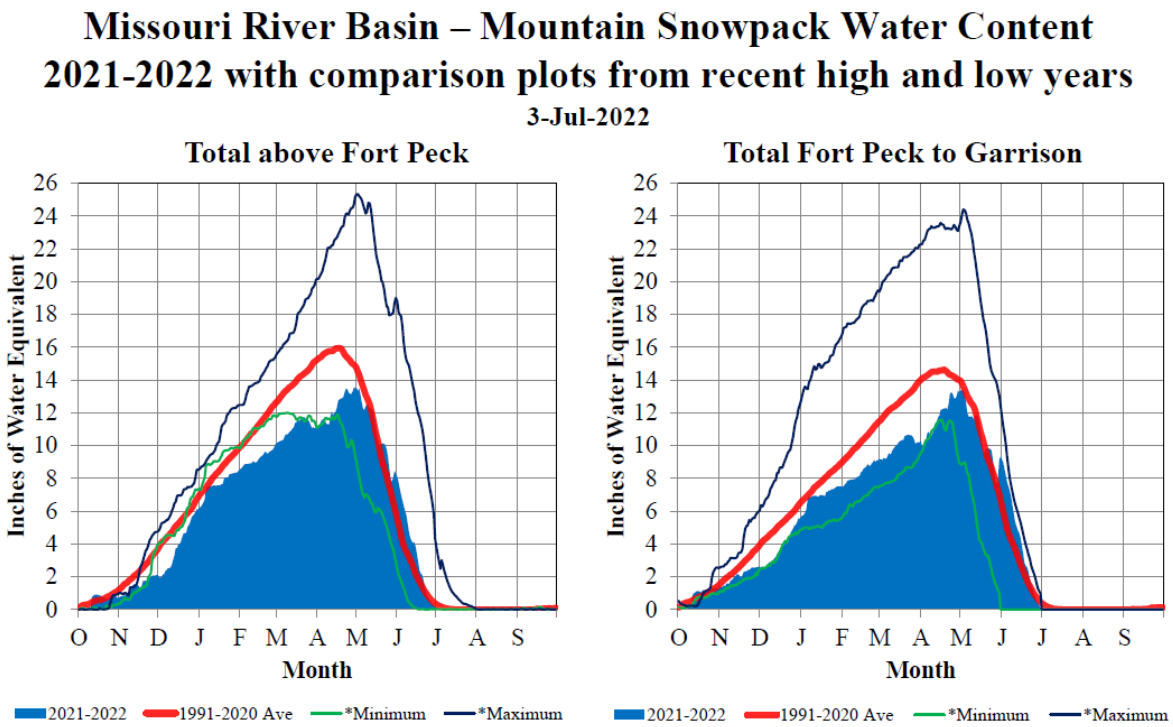

Figure 8. Mountain snowpack water content compared to normal and historic conditions. Source: Corps of Engineers - Missouri River Basin Water Management.

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Climate Outlook

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During El Niño winters, the favored storm track is typically across Canada, resulting in warm temperatures and less snowfall in the Basin. During La Niña winters, the storm track typically favors northwest flow across the Basin, resulting in cooler temperatures and above-normal snowfall across the northern Rockies.

The latest ENSO Outlook indicates La Niña conditions are present. La Niña conditions are favored to continue through February 2023.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center (CPC) outlooks provide the forecasted probability (or chance) of occurrence of future weather conditions during periods ranging from 1 to 12 months into the future. The CPC outlooks are available at https://www.cpc.ncep.noaa.gov/.

The December CPC outlooks (**Figure 9**) indicate increased chances for below-normal temperatures across most of the Basin, and increased chances for wetter-than-normal conditions in Montana and Wyoming. Equal chances of above-normal, normal, or below-normal precipitation is indicated in the Dakotas and Nebraska, and increased chances for drier-than-normal conditions is indicated in Kansas, Missouri, and Iowa.

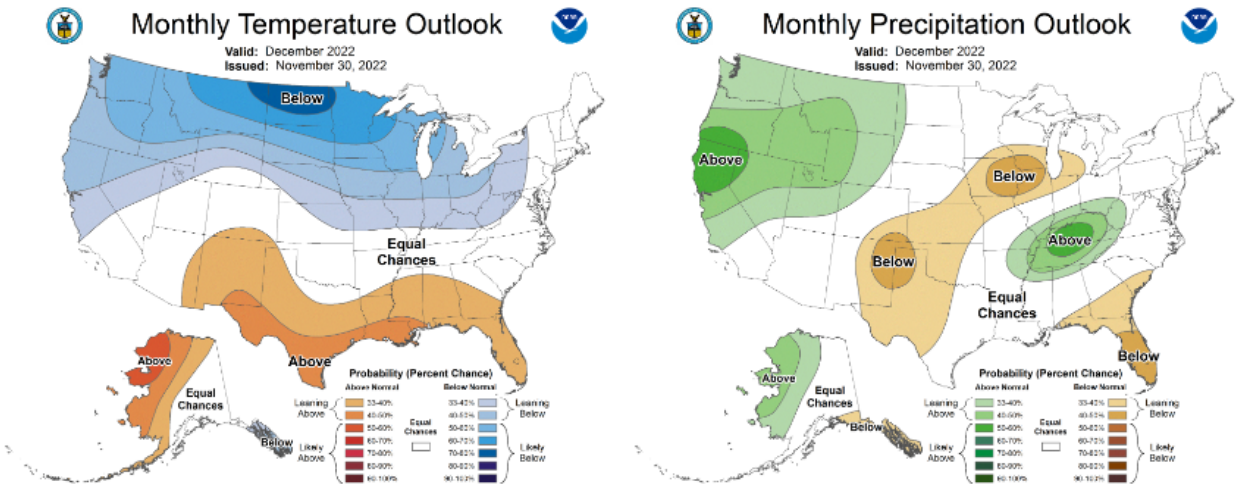

Figure 9. NOAA CPC One-Month Temperature and Precipitation Outlooks (October).

Three-month temperature and precipitation outlooks for December 2022 through February 2023 are shown below in **Figure 10**. Over the next three months, increased chances of below normal temperatures and above-normal precipitation are indicated across most of the upper Basin. Equal chances for above-normal, normal, or below-normal temperatures are possible in most of the lower Basin.

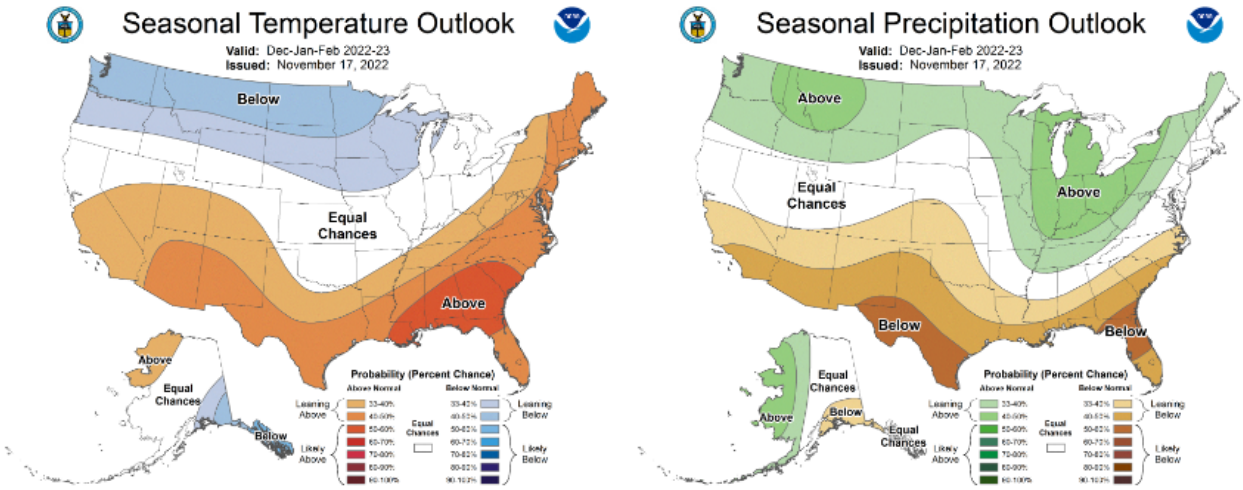

Figure 10. CPC Three-Month Temperature and Precipitation Outlooks (November 2022 through January 2023).

Summary

Given the above conditions, we expect runoff to be below normal in the reaches above Sioux City for the remainder of the year. In summary, the 2022 calendar year runoff forecast is **19.0 MAF (74% of average)**.