Upper Missouri River Basin
January 2016 Calendar Year Runoff Forecast
January 12, 2016

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

Calendar Year Runoff Forecast

Explanation and Purpose of Forecast

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

December 2015 Calendar Year Runoff

December 2015 Missouri River runoff was 1.2 MAF (155% of normal) above Sioux City. The (preliminary, with no holdouts) calendar year 2015 runoff summation above Sioux City, IA was 25.8 MAF (102% of average), while it was 23.3 MAF (101% of average) above Gavins Point. These preliminary runoff volumes will be finalized within the first few months of 2016.

2016 Calendar Year Forecast Synopsis

The January 1 forecast for the 2016 Missouri River runoff above Sioux City, IA is **23.8 MAF (94% of normal)**. Runoff above Gavins Point Dam is forecast to be **21.6 MAF (94% of normal)**. Due to the amount of variability in precipitation and other hydrologic factors that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 32.9 MAF upper basic forecast to the 15.7 MAF lower basic forecast. The upper and lower basic forecasts are used in long-term regulation planning models to “bracket” the range of expected runoff given much wetter or drier conditions, respectively. Given that 12 months are being forecasted for this January 1 forecast (0 months observed/12 months forecast), the range of wetter than normal (upper basic) and lower than normal (lower basic) is attributed to all 6 reaches for all 12 months. The result is a large range or “bracket” for each reach, and thus, for the total runoff forecast. As the year progresses, the range will lessen as the number of observed months increases and number of forecast months decreases.

Current Conditions

Drought Analysis

The latest National Drought Mitigation Center's drought monitor for December 29, 2015 (**Figure 1**), when compared to the drought monitor for November 24, 2015 (**Figure 2**), shows relatively little change in drought conditions in the upper Basin above Sioux City, IA. There has been some contraction in Abnormally Dry (D0) conditions in southern Montana, southwest South Dakota and northwest Nebraska; however, Abnormally Dry (D0) to Severe Drought (D2) conditions are still present in western Montana in the upper Basin. In the lower Basin, heavy December rainfall and snowfall has nearly erased any signs of drought and dryness in Kansas, making the lower Basin drought free. The U.S. Seasonal Drought Outlook in **Figure 3** indicates that drought will persist in western Montana and south central North Dakota; and, drought will likely develop in central and eastern Montana through the end of March 2016.

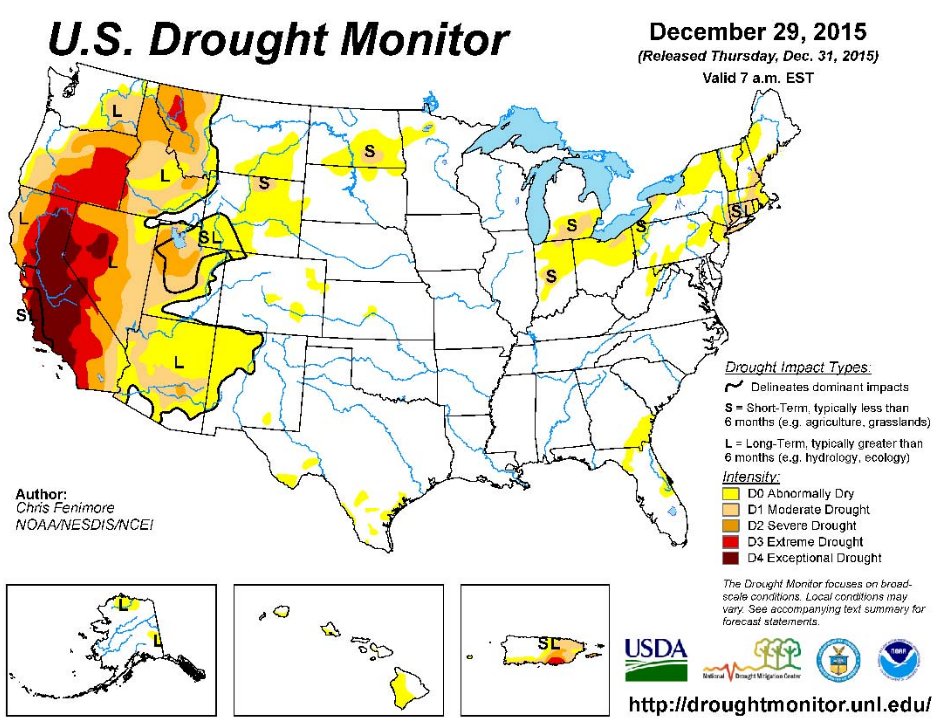


Figure 1. National Drought Mitigation Center U.S. Drought Monitor for December 29, 2015.

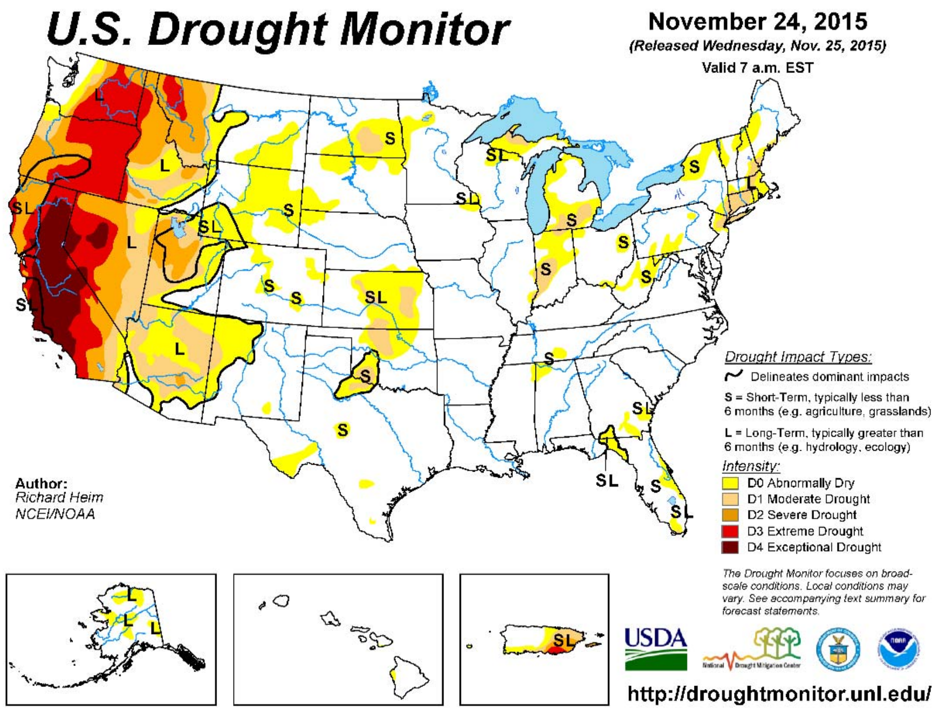


Figure 2. National Drought Mitigation Center U.S. Drought Monitor for November 24, 2015.

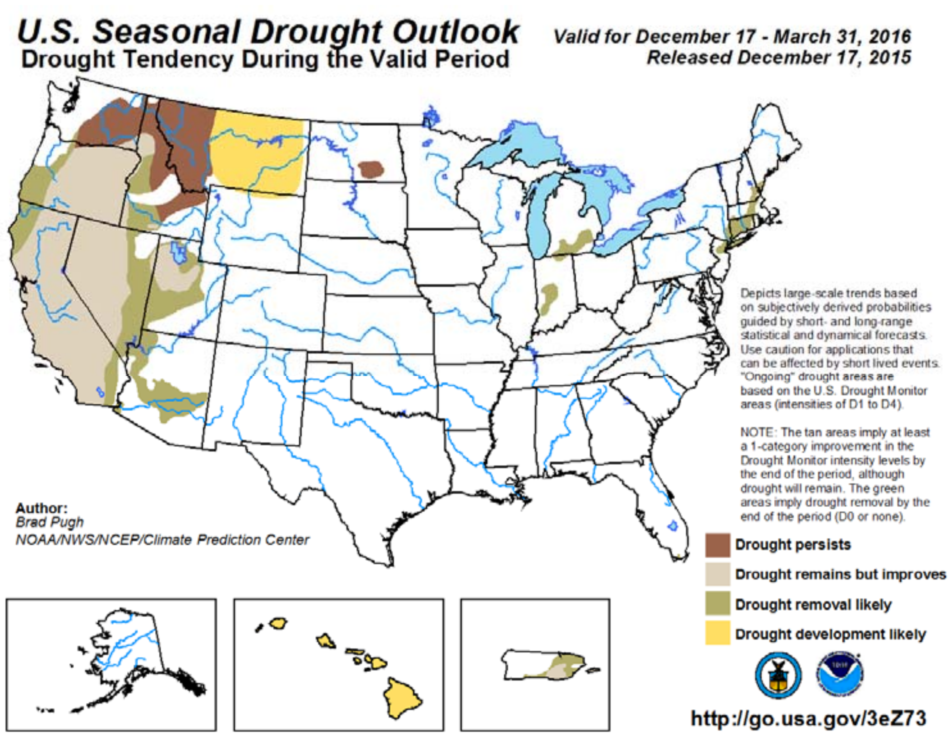


Figure 3. National Drought Mitigation Center U.S. Drought Seasonal Drought Outlook.

Precipitation

December precipitation accumulations are shown in **Figure 4** as both inches of precipitation (left) and percent of normal monthly precipitation (right). Heavy precipitation occurred in two storms during December 12-14 and December 25-28. Heavy precipitation totals ranging from 3 to 6 inches occurred in eastern Nebraska and western Iowa; while precipitation totals in eastern Kansas and Missouri averaged about 6 inches. The Osage and Gasconade Basins in Missouri received 6 to 12 inches of precipitation in December causing major flooding in the lower Basin. December precipitation accumulations were more than 2 times normal in western Montana, central North Dakota, South Dakota, Nebraska, Iowa, Kansas and Missouri.

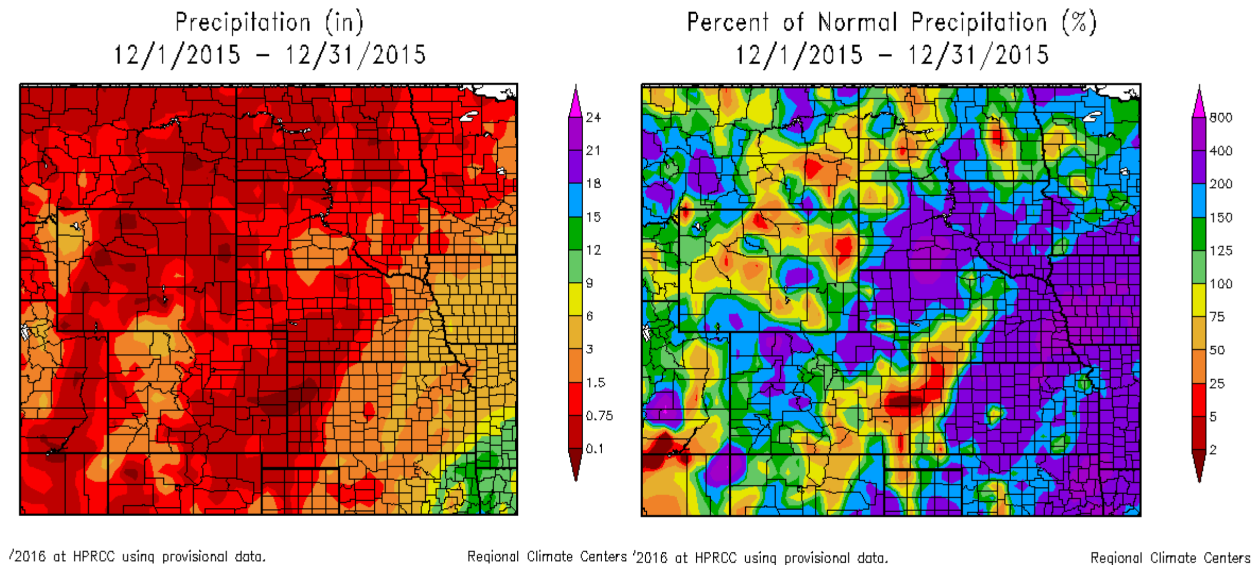


Figure 4. December 2015 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

October-November-December precipitation accumulations are shown in **Figure 5**. The three-month accumulations reflect a dry pattern across central and northern Wyoming, southern and eastern Montana, North Dakota and northern South Dakota. Wetter-than-normal precipitation accumulations occurred in all other areas, highlighted by more than 150% of normal precipitation in central and northern Montana, southwest South Dakota, Nebraska, Iowa, Kansas and Missouri.

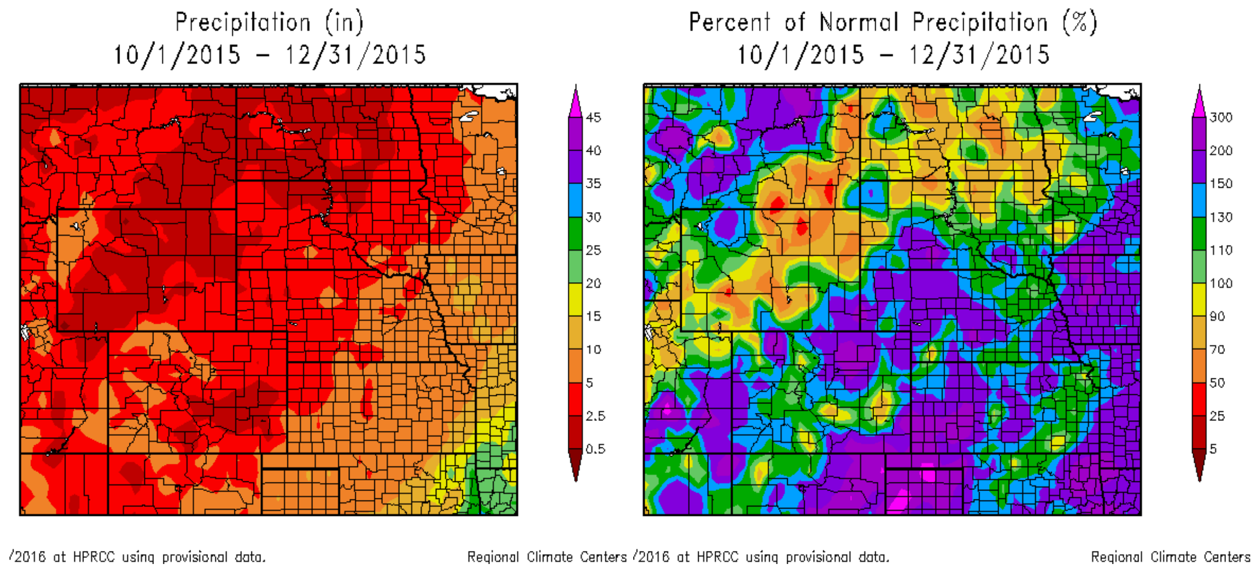


Figure 5. October-November-December 2015 Precipitation (inches) and Percent of Normal Precipitation. Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

Temperature

December temperature departures from normal in degrees Fahrenheit (deg F) are shown in **Figure 6**. December temperatures in the Basin ranged from near normal in the Rocky Mountains to over 9 deg F above normal in the Midwest. The warmest temperatures (greater than 9 deg F above normal) occurred over Minnesota, Iowa and Missouri. In December, cold temperatures typically form river ice on the Missouri River and its tributaries above Sioux City; however, much warmer-than-normal temperatures in December inhibited the development of river ice. As a result, December runoff was higher than average due in part to the lack of river ice formation. Three-month (November-December-January) temperature departures are shown in **Figure 7**. The map indicates a very similar pattern of temperature departures over the Missouri Basin.

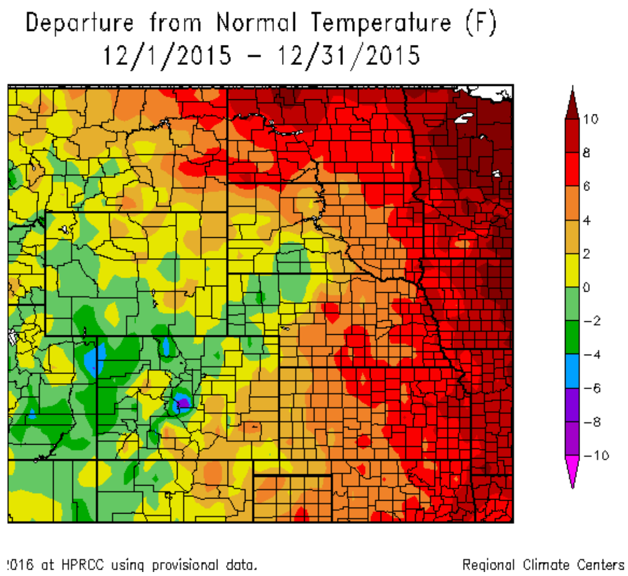


Figure 6. December 2015 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

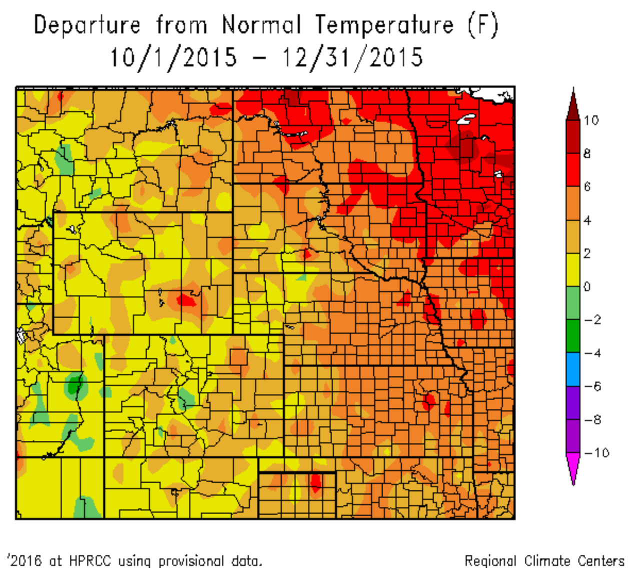


Figure 7. October-November-December 2015 Departure from Normal Temperature (deg F). Source: High Plains Regional Climate Center, http://www.hprcc.unl.edu/.

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, it can be used as an indicator of future runoff.

Figure 8 shows the NOAA NLDAS ensemble mean soil moisture percentiles on December 30, 2015 for the top 1-meter of the modeled soil column. The NLDAS soil moisture depiction is an average value for the soil moisture column. **Figure 8** indicates above normal soil moisture conditions are present throughout much of the upper Basin, though there are dry areas including north central Wyoming, eastern Montana, and eastern North Dakota. Very wet soil moisture conditions (greater than 95th percentile moisture) are indicated in north central Montana, eastern Nebraska, western Iowa, and the lower Missouri Basin in Missouri.

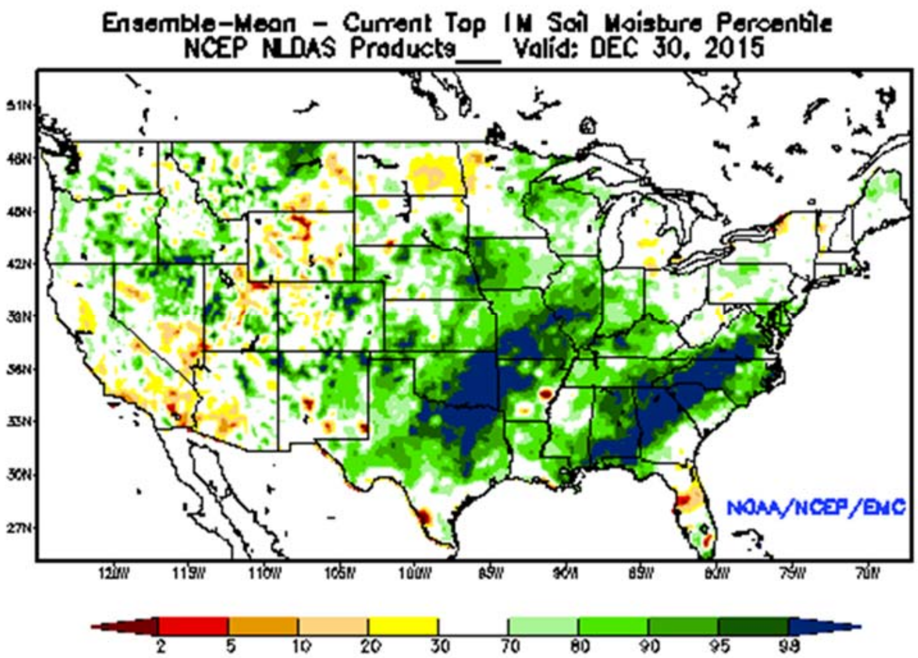


Figure 8. Top 1-Meter Soil Moisture Percentile on December 30, 2015. Source: NOAA NLDAS Drought Monitor Soil Moisture. http://www.emc.ncep.noaa.gov/mmb/nldas/drought/

Frost Conditions

Figure 9 shows depth of frost penetration at National Weather Service (NWS) Warning Forecast Office (WFO) locations in the Missouri Basin as of January 4, 2016. While some frost depth measurements are missing, measurements indicate soils have frozen at 12- to 18-inch depths in Montana, 19 inches deep in northwest North Dakota, 16- to 18-inch depths in southern North Dakota and northern and western South Dakota, but only 1 inch deep in Sioux Falls, SD. Shallower frost depths of 6 to 12 inches are also present in central Nebraska, while frost depths ranging from 0 to 2 inches are present in Missouri. Soil frost acts as a semi-impervious layer to snowmelt or precipitation infiltration into the soil.

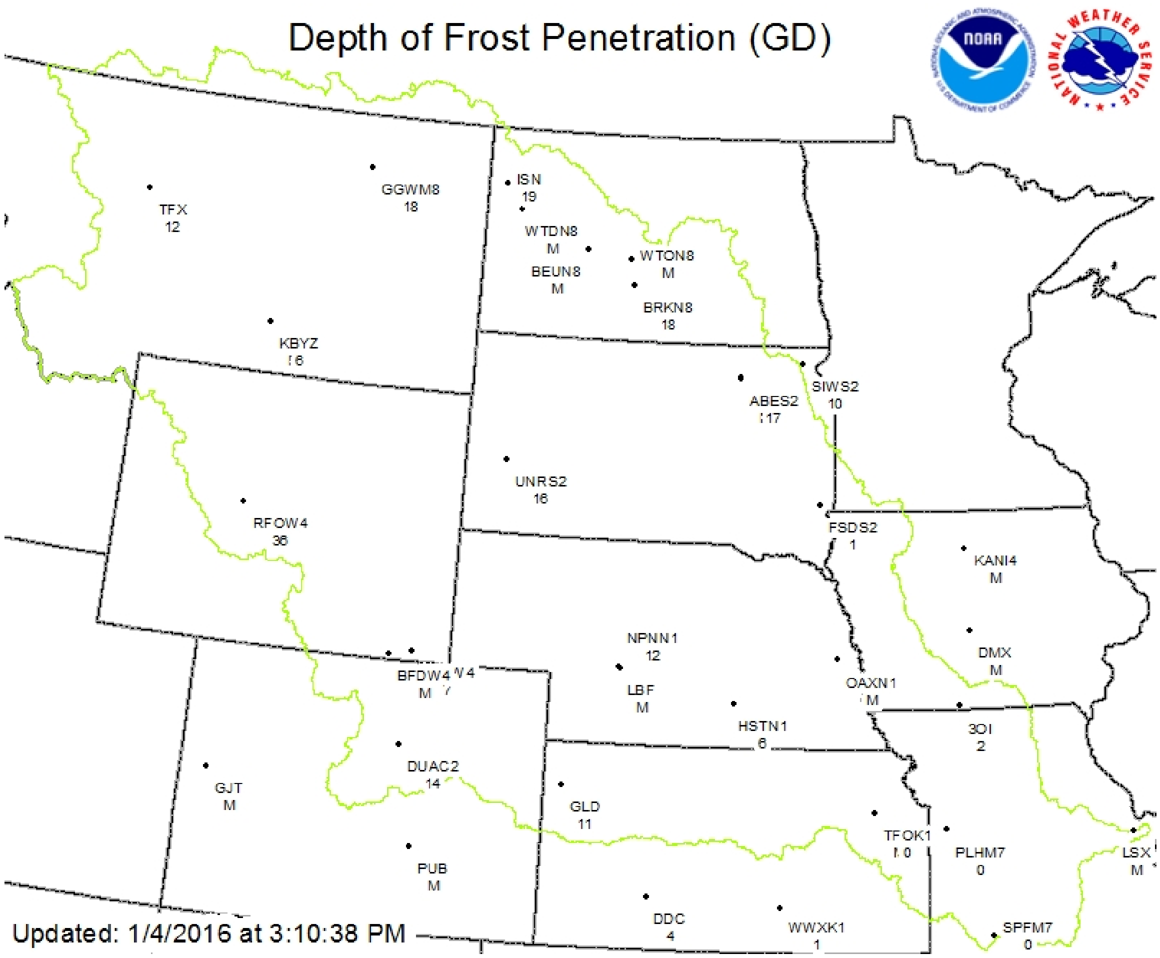
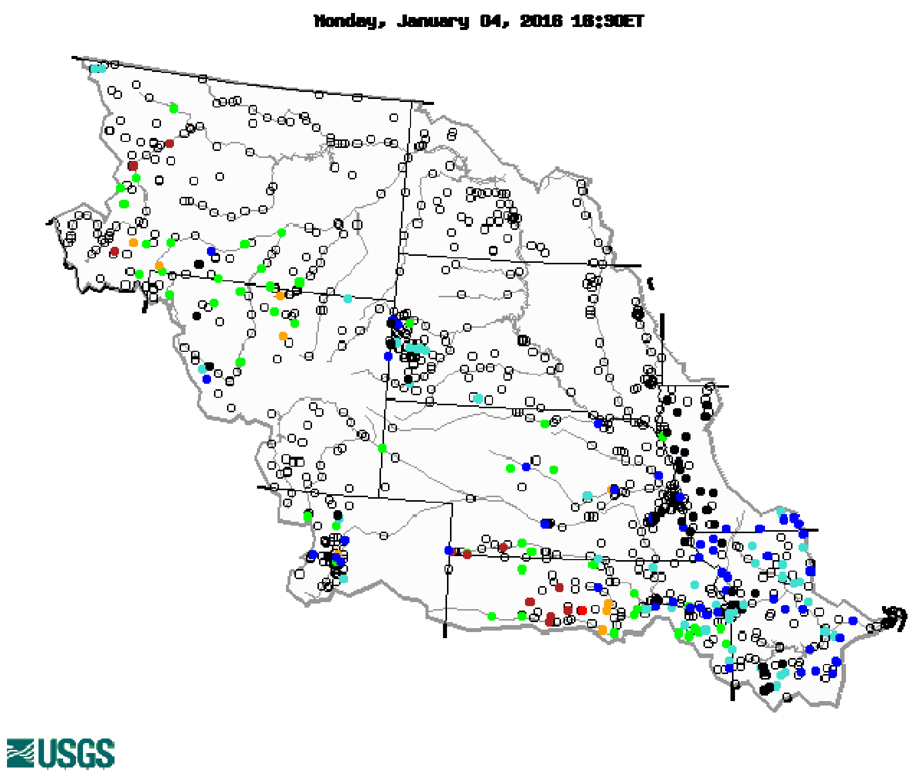


Figure 9. Measured frost depth (inches) at NWS WFO offices as of January 4, 2016. Source: NWS MBRFC. http://www.crh.noaa.gov/mbrfc

Streamflow Conditions

Missouri Basin streamflow conditions are shown in **Figure 10**. These conditions are based on the ranking of the January 4, 2016 daily streamflow versus the historical record of streamflow for that date. As shown in Figure 10, where streams are currently not influenced by ice formation, streamflow conditions continue to be "Much above normal" (greater than the 90th percentile) in Nebraska, Iowa, Kansas and Missouri. Some locations on the lower Missouri River and its tributaries are considered "High" as a result of record high December precipitation. As a result of this precipitation the Osage River, Gasconade River and lower Missouri River in Missouri experienced "Major" flooding at the end of December. In the upper Basin, a majority of stations have no classification because the current stream gages are either ice-affected or the historical record is ice-affected. The few stations in the upper Basin that are reporting indicate streamflow conditions, particularly in Montana and Wyoming, are "Normal" (25th-75th percentile) to "Below normal" (10th-24th percentile).



Explanation - Percentile classes						
Low	<10 Much below normal	10-24 Below normal	25-75 Normal	76-90 Above normal	>90 Much above normal	High

Plains Snowpack

Figure 10. USGS Streamflow Conditions as a Percentile of Normal in the Missouri River Basin as of January 4, 2016. Source: USGS. http://waterwatch.usgs.gov/index.php

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

Based on the National Operational Hydrologic Remote Sensing Center (NOHRSC) assessment (**Figure 11**) as of January 1, 2016 there were trace to 1-inch amounts of snow water equivalent (SWE) over most of the upper Missouri Basin above Sioux City, IA. Greater amounts ranging from 1 to 2 inches of SWE are present in western and south central Montana, southern and eastern South Dakota, Wyoming, and northern Nebraska.

To supplement the NOHRSC snow assessment and verify modeled snow depths and SWE, MRBWMD began the 2016 cooperative plains snow survey on January 4, 2016. Volunteers made in-situ depth and SWE measurements in locations across Montana, South Dakota and North Dakota and reported the measurements to MRBWMD. These measurements were provided to NOHRSC and MBRFC, and are posted to MRBWMD's website at: http://www.nwd-mr.usace.army.mil/rcc/snowsurvey/snowsurvey.html.

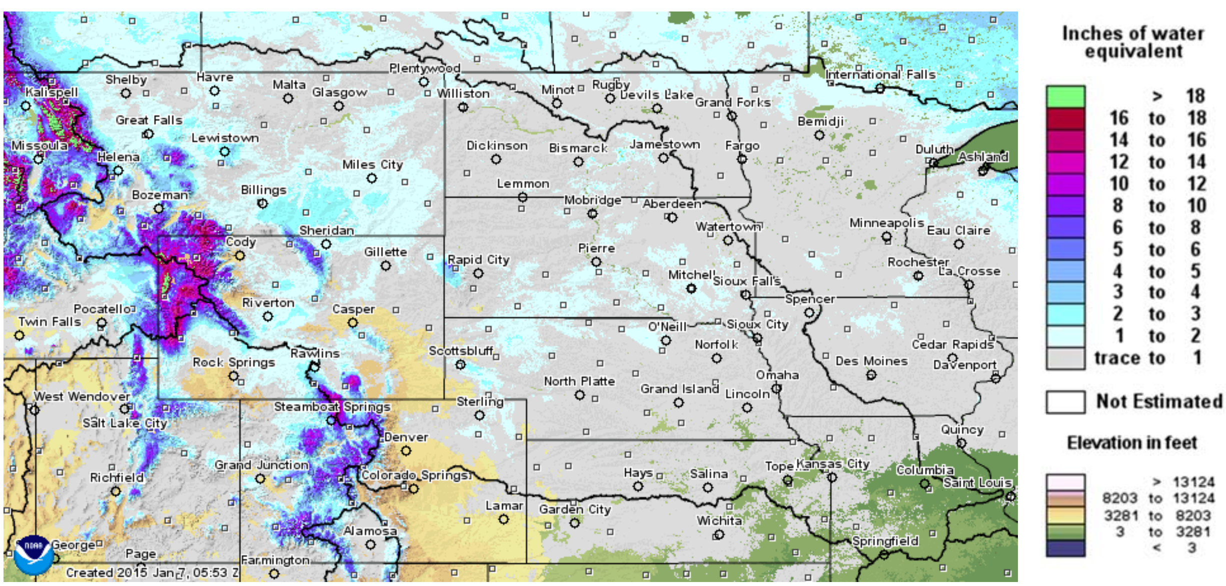
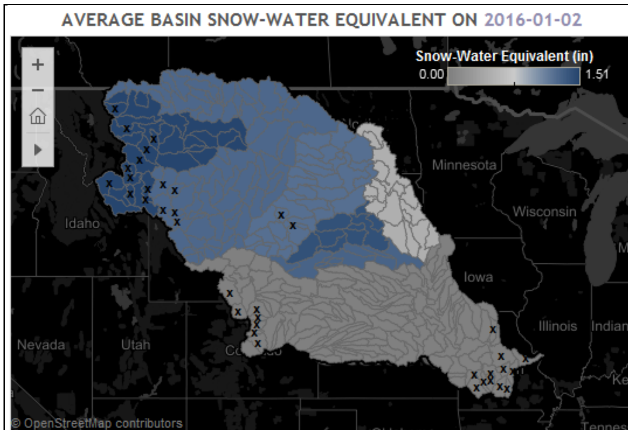


Figure 11. January 1, 2016 NOHRSC modeled plains snow water equivalent. Source: NOAA National Operational Hydrologic Remote Sensing Center. http://www.nohrsc.nws.gov/interactive/html/map.html

MRBWMD and the USACE Cold Regions Research and Engineering Laboratory (CRREL) has developed an application to estimate plains snowpack in the upper Missouri Basin using SSM/I satellite-based estimates of SWE. This application can estimate HUC-8 and reservoir reach basin-average SWE on a weekly basis. **Figure 13** includes a map of the Missouri Basin with SWE estimated in each of the Mainstem Reservoir reaches for the week ending on January 2, 2016. **Figure 13** indicates that the greatest average reach SWE was present in the Fort Peck and Fort Randall reaches. The least reach SWE was present in the Gavins Point to Sioux City reach. The table in **Figure 13** lists a calculated estimate of average basin SWE for the week ending on January 2, versus the historical median SWE (1987-2015). The table indicates that average basin SWE was greater than median in all reaches except the Gavins Point to Sioux City reach.



DETAILED DATA FOR 2016-01-02

Region	Avg Basin SWE (in)	Historical Median SWE (in)	% of Median SWE
Above Fort Peck	1.51	0.96	156%
Fort Peck to Garrison	1.27	1.26	101%
Fort Randall to Gavins Point	1.30	0.37	350%
Garrison to Oahe	1.22	0.84	145%
Gavins Point to Sioux City	0.49	0.94	52%
Oahe to Fort Randall	1.42	0.65	219%

Figure 12. Experimental SSM/I Satellite-Based Plains Snowpack Estimate for the Mainstem Reservoir System.

Using the MRBWMD snowpack classification method, plains snowpack for the January 1, 2016 runoff forecast was classified according to the terminology listed in **Table 3**. A “Light” snowpack indicates snow cover that is above the median SWE, and a “Moderate” snowpack is greater than “Light”. “Average” basin conditions indicate snowpack is less than “Light” with no measureable snow accumulations. March-April runoff in “Average” conditions is expected to be below or near long term average runoff. Runoff resulting from “Light” and “Moderate” snowpack accumulations is expected to be above long term average March-April runoff.

Table 1. Plains snowpack classification for the January 1, 2016 runoff forecast.

Reservoir Reach	Plains Snowpack Classification
Above Fort Peck	Light - Moderate
Fort Peck to Garrison	Average - Light
Garrison to Oahe	Light
Oahe to Fort Randall	Light
Fort Randall to Gavins Point	Light
Gavins Point to Sioux City	Average

Mountain Snow Pack

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

Figure 14 includes time series plots of the average mountain SWE beginning on October 1, 2015 based on the NRCS SNOTEL gages 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).

As of **December 31, 2015**, the Corps of Engineers computed an average mountain SWE in the **Fort Peck reservoir reach of 7.0 inches, which is 100% 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 **4.8 inches, which is 76% of average** based on the 1981-2010 average SWE for the Garrison reach. Normally by January 1, 44% of the peak snow accumulation has occurred in the mountains.

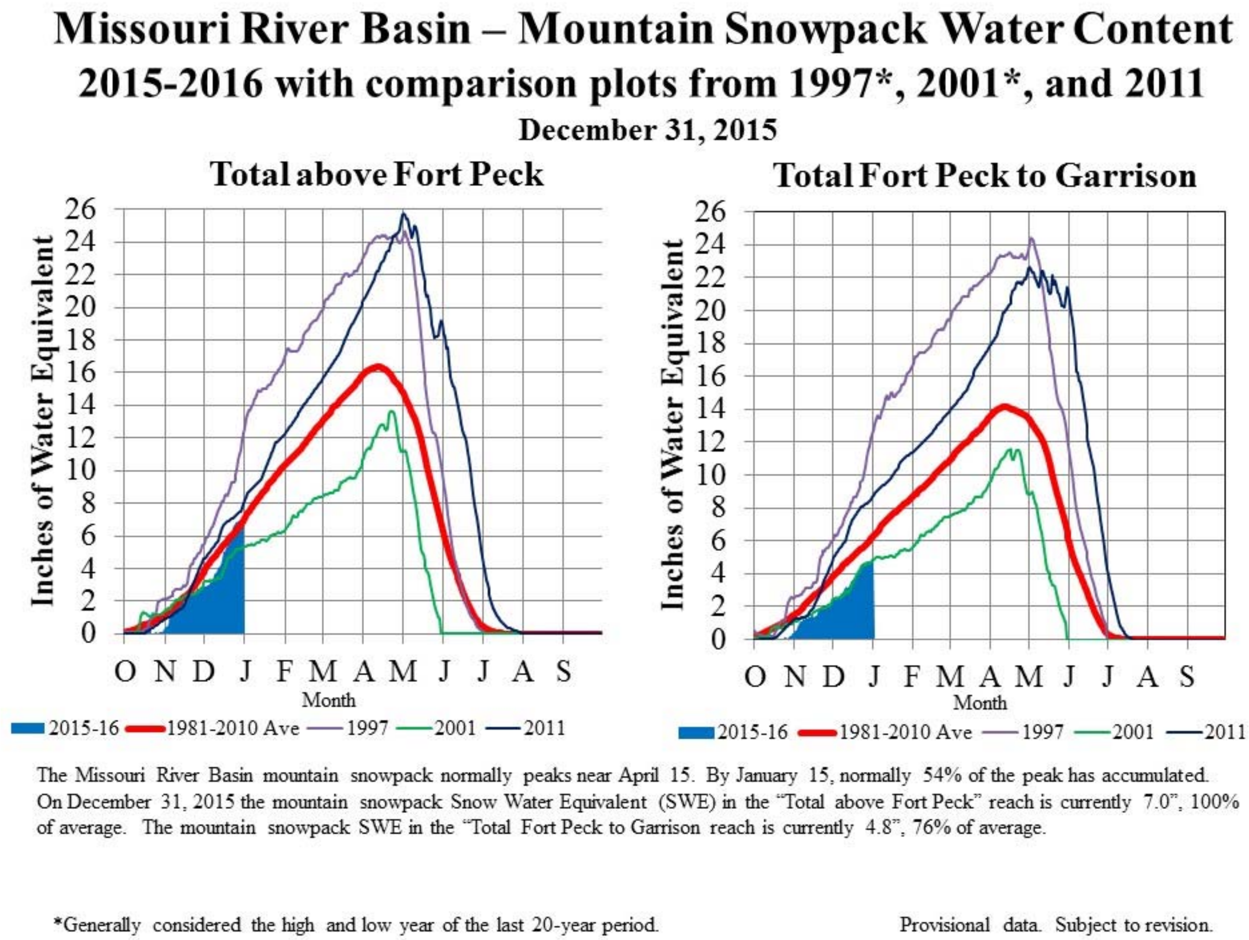


Figure 13. Mountain snowpack water content on December 31, 2015 compared to normal and historic conditions. Corps of Engineers - Missouri River Basin Water Management.

Climate Outlook

ENSO (El Niño Southern Oscillation)

According to the CPC's latest monthly update[1] on January 4, 2016, "***El Niño is expected to remain strong through the Northern Hemisphere winter 2015-2016, with a transition to ENSO-neutral anticipated during the late spring or early summer 2016***". CPC studies are predicting a strong El Niño event at its peak. El Niño winters have a tendency to be warmer and drier than normal in the upper Missouri Basin, and the influence of El Niño has been factored into the CPC's climate outlooks.

MRBWMD 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

[1] http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf

impacts including the El Niño climate pattern and its implications on late summer, fall and early winter temperature and precipitation patterns in the Missouri River Basin. The possible impacts of El Niño have been factored into the CPC climate outlooks described below.

Temperature and Precipitation Outlooks

The NOAA Climate Prediction Center climate outlook for January 2015 (**Figure 15**) indicates an increased probability for above normal temperatures in Montana, North Dakota and northern South Dakota, and equal chances for below normal, normal and above normal temperatures over the remainder of the Missouri Basin. Probabilities for above normal temperatures in Montana, North Dakota and South Dakota range from 33.3% to over 40%, complimented by a 33.3% chance that temperatures will be in the normal range, and a 26.7% to 33.3% chance temperatures will be below normal. Stated simply, there is only a slight increase in the chance for above normal temperatures. With regard to precipitation, there are similar increased chances that precipitation will be below normal in Montana, Wyoming, North Dakota and northwest South Dakota, but equal chances precipitation will be below normal, normal and above normal in January throughout the remainder of the Missouri Basin.

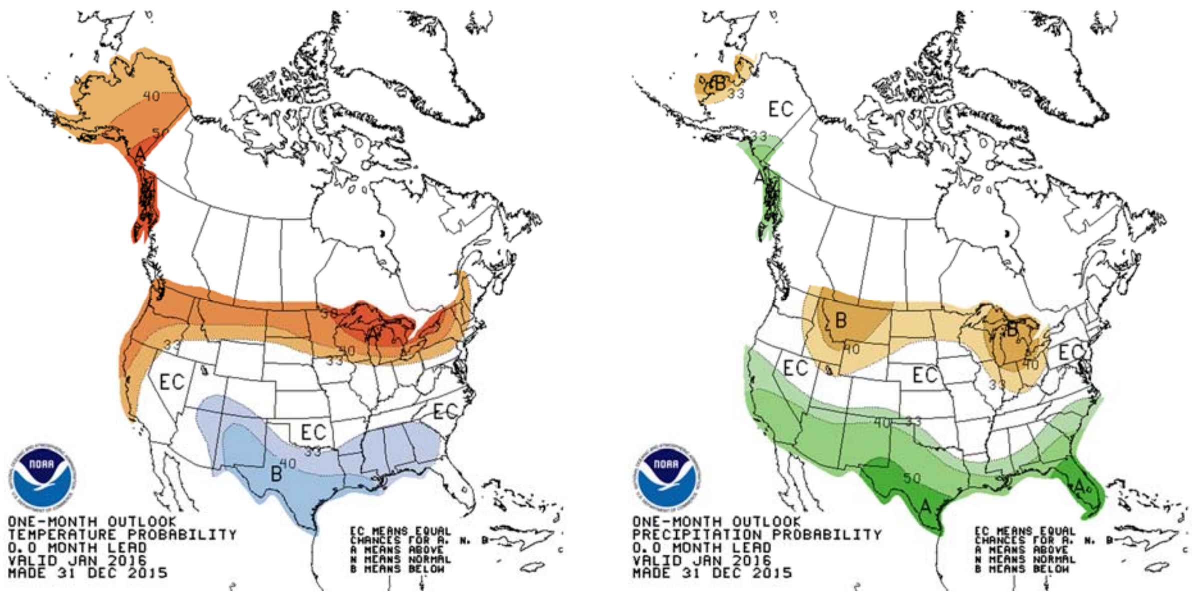


Figure 14. CPC January 2016 temperature and precipitation outlooks.

The winter (January-February-March) temperature outlook (**Figure 16**) indicates a slightly higher probability (33.3% to 40%) that temperatures will be above normal in all of the upper Basin and a majority of the lower Basin. The January-February-March precipitation outlook indicates a greater than 50% chance that precipitation in western Montana will be below normal, and a 33% to 50% chance that precipitation will be below normal in central and eastern Montana, northern Wyoming and North Dakota. Probabilities transition to above normal precipitation in Nebraska and Kansas. Both temperature and precipitation outlooks reflect the influences of El Niño conditions.

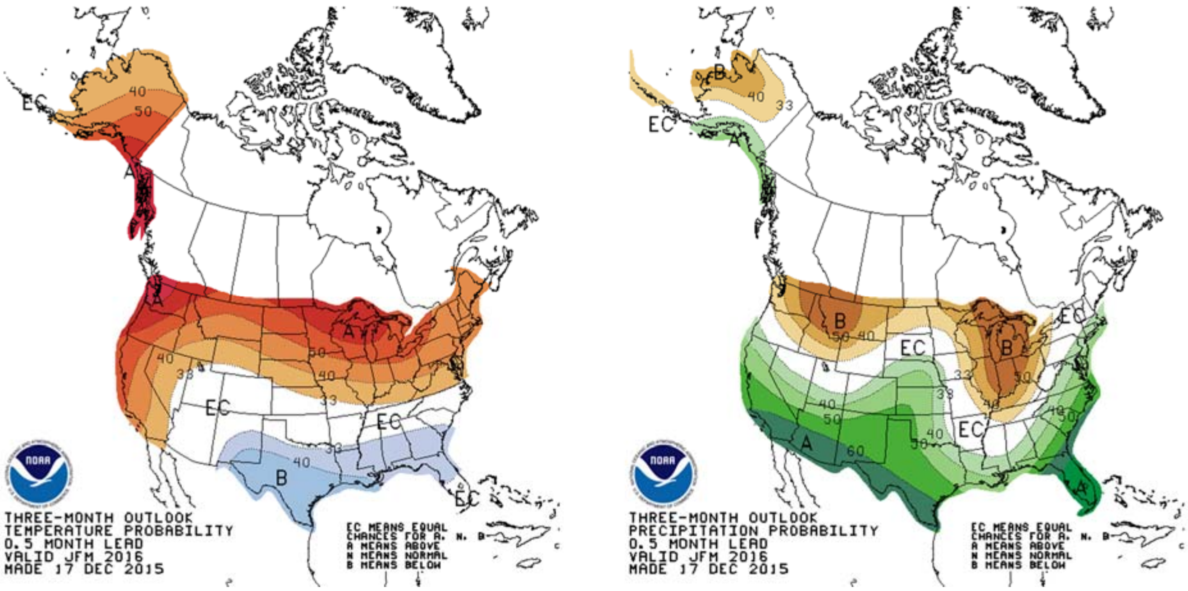


Figure 15. CPC January-February-March 2016 temperature and precipitation outlooks.

The April-May-June 2016 CPC temperature outlook (**Figure 17**) indicates there are increased chances for above normal temperatures across much of the Missouri Basin. In terms of precipitation, there are increased chances for above normal precipitation in the central Rockies transitioning to equal chances in the Northern Rockies. The Plains are expected to have equal chances for above normal, normal, and below normal precipitation; however, there is a slight tilt toward below normal precipitation in the lower Missouri Basin.

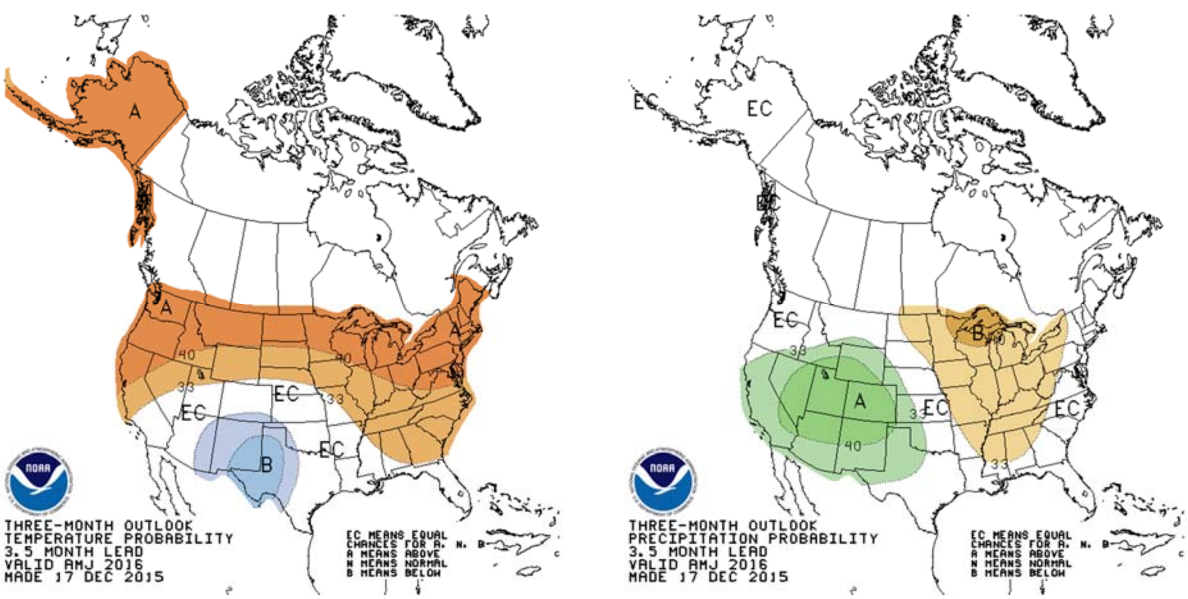


Figure 16. CPC April-May-June 2016 temperature and precipitation outlooks.

During the July-August-September period (**Figure 18**) the CPC outlooks indicate increased chances for above normal temperatures across the entire Missouri Basin, and equal chances for above normal, normal and below normal precipitation. The October-November-December period (**Figure 19**) outlook indicates increased chances for above normal temperatures in the southern half of the Missouri Basin and equal chances for above normal, normal and below normal temperatures in the northern half of the Missouri Basin. With regard to precipitation, the October-November-December outlook indicates there is an increased chance for above normal precipitation in the Northern Rockies and equal chances for much of the remaining Missouri Basin.

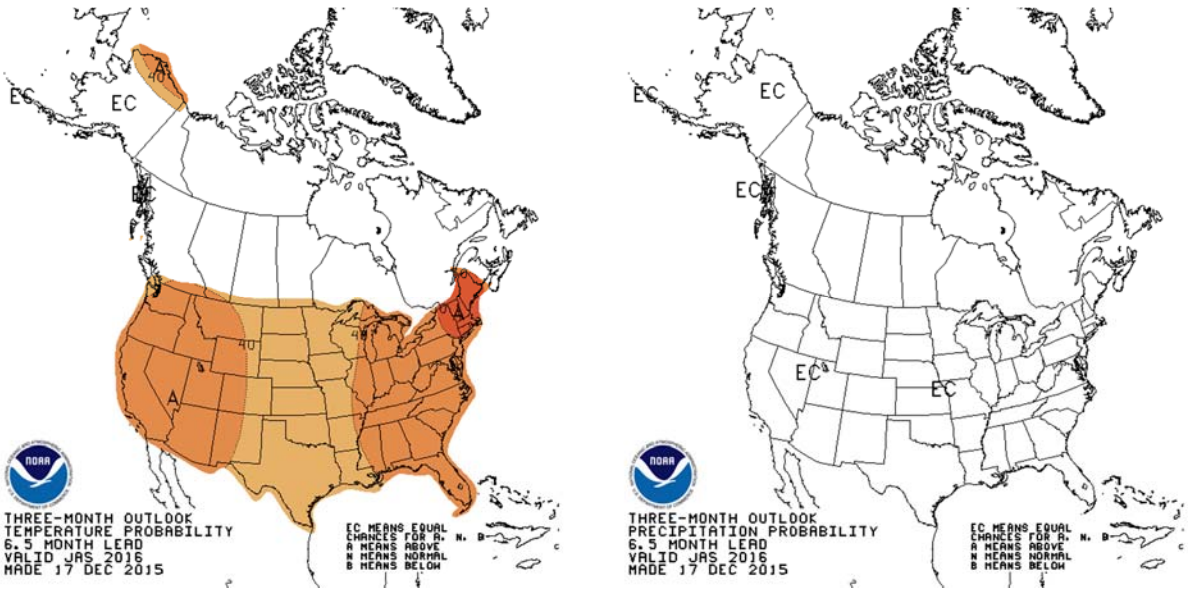


Figure 17. CPC July-August-September 2016 temperature and precipitation outlooks.

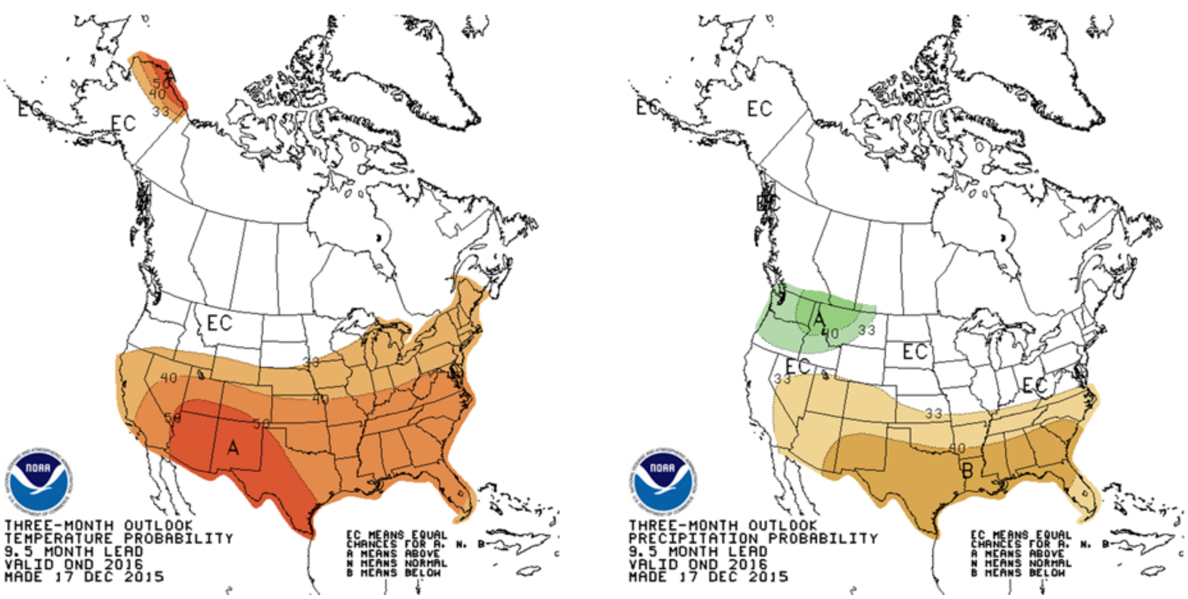


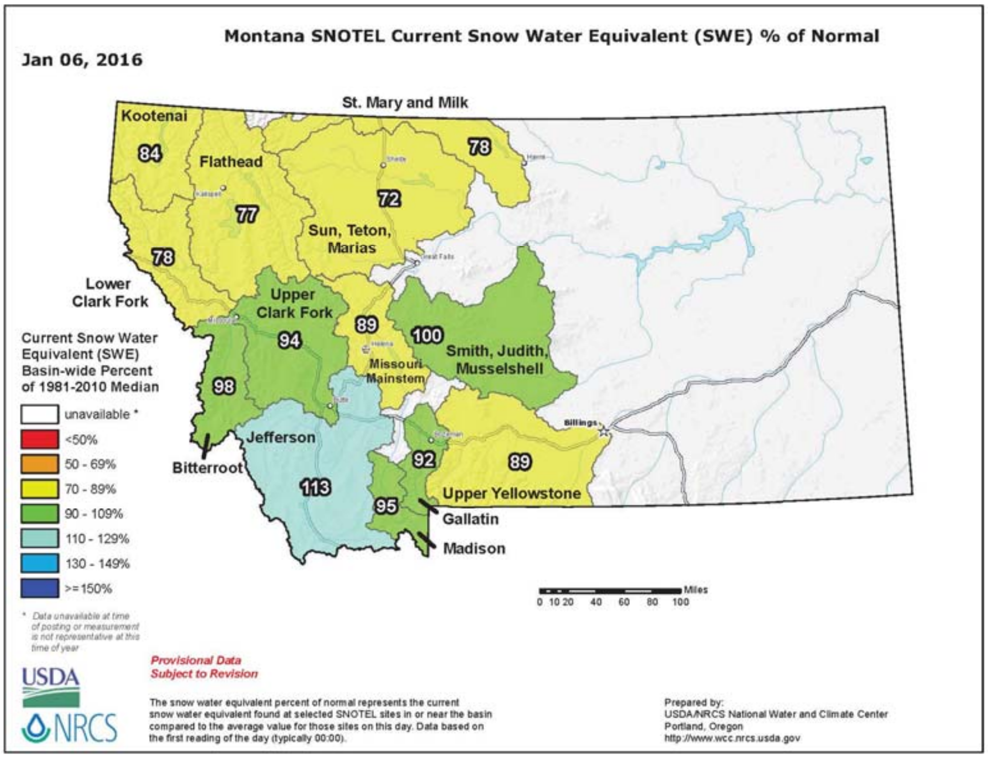
Figure 18. CPC October-November-December 2016 temperature and precipitation outlooks.

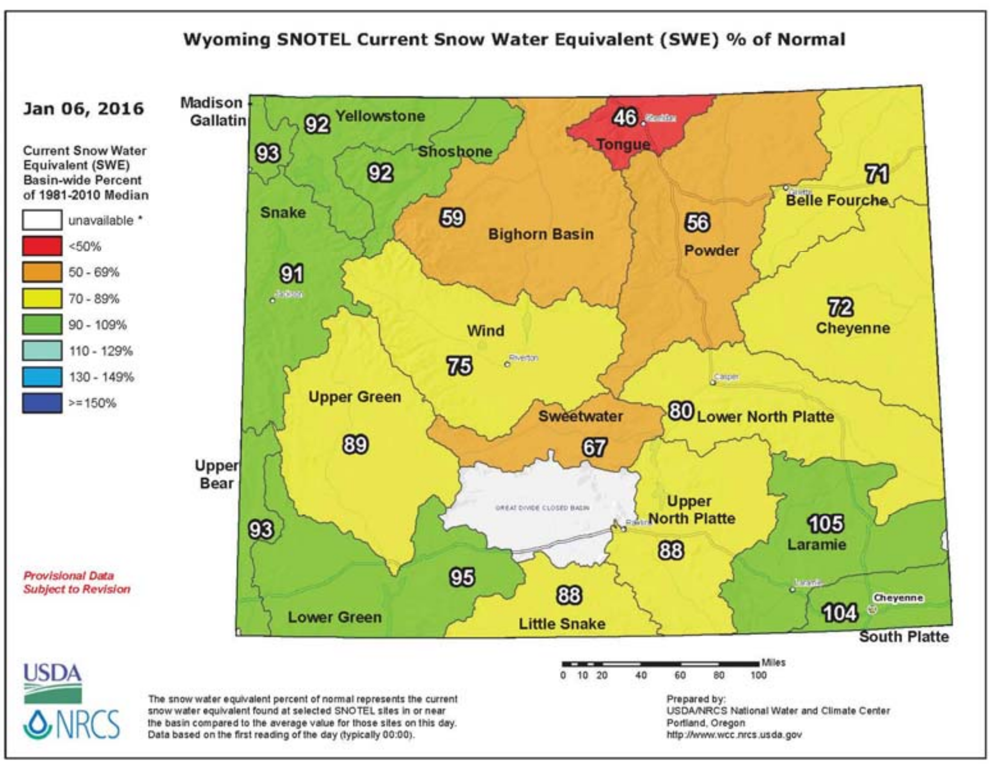
January 2016 Calendar Year Runoff Forecast

In summary, the 2016 calendar year runoff forecast is **23.8 MAF**, **94% of average**. The warmer than normal temperatures that are forecast over the next three months and average plains snowpack will lead to slightly above average runoff during the first three months of 2016. The outlook for warmer temperatures and below normal precipitation in late-winter could limit mountain snowpack accumulations and late-winter plains snowpack formation, and thus cause less than average runoff from April through July.

Due to the amount of variability in precipitation that can occur over the next 12 months, the range of expected inflow is quite large and ranges from the 32.9 MAF upper basic forecast to the 15.7 MAF lower basic forecast.

Additional Figures





USDA NRCS National Water & Climate Center
*** - DATA CURRENT AS OF: January 06, 2016 05:13:39 PM**
- Based on January 01, 2016 forecast values

PRELIMINARY MISSOURI RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
Lake Sherburne Inflow	APR-JUL	90	93	110	99	82	70	97
	APR-SEP	105	94	125	113	97	85	112
St. Mary R at Int'l Boundary (2)	APR-JUL	385	89	505	435	340	270	435
	APR-SEP	450	89	570	500	400	330	505
Lima Reservoir Inflow (2)	APR-JUL	77	94	113	92	62	41	82
	APR-SEP	84	94	125	101	67	43	89
Clark Canyon Reservoir Inflow (2)	APR-JUL	94	93	192	134	54	-4.4	101
	APR-SEP	116	97	225	160	72	7.7	120
Jefferson R nr Three Forks (2)	APR-JUL	730	99	1190	915	545	270	740
	APR-SEP	800	100	1310	1010	595	290	800
Hebgen Reservoir Inflow (2)	APR-JUL	340	92	425	375	305	255	370
	APR-SEP	430	91	535	470	390	325	470
Ennis Reservoir Inflow (2)	APR-JUL	560	90	715	620	495	400	625
	APR-SEP	690	89	875	765	615	505	775
Missouri R at Toston (2)	APR-JUL	1690	94	2450	2000	1380	920	1790
	APR-SEP	1940	94	2820	2290	1580	1050	2070
Smith R bl Eagle Ck (2)	APR-JUL	107	101	162	129	85	52	106
	APR-SEP	121	104	185	147	95	58	116
Gibson Reservoir Inflow (2)	APR-JUL	315	80	435	365	270	197	395
	APR-SEP	350	80	480	405	300	225	440
Marias R nr Shelby (2)	APR-JUL	280	81	475	360	197	79	345
	APR-SEP	285	79	490	370	200	80	360
Milk R at Western Crossing	MAR-JUL	26	93	51	36	16.2	1.48	28
	MAR-SEP	27	82	54	38	16.8	1.48	33
	APR-JUL	21	84	43	30	12.6	1.00	25
	APR-SEP	22	85	46	32	12.5	1.00	26

PRELIMINARY YELLOWSTONE RIVER BASIN FORECASTS

Forecast Point	period	50% (KAF)	% of avg	max (KAF)	30% (KAF)	70% (KAF)	min (KAF)	30-yr avg
West Rosebud Ck nr Roscoe (2)	APR-JUL	58	98	68	62	54	48	59
	APR-SEP	74	100	87	79	69	61	74
Wind R ab Bull Lake Ck (2)	APR-JUL	400	88	565	465	330	230	455
	APR-SEP	420	86	605	495	345	235	490
Bull Lake Ck nr Lenore	APR-JUL	117	84	152	131	103	82	139
	APR-SEP	142	84	185	159	125	99	169
Boysen Reservoir Inflow (2)	APR-JUL	400	66	750	540	260	50	610
	APR-SEP	415	62	790	565	265	44	665
Greybull R nr Meeteetse	APR-JUL	118	90	173	140	95	62	131
	APR-SEP	159	90	225	185	132	93	177
Shell Ck nr Shell	APR-JUL	35	64	51	42	28	18.6	55
	APR-SEP	44	67	61	51	36	26	66
Bighorn R at Kane (2)	APR-JUL	515	61	1010	715	320	25	840
	APR-SEP	515	57	1050	730	300	20	905
NF Shoshone R at Wapiti	APR-JUL	450	98	550	490	410	350	460
	APR-SEP	505	98	605	545	460	400	515
SF Shoshone R nr Valley	APR-JUL	210	98	260	230	190	161	215
	APR-SEP	240	98	295	260	220	185	245
Buffalo Bill Reservoir Inflow (2)	APR-JUL	665	99	825	730	600	505	675

	APR-SEP	730	98	900	800	660	560	745
Bighorn R nr St. Xavier (2)	APR-JUL	1040	75	1620	1280	810	470	1380
	APR-SEP	1050	72	1700	1310	790	405	1460
Little Bighorn R nr Hardin	APR-JUL	54	55	108	76	32	1.00	98
	APR-SEP	61	55	121	85	37	1.00	111
Tongue R nr Dayton (2)	APR-JUL	55	64	89	69	41	21	86
	APR-SEP	63	64	100	78	48	26	98
Tongue River Reservoir Inflow (2)	APR-JUL	112	58	220	156	69	5.4	193
	APR-SEP	125	58	245	171	79	12.3	215
NF Powder R nr Hazelton	APR-JUL	5.5	60	9.0	6.9	4.1	2.0	9.1
	APR-SEP	6.0	61	9.6	7.4	4.5	2.4	9.9
Powder R at Moorhead	APR-JUL	76	43	192	123	29	1.00	177
	APR-SEP	92	47	210	141	43	1.00	196
Powder R nr Locate	APR-JUL	83	42	225	140	27	1.00	199
	APR-SEP	98	45	250	160	37	1.00	220

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

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