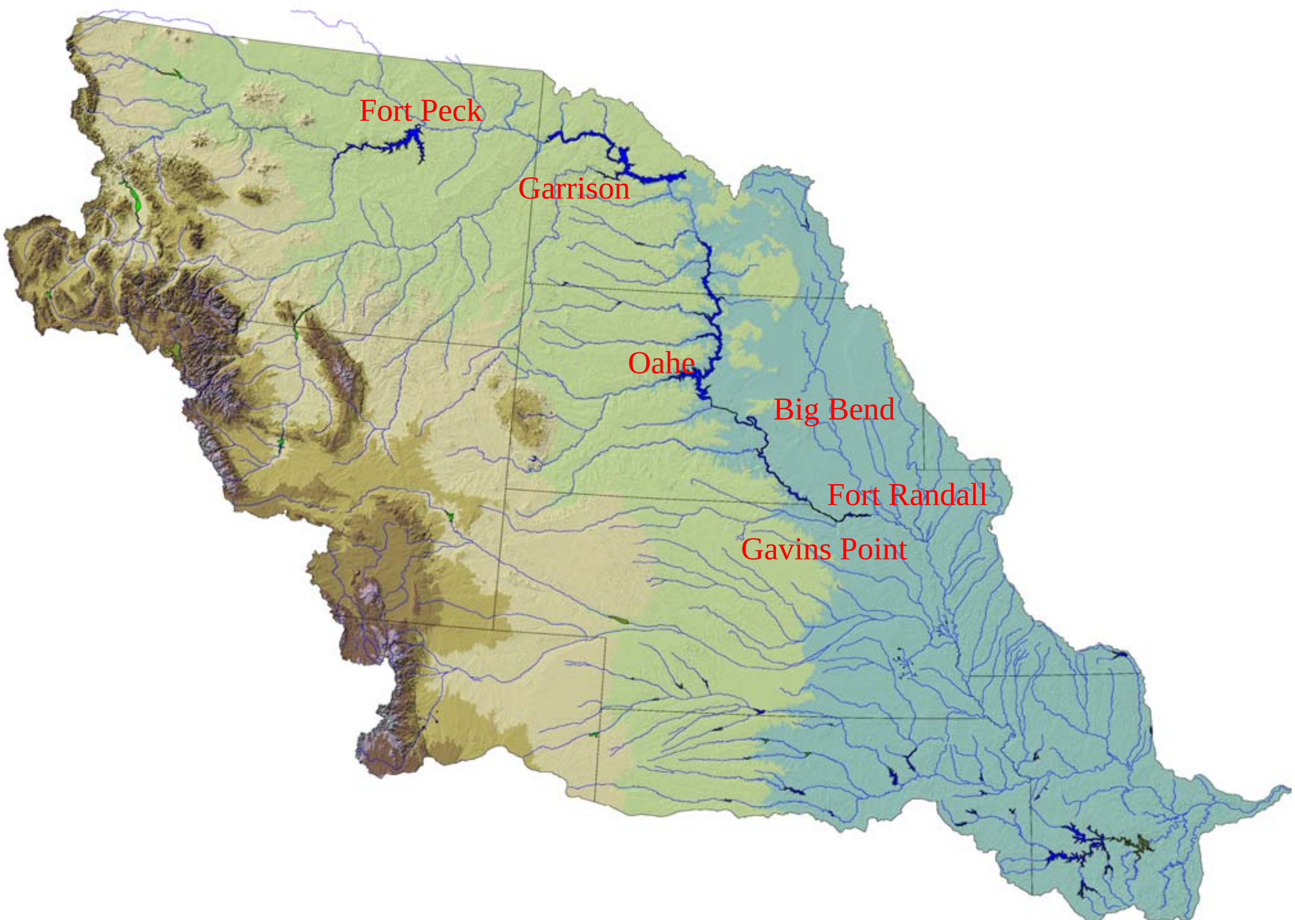
US Army Corps
of Engineers

Northwestern Division

Missouri River Mainstem Reservoir System

Summary of Actual 2018 Regulation

Missouri River Basin



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

July 2019

Missouri River Mainstem Reservoir System

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LIST OF ABBREVIATIONS AND ACRONYMS

AOP	annual operating plan
AF	acre-feet
cfs	cubic feet per second
BIA	Bureau of Indian Affairs
consultation	government-to-government consultation
CPFLP	coldwater permanent fish life propagation
CY	calendar year (January 1 to December 31)
DMS	Data Management System
deg C	degrees Celsius
deg F	degrees Fahrenheit
EA	Environmental Assessment
ENSO	El Niño Southern Oscillation
EOM	end of month
Five Year Plan	Cultural Resources Program Five Year Plan
FTT	flow to target
HPRCC	High Plains Regional Climate Center
kAF	thousand acre-feet
kW	kilowatt
kWh	kilowatt hour
M	million
MAF	million acre-feet
Master Manual	Master Water Control Manual
MGD	million gallons per day
µg/l	micrograms per liter
mg/l	milligrams per liter
MRNRC	Missouri River Natural Resources Committee
MRBWM	Missouri River Basin Water Management
MV	motor vessel
MVD	Corps' Mississippi Valley Division
MW	megawatt
MWh	megawatt hour
M&I	municipal and industrial
NDEQ	Nebraska Department of Environmental Quality
NDMC	National Drought Mitigation Center
ND-SWC	North Dakota State Water Commission
NHPA	National Historic Preservation Act
NOAA-CPC	National Oceanic and Atmospheric Administration - Climate Prediction Center
NOAA-NCDC	National Oceanic and Atmospheric Administration - National Climatic Data Center
NOAA-NLDAS	National Oceanic and Atmospheric Administration - North-American Land Data Assimilation Systems
NOAA-NWS	National Oceanic and Atmospheric Administration - National Weather Service

LIST OF ABBREVIATIONS AND ACRONYMS (cont'd)

NOHRSC	National Operational and Hydrologic Remote Sensing Center
NOW Data	NOAA Online Weather Data
NRCS-SNOTEL	Natural Resources Conservation Service SNOwpack TELemetry
NWD	Corps' Northwestern Division
NWK	Corps' Kansas City District
NWO	Corps' Omaha District
OPPD	Omaha Public Power District
PA	2004 Programmatic Agreement
plover	piping plover
P-S MBP	Pick-Sloan Missouri Basin Program
RM	river mile
SD GFP	South Dakota Game Fish and Parks
SHPO	State Historic Preservation Officer
SNODAS	Snow Data Assimilation System
SR	steady release
SWE	snow water equivalent
System	Missouri River Mainstem Reservoir System
tern	interior least tern
THPO	Tribal Historic Preservation Officer
TMDL	total maximum daily load
T&E	threatened and endangered
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VERS	Visitation Estimation Reporting System
WCSC	Waterborne Commerce Statistics Center
Western	Western Area Power Administration
WPFLP	warmwater permanent fish life propagation

DEFINITION OF TERMS

Acre-foot (AF, ac-ft) is the quantity of water required to cover 1 acre to a depth of 1 foot and is equivalent to 43,560 cubic feet or 325,850 gallons.

Cubic foot per second (cfs) is the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute. The volume of water represented by a flow of 1 cubic foot per second for 24 hours is equivalent to 86,400 cubic feet, approximately 1.983 acre-feet, or 646,272 gallons. Conversely, 1.5 cfs for 24 hours is approximately 1 million gallons; therefore, 1.5 cfs is approximately 1 million gallons per day (MGD).

Discharge is the volume of water (or more broadly, volume of fluid plus suspended sediment) that passes a given point within a given period of time.

Drainage area of a stream at a specific location is that area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the river above the specified point. Figures of drainage area given herein include all closed basins, or noncontributing areas, within the area unless otherwise noted.

Drainage basin is a part of the surface of the earth that is occupied by drainage system, which consists of a surface stream or body of impounded surface water together with all tributary surface streams and bodies of impounded water.

Drought is three or more consecutive years of below-average calendar year runoff into the Missouri River above Sioux City, IA.

Gaging station is a particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Runoff in inches shows the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

Streamflow is the discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

MISSOURI RIVER MAINSTEM RESERVOIR SYSTEM

Summary of Actual 2018 Regulation

I. FOREWORD

This document contains a summary of the actual regulation of the Missouri River Mainstem Reservoir System (System) for the 2018 Calendar Year (CY). Two other reports related to System regulation are also available, the ***System Description and Regulation*** and ***Final 2017-2018 Annual Operating Plan.*** All three reports can be obtained by contacting the Missouri River Basin Water Management Division (MRBWM), Northwestern Division, U.S. Army Corps of Engineers at 1616 Capitol Avenue, Suite 365, Omaha, Nebraska 68102-4909, phone (402) 996-3841. The reports are also available on the MRBWM website at www.nwd-mr.usace.army.mil/rcc.

A Missouri River Basin (Basin) map is presented on ***Plate 1*** and the pertinent data for the System are shown on ***Plate 2.***

II. REVIEW OF REGULATION – JANUARY-DECEMBER 2018

A. General

This report summarizes the System regulation as it pertains to all eight congressionally-authorized purposes. During 2018 the System was regulated in accordance with the Master Water Control Manual (Master Manual) and the applicable provisions of the Final 2017-18 Annual Operating Plan (AOP), which was made available for review and comment by representatives of State and Federal agencies, Tribes, the general public, and specific interest groups. For the purposes of this report, the upper Missouri River Basin (upper Basin) is the Missouri River Basin above Sioux City, IA and the lower Missouri River Basin (lower Basin) is the Missouri River Basin from Sioux City, IA to the mouth.

B. Precipitation and Water Supply Available in 2018

Plains snowpack, mountain snowpack and general weather conditions in the Missouri River Basin during the 2018 calendar year are discussed in the following sections. The 1981-2010 30-year period is the reference period for averages as it relates to plains and mountain snowpack, precipitation and temperature conditions.

The winter of 2017-18 was influenced by La Niña conditions in the equatorial Pacific Ocean. Based on National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC) data, La Niña conditions were present from October 2017 to March 2018. During a La Niña or cold episode of the El Niño Southern Oscillation (ENSO), there are increased probabilities for above-normal precipitation and below-normal temperatures in the upper Basin during the winter season, especially in the northern plains region. The La Niña episode allows colder air masses to build over the Gulf of Alaska and penetrate into the northern Great Plains. When met with moist air, this often results in above-average snowfall in both the plains and mountains.

During the fall of 2017, prior to significant plains snow accumulation, soil moisture conditions in the upper Basin were wetter than normal in much of western and central Montana and Wyoming, based on the NOAA National Land Data Assimilation System (NLDAS) Ensemble Mean for total column soil moisture (see ***Figure 1***). Soil moisture ranked in the 95th to 98th percentile categories in the mountainous areas of Montana and Wyoming, and slightly above normal in the plains. In contrast, soil moisture was below normal in eastern Montana, the Dakotas, and much of the lower Basin. Soil moisture ranked in the 20th to 5th percentile categories in the driest areas of the Dakotas.

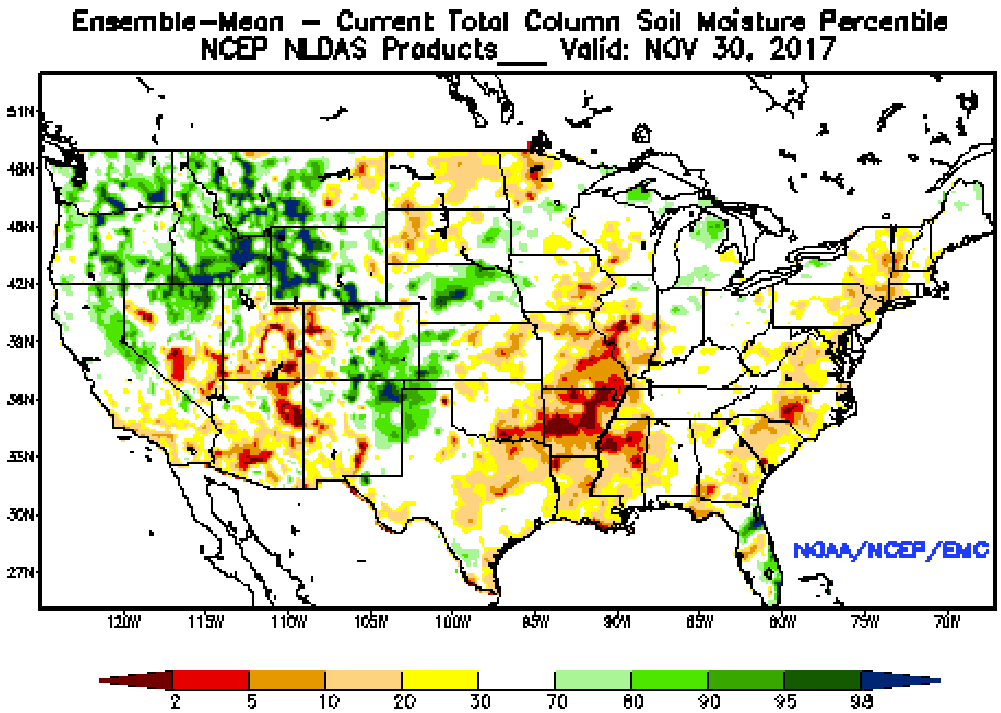


Figure 1. Soil moisture percentile ranking, November 30, 2017. Source: NOAA NLDAS

Fall soil moisture is significant in its relation to upper Basin spring runoff. During the onset of the winter, much of this moisture is frozen in the soil and is later released during the spring thaw as baseflow. Soil moisture typically does not change during the winter; therefore, high or low fall soil moisture typically establishes wet or dry spring soil moisture conditions, respectively.

1. Plains Snowpack

Plains snowpack is an important parameter that influences the volume of runoff occurring in the upper Basin during the months of March and April. Historically, about 25% of annual upper Basin runoff occurs in March and April. Runoff in March and April is due to melting snowpack and rainfall runoff. Intermittent warm-ups in late January and February can result in plains snowmelt during those months. Plains snowpack accumulation, and the plains snow water equivalent (SWE) in that snowpack, is used as the primary indicator of February-April runoff in the upper Basin. In addition, antecedent soil moisture conditions, observed accumulated precipitation, and observed seasonal temperature are factored into the forecasting of February-April runoff.

Plains snowfall in the upper Basin during the 2017-18 winter varied from light to heavy. The deepest and most persistent plains snowpack occurred throughout much of Montana, and some of the heaviest plains snowpack persisted into April in northern Montana. In contrast, plains snowfall was generally moderate to light in North Dakota and in the drainage area between Gavins Point and Sioux City, IA (i.e., James and Big Sioux River basins in eastern South Dakota).

Intense, cold temperatures and well-above-normal precipitation were major factors that caused the rapid formation of moderate to heavy snowpack in the upper Basin. From December 2017 to February 2018, the temperature departures in Montana ranged from 4 to 8 degrees Fahrenheit (deg F) below normal (see ***Figure 2***). Colder-than-normal temperatures extended throughout the upper Basin and into the lower Basin. With regard to precipitation, greater than 150 percent of normal precipitation occurred over Montana, northern Wyoming and western South Dakota (see ***Figure 3***). In contrast, below-normal precipitation occurred throughout North Dakota, northeastern South Dakota and in much of the lower Basin.

Table 1 provides a month-by-month tabulation of snowfall at a number of observation points throughout the Basin. Plains snowpack began accumulating rapidly in November in western and central Montana; however, accumulations began more slowly in all other regions. The first significant plains snowpack accumulation occurred in early November in Billings, MT and Great Falls, MT. During the remainder of November and the first half of December, very little snowfall occurred. Two large snowstorms occurred in Montana during the last two weeks of December, resulting in a majority of the monthly snowfall listed in ***Table 1***. The 25.3 inches of snowfall in Billings, MT was more than three times the December average of 8.2 inches.

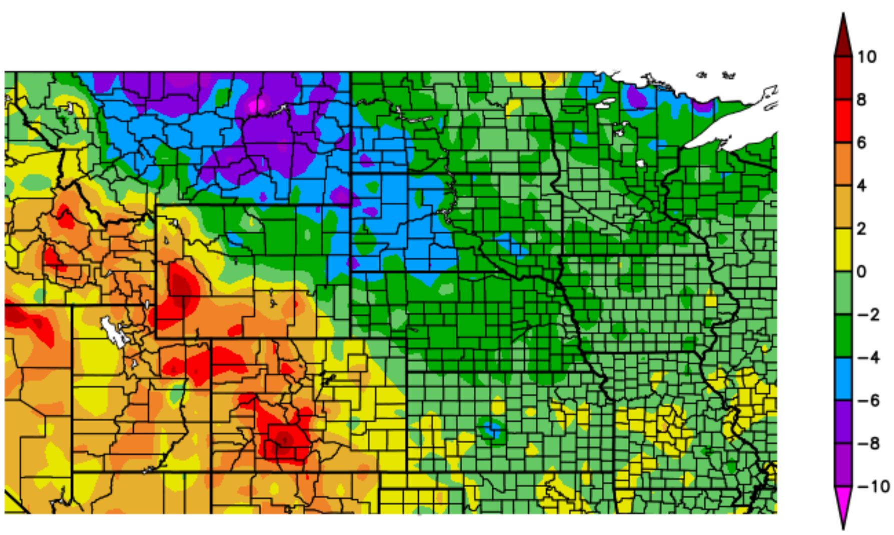


Figure 2. December 2017 – February 2018 departure from normal temperature (deg F).
Source: High Plains Regional Climate Center (HPRCC).

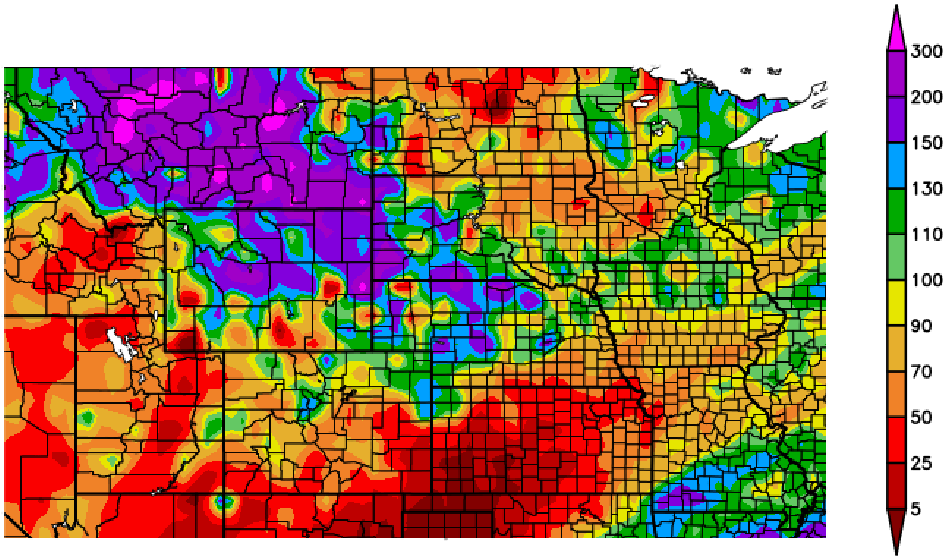


Figure 3. December 2017 – February 2018 percent of normal precipitation. Source: HPRCC.

Table 1
Missouri River Basin – Monthly Plains Snowfall Totals (inches)

Location	Nov	Dec	Jan	Feb	Mar	Apr	Nov-Apr	Average Annual*
Billings, MT**	12.2	25.3	7.0	32.4	9.8	19.4	106.1	55.1
Glasgow, MT	0.9	13.1	7.2	16.2	19.7	5.6	62.7	34.6
Great Falls, MT	13.4	20.7	3.6	32.6	12.4	20.2	102.9	63.2
Bismarck, ND	1.3	5.6	6.2	4.7	21.0	5.3	44.1	51.2
Rapid City Arpt, SD	T	8.0	5.0	16.8	13.2	17.1	60.1	41.1
Aberdeen, SD	0.8	3.6	0.6	13.8	14.1	10.3	43.2	38.1
Watertown, SD	1.9	4.5	1.7	11.3	16.2	17.5	53.1	35.9
Sioux Falls, SD	0.2	10.4	5.8	15.2	7.4	31.4	70.4	44.5
Sioux City, IA	T	7.3	13.4	11.1	3.9	9.5	45.2	34.8
Omaha, NE	0.0	3.6	3.3	7.7	0.9	1.5	17.0	26.4
Kansas City, MO	0.0	2.2	2.7	0.9	0.0	1.9	7.7	18.8

* Average annual snowfall is computed from the 1981-2010 period.
** Snowiest season on record.
T = trace
Data source: NOAA Online Weather Data (NOWData).

By January 1, heavy snowpack had developed throughout the plains area in Montana, while more moderate plains snowpack depths were present in Wyoming, the Dakotas, Nebraska and Iowa. Based on the National Weather Service (NWS) National Operational Hydrologic Remote Sensing Center's (NOHRSC) SNODAS modeled snow depth (see ***Figure 4)***, much of western and central Montana was covered in 12 to 16 inches of snow, while an area east of Billings, MT was covered with 16 to 20 inches of snow. Snow depths in southeastern Montana ranged from 8 to 12 inches, while many other areas of the upper Basin were covered in 4 to 8 inches of snow. On January 1, the Billings Logan Airport reported 16 inches of snow depth, while Lewiston in central Montana reported 12 inches.

Snowfall in January was much less than was observed in December (see ***Table 1***) with the exception of Sioux City, IA, which received 13.4 inches of snowfall (12 inches on January 22). Snowfall in February was heavy, producing significant monthly totals in all listed locations of the upper Basin (see ***Table 1***), except for Bismarck, ND. Bismarck continued to receive below-normal precipitation and reported only 4.7 inches of snow. Both Billings, MT and Great Falls, MT received more than 32 inches of snowfall in February, while Glasgow, MT and Rapid City, SD received over 16 inches. Lewistown, MT reported 24 inches of snow depth on February 18; Billings, MT reported 15 inches of snow depth on February 19.

Following a fairly moderate snowstorm from February 19-25 in South Dakota, Nebraska and Iowa, the plains snowpack coverage and SWE within the Basin reached its overall maximum. The plains SWE on February 26 is shown in ***Figure 5***. As seen on ***Figure 5***, the NOHRSC modeled SWE amounts ranged from 4 to 6 inches in north central, central and southeastern Montana. SWE amounts ranging from 2 to 4 inches extended into northeastern Wyoming; SWE amounts ranging from 1 to 3 inches extended into the plains of western and central South Dakota.

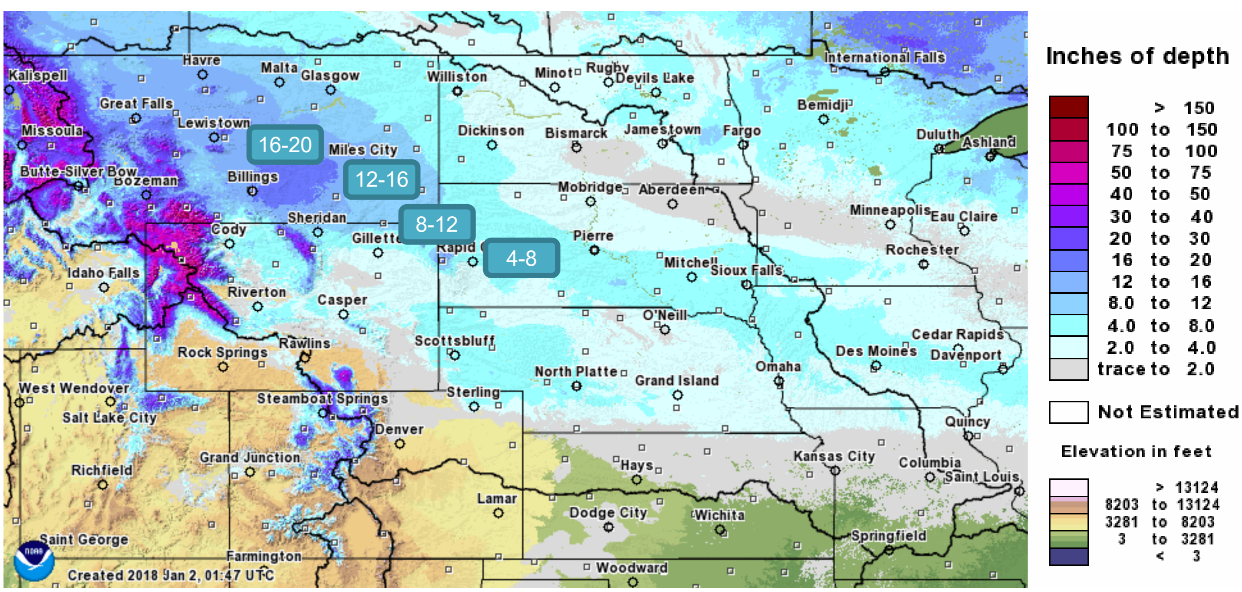


Figure 4. Modeled snow depth (inches) on January 1, 2018.
Source: NOAA NOHRSC SNODAS – Interactive Snow Information

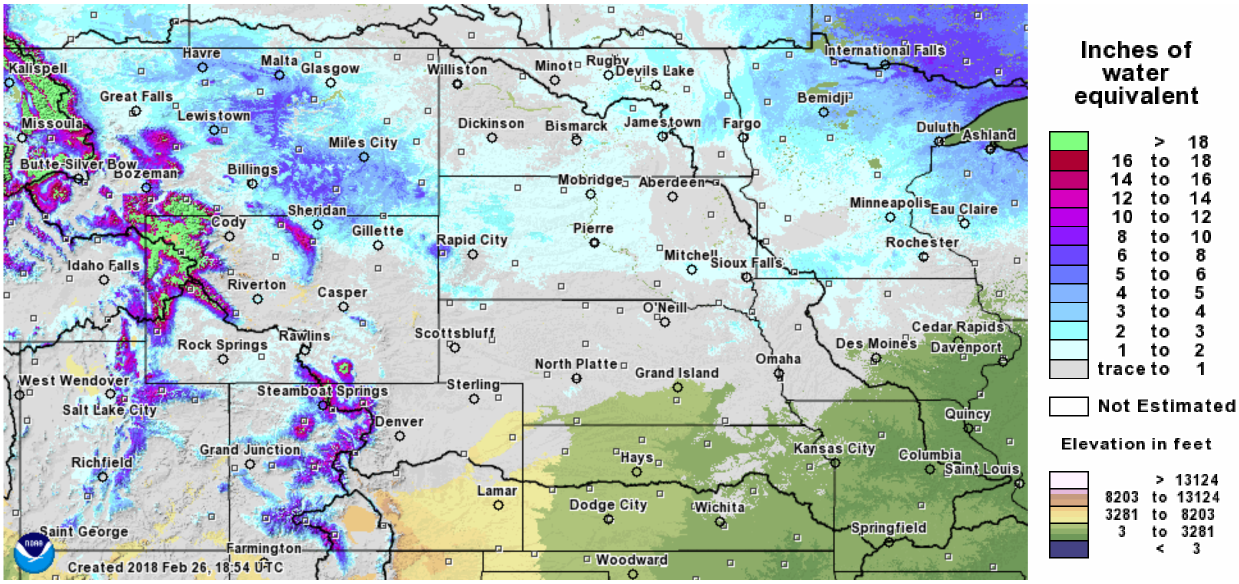


Figure 5. Modeled snow water equivalent (inches) on February 26, 2018.
Source: NOAA NOHRSC SNODAS – Interactive Snow Information

By March 1, some snowmelt had occurred in Nebraska, eastern South Dakota and western Iowa. Compared to January 1, plains snowpack had increased significantly in Montana, northern Wyoming and South Dakota. NOHRSC indicated the heaviest modeled snow depths extending from north central to southeastern Montana (see ***Figure 6***) ranged from 16 to 20 inches. Although snow depths settled in urban areas near the major observation points, reports of 16 inches at Malta, MT and 19 inches at Hardin, MT indicated very heavy snowpack was still present in Montana.

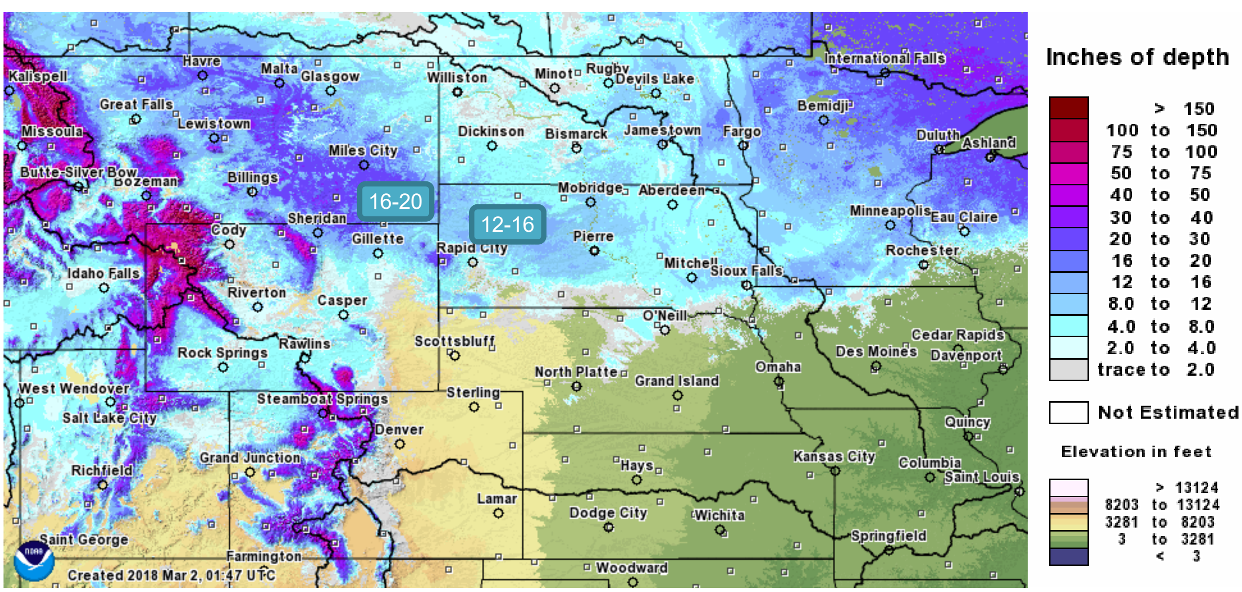


Figure 6. Modeled snow depth (inches) on March 1, 2018.
Source: NOAA NOHRSC SNODAS – Interactive Snow Information

In March, heavy snowfall continued in Montana and South Dakota. Glasgow, MT received 19.7 inches and Watertown, SD received 16.2 inches. During March, average temperatures were well-below normal in the plains of Montana and the western Dakotas (see ***Figure 7***). The plains snow cover persisted in much of Montana in March, but it mostly melted in mid-March in South Dakota, northern Nebraska and Iowa (see ***Figure 8***). The greatest snow depths on April 1 were in northern Montana in the Milk River basin, southeastern Montana and central North Dakota. Areas of 12 to 20 inches of snow depth were observed between Malta and Havre, MT, and also in the Canadian reach of the Milk River Basin.

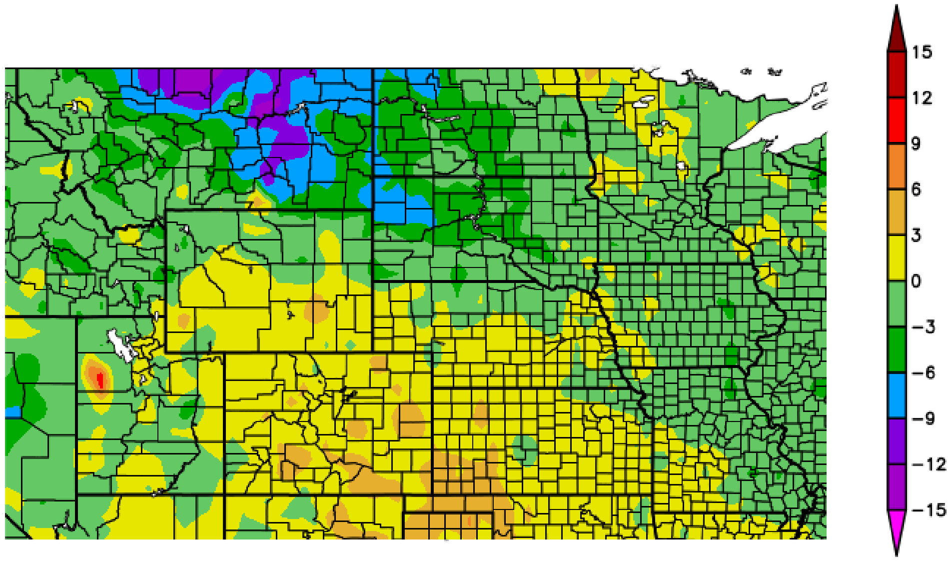


Figure 7. March 2018 departure from normal temperature (deg F). Source: HPRCC.

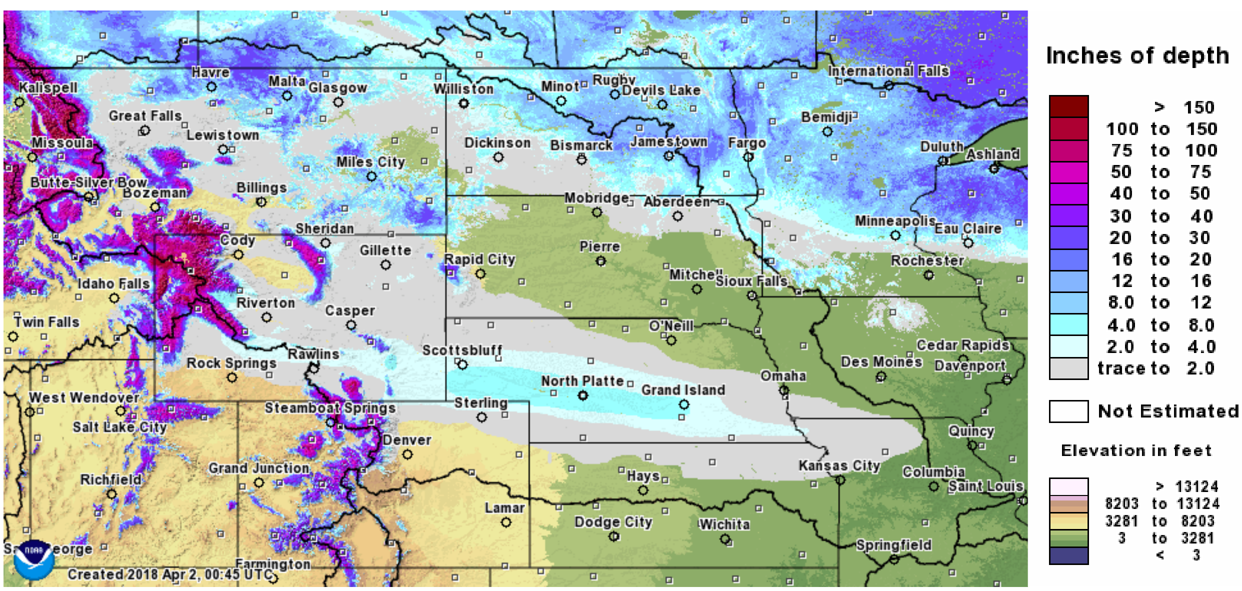


Figure 8. Modeled snow depth (inches) on April 1, 2018.
Source: NOAA NOHRSC SNODAS – Interactive Snow Information

During the first two weeks of April, additional heavy snowfall occurred over the upper Basin in three separate snow storms. Between these storms variable temperatures caused periodic snowmelt; therefore, accumulations heavier than the previous peak SWE did not occur. ***Figure 9*** shows the modeled depth and extent of the plains snowpack on April 14. Additional snow accumulated on the existing snowpack in northern Montana, and new snowpack had developed in eastern Montana, South Dakota and northern Nebraska. Snow depths generally ranged from 8 to 16 inches and up to 20 inches in southern and central South Dakota. In Sioux Falls, 13.7 inches of snow fell on April 14, contributing to a record 31.4 inches of snowfall in April (see ***Table 1***). Areas in Montana also received heavy snowfall in April, including 20.2 inches in Great Falls and 19.4 inches in Billings.

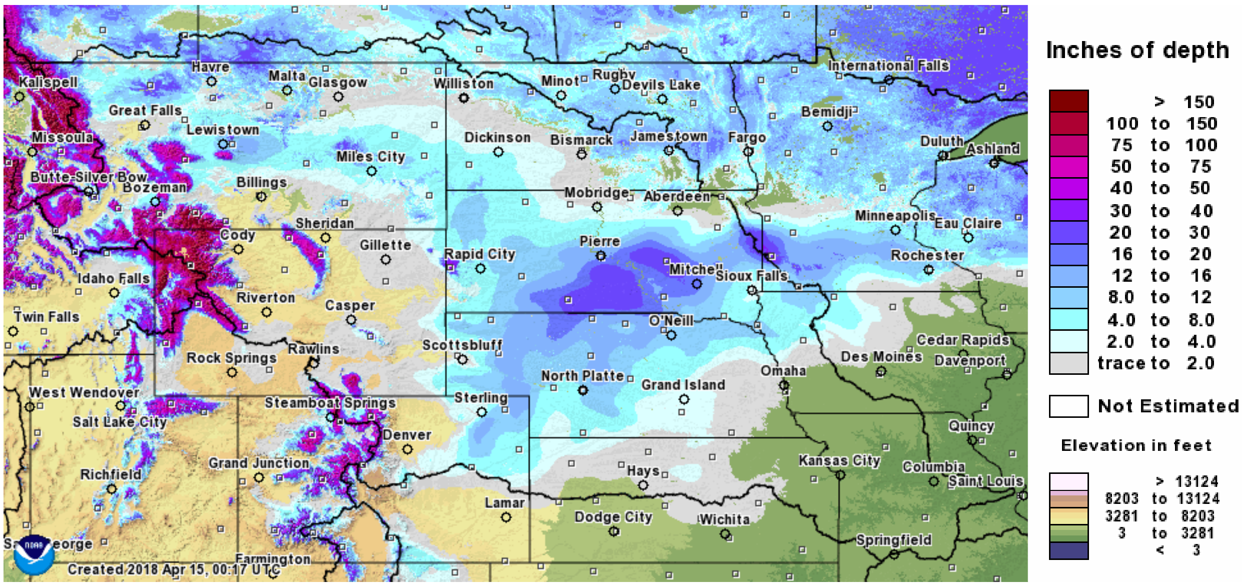


Figure 9. Modeled snow depth (inches) on April 14, 2018.
Source: NOAA NOHRSC SNODAS – Interactive Snow Information

During the January-March period, volunteers for the NWD MRBWM cooperative plains snow survey made snow depth and SWE measurements approximately two times per month until the snow melted. These measurements are primarily used by the Corps and NOHRSC to monitor the accumulation and melt of plains snowpack in the upper Basin, and to verify NOHRSC modeled estimates of plains snowpack. The network of observers includes Omaha District (NWO) employees, NWS employees, state agencies, county emergency managers and the public. The measurements provided in ***Table 2*** provide a portrait of plains snowpack conditions during the winter. Measurements in ***Table 2*** are ordered by decreasing SWE depth in groups of similar measurement dates. The first six measurements made in mid-February indicate that relatively moderate to heavy plains snowpack had developed across the upper Basin; the snowpack was particularly heavy in northern Montana in the Milk River and upper Missouri River basins. The late February measurements in South Dakota characterize the light-to-moderate snowpack that had developed following the late February snowfall in South Dakota, northeastern Nebraska and Iowa. The third group of SWE measurements in early to mid-March depict heavy plains SWE in central Montana near Mosby, MT, persistent light-to-moderate SWE in northeastern Montana, and light SWE in North Dakota and central South Dakota. The final measurement at Pipestem Dam near Jamestown, ND indicates that the snowpack persisted into early April in eastern North Dakota.

Table 2
Maximum Plains Snow Water Equivalent Measurements During 2018

Location	Agency	Date	Depth (inches)	SWE (inches)
Winnett, MT	NWS	2/13/2018	20.0	6.9
Dodson, MT	NWS	2/14/2018	14.0	5.4
Malta, MT	NWS	2/14/2018	17.0	5.3
Landusky, MT	NWS	2/13/2018	18.0	3.3
Jordan, MT	NWS	2/13/2018	7.0	2.3
Wayne, NE	USACE-NWO	2/12/2018	8.0	1.8
Chamberlain, SD	USACE-NWO	2/26/2018	6.2	1.4
Oahe Dam, SD	USACE-NWO	2/26/2018	8.6	1.3
Aberdeen, SD	NWS	2/26/2018	6.7	1.1
Ashton, SD	County EM	2/26/2018	4.8	0.8
Mosby, MT	NWS	3/12/2018	15.0	5.1
Fort Peck Dam, MT	USACE-NWO	3/16/2018	10.9	2.4
Plentywood, MT	NWS COOP	3/9/2018	8.0	2.2
Onida, SD	USACE-NWO	3/12/2018	6.7	2.0
Edgeley, ND	ND-SWC*	3/13/2018	10.0	1.9
Riverdale, ND	USACE-NWO	3/15/2018	5.0	1.9
Turtle Lake, ND	USACE-NWO	3/15/2018	7.3	1.7
Fargo, ND	NDSU	3/12/2018	6.0	1.5
Glasgow, MT	NWS	3/12/2018	5.0	1.4
Pipestem Dam, ND	USACE-NWO	4/2/2018	11.4	2.7

*North Dakota – State Water Commission

Seasonal plains snowfall totals for the winter of 2017-18, and the four previous high snowfall seasons since 2010-11, for locations in the plains are listed in ***Table 3***. During the 2017-18 winter, snowfall totals were above average in most locations except for Bismarck, ND; Omaha, NE; and Kansas City, MO. Billings, MT received an all-time record total snowfall of 106.1 inches, slightly more than the 2013-14 winter. Great Falls received 104.9 inches of snowfall, which is one of the snowiest winters on record. In South Dakota, snowfall was well-above normal in most locations. The Rapid City Airport recorded 60.1 inches, 19 inches more than average. Sioux Falls, SD recorded 70.4 inches, nearly 25 inches more than average. In contrast, snowfall was well-below average in the lower Basin, as noted in ***Table 3***.

As a simplistic means to compare winter snowfall from year to year, the location totals were averaged and are provided for each winter season in the final row of ***Table 3***. The 2017-18 location average was 55.9 inches of snowfall, more than 15 inches more than average. Compared to previous high years, 2017-2018 exceeded 2012-13 and 2013-14, but was much less than the location average snowfall in 2010-11, which was 69.4 inches.

Table 3
Missouri River Basin - Plains Snowfall Totals (inches)

Location	2010-11 Total	2012-13 Total	2013-14 Total	2016-17 Total	2017-18 Total	Average Annual*
Billings, MT	72.2	40.4	103.5	74.1	106.1**	55.1
Glasgow, MT	108.6	62.3	30.4	37.7	63.4	34.6
Great Falls, MT	108.6	76.1	74.6	48.4	104.9	63.2
Bismarck, ND	85.4	57.3	40.5	71.6	44.1	51.2
Rapid City Arpt, SD	71.1	76.7	63.8	35.7	60.1	41.1
Aberdeen, SD	79.3	62.8	32.7	39.9	43.2	38.1
Watertown, SD	79.4	47.1	28.2	40.7	53.1	35.9
Sioux Falls, SD	45.6	50	45.3	42.9	70.4	44.5
Sioux City, IA	41.3	38.3	23.8	28.6	45.2	34.8
Omaha, NE	34.9	35.7	17.8	11.4	17.0	26.4
Kansas City, MO	36.9	31.8	26.1	4.9	7.7	18.8
Location Average	**69.4**	**52.6**	**44.3**	**39.6**	**55.9**	**40.3**

* Average annual snowfall is computed from the 1981-2010 period.
** Snowiest season on record.
Source: NOAA Online Weather Data (NOWData). Totals represent total snowfall from July to June of the following year.

2. Mountain Snowpack

Mountain snowpack is monitored by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) network of SNOwpack TELemetry (SNOTEL) stations. For purposes of monitoring the mountain snowpack and forecasting spring and summer runoff from the Rocky Mountains, average mountain snowpack expressed as inches of SWE is computed from the SNOTEL stations within the reservoir reaches above Fort Peck and from Fort Peck to Garrison. For the purposes of this report, the mountain snowpack reaches are referred to as “Fort Peck” and “Garrison”. The 2017-18 mountain snowpack accumulation and melt pattern for the two reaches is illustrated in ***Figure 10***. The 2017-18 mountain SWE is described as a percent of the 1981-2010 average SWE occurring on the first day of each month. SWE accumulation for the two reaches is summarized in ***Table 4***, which contains the mountain snowpack as a percent of the seasonal average and as a percent of the average April 15 snowpack.

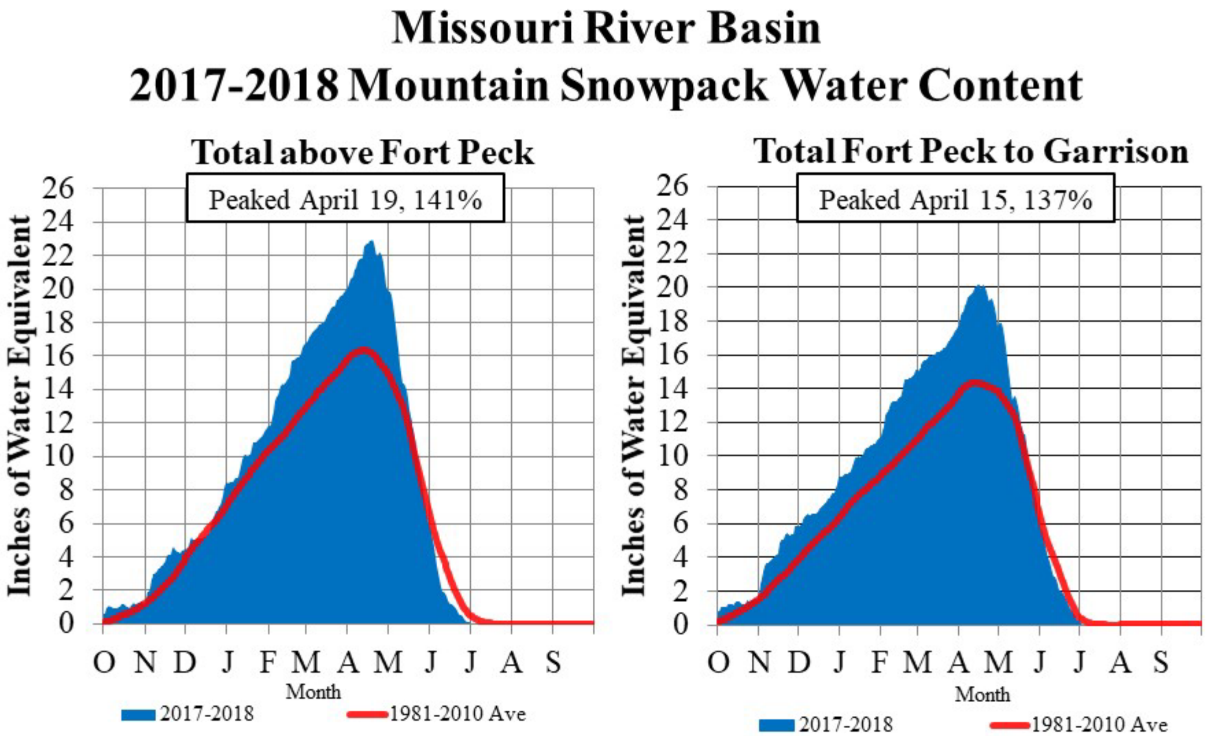


Figure 10. Missouri River Basin 2017-2018 Mountain SWE. Data Source: USDA-NRCS National Water and Climate Center.

In both reaches, the mountain snowpack SWE was above average from October 2017 through the end of May 2018. During the first half of the mountain snowpack accumulation season from October 2017 until mid-January 2018, the Fort Peck reach SWE was slightly more than the 1981-2010 computed average snowpack, while the Garrison reach SWE was well-above average from mid-November until it peaked on April 15. In the Fort Peck reach, heavy snowfall prior to the first day of December and January increased the SWE to 113 and 118 percent of average, respectively. Limited snowfall accumulations during December and in mid-January resulted in near-average accumulations in those months. In the Garrison reach, January 1 SWE was 134 percent of average. Due to well-above-normal precipitation (see ***Figure 15)*** and very cold temperatures, SWE increased rapidly in February. On March 1, the Fort Peck and Garrison SWE was 130 and 136 percent of average, respectively. The above-average snowfall accumulations continued through March and April. As shown on ***Figure 10*** and ***Table 4***, SWE in the Fort Peck reach peaked at 141 percent of average on April 19. In the Garrison reach, SWE peaked at 137 percent of average on April 15. Normally, the mountain snowpack peaks in both reaches around April 15. Warmer-than-normal temperatures in May caused the mountain snowpack to melt rapidly. By June 1, the SWE was less than the average June 1 average. By July 4, all mountain snowpack in both reaches had essentially melted.

Table 4
Mountain SWE Accumulation, 2017-2018

Month	Above Fort Peck (Percent of Average)	Fort Peck to Garrison (Percent of Average)	Average Percent of Actual Peak Accumulation
November 1	102	100	3
December 1	113	147	10
January 1	118	134	33
February 1	114	124	47
March 1	130	136	74
April 1	127	123	89
Peak	April 19, 141	April 15, 137	100
May 1*	135 / 124	129/ 123	88
June 1*	91 / 35	88 / 40	45
July 1*	6 / 0	29 / 0	27
Melt-out	July 2	July 4	

*Percent of May 1, June 1 or July 1 average / Percent of average April 15 peak

Mountain snowpack in 2017-2018 was well-above average in both the Fort Peck and Garrison reaches. As stated by the USDA-NRCS Montana Snow Survey in the *May 1 Montana Water Supply Report*, some subbasins in the Upper Yellowstone River basin accumulated record mountain snowpack. Overall, the 2017-2018 mountain snowpack ranked high when compared to other years of snowpack beginning in 1997. The 1996-1997 winter is used as a starting point for year-to-year comparisons because the number of stations in the SNOTEL program, which this data is based upon, grew rapidly following the large snowpack and upper Basin runoff during 1997. ***Table 5*** lists the ranking of the peak SWE calculated from SNOTEL data in the Fort Peck and Garrison reaches and the dates of peak SWE. In the Fort Peck reach, the 2018 peak SWE ranks as the third highest peak SWE, surpassed only by 2011 and 1997. The 2018 peak SWE in the Fort Peck reach was 23.0 inches, 2.8 inches less than the 2011 peak SWE. In the Garrison reach, the 2018 peak ranks fifth highest among recent years, behind 1997, 2011, 1996 and 2017. The 2018 peak SWE in the Garrison reach was 20.1 inches, 4.3 and 2.5 inches less than the 1997 and 2011 peak SWEs, respectively. When considering both reaches, the 2018 mountain snowpack was greater than the 2017 mountain snowpack because snowpack in both reservoir reaches was well-above average.

3. Weather Conditions

The upper Basin experienced wetter-than-average precipitation conditions and near-average temperatures during 2018. January-December statewide precipitation rankings compared to the last 124 years are shown in ***Figure 11A*** and January-December climate division precipitation rankings are shown in ***Figure 11B***. With regard to precipitation rankings, Montana, North Dakota and Wyoming were Near Average though some months in 2018 were Much Above Average. South Dakota was ranked in the Above Average category, while Nebraska was ranked Much Above Average (6th wettest/119th driest) and Iowa was ranked Much Above Average (2nd wettest/123rd driest). Precipitation rankings by climate division show several areas in the Much Above Average category including south central Montana, eastern Wyoming, the Black Hills of South Dakota, southern South Dakota and northern Nebraska, and central Iowa. Due to extremely heavy precipitation in northwestern Iowa and southwestern Minnesota, the two climate divisions partially in the Missouri Basin ranked as the Record Wettest calendar years, outranking the previous Record Wettest year of 1993.

With regard to temperature rankings, January-December statewide and divisional temperature rankings for the past 124 years are shown in ***Figure 12A*** and ***Figure 12B***, respectively. On a statewide basis, temperature rankings were Near Average in much of the Missouri Basin. Temperature rankings were Above Average in Wyoming and Missouri, while the Colorado temperature ranking was Much Above Average (7th warmest/118th coolest). On a divisional basis (***Figure 12B***) most of the interior of the Missouri Basin was Near Average, while the mountainous divisions and some divisions in the lower Basin were Above Average. Divisions in northeastern Montana, southeastern South Dakota and northeastern Nebraska ranked in the Below Average temperature category.

Figure 13 includes the National Drought Mitigation Center's (NDMC) drought maps of the four three-month periods during 2018. ***Figure 14*** shows percent of normal precipitation maps for each month of 2018. ***Figure 15*** shows departure from normal temperature maps for three-month periods in 2018.

La Niña conditions were present in the equatorial Pacific Ocean based on three-month sea surface temperature anomalies from October 2017 to March 2018. La Niña is the cold phase of the El Niño Southern Oscillation Index (ENSO) describing temperature anomalies of sea water in the equatorial Pacific Ocean. During La Niña episodes of ENSO, there is a higher probability for colder-than-normal temperatures during the winter months in the upper Basin. During years when La Niña is present and colder temperatures occur, snowfall accumulations can be enhanced in both the Montana and Wyoming Rocky Mountains, and the upper Basin plains. Snowfall accumulations in 2018 were greater than average in the upper Basin as a result of colder-than-normal temperatures during the 2017-2018 La Niña winter.

In early January, Severe (D2) and Extreme (D3) Drought conditions (***Figure 13***) were present over much of northeastern Montana and western South Dakota. Moderate (D1) Drought conditions covered much of western North Dakota and South Dakota where soil moisture conditions were below normal. Furthermore, much of the lower Basin was affected by Abnormally Dry (D0) conditions as a result of below-normal precipitation during the last three months of 2017. In contrast, drought conditions were not present in western Montana nor much of Wyoming in the upper Basin because soil moisture conditions were above normal as a result of above-normal precipitation in these areas during the last three months of 2017.

In 2018, the System reservoirs stored runoff in the Annual Flood Control and Multiple Use Zones and the Exclusive Flood Control Zones due to the very high volume of runoff that occurred in the upper Basin in 2018. As downstream conditions permitted, water stored in these zones was carefully metered out of the System throughout the summer and fall. Plots of the actual or regulated flow versus the unregulated or natural flow are shown in ***Figure 16A*** at Wolf Point, MT and Bismarck, ND; ***Figure 16B*** at Sioux City, IA and St. Joseph, MO; and ***Figure 16C*** at Boonville, MO and Hermann, MO. As it relates to actual and unregulated flows on the

Missouri River, the following paragraphs are discussions of precipitation and temperature conditions during three-month periods in 2018.

a. January – March

During January, up to 150 percent of normal precipitation occurred primarily in central and southern Montana, Wyoming, southern South Dakota and Nebraska; however, in other areas of the upper Basin, precipitation was below normal. The lack of precipitation in northern Montana, North Dakota and South Dakota led to below-average plains snowpack accumulations in January. On January 1, the mountain SWE was 118 and 134 percent of average in the Fort Peck and Garrison reaches, respectively (***Table 4***). January precipitation in the mountains was variable; however, cold temperatures maintained mountain SWE at above-average levels in the Fort Peck and Garrison reaches. By February 1, the mountain SWE was 114 and 124 percent of average in the Fort Peck and Garrison reaches, respectively.

In February, a very persistent storm track and colder-than-normal temperatures produced well-above normal precipitation in Montana, northern Wyoming, South Dakota and northern Nebraska. February precipitation was unseasonably high in Montana, ranging from 200 percent of normal to greater than 400 percent of normal (see ***Figure 14***). February plains snowfall accumulations were very high across Montana including 32.4 inches in Billings and 32.6 inches in Great Falls, nearly three times the normal February snowfall (see ***Table 1***). Plains SWE at the end of February was near its peak accumulation for 2018 based on the NOHRSC modeled SWE (***Figure 5***). Modeled SWE, verified by plains SWE measurements listed in ***Table 2***, ranged from 3.0 to 6.0 inches in central Montana and northern Wyoming. Mountain SWE accumulations increased during February due to the above-normal precipitation and colder-than-normal temperatures. By March 1, mountain SWE had increased to 130 and 136 percent of average in the Fort Peck and Garrison reaches, respectively.

In March, precipitation was above normal throughout much of the upper Basin, and below normal in the lower Basin. Plains snowfall continued at an above-normal monthly pace, however, it was less than February snowfall (***Table 1***). Plains snowfall was more widespread in North Dakota, as exhibited by 21 inches of snowfall in Bismarck. Snowfall decreased as a percent of normal; however, much colder-than-normal temperatures (***Figure 7***) in the upper Basin maintained the mountain SWE at above-normal amounts. Mountain SWE on April 1 was 127 and 123 percent of average in the Fort Peck and Garrison reaches, respectively.

Above-normal precipitation and above-normal snowpack from January through March helped improve drought conditions in the upper Basin (***Figure 13***). By early April, all Extreme (D3) Drought conditions were removed from Montana and South Dakota, and drought impacts were no longer present in most of Montana and Wyoming. Drought conditions in the Dakotas had also improved significantly, and eastern South Dakota, Nebraska and Iowa were nearly free of drought impacts. Above-normal soil moisture conditions in these areas, notably Montana and Wyoming, were indicating that calendar year runoff had the potential to be above average under average future precipitation conditions.

b. April – June

Precipitation during the April-May-June period was well-above normal in western, central and southern Montana, Wyoming, western South Dakota, Nebraska and northwestern Iowa. Precipitation was below normal in northern Montana, northeastern South Dakota, eastern Kansas and Missouri. Three-month precipitation totals and departures from normal are tabulated for specific locations in ***Table 5*** for 2018. April-May-June precipitation departures from normal were above normal throughout the upper Basin, particularly in Montana, Wyoming and southeastern South Dakota. For example, Billings, MT received 11.3 inches of precipitation in the April-May-June period, 5.3 inches above normal. Vermillion, SD received 20.3 inches in April-May-June, 9.2 inches above normal. Temperatures during this time period were about normal in the mountains, slightly below normal in the upper Basin plains, and above normal in Kansas and Missouri (***Figure 15***).

April precipitation ranged from 130 to 200 percent of normal over much of southern Montana and northwestern Wyoming including the upper Missouri River Basin and upper Yellowstone River Basin (***Figure 14***). The above-normal precipitation added to the plains snowpack in the lower Yellowstone Basin, and caused additional increases in the mountain snowpack. Although plains SWE and snow depth declined throughout March in the Yellowstone and Missouri River basins, new April snowfall replaced the melted snowpack in some areas of the Fort Peck and Garrison reaches including the Milk River Basin and the lower Yellowstone River Basin (***Figure 8***). Also, a mid-April blizzard generated 12 to 20 inches of snowfall in central and southern South Dakota and northern Nebraska. Heavy April snowfall amounts included 19.4 inches in Billings, MT; 20.2 inches in Great Falls, MT. Sioux Falls, SD received 31.4 inches, which was 26.8 inches above the April normal snowfall, and the snowiest April on record. In regard to precipitation, notable April amounts include 4.4 inches (2.1 inches above normal) in Bozeman, MT; 3.1 inches (1.7 inches above normal) at Miles City, MT; and 4.0 inches (1.9 inches above normal) at Lake Yellowstone, WY. Mountain SWE, described in the previous mountain snowpack section, peaked at 137 percent of average in the Fort Peck to Garrison reach on April 15, and peaked at 141 percent of average in the Fort Peck reach on April 19.

The April runoff summation for the upper Basin was 5.6 MAF (192 percent of average). The well-above average runoff was due to the above-average plains snowmelt runoff from the winter plains snowpack and additional snowfall precipitation during April in the Fort Peck, Garrison and Sioux City reaches. Fort Peck runoff was 1.6 MAF (243 percent of average), and Garrison runoff was 2.3 MAF (210 percent of average). Runoff in the Sioux City reach was 0.8 MAF (210 percent of average).

Table 5
Three-Month Precipitation Totals and Departures from Normal in 2018.

Location, State	Jan-Feb-Mar		Apr-May-Jun		Jul-Aug-Sep		Oct-Nov-Dec	
	Total Inches	Departure Inches	Total Inches	Departure Inches	Total Inches	Departure Inches	Total Inches	Departure Inches
Bozeman, MT	3.0	0.9	12.2	3.6	2.0	-1.9	2.6	-0.2
Helena, MT	2.6	1.3	8.3	3.3	1.2	-2.3	0.9	-0.7
Great Falls, MT	2.8	0.9	8.3	2.0	2.2	-2.3	1.7	-0.3
Lewistown, MT	2.7	0.7	12.5	5.2	3.2	-1.7	2.5	-0.1
Havre, MT	2.8	1.7	8.3	3.3	2.9	-1.0	1.0	-0.4
Glasgow, MT	2.4	1.3	3.5	-1.6	2.8	-1.3	2.6	1.1
Lake Yellowstone, WY	7.2	2.5	10.5	4.1	2.5	-1.8	5.7	0.7
Billings, MT	3.0	0.9	11.3	5.3	3.5	0.3	1.9	-0.5
Yellowtail Dam, MT	3.9	1.4	11.7	4.5	3.7	-0.1	3.4	0.0
Miles City, MT	1.4	0.3	11.8	5.7	3.2	-0.5	2.1	0.5
Lander, WY	2.7	0.6	7.3	1.9	0.9	-1.5	7.1	2.9
Rapid City, SD	2.7	1.0	14.5	5.0	7.6	1.5	8.1	3.6
Brookings, SD	2.7	0.7	6.8	-2.6	18.2	8.7	4.1	0.6
Sioux Falls, SD	3.6	0.7	13.1	2.8	17.5	8.8	4.8	0.6
Yankton, SD	4.1	1.1	18.7	8.0	12.9	4.1	7.5	3.0
Vermillion, SD	2.7	-0.1	20.3	9.2	11.1	1.7	6.5	2.1
Sioux City, IA	4.4	1.1	13.5	3.0	14.2	4.7	5.6	1.4
Scottsbluff, NE	2.0	0.3	12.1	4.9	3.0	-0.9	1.9	-0.3
Lincoln, NE	3.9	0.5	11.7	0.4	12.8	2.9	7.2	2.9
Omaha, NE	2.9	-1.1	7.3	-6.0	14.6	3.8	9.7	4.1
Nebraska City, NE	4.6	1.0	9.1	-2.8	16.2	5.9	6.9	2.1
Topeka, KS	2.8	-1.9	9.5	-4.4	6.5	-5.3	11.3	5.1
St. Joseph, MO	1.8	-1.9	8.2	-5.2	3.2	-9.4	9.5	3.6
Kansas City, MO	4.1	-0.8	10.2	-3.9	11.1	-1.9	15.4	8.6

The calculated unregulated (natural) flow events at Wolf Point, MT and Bismarck, ND that would have occurred without reservoir regulation are shown in ***Figure 16A***. Two unregulated snowmelt and precipitation runoff hydrographs would have occurred in early and late April at Wolf Point and Bismarck, but the runoff was captured by Fort Peck and Garrison reservoirs, respectively. The actual (regulated) flows at these locations were much lower.

May precipitation departures were greater and more widespread than April precipitation departures, ranging from 150 to over 200 percent of normal in much of southern Montana, Wyoming, southwestern South Dakota, and western Nebraska (***Figure 14***). Very abundant rainfall followed the last of the plains snowmelt and coincided with the beginning of the mountain snowmelt season. Above-normal May precipitation in locations of the upper Basin included 3.3 inches (1.1 inches above normal) in Great Falls, MT; 5.1 inches (2.3 inches above normal) in Lewistown, MT; 5.2 inches (3.0 inches above normal) in Billings, MT; 4.2 inches (2.0 inches above normal) in Miles City, MT; 4.1 inches (1.9 inches above normal) in Lander, WY; and 7.5 inches (5.0 inches above normal) in Scottsbluff, NE. Precipitation in the lower Basin was generally below normal.

The May runoff summation in the upper Basin was 6.6 MAF (199 percent of average) and ranked as the fourth highest May runoff summation in 120 years of runoff record. Above-normal precipitation as rainfall in Montana significantly influenced the above-normal runoff in the Fort

Peck and Garrison reaches. Fort Peck runoff was 2.5 MAF (207 percent of average), and Garrison runoff was 2.9 MAF (232 percent of average). Runoff in the Sioux City reach was 0.8 MAF (246 percent of average) as a result of April snowmelt in the upper James River Basin.

Above-normal precipitation departures in June were widespread across much of the upper Basin, ranging from 110 to over 200 percent of normal. Precipitation was very heavy in central Montana, northeastern Nebraska, western and southeastern South Dakota, and northwestern Iowa (***Figure 14***). In contrast, precipitation was well-below normal in eastern Kansas and Missouri. At the same time heavy precipitation was occurring, the peak of the mountain snowmelt runoff was occurring in the Fort Peck and Garrison reaches.

During June several heavy rainfall events occurred in the Missouri Basin. On June 17 and 19, nearly 4 inches of rainfall were reported near Augusta, MT above Fort Peck. Also on June 19, 5.5 inches of rainfall was reported in Council Bluffs, IA with lesser amounts occurring in western Iowa. On June 20, widespread heavy rainfall ranging from 1.5 to 2.5 inches, and locally heavier amounts ranging from 3.0 to 4.0 inches, occurred in southern Nebraska, northern Kansas, and the northern Black Hills of South Dakota. Some of the heaviest rainfall occurred on June 21 with reports of 5.8 inches in Sioux Falls, SD with widespread amounts of 4 inches near Sioux Falls. Along the Missouri River below Gavins Point Dam, 4.6 inches was reported in Vermillion, SD; 3.9 inches was reported near Sheldon in northwestern Iowa; and 3.0 inches was reported in Yankton, SD. Additional heavy rainfall occurred on June 26 with 4.0 inches in Vermillion, SD; 3.6 inches in Yankton, SD; and 3.8 inches in Sioux Center, IA.

June precipitation totals were well-above normal at many locations throughout the upper Basin. In Montana, Lewistown recorded 5.6 inches (2.6 inches above normal), Miles City recorded 4.5 inches (2.0 inches above normal); while in Wyoming, Lake Yellowstone recorded 4.0 inches (2.0 inches above normal). In South Dakota, Rapid City recorded 7.3 inches (4.1 inches above normal), Sioux Falls recorded 7.3 inches (3.4 inches above normal), Yankton recorded 12.5 inches (8.6 inches above normal) and Vermillion recorded 15.0 inches (11.0 inches above normal). Also, Sioux City, IA recorded 8.7 inches (4.8 inches above normal). Much of this heavy rainfall occurred from June 16 to June 21 described in the previous paragraph, and it contributed significantly to tributary streamflow below Gavins Point Dam on the Missouri River. Prior to June 16, average daily incremental flow caused by tributary streamflow between Gavins Point Dam and Sioux City, IA was about 6,000 cfs. After June 16, average daily incremental flow between Gavins Point Dam and Sioux City, IA was about 35,000 cfs due to high streamflow from the James, Vermillion, Big Sioux and Floyd Rivers.

As a result of the heavy rainfall and high tributary streamflow downstream of the System, observed stages and streamflows temporarily rose to near flood stage at Omaha, NE and above flood stage from Omaha to St. Joseph, MO between late June and the first two weeks of July. Unregulated Missouri River hydrographs calculated for 2018 are shown in ***Figures 16A*** through ***16C***. Due to the precipitation runoff in the upper Basin and below the System coinciding with the mountain snowpack runoff, unregulated (natural) flows were very high at all locations along the Missouri River. Mainstem System regulation of runoff greatly reduced the peak unregulated flows from Wolf Point to Hermann, MO; however, the heavy precipitation that occurred in June in southeastern South Dakota, northwestern Iowa, and northeastern Nebraska diminished the effect of System release reductions.

The June runoff summation for the upper Basin above Sioux City, IA was 9.7 MAF (177 percent of average) and ranked as the fourth highest June runoff summation in 120 years of runoff record. Fort Peck runoff was 2.6 MAF (158 percent of average) and Garrison runoff was 5.0 MAF (183 percent of average). All other reaches produced well-above average June runoff, including 1.2 MAF (354 percent of average) in the Sioux City reach.

By early July, drought conditions improved even more in the upper Basin (***Figure 13***). Only Abnormally Dry (D0) conditions and a few pockets of Moderate Drought (D1) conditions lingered in the Dakotas. Some Moderate (D1) to Severe (D2) Drought conditions continued to impact eastern Kansas and western Missouri. Furthermore, below-normal precipitation in northern Montana prompted the NDMC to add an area of Abnormally Dry (D0) and Moderate (D1) drought conditions to north central Montana. Soil moisture conditions were at their wettest during late June and early July in Montana and Wyoming ranking in the top 5 percent of soil moisture wetness for this time period.

c. July – September

By early July, drought conditions improved even more in the upper Basin (***Figure 13***). Only Abnormally Dry (D0) conditions and a few pockets of Moderate Drought (D1) conditions lingered in the Dakotas. Some Moderate (D1) to Severe (D2) Drought conditions continued to impact eastern Kansas and western Missouri. Furthermore, below-normal precipitation in northern Montana prompted the NDMC to add an area of Abnormally Dry (D0) and Moderate (D1) drought conditions to north central Montana. Soil moisture conditions were at their wettest during late June and early July in Montana and Wyoming ranking in the top 5 percent of soil moisture wetness for this time period.

With regard to the overall precipitation pattern, the July to September precipitation accumulation was drier in the upper Basin and wetter in the lower Basin, but the three-month period was not without shorter periods of heavy precipitation. Heavy precipitation continued into July in eastern Wyoming, South Dakota, eastern North Dakota and Nebraska (***Figure 14***). August was wetter than normal in central Montana, northern Wyoming and much of the lower Basin. September was wetter than normal in South Dakota, Iowa and Nebraska, while Missouri was drier than normal. Overall July-August-September precipitation totals and departures listed in ***Table 5*** indicated very wet conditions in eastern South Dakota, northwestern Iowa and eastern Nebraska. Temperatures during the July - September period were slightly cooler than normal in the upper Basin, and normal to above normal in the lower Basin (***Figure 15***).

During July precipitation was well-below normal in Montana and western Wyoming, but it was above normal in many locations throughout the Dakotas (see ***Figure 14***). Precipitation was well-above normal in western and central Nebraska, eastern Wyoming, and parts of eastern South Dakota. The most notable heavy precipitation reports included 3.5 inches in Yankton, SD and 6.8 inches in Brookings, SD on July 19. Above-normal July precipitation amounts include 4.9 inches (2.4 inches above normal) in Rapid City, SD; 9.5 inches (6.3 inches above normal) in

Brookings, SD; 4.9 inches (1.9 inches above normal) in Sioux Falls, SD; and 7.0 inches (3.9 inches above normal) in Yankton, SD. As a result, South Dakota and Nebraska tributary rivers continued to flow at above-average rates.

Precipitation accumulations were more moderate in August with less severe negative departures overall. Areas that continued to receive above-normal precipitation included south central Montana and southeastern South Dakota. In addition rainfall was abundant in Iowa, eastern Nebraska, Kansas and Missouri. The region affected by the heaviest rainfall extended from eastern South Dakota through eastern Nebraska, Iowa and northwestern Missouri. Heavy rainfall amounts August 20 include 7.1 inches in Logan, IA; 6.2 inches in Omaha, NE; and 3.8 inches in Little Sioux, IA. For the month of August, Sioux Falls, SD received 5.3 inches (2.3 inches above normal normal), Sioux City, IA received 4.5 inches (1.5 inches above normal) and Omaha, NE received 9.8 inches (6.0 inches above normal).

Precipitation in September was much heavier in certain regions of the Basin including north central Montana, north central South Dakota, southeastern South Dakota, Iowa, southeastern Nebraska, and north central Kansas. Heavy rainfall amounts in September include 3.3 inches (1.8 inches above normal) in Mobridge, SD; 7.3 inches (4.6 inches above normal) in Sioux Falls, SD; 7.4 inches (4.5 inches above normal) in Sioux City, IA; 9.4 inches (6.2 inches above normal) in Sheldon, IA; and 7.1 inches (4.1 inches above normal) in Lincoln, NE. Much of this heavy rainfall occurred September 18-20 on nearly saturated soil. September rainfall amounts caused additional tributary runoff to enter the Missouri River below Gavins Point Dam, raising Missouri River stages to above flood stage from Nebraska City, NE to Waverly, MO during early September. In late September, flood stages were exceeded at Nebraska City, Rulo, NE and St. Joseph, MO.

September runoff in the upper Basin was 1.9 MAF (166 percent of average) due in large part to above-average runoff in the Gavins Point and Sioux City reaches. Gavins Point runoff was 0.2 MAF, more than twice the average volume, and Sioux City runoff was 0.9 MAF, more than eight times the average volume. September runoff in the Sioux City reach was the highest September runoff volume on record in 120 years of record-keeping.

d. October – December

Dry conditions in the upper Basin during the July-August-September period caused drought conditions to develop in northern Montana, northern North Dakota and central South Dakota. On October 2, the NDMC (***Figure 14***) indicated areas of Moderate Drought (D1) were present with very small pockets of Severe Drought (D2) in western North Dakota and western South Dakota. In October, the dry pattern returned to much of Montana and Wyoming, which received less than 75 percent of normal precipitation (***Figure 14***). In contrast, October precipitation in southeastern Nebraska, southwestern Iowa, Kansas and northwestern Missouri was over 200 percent of normal. Some notable October precipitation totals included 5.2 inches (2.6 inches above normal) at Nebraska City, NE; 6.4 inches (3.6 inches above normal) at St. Joseph, MO; 12.0 inches (8.5 inches above normal) at Bonner Springs, KS; and 10.8 inches (7.6 inches above normal) at Kansas City, MO. Most of the October precipitation occurred October 6-9, and resulted in additional increases to Missouri River stages from Rulo, NE to the mouth. The regulated flows compared to the unregulated flows at St. Joseph, Boonville, MO and Hermann, MO are shown in ***Figure 16B*** and ***Figure 16C***.

In November, the dry pattern moved to the lower Basin, while Montana, western North Dakota and Wyoming received above-normal precipitation (***Figure 14***). Although precipitation was more than 150 percent of normal in Montana and western North Dakota, the departures were only a few tenths of an inch above normal because November is normally a low-precipitation month in these areas. The above-normal precipitation in the upper Basin had no impact on November runoff, and November runoff was actually below average for the upper Basin above Gavins Point Dam. Below-normal precipitation in the lower Basin allowed the Missouri River to recede some in November; however, much colder-than-normal temperatures in the lower Basin, ranging from 4 to 8 deg F below normal, did not allow soil conditions to dry out.

December was also a wet month in much of the Missouri Basin except for western Montana and western Wyoming. Precipitation was greater than 200 percent of normal in many areas of eastern Montana, northeastern Wyoming, South Dakota, Nebraska and western Iowa. Precipitation departures ranged from 1 to 3 inches above normal in Nebraska and Kansas. The wet conditions continued to produce higher-than-normal tributary flows and Missouri River flows until the end of the year.

October-November-December precipitation totals and departures in ***Table 5*** indicate below-normal precipitation in Montana and normal precipitation in southern Montana and Wyoming. Much-above normal precipitation occurred during this period in southeastern Montana, northwestern Iowa, eastern Nebraska and Missouri, placing soil moisture conditions in these areas in a wetter-than-normal condition going into the winter.

Temperatures during the October-November-December period ranged from normal to 2 deg F above normal in Montana and western North Dakota to several degrees below normal in all other areas of the Missouri Basin (***Figure 15***). Temperatures were 1 to 3 deg F below normal most of the lower Basin.

Runoff in the upper Basin continued to be above average in October, November and December due in large part to above-average runoff in the Gavins Point and Sioux City reaches during those months. October-November-December runoff in the Gavins Point reach was almost two times the average volume. Sioux City runoff continued to be well-above average, with record highest runoff volumes in October and November, followed by the second highest December runoff volume in 120 years of record-keeping. The 2018 calendar year runoff summation above Sioux City was 42.1 MAF (166 percent of average) and the third highest runoff summation in 120 years of record-keeping. The runoff summation included 16.7 MAF in the Garrison reach (third highest), 7.9 MAF in the Sioux City reach (fourth highest), and 10.9 MAF in the Fort Peck reach (seventh highest).

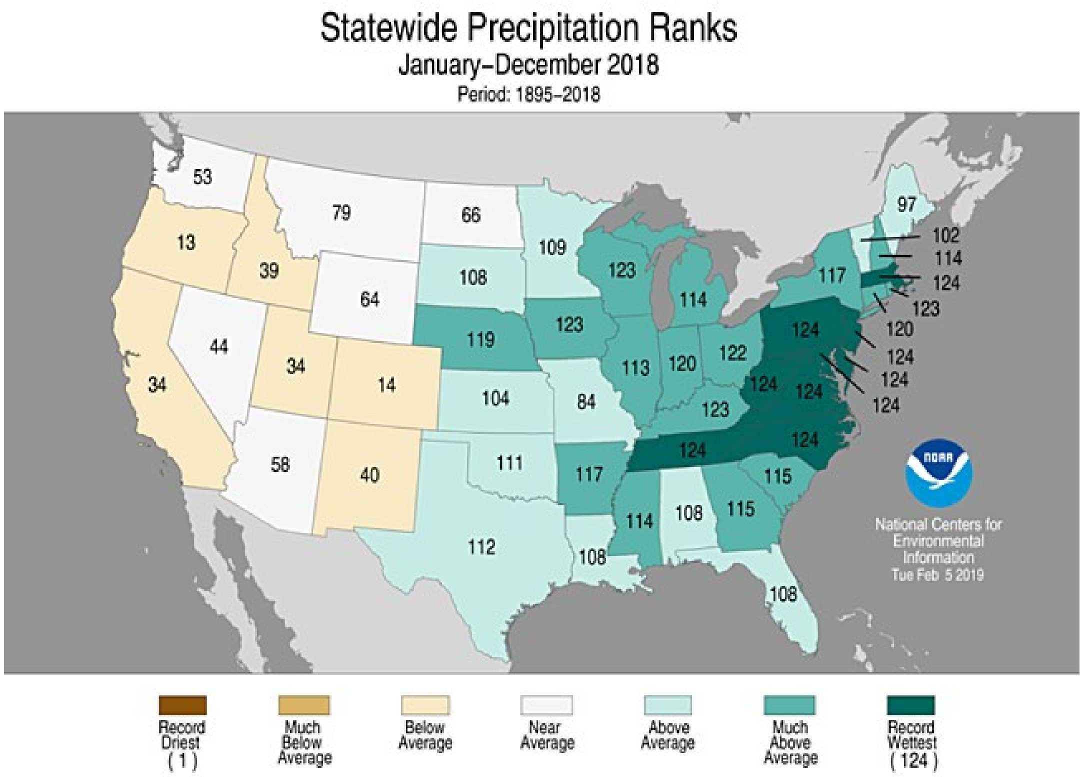


Figure 11A. January-December 2018 Statewide Precipitation Ranks (Source: NOAA/NCDC).

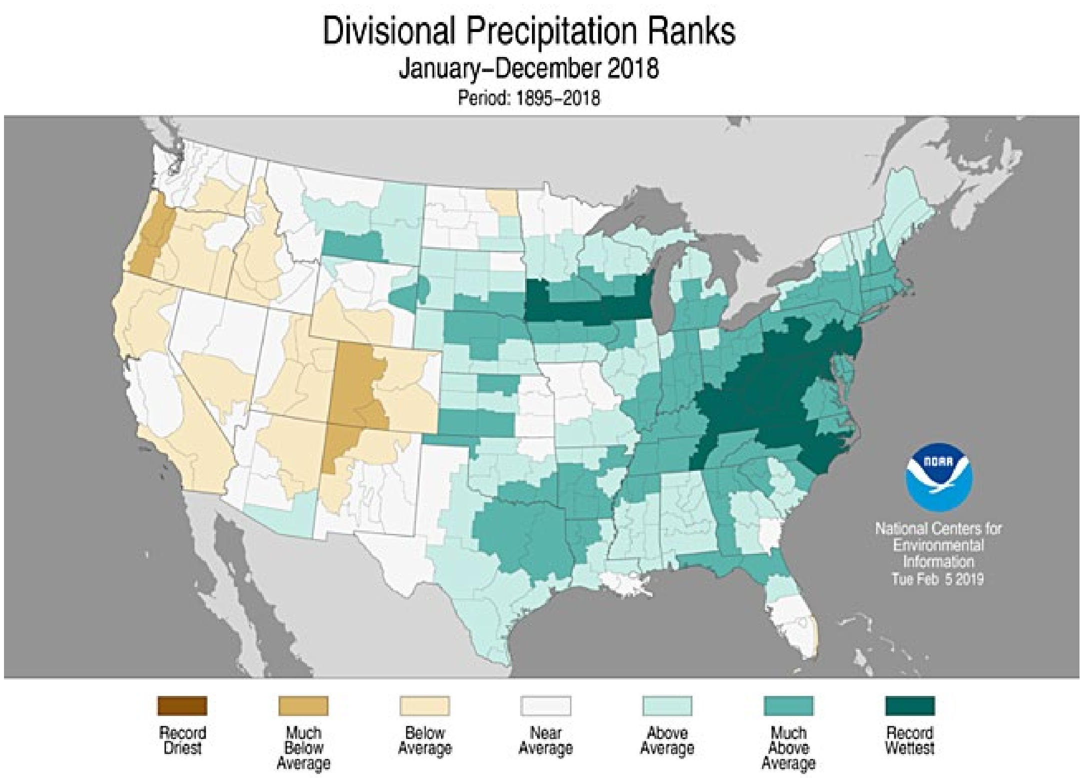


Figure 11B. January-December 2018 Divisional Precipitation Ranks (Source: NOAA/NCDC).

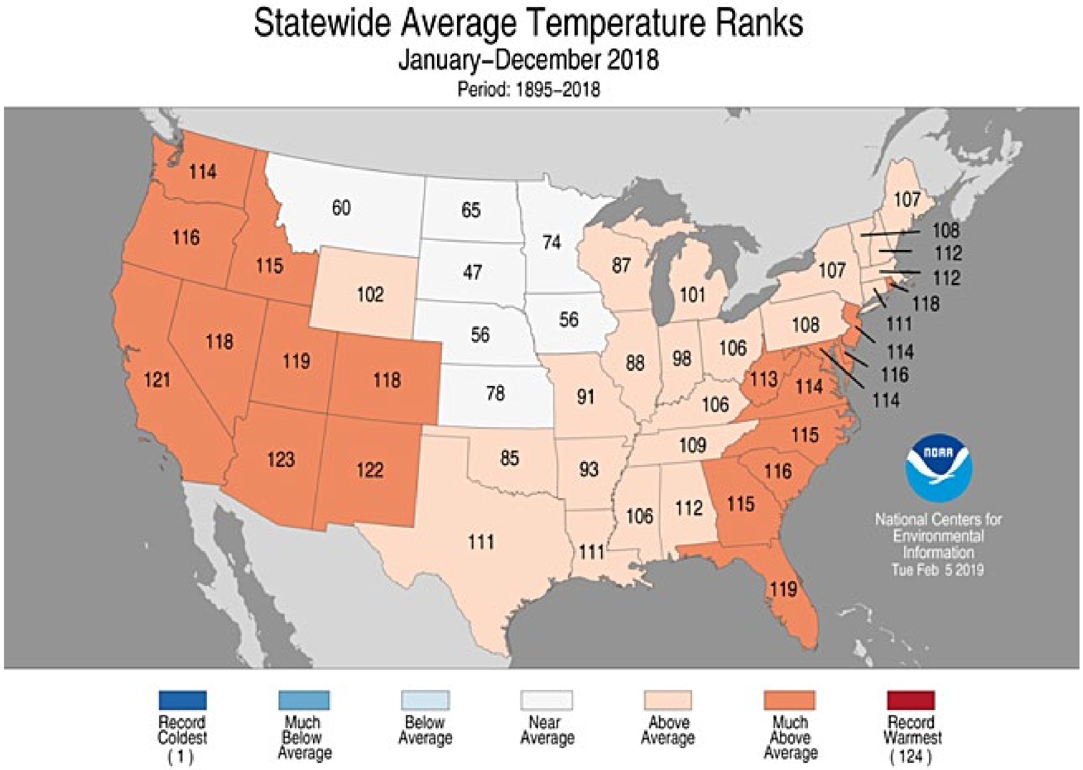


Figure 12A. January-December 2018 Statewide Temperature Ranks (Source: NOAA/NCDC).

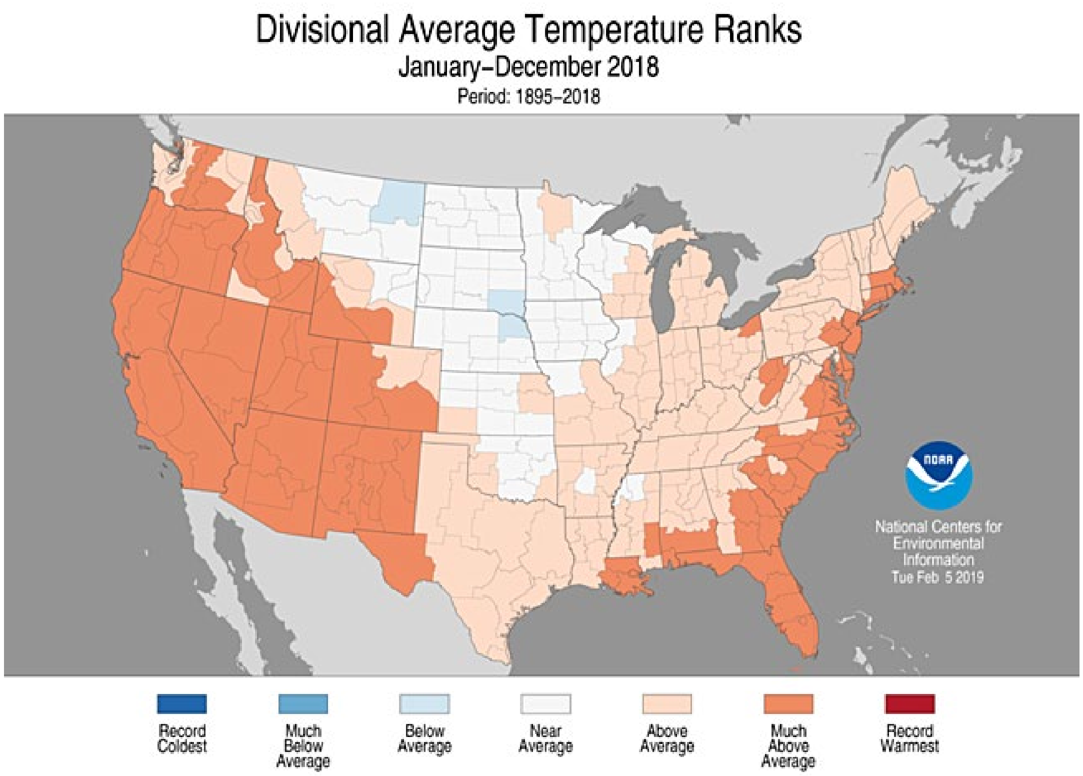


Figure 12B. January-December 2018 Divisional Temperature Ranks (Source: NOAA/NCDC).

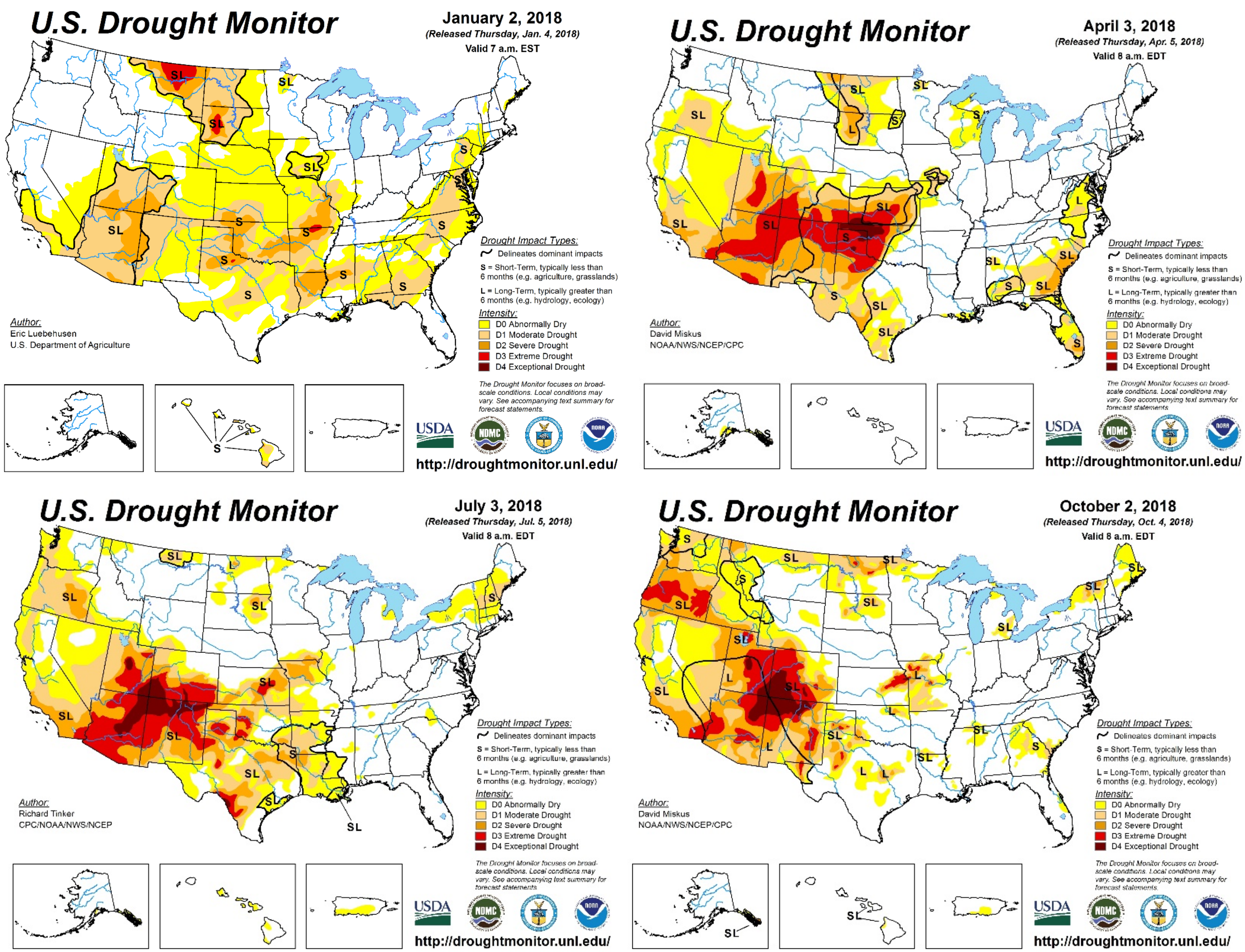


Figure 13. The National Drought Mitigation Center's drought maps for early January, April, July and October 2018.

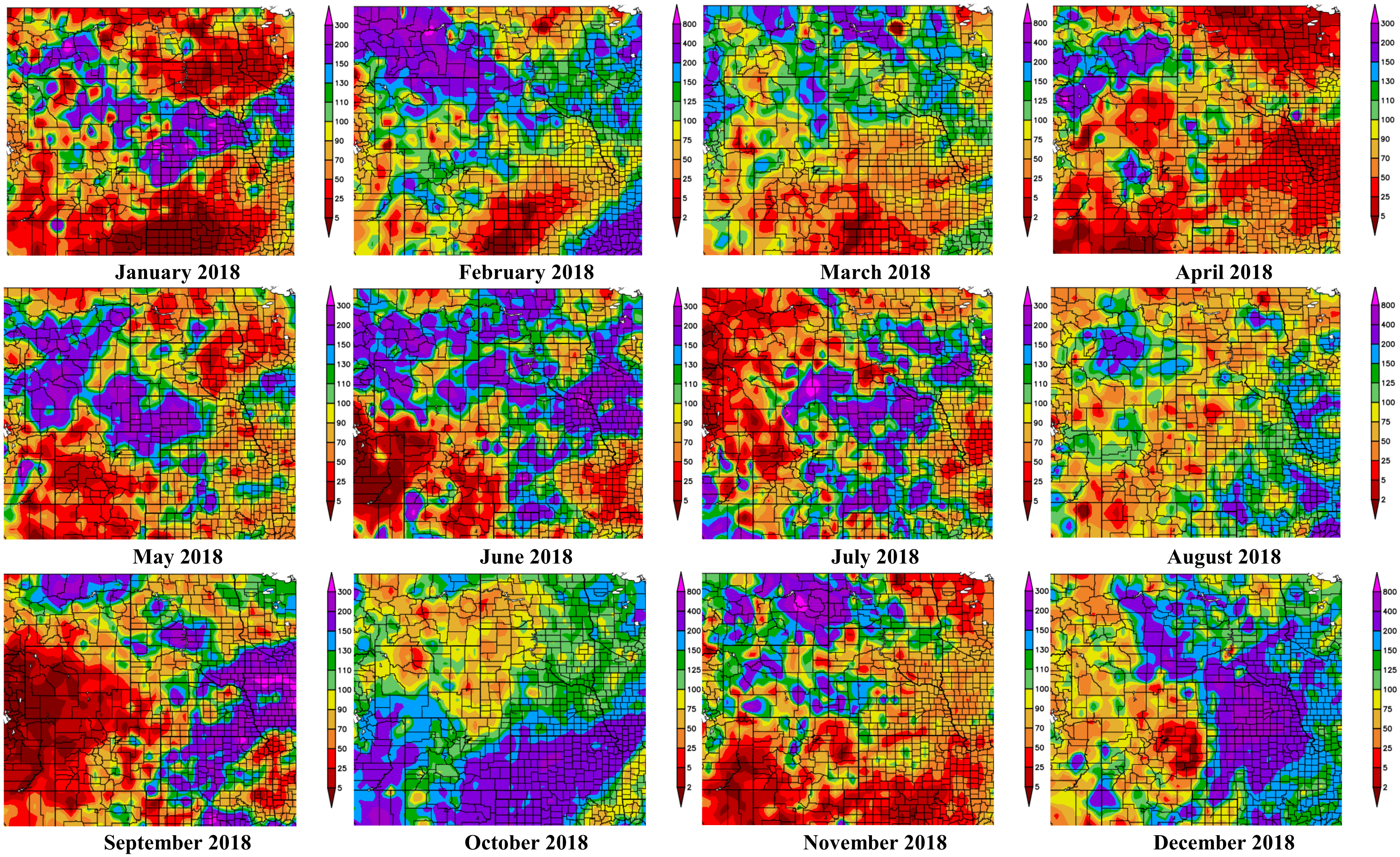


Figure 14. Percent of normal precipitation maps for 2018, by month. Reformatted from the High Plains Regional Climate Center Climate Summary Maps.

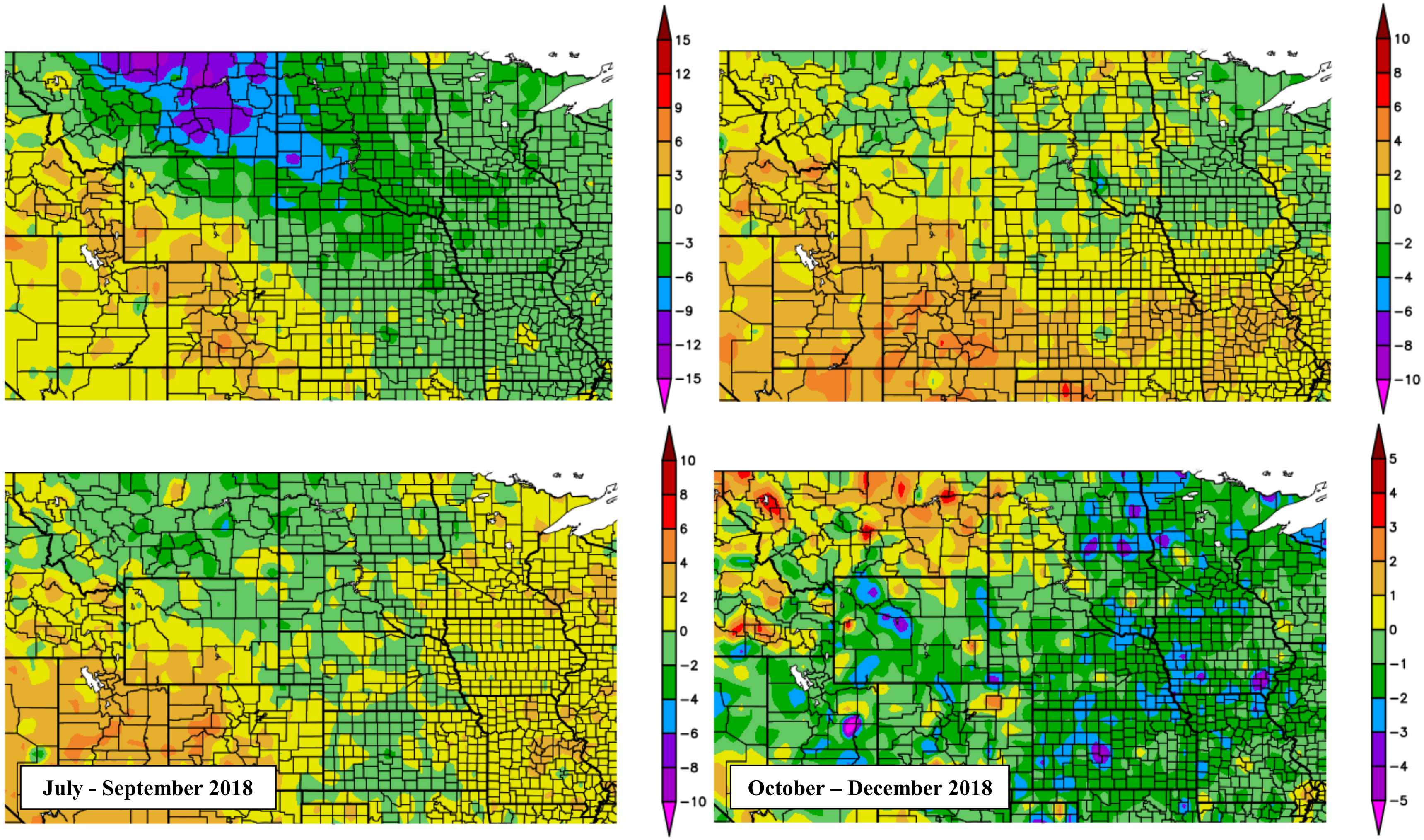
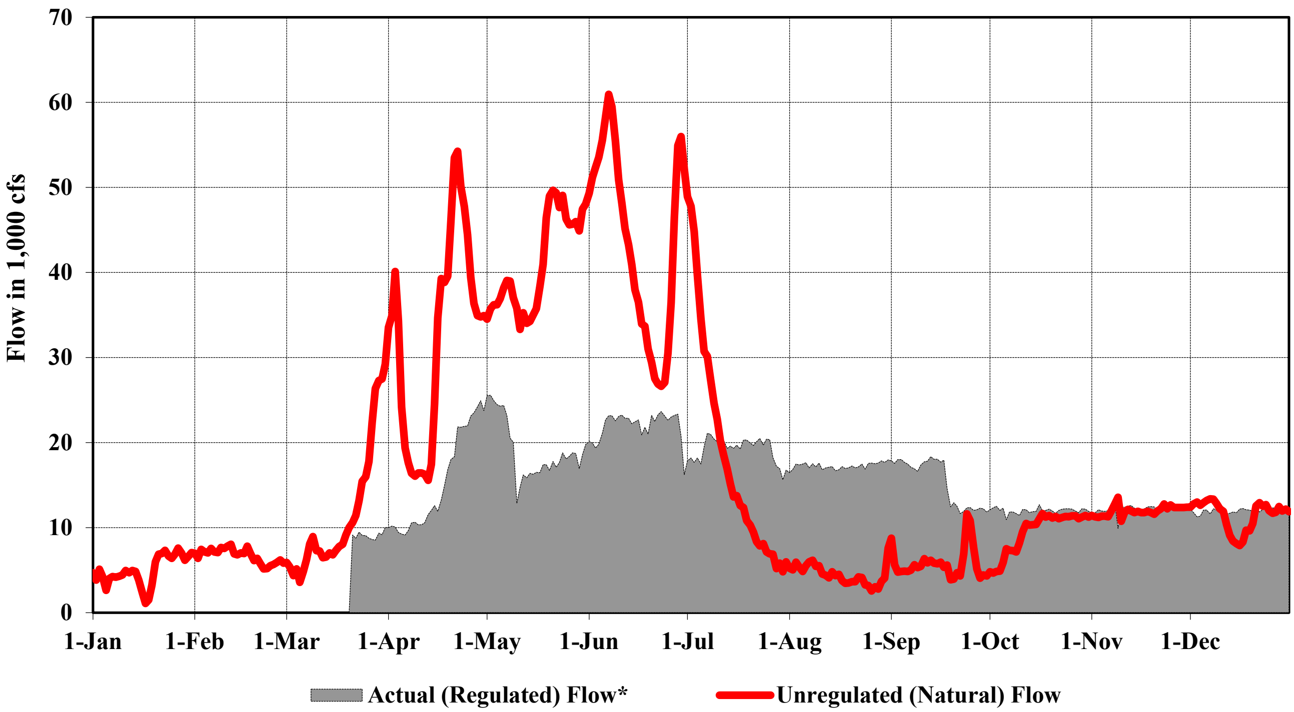


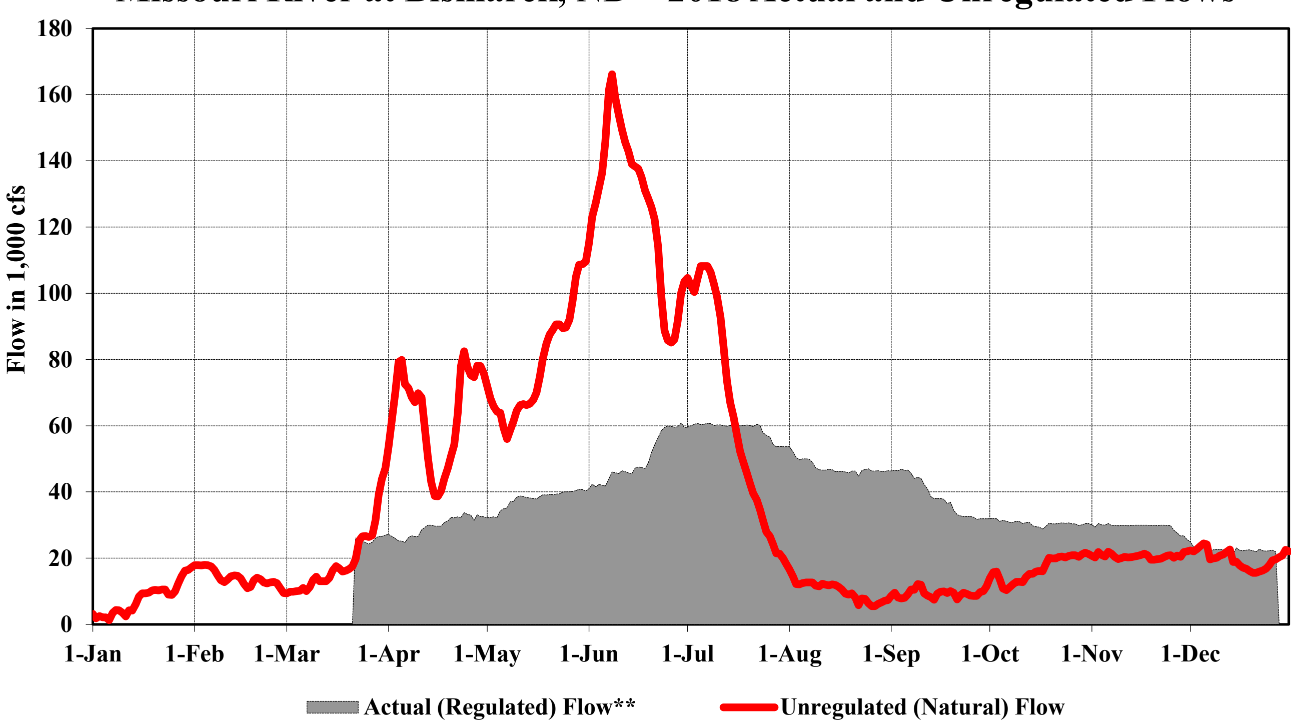
Figure 15. Departure from normal temperature (deg F) for the 2018 three-month periods: January-March, April-June, July-September and October-December. Reformatted from the High Plains Regional Climate Center Climate Summary Maps.

Missouri River at Wolf Point, MT – 2018 Actual and Unregulated Flows



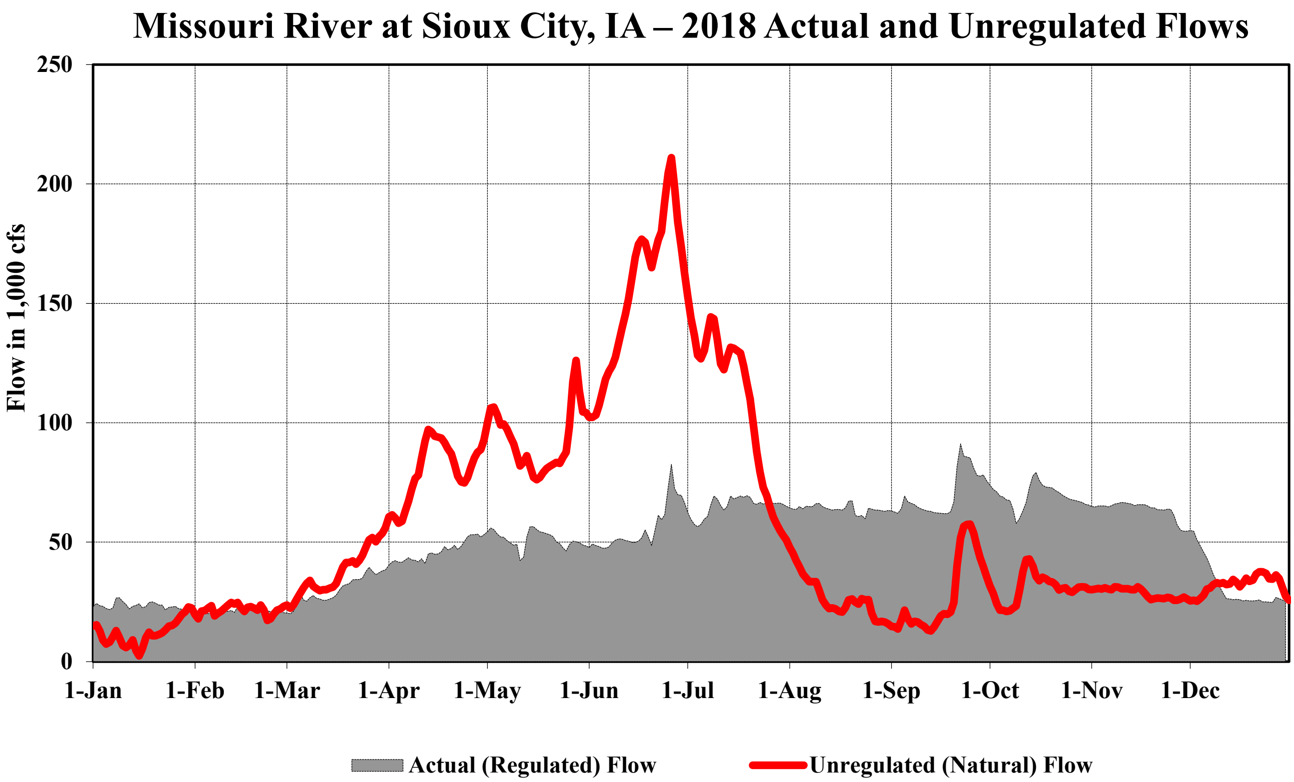
*Actual flow prior to March 21, 2018 is ice affected.

Missouri River at Bismarck, ND – 2018 Actual and Unregulated Flows



**Actual flow prior to March 22, 2018 and after December 27, 2018 is ice affected.

Figure 16A. 2018 actual and unregulated flows – Wolf Point, MT and Bismarck, ND.



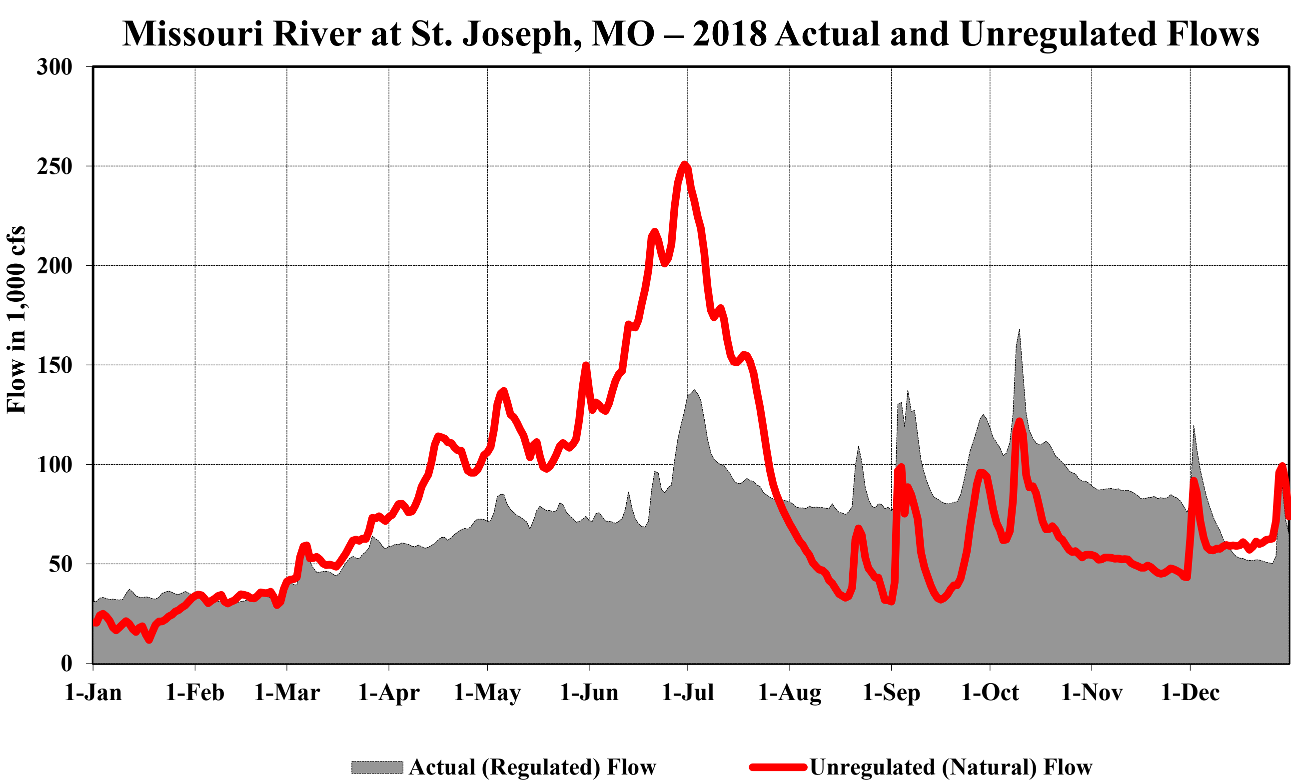
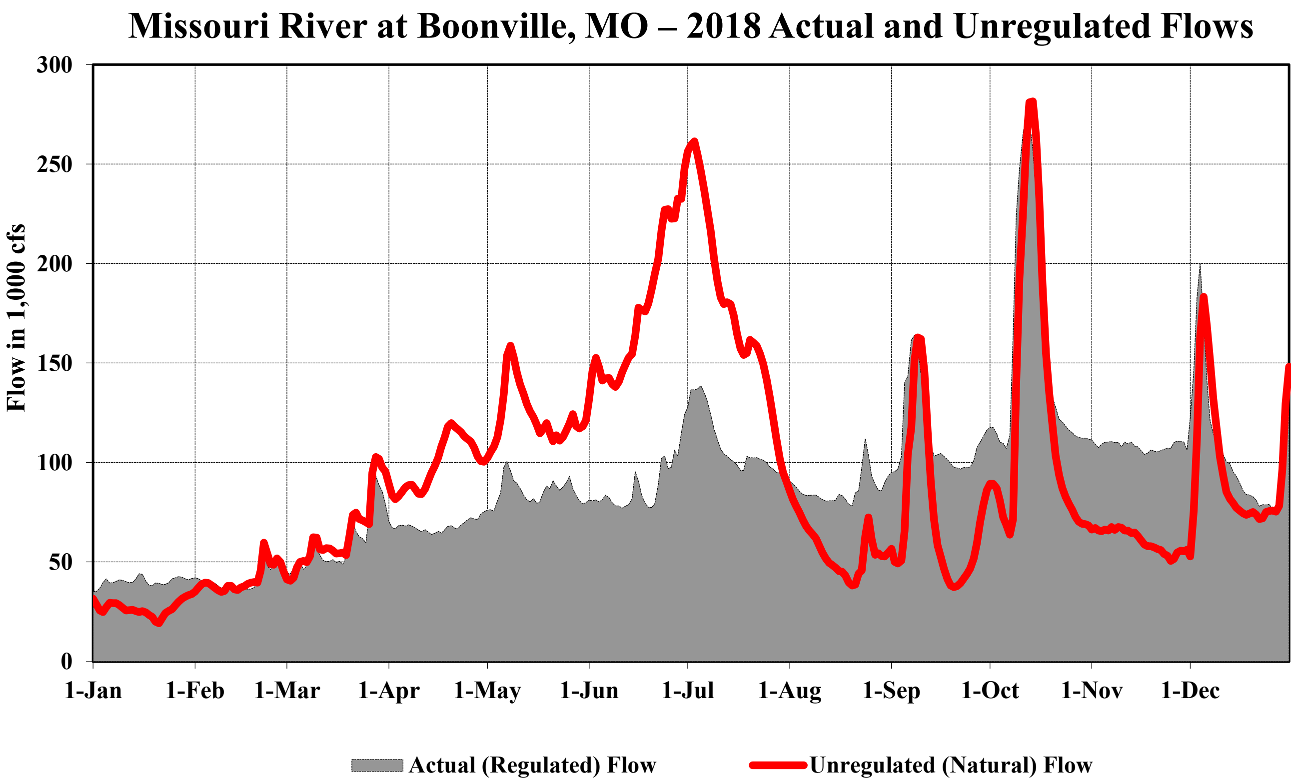


Figure 16B. 2018 actual and unregulated flows – Sioux City, IA and St. Joseph, MO.



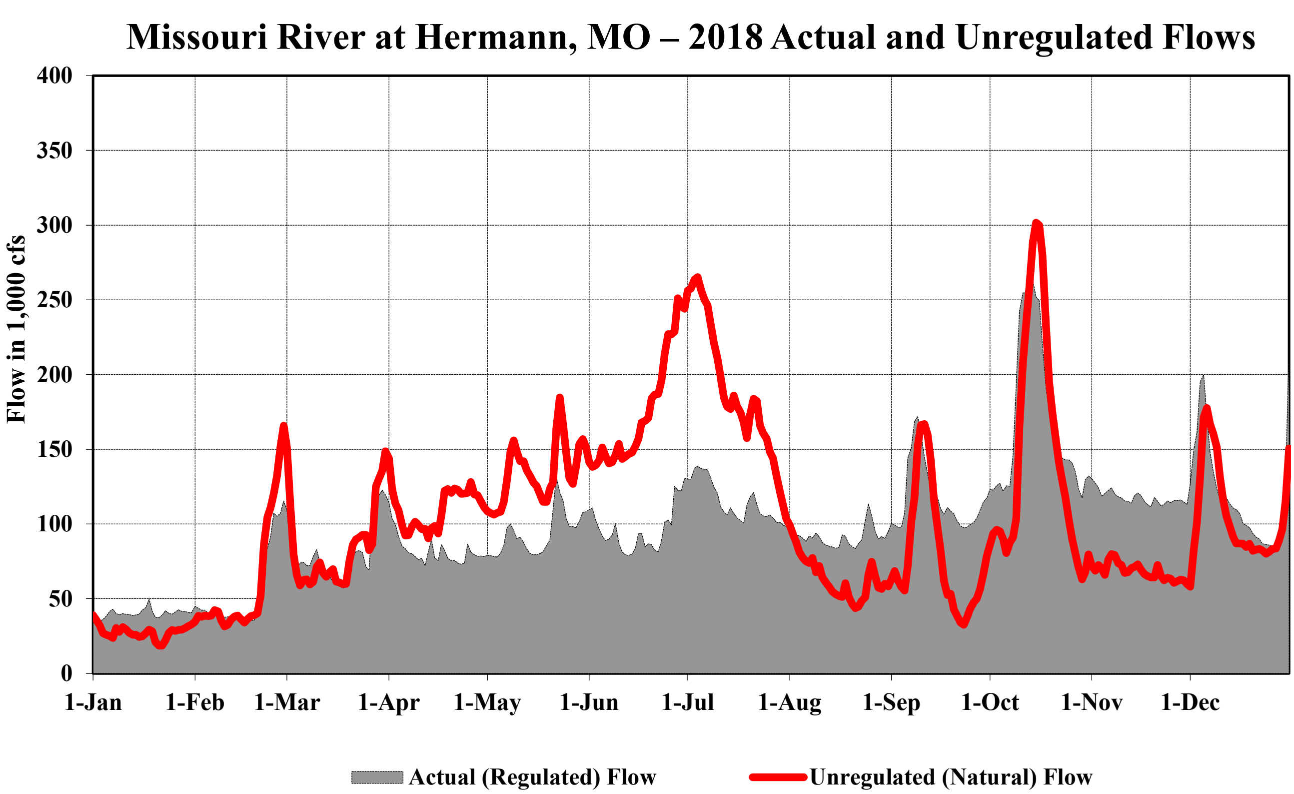


Figure 16C. 2018 actual and unregulated flows – Boonville, MO and Hermann, MO.

4. 2018 Calendar Year Runoff

The 2018 unregulated runoff volume for the upper Basin above Sioux City, IA totaled 42.1 million acre-feet (MAF), 166 percent of average, based on the historical period of 1898-2017, as shown in ***Table 7*** and ***Figure 17***. The 2018 upper Basin runoff is the third highest runoff in 120 years of record-keeping, exceeded only in 1997 (49.0 MAF) and 2011 (61.0 MAF). ***Table 7*** lists the runoff for the upper Basin by month and reach and compares the 2018 monthly and calendar year totals to the 1898-2017 historical period average. Monthly and calendar year totals are the adjusted compilation of runoff into the System. This forecast forms a basis for intra-system balancing of storage accumulated in the System and is updated by MRBWM on the first of each month to forecast the runoff for the remainder of the year. The monthly accumulation of actual runoff is shown under the "Accumulated Summation above Sioux City" column.

Runoff was above average in all six reaches in the upper Basin, as outlined in ***Table 6.*** Within the first six months of the runoff year (end of June) the upper Basin had already received 27.5 MAF (***Table 7***), more than an average year's runoff. Average May-July runoff in the Fort Peck and Garrison reaches are 3.5 MAF and 5.8 MAF, respectively. This total of 9.3 MAF is nearly 40 percent of the long-term average runoff in the upper Basin (25.3 MAF). In 2018, the runoff in these two reaches were 6.0 MAF and 10.6 MAF, which were about 180 percent of average and about 40 percent of the total upper Basin runoff, respectively. Also of note, runoff in the Gavins Point to Sioux City reach of 7.9 MAF was more than three times the long-term average.

Total runoff in the lower Basin, from Sioux City, IA to Hermann, MO totaled 35.8 MAF, 82 percent of average (see ***Table 6***). Of the three reaches in the lower Basin, the runoff in the reach from Sioux City, IA and Nebraska City, NE was much above average. Runoff was near or below average in the other two lower reaches, Nebraska City to Kansas City, MO and Kansas City to Hermann, MO.

Figure 18 illustrates the monthly variation of the runoff summation above Sioux City, IA compared to the long-term average variation of runoff based on the 1898-2017 historic period. Normally during the March-April period, when plains snow is melting and early spring rains are occurring, the upper Basin runoff is about 25 percent of the annual total. In 2018, March-April runoff was 9.0 MAF, about 20 percent of the annual total. Of that two-month total of 9.0 MAF, 5.5 MAF, or more than 60 percent, derived from the Fort Peck (2.3 MAF) and Garrison (3.2 MAF) reaches, primarily from the melting of the heavy plains snowpack. About 50 percent of the annual upper Basin runoff historically occurs in the May-July period, when mountain snow is melting and spring rains are occurring. Runoff in the upper Basin during this three-month period was 19.0 MAF, almost two times the long-term average of 11.2 MAF and about 45 percent of the annual total. Significant late summer and fall rainfall events in the upper Basin resulted in about 160 percent of average runoff during the remaining five months of 2018. Of note, runoff in the Sioux City reach in the August-December period was 3.0 MAF, nearly six times average for that five-month period.

Table 6
2018 CY Runoff Volumes for Selected Reaches (1,000 acre-feet)

Reach	1898-2017 Average Runoff	2018 CY Runoff	% of Average Runoff
Above Fort Peck	7,217	10,859	150
Fort Peck to Garrison	10,756	16,695	155
Garrison to Oahe	2,491	2,622	105
Oahe to Fort Randall	912	1,404	154
Fort Randall to Gavins Point	1,693	2,601	154
Gavins Point to Sioux City	2,277	7,896	347
TOTAL ABOVE SIOUX CITY	**25,346**	**42,077**	**166**
	1967-2017 Average Runoff	**2018 CY Runoff**	**% of Annual Runoff**
Sioux City, IA to Nebraska City, NE*	8,070	13,269	164
Nebraska City, NE to Kansas City, MO*	11,573	9,984	86
Kansas City, MO to Hermann, MO*	24,067	12,536	52
TOTAL BELOW SIOUX CITY*	**43,710**	**35,789**	**82**

** Runoff in the reaches from Sioux City, IA to Hermann, MO is not adjusted to 1949 depletion levels. Annual monthly averages are taken from the USGS Water Data Reports for the period 1967-2017.*

Table 7
Missouri River Basin
2018 Runoff above Sioux City, IA

Values in 1000 Acre Feet

Reach Above	Fort Peck	Garrison	Oahe	Fort Randall	Gavins Point	Sioux City	Summation above Gavins Point	Summation above Sioux City	Accumulated Summation above Sioux City
	(Actual)								
JAN 2018	296	248	-70	167	155	184	796	980	980
AVERAGE*	312	264	13	31	100	55	720	775	775
DEPARTURE	-16	-16	-83	136	55	129	76	205	205
% OF AVE	95%	94%	-556%	539%	155%	335%	111%	126%	126%
FEB 2018	363	380	70	47	121	200	981	1,181	2,161
AVERAGE	364	362	100	58	134	105	1,018	1,123	1,898
DEPARTURE	-1	18	-30	-11	-13	95	-37	58	263
% OF AVE	100%	105%	70%	81%	90%	190%	96%	105%	114%
MAR 2018	778	949	381	334	356	592	2,798	3,390	5,551
AVERAGE	596	1,002	579	211	209	326	2,597	2,923	4,821
DEPARTURE	182	-53	-198	123	147	266	201	467	730
% OF AVE	131%	95%	66%	158%	170%	182%	108%	116%	115%
APR 2018	1,550	2,255	503	239	260	803	4,807	5,610	11,161
AVERAGE	639	1,073	501	145	179	382	2,537	2,919	7,741
DEPARTURE	911	1,182	2	94	81	421	2,270	2,691	3,420
% OF AVE	243%	210%	100%	165%	145%	210%	189%	192%	144%
MAY 2018	2,233	2,944	307	179	175	807	5,838	6,645	17,806
AVERAGE	1,079	1,270	324	149	187	328	3,009	3,337	11,077
DEPARTURE	1,154	1,674	-17	30	-12	479	2,829	3,308	6,729
% OF AVE	207%	232%	95%	120%	94%	246%	194%	199%	161%
JUN 2018	2,566	4,992	441	282	240	1,156	8,521	9,677	27,483
AVERAGE	1,628	2,727	446	161	184	327	5,146	5,473	16,550
DEPARTURE	938	2,265	-5	121	56	829	3,375	4,204	10,933
% OF AVE	158%	183%	99%	175%	130%	354%	166%	177%	166%
JUL 2018	1,218	2,680	443	99	185	1,142	4,625	5,767	33,250
AVERAGE	825	1,818	191	58	138	247	3,031	3,278	19,828
DEPARTURE	393	862	252	41	47	895	1,594	2,489	13,422
% OF AVE	148%	147%	232%	170%	134%	462%	153%	176%	168%
AUG 2018	441	718	181	39	233	478	1,612	2,090	35,340
AVERAGE	360	613	81	43	116	152	1,213	1,365	21,193
DEPARTURE	81	105	100	-4	117	326	399	725	14,147
% OF AVE	123%	117%	223%	91%	201%	314%	133%	153%	167%
SEP 2018	296	354	107	5	242	902	1,004	1,906	37,246
AVERAGE	327	450	112	38	110	112	1,036	1,148	22,341
DEPARTURE	-31	-96	-5	-33	132	790	-32	758	14,905
% OF AVE	91%	79%	96%	13%	221%	805%	97%	166%	167%
OCT 2018	348	507	14	-22	242	870	1,089	1,959	39,205
AVERAGE	380	533	71	4	119	95	1,107	1,202	23,543
DEPARTURE	-32	-26	-57	-26	123	775	-18	757	15,662
% OF AVE	92%	95%	20%	--	204%	916%	98%	163%	167%
NOV 2018	392	261	42	-111	199	422	783	1,205	40,410
AVERAGE	380	391	68	4	118	84	961	1,045	24,588
DEPARTURE	12	-130	-26	-115	81	338	-178	160	15,822
% OF AVE	103%	67%	62%	--	169%	505%	81%	115%	164%
DEC 2018	378	407	203	146	193	340	1,327	1,667	42,077
AVERAGE	326	251	5	12	100	62	695	757	25,345
DEPARTURE	52	156	198	134	93	278	632	910	16,732
% OF AVE	116%	162%	--	1177%	192%	551%	191%	220%	166%
Calendar Year Totals									
	10,859	16,695	2,622	1,404	2,601	7,896	34,181	42,077	
AVERAGE	7,217	10,756	2,491	912	1,693	2,277	23,069	25,346	
DEPARTURE	3,642	5,939	131	492	908	5,619	11,112	16,731	
% OF AVE	150%	155%	105%	154%	154%	347%	148%	166%	

*1898-2017

Annual Runoff above Sioux City, IA

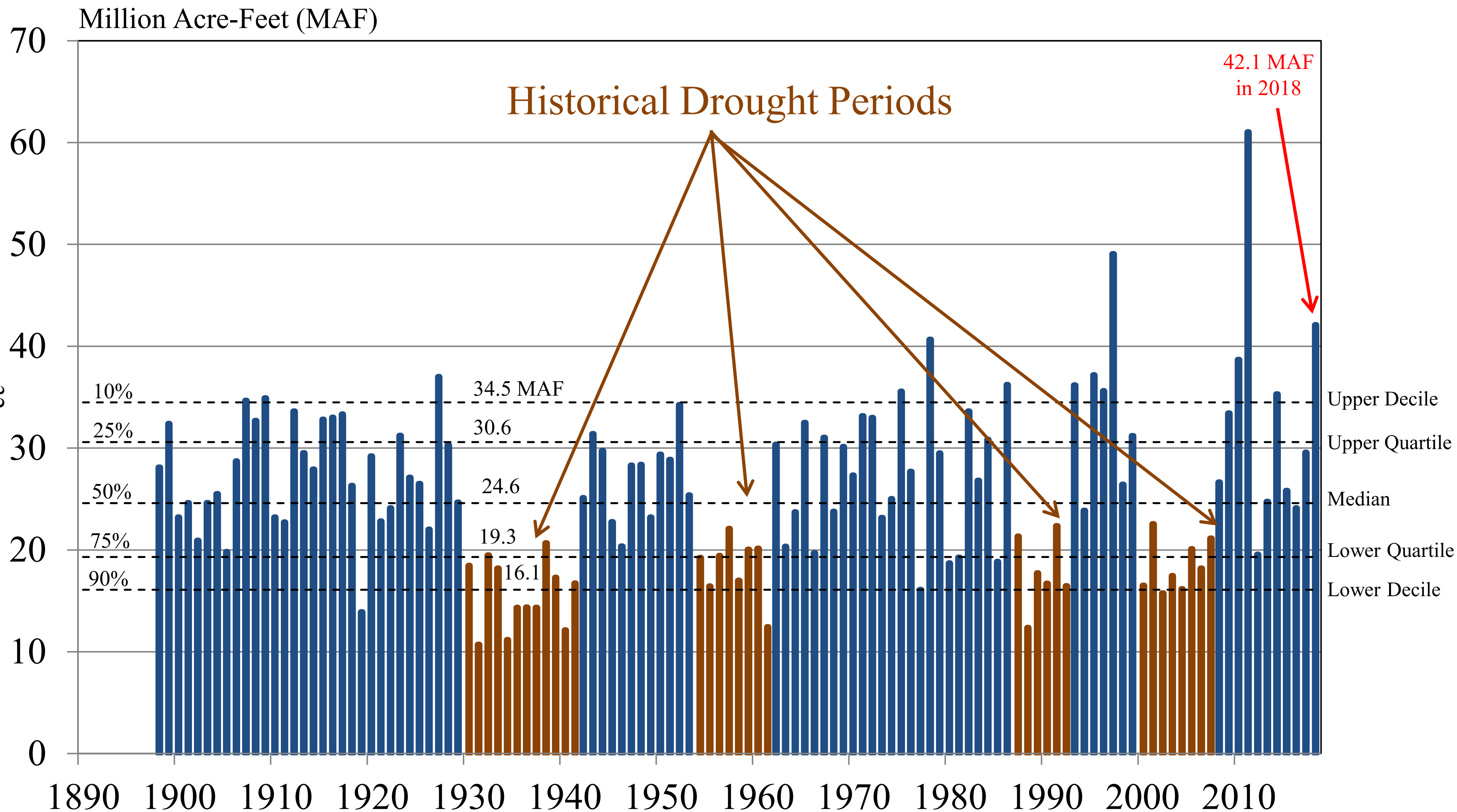


Figure 17. Missouri River Basin annual runoff above Sioux City, IA.

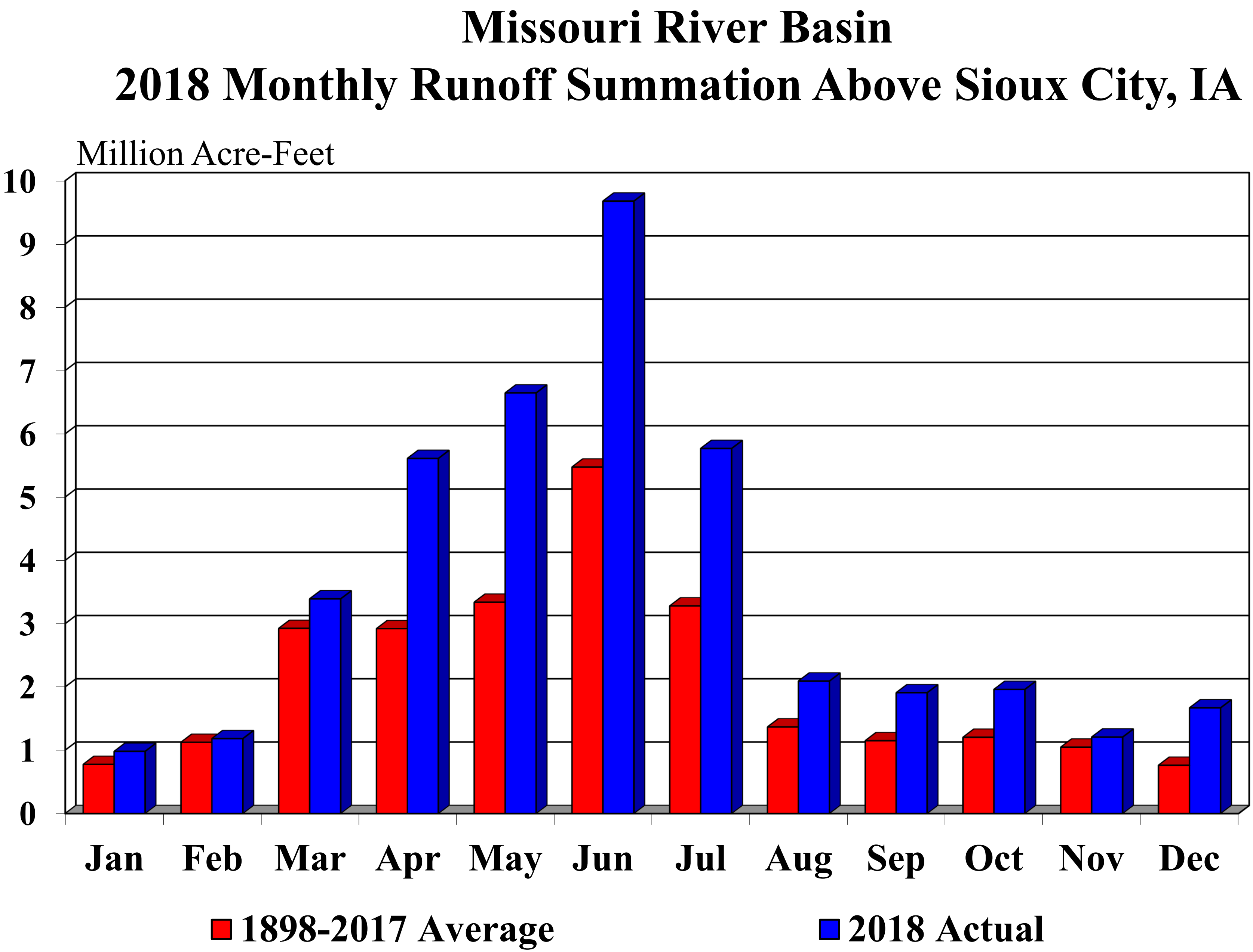


Figure 18. Missouri River Basin 2018 monthly runoff summation above Sioux City, IA.

C. System Regulation – January to December 2018

1. Basin Conditions and System Regulation

The System provided good service to all authorized purposes and significant flood control benefits during 2018. Runoff above Sioux City, IA was 42.1 MAF, 166 percent of average (see ***Table 7***). The runoff summation above Sioux City, IA was the third highest runoff total in 120 years of record-keeping (1898-2017) following only 2011 (61.0 MAF) and 1997 (49.0 MAF). Runoff in the Missouri River reach from Sioux City, IA to Nebraska City, NE, was 13.3 MAF, 164 percent of average (see ***Table 6***). System storage was at the base of the Annual Flood Control and Multiple Use Zone by January 16, at the beginning of the 2018 runoff season. From June 30 to July 27 water was stored in the System's Exclusive Flood Control Zone.

a. Conditions in January and February

System storage reached 56.1 MAF, the base of the Annual Flood Control and Multiple Use Zone on January 16, when all the stored flood waters from the 2017 runoff year were evacuated. Upper basin runoff was above average in January and February (see ***Table 7***). The January 1 mountain SWE totals for the Fort Peck and Fort Peck to Garrison reaches were 118 percent and 134 percent of average, respectively. The February 1 mountain snowpack SWE was 114 percent of average in the Fort Peck reach and 124 percent of average in the Fort Peck to Garrison reach (see ***Table 4***). System storage remained near the base of the Annual Flood Control and Multiple Use Zone throughout the remainder of February as plains snowpack continued to accumulate with minimal plains snowmelt occurring in the upper Basin. Plains snowpack reached its maximum areal coverage and overall maximum SWE in late February (see ***Figure 5***).

b. Conditions on March 1

On March 1 the System storage was 56.3 MAF, 0.2 MAF above the base of the Annual Flood Control and Multiple Use Zone. There was light-to-moderate plains snow cover over the Dakotas and moderate-to-heavy plains snow cover in parts of the Montana plains region. Soil moisture conditions in early March were wetter than normal in much of Wyoming and Montana, and drier than normal in northeastern Montana, North Dakota and South Dakota (***Figure 19***). During February, the mountainous areas received above-normal precipitation and below-normal temperatures. On March 1, the mountain SWE increased to 130 percent of average in the Fort Peck reach; in the Fort Peck to Garrison reach, mountain SWE increased to 136 percent of average (***Table 4***). The March 1 annual runoff forecast was 29.0 MAF, 115 percent of average. March-April runoff was expected to be above average in the upper Basin due to 1) the wetter-than-normal soil conditions in Montana and Wyoming, 2) the moderate-to-heavy plains snow cover in Montana, and 3) the March-April-May climate outlooks that indicated an increased probability for below-normal temperatures and a slight increase in the probability for above-normal precipitation.

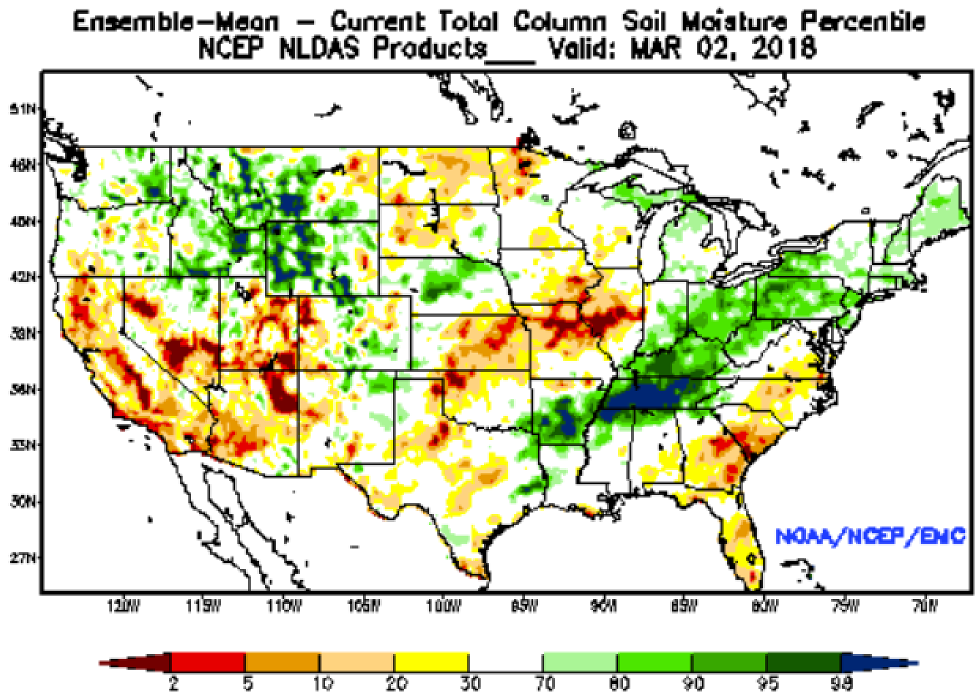


Figure 19. Soil moisture ranking percentile, March 2, 2018. Source: NOAA NLDAS.

Per the Master Manual, the March 15 System storage check of 56.6 MAF set navigation flow support to the full service level for the first half of the navigation season. During the first two weeks of March, inflows were higher than forecast in the March 1 runoff forecast. The mid-month runoff forecast increased to 29.6 MAF based on higher-than-forecast runoff during the first two weeks of March, above-average mountain SWE and moderate-to-heavy plains snow in central Montana and western North Dakota.

On March 19, based on a mid-March calendar year runoff forecast update, current System and tributary storage levels, and Plate VI-1 of the Master Manual, the service level was increased from 35,000 cfs to 40,000 cfs for the evacuation of stored waters in anticipation of higher-than-average upper Basin runoff. System releases at Gavins Point Dam were increased from 23,000 to 24,500 cfs on March 20 in response to the expanded service level. No additional increases were made to Gavins Point releases because downstream flow targets were met or exceeded at the three downstream target locations: Omaha, Nebraska City and Kansas City.

On March 27, the Gavins Point release was reduced to 22,000 cfs because the lower Missouri River forecast indicated the flow at Nebraska City would exceed the flood target, due to elevated tributary flows. After downstream tributary flows receded over the next few days, System releases at Gavins Point Dam were increased.

c. Conditions on April 1

System storage on April 1 was 58.2 MAF, 2.1 MAF above the base of the Annual Flood Control and Multiple Use Zone. The April 1 annual runoff forecast was 30.2 MAF, 119 percent of average. On April 1, the mountain SWE was 127 percent of the April 1 average above Fort Peck and 123 percent of average in the Fort Peck to Garrison reach.

Based on the April 1 calendar year runoff forecast above Gavins Point, System and tributary storage levels, and Plate VI-1 of the Master Manual, the service level was increased another 5,000 cfs -- from 40,000 to 45,000 cfs -- on April 3. During early April, System releases at Gavins Point were increased from 24,000 to 38,000 cfs as part of the expanded service level.

By mid-April, high tributary streamflow resulted in Missouri River flows at several downstream target locations being forecast to exceed downstream expanded-service-level flood targets. Gavins Point releases were reduced to 35,000 cfs to lessen downstream high flows.

On April 16, the service level was re-evaluated based on the current System and tributary reservoir storage levels and a mid-April updated calendar year runoff forecast. System storage was 59.1 MAF, 3.0 MAF above the base of the Annual Flood Control and Multiple Use Zone. Upper basin runoff during the first two weeks of April had been much-above average and higher than forecast. During this two-week period mountain snowpack increased significantly. In the Fort Peck to Garrison reach, the mountain SWE peaked on April 15 at 137 percent of average; in the Fort Peck reach, the mountain SWE peaked on April 19 at 141 percent of average (see ***Table 4***). As a result, the mid-April runoff forecast was increased to 33.0 MAF. Based on the April mid-month calendar year runoff forecast above Gavins Point, System and tributary storage levels, and Plate VI-1 of the Master Manual, the service level was increased another 5,000 cfs -- from 45,000 to 50,000 cfs -- to allow for increased flood storage evacuation.

Following the increase to the service level on April 16, the Gavins Point release was decreased to 32,000 cfs because the lower Missouri River forecast indicated that the Missouri River flows at Omaha and Nebraska City would exceed the downstream flood targets per the 50,000-cfs expanded service level.

d. Conditions on May 1

The May 1 annual runoff forecast was increased to 33.2 MAF, 131 percent of average. The May 1 forecast reflected 1) the higher-than-average observed and forecasted runoff in the Gavins Point to Sioux City reach, 2) the remaining higher-than-average mountain SWE in both reaches, 3) much wetter-than-normal soil moisture conditions in Montana and Wyoming, and 4) the CPC outlook indicating increased chances for above-normal May precipitation in the upper Basin. System storage on May 1 was 60.6 MAF, 4.5 MAF above the base of the Annual Flood Control and Multiple Use Zone.

May precipitation and temperatures were well-above normal in Montana and Wyoming. The above-normal temperatures resulted in a rapid melt of the remaining mountain snowpack. During the first week of May the Gavins Point release was maintained at 37,000 cfs. The Gavins Point release was decreased to 33,000 cfs for a two-day period to lessen downstream flooding and then increased to 42,000 cfs on May 13 as downstream tributary flows declined. Soon after releases were increased, another precipitation event in the lower basin was forecast to result in increased tributary flows and the Missouri River at Nebraska City exceeding its expanded flood target. Therefore, the Gavins Point release was reduced 4,000 cfs on May 23 and then increased to 42,000 cfs on May 26.

e. Conditions in June and July

Heavy precipitation and mountain snowmelt resulted in an upper Basin May runoff of 6.6 MAF, nearly two times average. May runoff was 207 percent of average in the Fort Peck reach, 232 percent of average in the Garrison reach and 246 percent of average in the Sioux City reach. The 2.2 MAF of runoff in the Fort Peck reach was the second highest May runoff volume in 120 years of record. System storage on June 1 was 63.4 MAF, 7.3 MAF above the base of the Annual Flood Control and Multiple Use Zone.

The June 1 annual runoff forecast was 34.6 MAF, 136 percent of average. June precipitation was well-above normal in much of the upper Basin and in several tributary regions in the lower Basin. In addition, the wet soil moisture conditions increased the volume of rainfall runoff. The June runoff summation above Gavins Point was 9.7 MAF, 177 percent of average, and fourth highest in 120 years record-keeping. June runoff was above average in all reaches including the Garrison reach, which received 5.0 MAF of incremental runoff, 183 percent of average, and third highest in 120 years of record-keeping. Above-average precipitation in the eastern Dakotas resulted in 1.2 MAF of runoff in the Gavins Point to Sioux City reach, 354 percent of average. The much-above-average runoff from this unregulated area of the upper Basin resulted in high tributary flows and increased Missouri River flows downstream of Gavins Point.

June precipitation was above normal throughout the basin. During the first half of June Gavins Point releases were maintained in the 42,000 – 44,000 cfs range depending on downstream conditions. Starting on June 18, releases were reduced from 44,000 to 24,000 cfs over a five-day period to lessen downstream high flows resulting from a heavy precipitation event in the lower basin. Even with the 20,000 cfs release reduction, the expanded flood targets were exceeded at the downstream target locations. However, additional Gavins Point releases reductions were not made because the System storage was forecasted to enter the Exclusive Flood Control Zone. On June 25, based on the current System storage of 66.6 MAF, 1.1 MAF below the base of the Exclusive Flood Control Zone, tributary storage, forecasted runoff above Gavins Point Dam and Plate VI-1 of the Master Manual, the service level was increased another 10,000 cfs -- from 50,000 to 60,000 cfs -- to allow for increased flood storage evacuation.

On July 1, System storage was 67.8 MAF, filling the 11.6-MAF Annual Flood Control and Multiple Use Zone and 0.1 MAF into the 4.7-MAF Exclusive Flood Control Zone. The 10,000-cfs increase in the service level and downstream flow targets allowed the Gavins Point release to be stepped up from 24,000 cfs on July 1 to 50,000 cfs by July 9. Even with the higher Gavins Point releases, System storage continued to climb until it peaked on July 9 at 68.4 MAF, 0.7 MAF above the base of the Exclusive Flood Control Zone. Gavins Point releases were slowly increased to 58,000 cfs by July 29.

The July 1 annual runoff forecast was 39.8 MAF, 157 percent of average. The July upper basin runoff was 5.8 MAF, 176 percent of average. Runoff was above average in all reaches, including nearly five times the average runoff in the Sioux City reach. The System storage was in the Exclusive Flood Control Zone from June 30 through July 27.

f. Conditions from August through December

August 1 System storage was 67.4 MAF, 11.3 MAF above the base of the 11.6-MAF Annual Flood Control and Multiple Use Zone. The August 1 annual runoff forecast was 39.8 MAF, 157 percent of average and reflected a continuation of above-average runoff in the upper Basin from above-average precipitation. August precipitation was above normal in southeastern South Dakota, eastern Nebraska, western Iowa and northwestern Missouri as a result of several periods of heavy rainfall. As a result, tributary flows continued to be above average in these areas. The System release was maintained at 58,000 cfs throughout August with the exception of August 20-24, when 52,000 cfs was released to lessen downstream flows.

September 1 System storage was 64.7 MAF, 8.6 MAF above the base of the Annual Flood Control and Multiple Use Zone. Based on the September 1 System storage check, the Gavins Point winter release would be at least 17,000 cfs. The September 1 annual runoff forecast for the upper Basin was 39.8 MAF, 157 percent of average. During September, very heavy precipitation occurred over southeastern South Dakota, Iowa, eastern Nebraska and northern Missouri (see ***Figure 15***). As a result, peak discharges of about 36,000 and 22,000 cfs were observed on the Big Sioux and Little Sioux Rivers, respectively, near the end of September. Since the lower Missouri River forecast was indicating Missouri River flows would exceed the flood targets at Omaha, Nebraska City and Kansas City, the Gavins Point release was temporarily reduced to 46,000 cfs from September 23-26. The September runoff in the Gavins Point to Sioux City reach was about eight times the average long-term average runoff and the highest September runoff in 120 years of record-keeping.

The October 1 System storage was 62.2 MAF, 6.1 MAF above the base of the Annual Flood Control and Multiple Use Zone. Heavy October precipitation occurred in the lower Basin in Kansas, southern Nebraska, southwestern Iowa and northwestern Missouri. Once again, high tributary flows increased Missouri River flows above flood limits at Omaha, Nebraska City and Kansas City. The Gavins Point release was reduced from 58,000 to 46,000 cfs from October 8-11 to lessen the flow in the lower Missouri River. The October upper Basin runoff was well-above average, due to above-average runoff in the Gavins Point and Gavins Point to Sioux City reaches. The October runoff in the Gavins Point to Sioux City reach was more than nine times the long-term average, and was the second highest October runoff in 120 years of record-keeping.

November 1 System storage was 59.6 MAF, 3.5 MAF above the base of the Annual Flood Control and Multiple Use Zone. The Gavins Point to Sioux City reach runoff for November was five times the long-term average. In this reach, the September-November runoff was 2.2 MAF, nearly equivalent to the long-term average annual runoff of 2.3 MAF.

Gavins Point releases were reduced from 58,000 to 50,000 cfs from November 24-27. Releases were maintained at 50,000 cfs for 5 days and then stepped down 3,000 cfs/day until they reached 20,000 cfs on December 11, ending flow support for the navigation season.

December 1 System storage was 57.1 MAF, 1.0 MAF above the base of the Annual Flood Control and Multiple Use Zone. The upper Basin runoff forecast on December 1 was adjusted to 41.3 MAF, 163 percent of average. December precipitation was well-above normal in much of the lower Basin and in parts of the upper Basin. Temperatures in December were well-above normal across most of the Missouri Basin. As a result, the Missouri River and its tributaries continued to flow freely with limited ice formation. December's upper Basin runoff of 1.7 MAF was more than two times average.

The annual upper Basin runoff was 42.1 MAF, 166 percent of average, making it the third highest annual upper Basin runoff in 120 years of record-keeping. This amount was exceeded in 2011 (61.0 MAF) and in 1997 (49.0 MAF). System storage on December 31 was 56.9 MAF, 0.8 MAF above the base of the Annual Flood Control and Multiple Use Zone.

2. Fort Peck Regulation – January to December 2018

a. General

Fort Peck, the third largest Corps storage reservoir, serves all authorized purposes. Fort Peck's primary functions are: (1) to capture the snowmelt runoff and localized rainfall runoff from the large drainage area above Fort Peck Dam, which are metered out at controlled release rates to meet the authorized purposes while reducing flood damages in the Fort Peck to Garrison reach; (2) to serve as a secondary storage location for water accumulated in the System reservoirs from reduced System releases due to major downstream flood control regulation, thus helping to alleviate large pool increases in Garrison, Oahe and Fort Randall; and (3) to provide the water needed to meet all authorized purposes that draft storage during low-water years.

Table 8 lists the average monthly inflows and releases and the end-of-month (EOM) pool elevation for Fort Peck for 2017 and 2018 as well as the averages since the System first filled in 1967.

Table 8
Fort Peck – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2018	2017	1967-2017	2018	2017	1967-2017	2018	2017	1967-2017
January	6,400	6,700	7,200	9,900	6,700	10,300	2234.9	2233.9	2227.7
February	8,000	5,000	8,600	10,400	5,000	10,600	2233.9	2234.9	2227.1
March	16,000	4,700	11,600	8,300	4,700	7,700	2236.0	2236.2	2228.2
April	24,000	6,300	10,100	9,400	6,300	7,300	2239.9	2237.2	2228.9
May	31,700	8,700	15,500	14,200	8,700	9,000	2244.4	2239.1	2230.6
June	32,500	9,800	19,200	19,400	9,800	10,400	2247.5	2240.2	2233.0
July	13,600	9,900	11,900	17,400	9,900	10,400	2246.1	2238.9	2233.0
August	7,600	10,100	7,900	16,000	10,100	10,000	2243.5	2237.4	2231.9
September	7,800	7,500	7,700	14,300	7,500	8,800	2241.4	2236.8	2231.0
October	7,400	5,800	7,400	11,800	5,800	7,700	2240.0	2236.4	2230.6
November	7,500	6,000	7,100	11,700	6,000	8,100	2238.6	2236.0	2229.9
December	7,700	6,800	6,500	11,600	6,800	9,200	2237.2	2235.8	2228.8
Annual	**14,200**	**7,300**	**10,100**	**12,900**	**7,300**	**9,100**			

b. Winter Season 2017-18

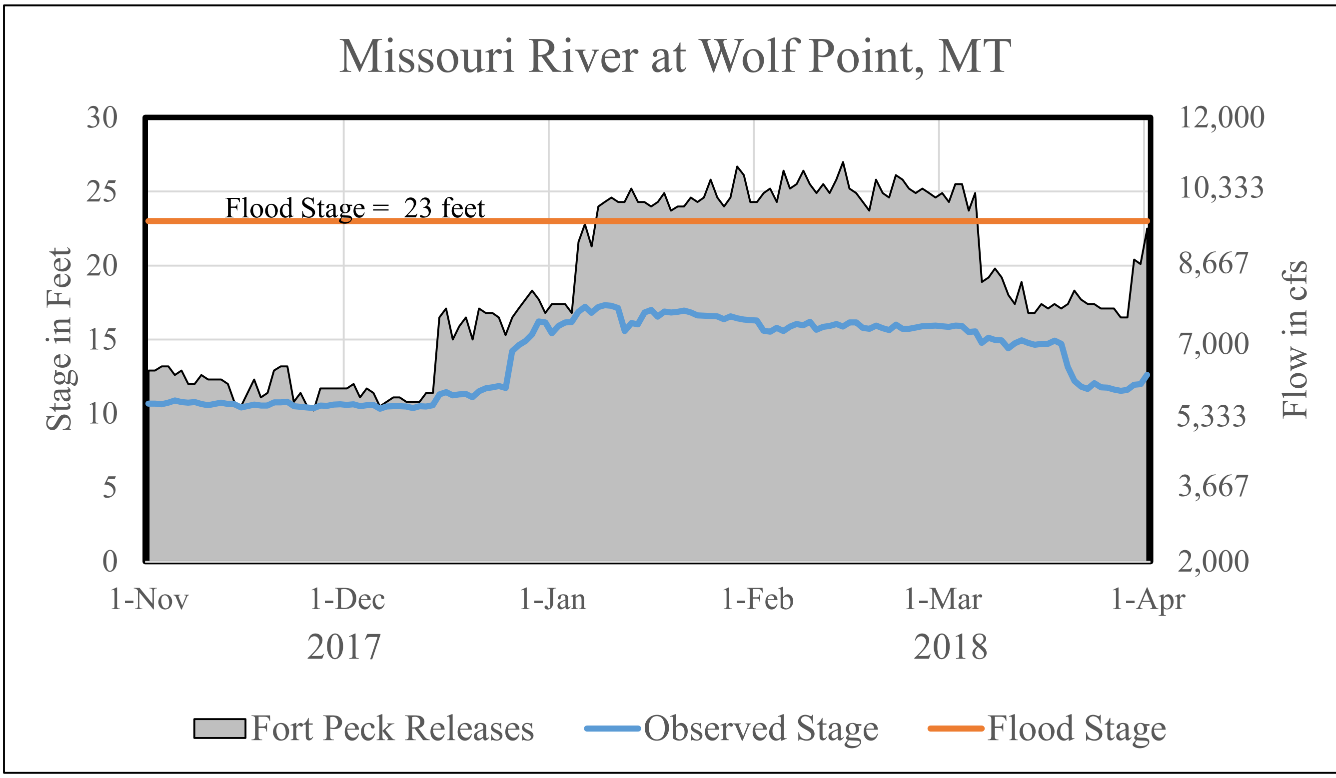
The Fort Peck reservoir level was at elevation 2236.0 feet on December 1, 2017, 2.0 feet above the base of the Annual Flood Control and Multiple Use Zone and 1.0 foot above the previous year's level. The reservoir reached elevation 2234.0 feet, the base of the Annual Flood Control Multiple Use Zone, on February 24. During the winter season the average monthly releases from Fort Peck were below average: December 2017 was 6,800 cfs (average is 9,200 cfs); January was 9,900 cfs (average is 10,300 cfs); and February was 10,400 cfs (average is 10,600 cfs). The Fort Peck reservoir froze over on December 31 and was free of ice on April 27.

c. Winter River and Ice Conditions below Fort Peck

No special release reductions were required due to ice-jam flooding downstream of Fort Peck. Sub-zero (deg F) temperatures were experienced at the end of December 2017 and in early January. Ice-cover formation on the Missouri River downstream of Fort Peck resulted in the Missouri River stage rising over 5 feet in the Wolf Point, MT reach from December 25-30, 2017. As seen on ***Figure 20***, the stage then increased another foot to over 17 feet by January 5 and remained in the range of 15-17 feet through the winter. The USGS reported on March 21 that the ice was out of the Missouri River channel at Wolf Point. The Missouri River stage remained well below the 23-foot flood stage at Wolf Point during the winter. No reports of ice-affected flooding on the Missouri River below Fort Peck were recorded during the 2017-18 winter season.

d. Spring Open Water Season 2018

Colder-than-normal temperatures and greater than 200 percent-of-normal precipitation during December, January and February resulted in a heavy plains snowpack accumulation in most of Montana. By March, the NOHRSC snow model indicated that SWE amounts ranged from 4 to 6 inches in north central and central Montana. Cooler-than-normal March temperatures in Montana delayed the melt until late March and April. The plains snowpack began to rapidly melt in April, which caused inflows in April and May to be well-above average. The mountain snowpack above Fort Peck was also above average, peaking at 141 percent of the long-term average peak on April 19. The rapidly melting mountain snowpack, coupled with the remaining runoff from the plains snowpack, kept inflows above average during June. Average monthly inflows to the reservoir were 24,000 cfs (238 percent of average) in April, 31,700 cfs (205 percent of average) in May and 32,500 cfs (169 percent of average) in June. As runoff continued to increase throughout April, May and June, releases from Fort Peck were increased to manage the high runoff. Fort Peck releases averaged 9,400 cfs (129 percent of average) in April, 14,200 cfs (158 percent of average) in May, and 19,400 cfs (187 percent of average) in June. Daily releases peaked at 20,500 cfs during June when the pool level entered the Exclusive Flood Control Zone and was forecast to continue rising. Fort Peck reservoir rose 11.5 feet from its March 31 elevation of 2236.0 feet to 2247.5 feet at the end of June, 13.5 feet above the base of the Annual Flood Control and Multiple Use Zone and 1.5 feet above the base of the Exclusive Flood Control Zone. Fort Peck reservoir rose 8.4 feet during the critical fish spawning period from 2236.0 feet (March 31) to 2244.4 feet (May 31).



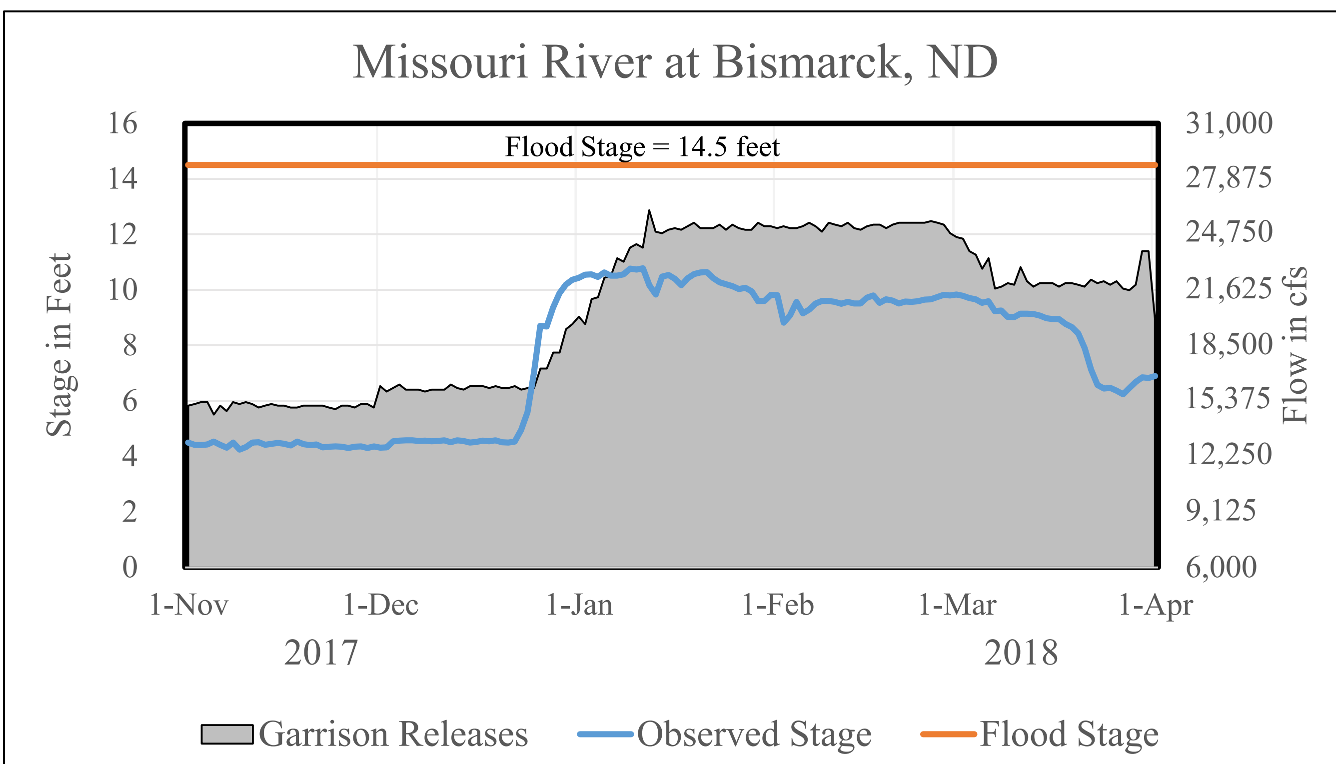


Figure 20. Observed Winter Ice Season Stage at Wolf Point, MT and Bismarck, ND and Fort Peck and Garrison Releases.

e. Summer Open Water Season 2018

Average monthly inflows decreased but were still near average during the summer months. Inflows averaged 13,600 cfs (114 percent of average) during July, 7,600 cfs (96 percent of average) during August, and 7,800 cfs (101 percent of average) during September. As inflows decreased and the reservoir elevation peaked, releases were decreased in July and September, but remained above average, to evacuate all of the stored flood waters. Average monthly releases were 17,400 cfs (167 percent of average) during July, 16,000 cfs (160 percent of average) during August, and 14,300 cfs (163 percent of average) during September. The reservoir level peaked in early July at 2247.9 feet before steadily decreasing over the remainder of the summer months. Over the 3-month period the reservoir level decreased 6.1 feet from 2247.5 feet (June 30) to 2241.4 feet (September 30).

f. Fall Open Water Season 2018

Releases during the fall continued to be above average as the remaining stored flood waters were evacuated and storage in the upper three reservoirs was balanced. Average monthly releases were 11,800 cfs in October (153 percent of average), 11,700 cfs in November (144 percent of average) and 11,600 cfs in December (126 percent of average). Inflows remained near average, averaging 7,400 cfs in October (100 percent of average), 7,500 cfs in November (106 percent of average), and 7,700 cfs in December (118 percent of average). The pool elevation decreased 4.2 foot over the 3-month period from 2241.4 feet (September 30) to 2237.2 feet (December 31), 3.2 feet above the base of the Annual Flood Control and Multiple Use Zone.

g. Summary

The highest 2018 Fort Peck midnight pool elevation occurred on July 3 at 2247.9 feet, 1.9 feet into the 4-foot Exclusive Flood Control Zone. The lowest 2018 midnight pool elevation was 2233.8 feet on March 1, 0.2 foot below the base of the Annual Flood Control and Multiple Use Zone. The 2018 average daily inflow of 14,200 cfs was 141 percent of average. The 2018 average daily release of 12,900 cfs was 142 percent of average.

3. Garrison Regulation – January to December 2018

a. General

Garrison, the largest Corps storage reservoir, is another key component in the regulation of the System. Its primary functions are (1) to capture the snowmelt runoff and localized rainfall runoff from the large drainage area between the Fort Peck and Garrison dams, which are metered out at controlled release rates to meet the authorized purposes while reducing flood damages in the Garrison to Oahe reach, particularly the urban Bismarck area; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control regulation, thus helping to alleviate large pool increases in Oahe and Fort Randall; and (3) to provide water needed to meet all authorized purposes that draft storage during low-water years.

Table 9 lists the average monthly inflows and releases and the EOM pool elevation for Garrison for 2017 and 2018 as well as the averages since the System first filled in 1967.

Table 9
Garrison – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2018	2017	1967-2017	2018	2017	1967-2017	2018	2017	1967-2017
January	16,500	15,900	15,100	24,200	15,900	22,100	1839.2	1837.5	1832.3
February	18,500	13,200	18,400	25,200	13,200	23,200	1837.9	1838.3	1831.3
March	28,800	14,000	26,400	22,400	14,000	18,900	1839.0	1841.5	1832.8
April	46,800	26,700	22,800	28,100	26,700	18,900	1842.4	1841.5	1833.4
May	61,200	32,100	29,800	36,800	32,100	21,800	1846.7	1843.1	1834.9
June	87,000	34,400	47,900	48,700	34,400	25,100	1852.8	1846.4	1839.0
July	47,200	33,500	33,000	58,700	33,500	26,000	1850.7	1846.2	1840.1
August	25,000	33,000	18,500	47,100	33,000	25,100	1846.5	1843.2	1838.3
September	23,300	23,500	16,900	37,300	23,500	20,900	1843.5	1841.6	1837.1
October	21,100	16,200	17,300	29,300	16,200	18,800	1841.7	1841.3	1836.5
November	20,800	15,100	15,900	28,000	15,100	19,500	1840.2	1841.8	1835.4
December	19,400	16,500	13,700	20,500	16,500	19,600	1839.6	1840.5	1833.9
Annual	**34,600**	**22,800**	**23,000**	**33,900**	**22,800**	**21,700**			

b. Winter Season 2017-18

The Garrison reservoir elevation was 1841.8 feet on December 1, 2017, 4.3 feet above the base of the Annual Flood Control and Multiple Use Zone and 2.4 feet above the previous year's level. The reservoir level declined through December and January and reached 1837.5 feet, the base of the Annual Flood Control and Multiple Use Zone, on March 14. The Garrison average monthly winter releases were below average for December and above average for January and February: December 2017 was 16,500 cfs (average is 19,600 cfs); January was 24,200 cfs (average is 22,100 cfs); and February was 25,200 cfs (average is 23,200 cfs). The Garrison reservoir froze over on December 27 and was free of ice on May 9.

c. Winter River and Ice Conditions Below Garrison

The Missouri River in the Bismarck, ND area rose about 6 feet, from a stage of about 4 feet to a stage of about 10 feet, from December 23-29, 2017, during the season's initial river ice formation. This type of rise in stage during river ice formation is normal. The river ice-cover conditions were generally continuous from December 26, 2017 through March 21. As seen on

Figure 20, the peak winter ice-affected Missouri River stage at Bismarck was over 10 feet from December 29, 2017 through January 27. The peak stage was more than 3 feet below the Bismarck flood stage of 14.5 feet and more than 2 feet below the Corps' winter freeze-in maximum target stage of 13 feet. A margin of ice cover remained on the left bank until March 21, when the Missouri River was free of ice. Two early spring rounds of cold temperatures on March 31 and April 1 produced frazzle ice on the Missouri River. A second round of extreme cold temperatures from April 4-8 brought record cold daily highs and frazzle ice formation on April 6. No reports of ice-affected flooding on the Missouri River below Garrison were recorded during the 2017-18 winter season.

d. Spring Open Water Season 2018

The heavy plains snowpack above Fort Peck extended into the reach between Fort Peck and Garrison. By March, the NOHRSC snow model indicated that modeled SWE amounts ranged from 4 to 6 inches in north central, central and southeastern Montana. Snow was particularly heavy in the Milk River Basin, which had total snowfall in excess of 60 inches. SWE amounts ranging from 2 to 4 inches extended into northeastern Wyoming. The plains snowpack in the Fort Peck to Garrison reach began to rapidly melt in April, which caused inflows in April and May to be well-above average. The mountain snowpack in the Fort Peck to Garrison reach was also above average, peaking at 137 percent of average on April 15. The rapidly melting mountain snowpack coupled with the remaining runoff from the plains snowpack kept inflows above average during June. Average monthly inflows to the reservoir were 46,800 cfs (205 percent of average) in April, 61,200 cfs (205 percent of average) in May and 87,000 cfs (182 percent of average) in June. Releases from Garrison were increased throughout the spring months as the runoff forecast and forecasted peak pool at Garrison reservoir continued to increase. Garrison releases averaged 28,100 cfs (149 percent of average) in April. The April 1 long-term forecast showed peak releases reaching 35,000 cfs and the reservoir peaking near 1845.0 feet, 5.0 feet below the base of the Exclusive Flood Control Zone. Observed runoff during April exceeded the forecasted runoff; releases were increased and averaged 36,800 cfs (169 percent of average) in May. The May 1 long-term forecast showed peak releases of 37,000 cfs and the reservoir level peaking near 1849.0 feet, 1.0 foot below the base of the Exclusive Flood Control Zone. Observed runoff during May exceeded forecasted amounts; releases were again increased during June. Based on the June 1 long-term forecast, releases were forecast to peak near 40,000 cfs and the reservoir level was forecast to peak near 1850.5 feet, 0.5 foot above the base of the Exclusive Flood Control Zone. High inflows during June led the MRBWM office to make release adjustments to balance the use of flood storage in Garrison reservoir and maintain operational flexibility in the System by keeping storage available in Oahe reservoir. The adjustments allowed for operational flexibility should a large rainfall occur downstream of Gavins Point; System releases could be reduced and water could be stored in Oahe reservoir with no release changes needed at Fort Peck and Garrison. Releases from Garrison were increased several times throughout June, peaking near 60,000 cfs and averaging 48,700 cfs (194 percent of average). The Garrison reservoir level rose 13.8 feet from its March 31 elevation of 1839.0 feet to 1852.8 feet at the end of June, filling all 12.5 feet of the Annual Flood Control and Multiple Use Zone (1837.5 to 1850.0 feet) and 2.8 feet of the 4-foot Exclusive Flood Control Zone (1850.0 to 1854.0 feet). The Garrison reservoir level rose 7.7 feet during the critical fish spawning period, from 1839.0 feet (March 31) to 1846.7 feet (May 31).

e. Summer Open Water Season 2018

Inflows into the Garrison reservoir peaked in June but remained above average during the summer months. Inflows averaged 47,200 cfs during July (143 percent of average), 25,000 cfs during August (135 percent of average), and 23,300 cfs during September (138 percent of average). As inflows declined, releases were steadily reduced during the summer months, but remained above average. Releases averaged 58,700 cfs (226 percent of average), 47,100 cfs (188 percent of average), and 37,300 cfs (178 percent of average) during July, August and September, respectively, so that all stored flood waters would be evacuated by the start of the 2019 runoff season. During the 3-month period, the pool level crested at 1853.2 feet on July 4, 3.2 feet into the 4-foot Exclusive Flood Control Zone. Following the crest, the Garrison pool slowly declined 9.7 feet to 1843.5 feet at the end of September. A daily peaking pattern was established at Garrison from May 15 through June 1 to protect T&E species nesting on sandbars below the project. Normally, the peaking pattern would remain in effect through August, but due to higher-than-average releases, hydropower peaking was eliminated during June, July, August and September.

f. Fall Open Water Season 2018

Inflows remained above average during October, November and December, 21,100 cfs (122 percent of average), 20,800 cfs (131 percent of average) and 19,400 cfs (142 percent of average), respectively. Releases also remained above average in October (29,300 cfs; 156 percent of average), November (28,000 cfs; 144 percent of average) and December (19,600 cfs; 105 percent of average). Releases were decreased in December in anticipation of the freeze-in of the Missouri River between Washburn and Bismarck, ND, which occurred December 28-31. The December 31 Garrison pool elevation was 1839.6 feet, 2.1 feet above the base of the Annual Flood Control and Multiple Use Zone.

g. Lake Audubon / Snake Creek Embankment

During the 2000-2007 drought, a restriction was put in place to limit the water level difference between Lake Audubon and Lake Sakakawea to 43 feet. This restriction required a pool restriction for Lake Audubon as a result of an under seepage evaluation of the Lake Audubon embankment by the Corps' Omaha District. Since the Garrison reservoir has returned to more average elevations following the 8-year drought, this water level difference restriction has not been an issue. Lake Audubon was drawn down to a winter level of 1844.6 feet in the fall.

h. Summary

The Garrison pool elevation peaked at 1853.2 feet on July 4 at midnight, occupying 3.2 feet of the 4-foot Exclusive Flood Control Zone. The lowest Garrison midnight pool level during 2018 occurred on March 19 at 1837.4 feet or 0.1 foot below the base of the Annual Flood Control and Multiple Use Zone. The average annual inflow of 34,600 cfs was 150 percent of average. The average annual release of 33,900 cfs was 156 percent of average.

4. Oahe and Big Bend Regulation – January to December 2018

a. General

Oahe, the second largest Corps storage reservoir, serves all authorized purposes. Oahe's primary functions are (1) to capture snowmelt and localized rainfall runoff from the large drainage area between the Garrison and Oahe dams, which are metered out at controlled release rates to meet the authorized purposes, while reducing flood damages in the Oahe to Big Bend reach, especially in the urban Pierre and Fort Pierre areas; (2) to serve as a primary storage location for water accumulated in the System from reduced System releases due to major downstream flood control regulation, thus helping to alleviate large reservoir level increases in Big Bend, Fort Randall and Gavins Point; and (3) to provide water needed to meet all authorized purposes that draft storage during low-water years, particularly downstream water supply and navigation. In addition, hourly and daily releases from Big Bend and Oahe fluctuate widely to meet varying power loads. Over the long term, their release rates are geared to back up navigation releases from Fort Randall and Gavins Point in addition to providing storage space to permit a smooth transition in the scheduled annual fall drawdown of Fort Randall. Big Bend, with less than 2 MAF of total storage, is primarily used for hydropower production, so releases from Oahe are generally passed directly through Big Bend.

Table 10 lists the average monthly inflows and releases and the EOM pool elevation for Oahe for 2017 and 2018 as well as the averages since the System first filled in 1967.

A settlement agreement was approved in an order of dismissal by the United States District Court, District of South Dakota on August 8, 2003, in the case of Lower Brule Sioux Tribe et al. v. Rumsfeld, et al. (Civil No. 02-3014 (D.S.D.)). The agreement provides that the Corps will consult with the Lower Brule Tribe and the Crow Creek Sioux Tribe during any review and revision of the Master Manual. This agreement also provides that the Corps will coordinate the regulation of Big Bend and the water level of the Big Bend reservoir with the two Tribes to include the following: the Corps will normally strive to maintain a Big Bend pool level between elevation 1419.0 feet and 1421.5 feet and, when the level of the Big Bend reservoir drops below elevation 1419.0 feet or exceeds elevation 1421.5 feet, the Chief of MRBWM will provide notice to such persons as the Tribes shall designate in writing. When it is anticipated that the water level will drop below 1418.0 feet or rise above 1422.0 feet or, in the event the water level falls below 1418.0 feet or rises above 1422.0 feet, the Commander, NWD, or his designee, shall immediately contact the Chairpersons of the Tribes or their designees to notify them of the situation and discuss proposed actions to remedy the situation. During 2018 the Big Bend reservoir level varied in the narrow range between elevations 1419.0 feet to 1421.5 feet. As per the settlement agreement, no additional coordination was necessary.

Table 10
Oahe – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2018	2017	1967-2017	2018	2017	1967-2017	2018	2017	1967-2017
January	23,300	18,700	22,600	24,600	18,700	20,800	1606.4	1607.9	1599.3
February	26,300	16,400	26,600	17,600	16,400	18,200	1607.8	1608.0	1600.9
March	28,400	19,000	30,400	21,000	19,000	18,200	1609.1	1607.8	1603.3
April	33,600	26,100	27,000	27,900	26,100	21,100	1610.3	1608.3	1604.3
May	40,400	24,100	28,300	34,100	24,100	21,900	1611.1	1609.8	1605.3
June	54,000	31,500	31,000	35,600	31,500	26,700	1614.3	1610.3	1605.7
July	61,200	33,200	28,500	43,300	33,200	30,900	1617.2	1610.2	1604.9
August	48,200	29,700	26,600	53,200	29,700	33,400	1615.9	1610.6	1603.0
September	39,600	25,100	22,500	47,800	25,100	29,500	1614.0	1610.2	1601.2
October	30,100	17,500	20,400	45,900	17,500	23,700	1610.6	1609.5	1600.1
November	29,200	22,400	20,900	45,600	22,400	22,500	1607.2	1608.3	1599.5
December	23,200	22,700	20,000	22,000	22,700	20,600	1607.2	1606.6	1599.1
Annual	**36,500**	**23,900**	**25,400**	**34,900**	**23,900**	**24,000**			

Table 11 lists the average monthly inflows and releases and the EOM pool elevation for Big Bend for 2017 and 2018 as well as the averages since the System first filled in 1967.

Table 11
Big Bend – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2018	2017	1967-2017	2018	2017	1967-2017	2018	2017	1967-2017
January	22,500	17,000	20,400	23,100	17,000	20,300	1420.3	1420.8	1420.5
February	16,000	16,400	18,100	15,700	16,400	18,100	1420.5	1420.8	1420.5
March	19,900	18,200	18,800	19,600	18,200	18,700	1420.7	1420.0	1420.4
April	26,000	23,200	21,300	25,900	23,200	20,900	1420.8	1420.7	1420.5
May	31,000	22,500	22,000	31,500	22,500	21,900	1419.8	1420.2	1420.4
June	32,500	28,800	26,800	31,600	28,800	26,500	1420.4	1419.9	1420.3
July	39,200	29,200	30,100	38,300	29,200	29,700	1420.8	1420.6	1420.2
August	48,500	27,700	32,600	48,400	27,700	32,100	1420.4	1420.2	1420.2
September	44,300	22,600	28,900	43,200	22,600	28,400	1421.1	1420.4	1420.3
October	42,700	15,700	23,300	42,500	15,700	22,800	1420.9	1420.2	1420.5
November	41,800	20,200	22,200	42,100	20,200	22,100	1420.3	1420.4	1420.4
December	20,300	19,800	20,300	19,800	19,800	20,000	1420.7	1421.1	1420.5
Annual	**32,100**	**21,800**	**23,700**	**31,800**	**21,800**	**23,500**			

b. Winter Season 2017-18

No ice-induced flooding problems were experienced downstream of Oahe and Big Bend during the 2017-18 winter. On January 16 the Oahe releases were restricted for a few hours due to exceedance of the notification stage of 23 feet at the Missouri River at Farm Island streamgaging station. A minimum generation of 100 MW, which is approximately a one-unit release of 8,000 cfs, was implemented at Oahe from February 5-26. The one-unit minimum ensures that water is always flowing in the Missouri River downstream of Oahe Dam, which reduces river ice formation directly below the dam. The Missouri River conditions were closely monitored by the Corps staff.

The Oahe reservoir froze over on January 16 and was ice free on April 23.

Big Bend was regulated in the winter season to follow power-peaking requirements and thus hourly releases varied widely. The average daily release during the winter season varied between 1,600 and 32,700 cfs. The Big Bend reservoir froze over on December 25, 2017 and was free of ice on April 21, the latest date for Lake Sharpe being ice free.

c. Spring Open Water Season 2018

Except for the far western portions of South Dakota, precipitation in most of the drainage area between Garrison and Oahe was either average or below average. Oahe inflows for the 3-month period were slightly below average in March and above average in April and May due to the above-average Garrison releases. March, April and May monthly inflows were 28,400 cfs (93 percent of average), 33,600 cfs (124 percent of average) and 40,400 cfs (143 percent of average), respectively. Oahe releases were also slightly above average in March (21,000 cfs; 115 percent of average), above average in April (27,900 cfs; 132 percent of average) and above average in May (34,100 cfs; 156 percent of average). The above-average releases in April and May are attributed to the increases in the service level. Early water supply forecasts indicated that an expanded service level would be required to evacuate all of the forecasted runoff above Gavins Point, so releases from Gavins Point were increased. Since Oahe is the most downstream project with significant storage, releases from Gavins Point were essentially drawing water from Oahe reservoir. The Oahe reservoir level rapidly rose 1.0 foot over the last seven days in March, but only rose 2.0 feet from March 31 to May 31 when releases were above average. The Oahe reservoir rose 2.0 feet during the critical fish spawning period from 1609.1 feet (March 31) to 1611.1 feet (May 31).

d. Summer Open Water Season 2018

During the first three weeks of June, most of the volume in the above-average inflows was attributed to the above-average releases from Garrison. Heavy rainfall on June 20 in western South Dakota over the Cheyenne River basin and moderate rainfall over and upstream of Oahe reservoir during the last three days of June increased inflows, which averaged 54,000 cfs (174 percent of average) during the month. Inflows remained above average during July, August and September, averaging 61,200 cfs (215 percent of average), 48,200 cfs (181 percent of average) and 39,600 cfs (176 percent of average), respectively. Steady, moderate rain over the last week of June in the unregulated Big Sioux River and Little Sioux River basins and an extreme rain event on June 21 in the Big Sioux River basin near Sioux Falls, SD resulted in significant rises on the lower Missouri River. Garrison was regulated to balance the use of flood storage in Garrison reservoir and the need to keep operational flexibility in the System. Thus, storage was available in Oahe reservoir to allow for reductions in releases from Gavins Point to reduce the flood risk in the lower Missouri River. Oahe releases were above average during June (35,600 cfs; 133 percent of average), but were lower than the summer months when stored flood waters were evacuated. Oahe releases were 43,300 cfs (140 percent of average) during July, 53,200 cfs (159 percent of average) during August and 47,800 cfs (162 percent of average) during September. The pool crested at 1617.2 feet on July 31, 0.2 foot into the 3-foot Exclusive Flood Control Zone. Following the crest, releases were made so that the Oahe reservoir level steadily declined 3.2 feet to 1614.0 feet by the end of September.

e. Fall Open Water Season 2017

Inflows remained above average from October through December. Inflows in October were 30,100 cfs (148 percent of average), 29,200 cfs in November (140 percent of average) and 23,200 cfs in December (116 percent of average). Average monthly releases for October were

45,900 cfs (194 percent of average), 45,600 cfs (203 percent of average) during November and 22,000 cfs (107 percent of average) during December. The December 31 pool elevation was 1607.2 feet, 0.3 foot below the base of the Annual Flood Control and Multiple Use Zone.

f. Summary

The highest 2018 Oahe midnight reservoir level of 1617.2 feet occurred on July 31, 0.2 foot above the base of the Exclusive Flood Control Zone. The 2018 minimum midnight pool elevation of 1605.8 feet occurred on January 16, 1.7 feet below the base of the Annual Flood Control and Multiple Use Zone. Oahe's 2018 average annual inflow was 36,500 cfs, 144 percent of average. Oahe's 2018 average annual release was 34,900 cfs, 145 percent of average. Big Bend's annual minimum midnight pool elevation of 1419.6 feet was recorded on June 8 and the annual maximum midnight pool elevation of 1421.3 feet was recorded on December 12.

5. Fort Randall Regulation – January to December 2018

a. General

Fort Randall, the fourth largest System reservoir, serves all authorized purposes. Fort Randall's primary functions are: (1) to capture snow and localized rainfall runoffs in the drainage area between Big Bend and Fort Randall dams, which are metered out at controlled release rates to meet the authorized purposes while reducing flood damages in the Fort Randall reach where several areas have homes and cabins in close proximity to the river; (2) to serve as a primary storage location along with the upstream projects for water accumulated in the System when System releases are reduced due to major downstream flood control regulation, thus helping to alleviate large pool increases in the very small Gavins Point Project; (3) to store the water necessary to increase winter hydropower energy by implementing an annual fall drawdown of the reservoir with a winter reservoir refilling that is unique to Fort Randall; and (4) to provide water needed to meet all authorized purposes, particularly navigation and downstream water supply, that draft storage during low-water years.

Table 12 lists the Fort Randall average monthly inflows and releases in cfs and the EOM pool elevation in feet for 2017 and 2018 as well as the historic averages since the System was first filled in 1967.

b. Winter Season 2017-18

No reports of ice-affected flooding on the Missouri River below Fort Randall were recorded during the 2017-18 winter season. Fort Randall's average daily winter release ranged from 13,800 to 24,000 cfs. The Fort Randall reservoir froze over on December 31 and was free of ice on April 12. This date tied the record for the second latest ice-free date (1969). The record latest date was set on April 14, 1960.

Table 12
Fort Randall – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2018	2017	1967-2017	2018	2017	1967-2017	2018	2017	1967-2017
January	28,100	14,900	22,000	18,600	14,900	15,300	1347.8	1346.0	1347.0
February	18,000	11,600	20,100	15,700	11,600	13,400	1348.3	1353.4	1351.9
March	26,500	18,200	21,600	16,000	18,200	15,800	1357.2	1355.1	1356.0
April	31,600	26,000	23,800	30,000	26,000	21,200	1358.6	1356.0	1357.6
May	37,300	25,200	24,900	37,200	25,200	25,000	1358.0	1356.1	1357.3
June	39,600	32,700	29,600	33,500	32,700	28,500	1362.0	1355.4	1357.8
July	43,300	30,800	31,300	48,300	30,800	32,500	1358.1	1356.0	1356.6
August	53,500	29,400	33,800	54,100	29,400	34,700	1357.2	1357.1	1355.5
September	46,900	30,000	29,700	52,600	30,000	34,500	1352.6	1353.1	1351.3
October	45,400	26,300	23,100	52,300	26,300	32,100	1346.4	1343.9	1343.4
November	44,000	27,000	22,100	53,000	27,000	28,600	1337.4	1338.3	1337.0
December	24,300	20,800	21,200	21,400	20,800	17,300	1340.5	1338.8	1340.9
Annual	**36,500**	**24,400**	**25,300**	**36,100**	**24,400**	**24,900**			

c. Spring Open Water Season 2018

The Fort Randall pool elevation was 1348.3 feet on February 28. The pool level rose to its typical spring and summer pool level of 1355.2 feet by late March. Releases were adjusted as needed to back up System releases from Gavins Point and to maintain the Gavins Point pool in the desired range. The average March release of 16,000 cfs was 101 percent of average and the average April release of 30,000 cfs was 142 percent of average. These releases corresponded with inflows of 26,500 cfs in March (123 percent of average) and 31,600 cfs in April (133 percent of average). During May, Fort Randall average inflows were 37,300 cfs (150 percent of average) and releases averaged 37,200 cfs (149 percent of average).

d. Summer Open Water Season 2018

Inflows averaged 39,600 cfs in June (134 percent of average), 43,300 cfs in July (138 percent of average), and 53,500 cfs in August (158 percent of average). Releases from Fort Randall averaged 33,500 cfs in June (118 percent of average), 48,300 cfs in July (149 percent of average) and 54,100 cfs in August (156 percent of average). September releases averaged 52,600 cfs (152 percent of average) to back up System releases from Gavins Point. September inflows averaged 46,900 cfs (158 percent of average). When Gavins Point releases were reduced in late June to reduce flood risk downstream of Gavins Point, a corresponding reduction was made at Fort Randall. Some of the reduction volume was stored in Fort Randall, which caused the reservoir level to rise to 1362.4 feet on July 5. The reservoir was then slowly drawn down and reached its typical elevation of 1355.2 feet by September 12.

A daily hydropower peaking pattern is typically established at Fort Randall during the nesting season to provide flexibility to regulate over a range of releases while minimizing impacts to T&E species nesting below the project. A hydropower peaking pattern was not conducted during this year's nesting season. Due to multiple unit outages beginning in March and higher-than-average releases due to the higher-than-average upper basin runoff and resulting higher-than-average releases from upstream System projects, releases from Fort Randall remained steady throughout the day.

e. Fall Open Water Season 2018

Normal regulation of Fort Randall includes the lowering of the pool level during the fall, reaching 1337.5 feet by the end of the navigation season, 17.5 feet below the normal summer level, to make room for capture of winter powerplant releases from the upper reservoirs. During a full navigation season, the pool is maintained above 1353.0 feet through the Labor Day weekend before starting the lowering of the pool. Inflows and releases were above average during the October-December period. On August 31, the pool level was 1357.2 feet, 4.2 feet above the typical pool elevation for that time of year. The lowering of Fort Randall pool started after Labor Day and reached its lowest 2018 level of 1337.0 feet on November 27.

f. Summary

The highest 2018 Fort Randall midnight reservoir level of 1362.4 feet occurred on July 5. The lowest 2018 midnight reservoir level was 1337.0 feet on November 27. The average annual inflow was 36,500 cfs, 144 percent of average and the average annual release was 36,100 cfs, 145 percent of average.

6. Gavins Point Regulation – January to December 2018

a. General

Gavins Point, the most downstream of the System projects, is primarily used for flow re-regulating to smooth out the release fluctuations of the upper projects to better serve downstream purposes. With a total storage of 428,000 acre-feet (AF), it provides only a small amount of flood control and is generally maintained in a narrow reservoir elevation band between 1205.0 and 1208.0 feet. Due to the limited storage, releases from Gavins Point must be backed up with releases from the upper reservoirs. Gavins Point is the key location in the initiation of release reductions for downstream flood control. Even though it has only a small amount of storage space for flood control, this volume is usually adequate to perform significant downstream flood control by coordinating Gavins Point release reductions with the upstream projects. Releases greater than the powerplant capacity, normally near 35,000 cfs, are passed through the spillway.

Table 13 lists the Gavins Point average monthly inflows and releases and the EOM pool elevation for 2017 and 2018 as well as the historic averages since the System was first filled in 1967.

Table 13
Gavins Point – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2018	2017	1967-2017	2018	2017	1967-2017	2018	2017	1967-2017
January	21,500	17,100	17,400	20,700	17,100	17,300	1206.9	1207.8	1207.5
February	18,000	16,500	16,500	18,000	17,000	17,300	1206.7	1206.5	1205.8
March	21,500	20,600	19,700	21,500	20,500	19,700	1206.6	1206.5	1205.7
April	34,200	28,500	25,000	34,000	28,500	24,800	1207.1	1206.2	1205.8
May	39,200	28,000	28,600	39,500	28,100	28,300	1205.8	1205.5	1206.1
June	37,900	33,500	31,700	37,000	33,000	31,500	1207.7	1206.3	1206.2
July	49,700	31,900	34,700	49,600	31,700	34,200	1207.4	1206.3	1206.7
August	57,300	31,300	36,400	57,300	31,000	35,900	1207.1	1206.9	1207.2
September	56,500	31,500	36,400	56,100	31,000	36,000	1207.5	1207.5	1207.6
October	56,400	28,900	34,300	56,200	28,600	34,100	1207.6	1207.8	1207.8
November	56,600	29,200	30,900	56,700	29,100	30,900	1206.8	1207.9	1207.6
December	25,300	21,400	19,300	25,600	22,500	19,400	1205.7	1204.7	1207.3

* monthly minimum of record ** monthly maximum of record

b. Winter Season 2017-18

Gavins Point releases were near average the entire winter season. Beginning on December 8, 2017 the Gavins Point release was set at 21,500 cfs. The releases were decreased to 21,000 on January 20 before being stepped down to 18,000 cfs on January 30. Releases were maintained at 18,000 cfs until the end of February. The Gavins Point reservoir froze over on December 27, 2017 and was free of ice on April 3.

c. Winter River and Ice Conditions below Gavins Point

The lowest Sioux City, IA stage recorded during the 2017-18 winter season was 8.5 feet on February 5, the same as the previous year's low stage. This drop in stage followed two nights of temperatures in the teens and two days of maximum air temperatures that were in the 20s (deg F). These conditions resulted in the formation of floating ice in the Missouri River. The first official ice sighting was near Neal North Power Plant, which is about 10 miles downstream of Sioux City, IA, on December 24, 2017. Subfreezing temperatures arrived in the Midwest in late December and produced floating ice on the Missouri River. The February 12-14 reports noted 2 to 10 percent floating and 2-6 feet in diameter pans extending downstream to Hermann, MO.

Reports of floating ice were reported in the Sioux City, IA area during three different periods: December 8-27, 2017, January 3-23 and February 6-10. Ice observers noted 5 to 80 percent floating ice with pan sizes ranging from 2 to 30 feet in diameter from Sioux City, IA downstream to the Chamois Power Plant near Chamois, MO. No reports of ice-affected flooding or lack of water supply on the Missouri River below Gavins Point were recorded during the 2017-18 winter season.

d. Spring Open Water Season 2018

The bimodal spring pulse from Gavins Point was not conducted in 2018. Since 2012, the Corps and the U.S. Fish and Wildlife Service (USFWS) have been working collaboratively with the Missouri River Recovery Implementation Committee (MRRIC) to aggressively pursue completing the recommendations laid out by the Independent Science Advisory Panel (ISAP). At the center of this effort is the development of the Missouri River Recovery Management Plan Environmental Impact Statement (MRRMP-EIS) that will establish an overarching adaptive management process for implementation of Corps actions required to avoid jeopardizing all of the listed species in the Missouri River basin. The draft EIS was released for public comment in December 2016. Since the Corps is consulting with the USFWS as this plan is being developed about what management actions are required, the agencies believed it was prudent to forego a spring pulse during the 2018 Missouri River operating season and that this suspension was not likely to have an adverse effect on the listed species. Furthermore, the MRRMP-EIS Record of Decision, finalized in November 2018, resulted in the bimodal spring pulse criteria being removed from the revised 2018 Master Manual.

Per the Master Manual, the March 15 System storage check of 56.6 MAF set navigation flow support to the full service flow level for the first half of the navigation season. Flow support for navigation typically begins on March 23 at Sioux City, IA; March 25 at Omaha, NE; March 26 at Nebraska City, NE; March 28 at Kansas City, MO; and April 1 at the mouth of the Missouri River near St. Louis, MO.

In mid-March, a service level determination was performed, based on an updated calendar year runoff forecast, System and tributary storage, and Plate VI-I of the Master Manual. The service level was increased -- from 35,000 cfs to 40,000 cfs -- on March 19, as shown on ***Figure 25AB***, for the evacuation of stored waters in anticipation of higher-than-average upper Basin runoff. System releases at Gavins Point Dam were increased from 23,000 cfs to 24,500 cfs on March 20 in response to the expanded service level. No additional increases were made to Gavins Point releases because downstream flow targets were met or exceeded at the three downstream target locations: Omaha, Nebraska City and Kansas City.

On March 27, the Gavins Point release was reduced to 22,000 cfs because the lower Missouri River forecast indicated the flow at Nebraska City would exceed the flood target, due to elevated tributary flows. After downstream tributary flows receded over the next few days, System releases at Gavins Point Dam were increased.

Based on the April 1 calendar year runoff forecast above Gavins Point, System and tributary storage levels, and Plate VI-1 of the Master Manual, the service level was increased another 5,000 cfs -- from 40,000 to 45,000 cfs -- on April 3. During early April, System releases at Gavins Point were increased from 24,000 cfs to 38,000 cfs as part of the expanded service level. By mid-April, high tributary streamflow resulted in Missouri River flows at several downstream target locations being forecast to exceed downstream expanded-service-level flood targets. Gavins Point releases were reduced to 35,000 cfs to lessen downstream high flows.

On April 16, the service level was re-evaluated based on the current System, tributary reservoir storage levels, a mid-April updated calendar year runoff forecast, and Plate VI-1 of the Master Manual. The service level was increased 5,000 cfs -- from 45,000 to 50,000 cfs -- to allow for increased flood storage evacuation. Following the increase in the service level on April 16, the Gavins Point release was decreased to 32,000 cfs because the lower Missouri River forecast indicated that the Missouri River flows at Omaha and Nebraska City would exceed the downstream flood targets per the 50,000-cfs expanded service level.

During the first week of May the Gavins Point release was maintained at 37,000 cfs. The Gavins Point release was decreased to 33,000 cfs for a two-day period to lessen downstream flooding and then increased up to 42,000 cfs on May 13 as downstream tributary flows declined. Soon after releases were increased, another precipitation event in the lower basin was forecast to result in increased tributary flows and the Missouri River at Nebraska City exceeding its expanded flood target. Therefore, the Gavins Point release was reduced 4,000 cfs on May 23 and then increased back to 42,000 cfs on May 26.

e. Summer Open Water Season 2018

During the first half of June, Gavins Point releases were maintained in a range from 42,000 to 44,000 cfs range, depending on downstream conditions. Starting on June 18, releases were reduced from 44,000 to 24,000 cfs over a five-day period to lessen downstream high flows resulting from a heavy precipitation event in the lower Basin. Even with the 20,000-cfs release reduction, the expanded flood targets were exceeded at the downstream target locations. However, additional Gavins Point releases reductions were not made because the System storage was forecast to enter the Exclusive Flood Control Zone. On June 25, based on the current System storage of 66.6 MAF (1.1 MAF below the base of the Exclusive Flood Control Zone), tributary storage, forecasted runoff above Gavins Point Dam and Plate VI-1 of the Master Manual, the service level was increased another 10,000 cfs -- from 50,000 to 60,000 cfs -- to allow for increased flood storage evacuation.

In July, the 10,000-cfs increase in the service level and downstream flow targets allowed the Gavins Point release to be stepped up from 24,000 cfs on July 1 to 50,000 cfs by July 9. Gavins Point releases were increased to 58,000 cfs by July 29 as downstream flows receded. The Gavins Point release was maintained at 58,000 cfs throughout August, with the exception of August 20-24 when 52,000 cfs was released to lessen downstream flows.

f. Fall Open Water Season 2018

Based on the September 1 System storage check, the Gavins Point winter release would be at least 17,000 cfs. During September, very heavy precipitation occurred over southeastern South Dakota, Iowa, eastern Nebraska and northern Missouri (see ***Figure 15***). Since the lower Missouri River forecast was indicating Missouri River flows would exceed the flood targets at

Omaha, Nebraska City and Kansas City, the Gavins Point release was temporarily reduced to 46,000 cfs from September 23-26.

Heavy October precipitation occurred in the lower Basin in Kansas, southern Nebraska, southwestern Iowa and northwestern Missouri. Once again, high tributary flows increased Missouri River flows above flood limits at Omaha, Nebraska City and Kansas City. The Gavins Point release was reduced from 58,000 to 46,000 cfs from October 8-11 to lessen the flow in the lower Missouri River, then returned to 58,000 cfs on October 14. The 58,000-cfs Gavins Point release was held until November 24, then reduced to 50,000 cfs on November 27. Beginning on December 2, the Gavins Point release was reduced 3,000 cfs per day until it reached 20,000 cfs on December 11, which ended navigation flow support.

g. Summary

The highest Gavins Point midnight reservoir level in 2018 was 1208.9 feet, reached on October 16. The lowest midnight reservoir level in 2018 was 1204.4 feet, reached on January 2. The average annual inflow to Gavins Point was 39,500 cfs, 11,900 cfs above average. The average annual System release was 39,400 cfs, 11,900 cfs above average.

D. <u>Non-Routine Regulation and Other Items Pertaining to System Regulation</u>

Numerous regulation activities are performed each year that, although at one time may have been considered special, are now considered routine. These include release restrictions from a particular project for a period of time to permit hydrographic surveys, to facilitate limited construction within or adjacent to the downstream channel, and to pattern releases to facilitate measurements of downstream discharges and water surface profiles. Two events that occurred recently with a connection to regulation activities are discussed in the following paragraphs.

On March 5, 2014, a takings claim was filed in the United States Court of Federal Claims by approximately 200 plaintiffs against the U.S. Army Corps of Engineers (Corps) for alleged flooding along the Missouri River from 2007 to 2013 (Ideker Farms, Inc., et al. v. U.S.). The claim was amended on October 15, 2014 adding approximately 170 new plaintiffs and CY 2014 flooding claims. The plaintiffs allege that the Corps, in the operation of the Missouri River Mainstem Reservoir System since the Master Manual was updated in 2004 and 2006, in conjunction with habitat creation efforts to comply with the 2003 Amended USFWS Biological Opinion, has caused an increase in flooding along the Missouri River. Plaintiffs contend, therefore, that through these actions the U.S. government has "taken" their property, in violation of the Fifth Amendment of the U.S. Constitution, for which they are entitled just compensation. In February 2019 the judge issued an opinion for Phase I of the trial that examined the claims of 44 representative plaintiffs and motions related to that opinion are currently being considered by the court.

On February 2, 2015, Natural Resources Defense Council and Defenders of Wildlife filed suit alleging violations of the Endangered Species Act (ESA) by the Corps, U.S. Fish and Wildlife Service (USFWS), and USBR based on operations at Fort Peck on the Missouri River and the Intake Diversion Dam on the Yellowstone River. The plaintiffs later amended their complaint in early 2015 to include allegations of violations of the Clean Water Act and National Environmental Policy Act. Three irrigation districts in Montana joined the lawsuit as defendants. On July 20, 2018, the U.S. District Court for Montana, Great Falls Division, granted the federal defendants' cross-motions for summary judgment and dismissed the claims.

E. Reservoir Elevations and Storage

Reservoir elevations and storage levels of the System reservoirs at the end of July 2018 are presented in ***Table 14*** and the same information for the end of December 2018 is presented as ***Table 15***. The upper three reservoirs, Fort Peck, Garrison and Oahe, contain nearly 90 percent of the total System storage and pool levels can vary, especially during high inflow (flood) or low inflow (drought) periods. The lower three reservoirs are generally regulated in such a manner that their pool levels do not fluctuate much from year to year. For the upper three reservoirs, the 12-month change columns for the end of July indicate that Fort Peck, Garrison and Oahe were higher than the previous year, ranging from 4.5 to 7.2 feet higher. By the end of December, Fort Peck and Garrison remained 3.2 and 2.1 feet above the base of their Annual Flood Control and Multiple Use Zones, respectively. Oahe was 0.3 foot below the base of its Annual Flood Control and Multiple Use Zone.

Table 14
Reservoir Levels and Storages – July 31, 2018

Project	Reservoir Elevation		Reservoir Storage in 1,000 AF		
	Elevation (feet)	12-Month Change (feet)	Total	Above Min. Level*	12-Month Change
Fort Peck	2246.1	+7.2	17,518	13,430	+1,649
Garrison	1850.7	+4.5	22,228	17,434	+1,652
Oahe	1617.2	+7.0	21,938	16,623	+2,435
Big Bend	1420.8	+0.2	1,687	56	+21
Fort Randall	1358.1	+2.1	3,676	2,207	+182
Gavins Point	1207.4	+1.1	359	64	+24

Table 15
Reservoir Levels and Storages – Dec 31, 2018

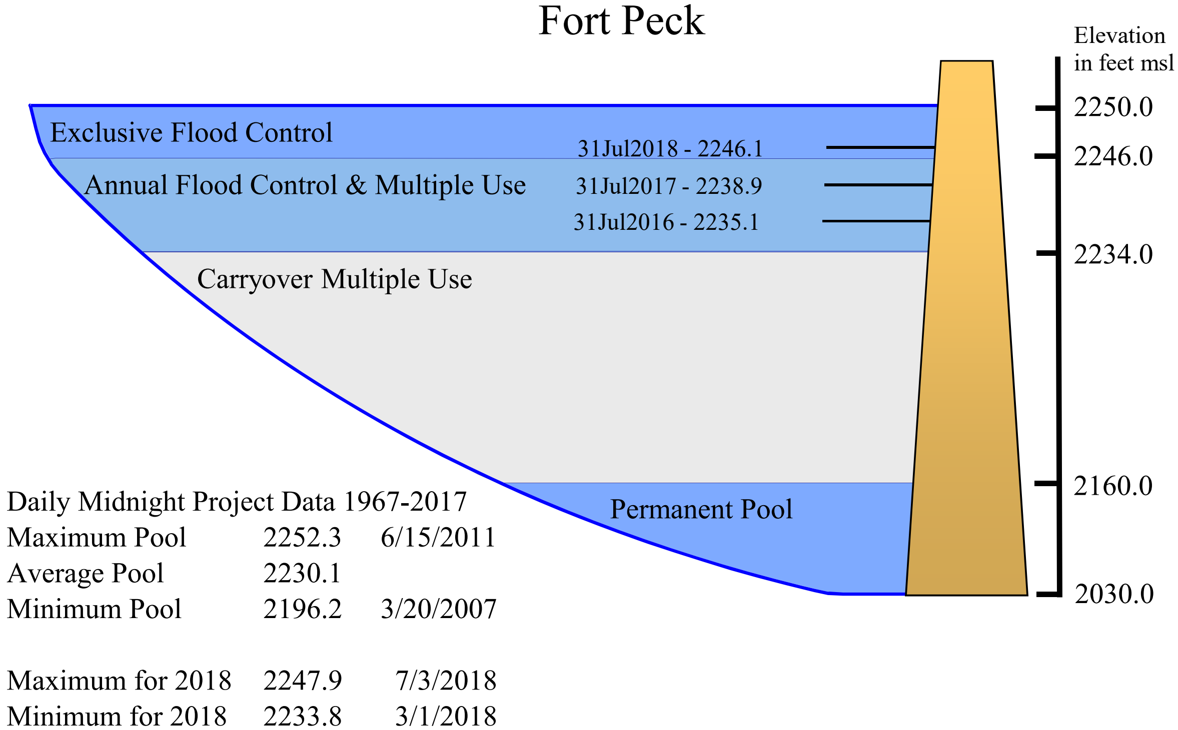
Project	Reservoir Elevation		Reservoir Storage in 1,000 AF		
	Elevation (feet)	12-Month Change (feet)	Total	Above Min. Level*	12-Month Change
Fort Peck	2237.2	+1.4	15,485	11,397	+303
Garrison	1839.6	-0.9	18,411	13,617	-302
Oahe	1607.2	+0.6	18,567	13,252	+175
Big Bend	1420.7	-0.4	1,671	40	-20
Fort Randall	1340.5	+1.7	2,361	892	+101
Gavins Point	1205.7	+1.0	320	25	+22

*Net usable storage above minimum reservoir levels established for power, recreation, irrigation diversions and other purposes.

Figures 21A and ***21B*** show the end-of-July pool elevations for Fort Peck, Garrison and Oahe plus total System end-of-July storage for 2016 through 2018. Individual tables with the historic maximum, average and minimum pool elevations for each reservoir are also shown on ***Figures 21A*** and ***21B.***

Missouri River System Reservoirs
End-of-July Pool Elevations and Total System Storage

Fort Peck



Garrison

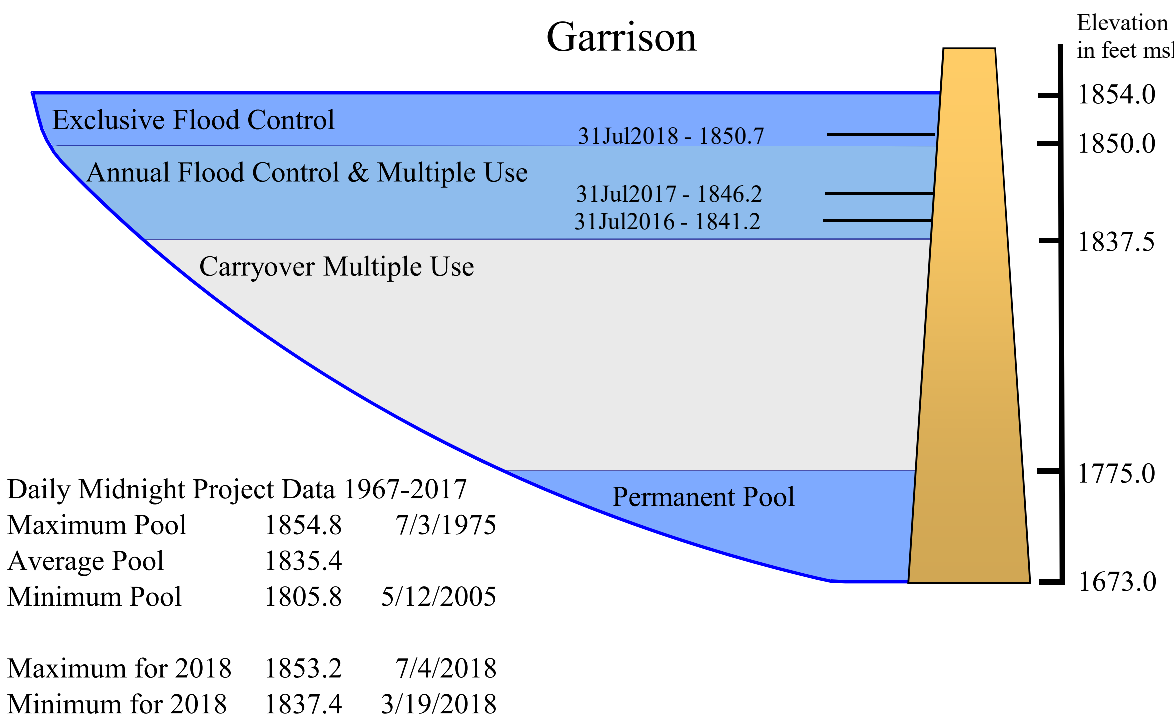
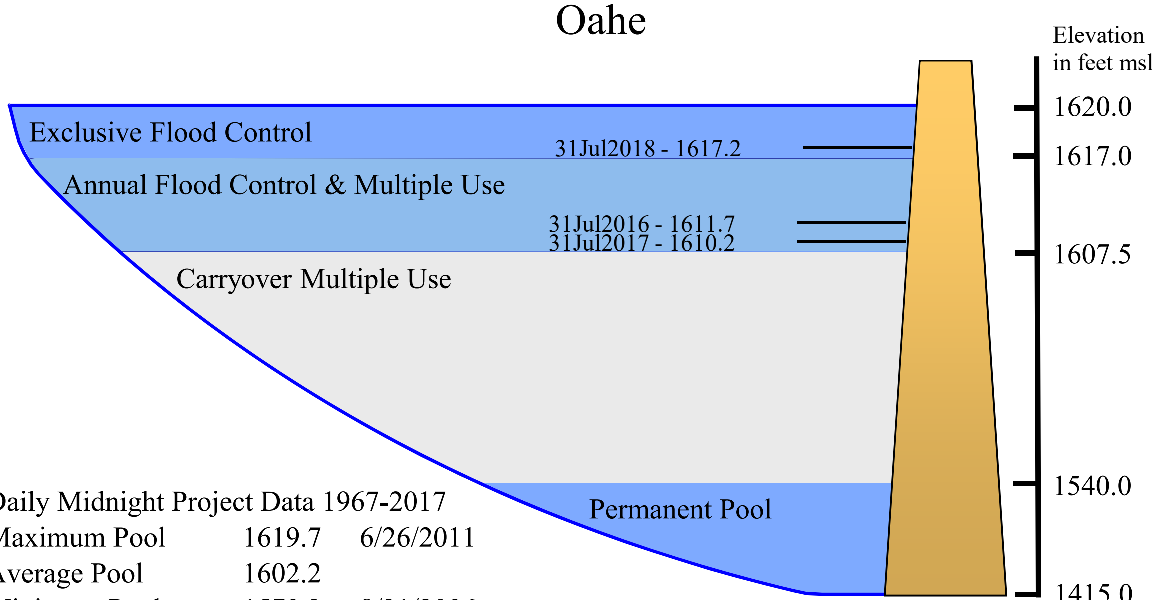


Figure 21A. End-of-July pool elevations for Fort Peck and Garrison.

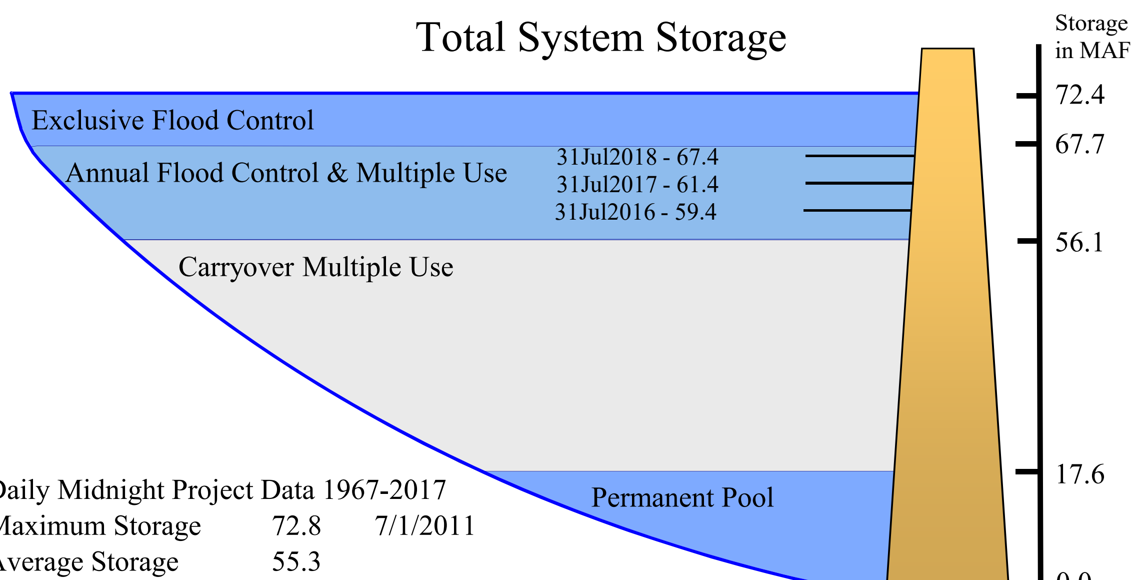
Missouri River System Reservoirs
End-of-July Pool Elevations and Total System Storage

Oahe



Daily Midnight Project Data 1967-2017		
Maximum Pool	1619.7	6/26/2011
Average Pool	1602.2	
Minimum Pool	1570.2	8/31/2006
Maximum for 2018	1617.2	7/31/2018
Minimum for 2018	1605.8	1/16/2018

Total System Storage



Daily Midnight Project Data 1967-2017		
Maximum Storage	72.8	7/1/2011
Average Storage	55.3	
Minimum Storage	33.9	2/8/2007
Maximum for 2018	68.4	7/8/2018
Minimum for 2018	56.1	1/17/2018

Figure 21B. End-of-July pool elevations for Oahe and total System storage.

F. Summary of Results

1. Flood Control

Upper basin runoff during 2018 was 42.1 MAF, the third highest runoff in 120 years of record-keeping (1898-2017). Per Plate VI-1 of the Master Manual, the service level was adjusted several times from a "full" service level of 35,000 cfs to an "expanded" service level during the spring to manage the above-average runoff. The service level determination is based on 1) current System storage, 2) current storage in 10 USBR reservoirs upstream of Oahe, and 3) forecasted annual runoff above Gavins Point. The service level was increased 5,000 cfs three times: mid-March (from 35,000 to 40,000 cfs); early April (from 40,000 to 45,000 cfs) and mid-April (from 45,000 to 50,000 cfs). The service level was increased an additional 10,000 cfs (from 50,000 to 60,000 cfs) in late June. The increase in service level does not indicate that releases from the System projects will be increased accordingly. Rather, the increase in service level increased the downstream flood targets at Omaha (from 41,000 to 66,000 cfs), Nebraska City (from 47,000 to 72,000 cfs) and Kansas City (from 71,000 to 96,000 cfs).

Operation of Federal projects during significant runoff events in the Omaha and Kansas City Districts resulted in flood damage reduction. As shown on ***Figures 16A*** through ***16C***, flows at locations downstream of the mainstem projects were significantly reduced due to operation of the mainstem reservoirs.

The total flood damages prevented by all Corps-controlled reservoir projects in the Missouri River Basin during 2018 were estimated to be about $2.2 billion ($1.8 billion Omaha District; $412 million Kansas City District). Flood damages prevented by the System reservoirs during 2018 were estimated to be $1.7 billion ($1.3 billion Omaha District; $389 million Kansas City District). The System flood damages prevented indexed to the September 2018 price level is illustrated in ***Figure 22A.*** Since 1938, the total flood control damages prevented by the System were $66.4 billion, an annual average of about $820 million, indexed to September 2018 price levels. The total un-indexed flood damages prevented at the original price levels is $37.4 billion, an annual average of about $460 million (see ***Figure 22B***). The bulk of the damages prevented occurred during the 6-year period from 1993 to 1999 and the 4-year period from 2008 to 2011. For comparison purposes, ***Figures 22A*** and ***22B*** include the construction cost of the dams. Indexed to 2018 price levels, the dams cost approximately $28.7 billion, whereas the original un-indexed cost was $1.2 billion.

Figures 16A through ***16C*** show the 2018 regulated (actual experienced) and unregulated (with no System reservoirs and tributary reservoirs) Missouri River flows downstream of Fort Peck Dam at Wolf Point, MT, downstream of Garrison Dam at Bismarck, ND, and downstream of Gavins Point Dam at Sioux City, IA, St. Joseph, MO, Boonville, MO and Hermann, MO.

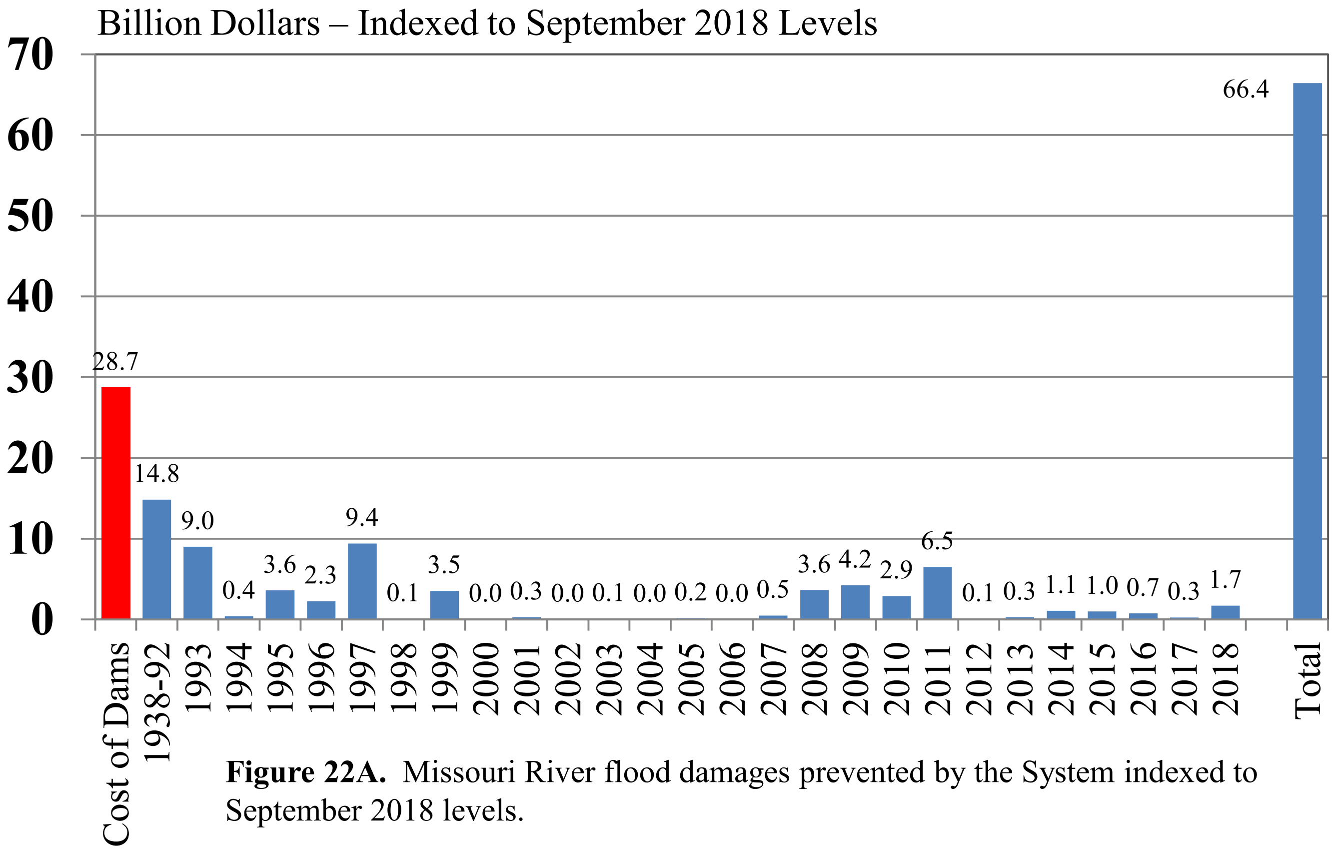


Figure 22A. Missouri River flood damages prevented by the System indexed to September 2018 levels.

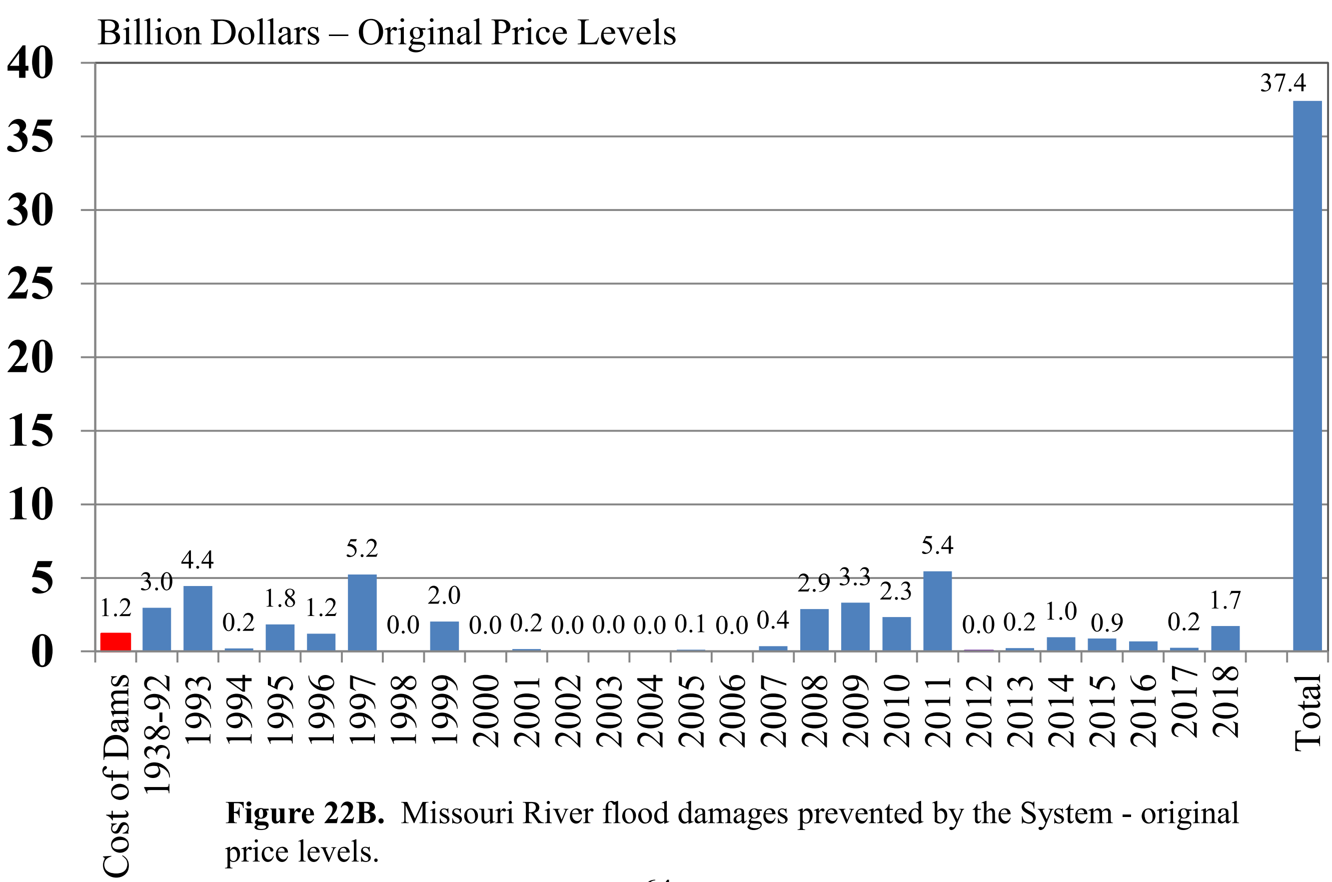


Figure 22B. Missouri River flood damages prevented by the System - original price levels.

2. Irrigation

Federally-developed irrigation projects are not being served directly from the System reservoirs. The reservoirs, however, are being utilized by numerous private irrigators as well as Federally financed projects that take water from the Missouri River. About 900 private irrigators pump directly from the reservoirs or river reaches.

3. Water Supply

Problems at municipal and industrial (M&I) intakes located in the river reaches and System reservoirs are related primarily to intake or river access problems rather than inadequate water supply. Intake owners today are generally better prepared to handle periods of low water with adjustments to intakes or regulation procedures. Some of these adjustments involve using warm water to keep ice formation from building up on intake screens; installing new pumps; lowering intakes; installing sediment redirection vanes and ice deflectors; obtaining, or arranging to obtain, alternate sources of water; and cleaning screens more thoroughly and frequently. While these remedial actions are expensive to install and operate, they significantly improved the ability of the intakes to operate at lower river stages and reservoir levels.

The September 1 storage check indicated a winter release of no less than 17,000 cfs. Releases were generally above 18,000 cfs, which did not result in any intake access issues.

4. Water Quality Control

a. Overview

During 2018 the Omaha District (NWO) conducted fixed-station ambient water quality monitoring at the mainstem reservoirs and on the lower Missouri River. Water quality conditions of the water discharged through each of the mainstem dams was continuously monitored. More detailed water quality monitoring information is available in the NWO water quality reports on the NWO website at http://www.nwo.usace.army.mil/Missions/WaterInformation/WaterQuality/Reports.aspx

NWO has identified seven priority water quality issues that have relevance to the mainstem reservoirs. These identified priority issues are:

1. Determine how regulation of the mainstem dams and reservoirs affect water quality in the impounded reservoirs. Utilize the CE-QUAL-W2 hydrodynamic and water quality model to facilitate this effort.
2. Evaluate how eutrophication is progressing in the mainstem reservoirs, especially regarding the expansion of hypoxic conditions in the hypolimnion during summer stratification.
3. Determine how flows released from mainstem reservoirs affect water quality in the downstream Missouri River. Utilize the HEC-RAS water quality model to facilitate this effort.

4. Determine how current water quality conditions in the Missouri River (e.g., water temperature, turbidity) may be affecting pallid sturgeon populations in the Missouri River.
5. Provide water quality information to support decision making (e.g., Corps reservoir regulation elements for effective surface water quality and aquatic habitat management, Tribes and States in the development of their Section 303(d) lists and development and implementation of total maximum daily loads (TMDLs) at NWO tributary projects).
6. Identify existing and potential surface water quality problems at NWO tributary projects and develop and implement appropriate solutions.
7. Evaluate surface water quality conditions and trends at NWO tributary projects.

Table 16 provides a summary of water quality issues and concerns at each of the mainstem reservoirs and the lower Missouri River based on NWO monitoring and a review of current State integrated water quality reports.

b. Occurrence of "Two-Story" Fisheries at Mainstem Reservoirs

The Fort Peck, Garrison, and Oahe reservoirs maintain "two-story" fisheries that are comprised of warmwater and coldwater species. The ability of the reservoirs to maintain "two-story" fisheries is due to their thermal stratification in the summer that allows coldwater habitat to be maintained in the deeper, colder region of the reservoir (i.e., hypolimnion). Warmwater fish species inhabit the warmer, shallower areas of the reservoirs (i.e., epilimnion), while coldwater fish species inhabit the hypolimnion. Certain coldwater fish species are used extensively as forage by both coldwater and warmwater predator fish species in the reservoirs. Coldwater forage species that inhabit the reservoirs include the rainbow smelt (*Osmerus mordax*) and lake herring/lake cisco (*Coregonus artedi*). Maintaining healthy populations of these coldwater forage fish is important to maintaining both the coldwater and warmwater recreational fisheries in the three reservoirs.

a. Bottom-Withdrawal Reservoirs

Bottom-withdrawal reservoirs have outlet structures located near the deepest part of the reservoir. During the summer thermal stratification period, bottom withdrawal releases cold water from the deep portion of the reservoir that may be hypoxic during latter periods of stratification. Hypoxic conditions in the hypolimnion can result in the release of water with low dissolved oxygen and high levels of nutrients and other constituents. Bottom outlets can cause density interflows or underflows through the reservoir and generally provide little or no direct control over the quality of the water released through the bottom withdrawal. Garrison and Fort Randall are bottom withdrawal projects with both their power and flood tunnels drawing water from the bottom of the impounded reservoirs. Fort Peck Dam has a near-bottom withdrawal (i.e., 60 feet above the reservoir bottom) for the power and flood tunnels. The power tunnels at Oahe Dam draw water at a mid-depth elevation (i.e., 114 feet above the reservoir bottom); however, the flood tunnels draw water from the bottom of the reservoir. The Big Bend and Gavins Point powerplants both draw water from the bottom of the reservoir; however, these are shallower, re-regulation projects and water drawn into the powerplants is usually fairly well mixed through the reservoir water column.

Table 16
Water Quality Issues and Concerns

Project	Total Maximum Daily Load (TMDL) Considerations*				Fish Consumption Advisories		Other Potential Water Quality Concerns
	On 303(d) List	Impaired Uses	Pollutant/Stressor	TMDL Completed	Advisory in Effect	Identified Contamination	
Fort Peck • Fort Peck Lake	Yes (MT)	Drinking Water Supply	Lead Mercury	No	Yes	Mercury	---
		Recreation	Aquatic plants - native	NA**			
• Missouri River, Fort Peck Dam to the Milk River	Yes (MT)	Aquatic Life Cold Water Fishery	Water temperature	No	No	---	---
			Degraded riparian vegetation Other flow regime alterations	NA**			
• Missouri River, Milk River to the Poplar River	Yes (MT)	Aquatic Life Warm Water Fishery	Water temperature	No	No	---	---
			Degraded riparian vegetation Other flow regime alterations	NA**			
• Missouri River, Poplar River to North Dakota	Yes (MT)	Aquatic Life Warm Water Fishery	Water temperature	No	No	---	---
			Other flow regime alterations	NA**			
Garrison • Lake Sakakawea	Yes (ND)***	Fish Consumption	Methyl-mercury	No	Yes	Mercury	Coldwater fishery during drought conditions. Tailwater dissolved oxygen levels.
• Missouri River, Garrison Dam to Lake Oahe	No	---	---	---	Yes	Mercury	Low dissolved oxygen in Garrison Dam tailwaters (associated with late summer hypolimnetic lake withdrawals).
Oahe • Lake Oahe	Yes (SD)	Coldwater Permanent Fish Life Fish/Wildlife Propagation Recreation Stock Watering	Mercury in Fish Tissue	Yes	Yes	Mercury	Fish consumption advisory issued by North Dakota and Cheyenne River Sioux Tribe for Lake Oahe. TMDL completed by South Dakota for Mercury in Fish Tissue.
Big Bend • Lake Sharpe	Yes	Coldwater Permanent Fish Life	Temperature Dissolved Oxygen	No	No	---	TMDL completed for sediment. A nonpoint source management project is being implemented in the Bad River watershed.
Fort Randall • Lake Francis Case	No	---	---	---	No	---	Low dissolved oxygen in Fort Randall Dam tailwaters (associated with late summer hypolimnetic reservoir withdrawals).
• Missouri River, Fort Randall Dam to Lewis and Clark Lake	Yes (NE)	Warmwater Aquatic Life (NE)	Mercury in Fish Tissue (NE)	No	Yes (NE)	Mercury	Fish consumption assessment completed by Nebraska
Gavins Point • Lewis and Clark Lake	Yes (NE)	Aquatic Life (NE)	*E. coli* (NE) Chlorophyll-a (NE)	No	No	---	Sedimentation. Emergent aquatic vegetation.
• Missouri River, Gavins Point Dam to the Big Sioux River	Yes (NE)	Recreation Drinking Water Supply	*E. coli* Sulfate	No	No	---	Reduced suspended sediment and turbidity impacts to pallid sturgeon. Assimilative capacity and flow reduction.
• Missouri River, Big Sioux River to Platte River	Yes (NE)	Recreation Drinking Water Supply	*E. coli* Sulfate	No	No	---	Reduced suspended sediment and turbidity impacts to pallid sturgeon. Assimilative capacity and flow reduction.
• Missouri River, Platte River (NE) to NE-KS Stateline	Yes (MO, NE)	Recreation Aquatic Life	*E. coli* Mercury in Fish Tissue	Yes (NE)	Yes (NE)	---	Reduced suspended sediment and turbidity impacts to pallid sturgeon. Assimilative capacity and flow reduction.

* Information taken from published state integrated water quality reports and impaired waters 303(d) listings as of January 1, 2019.

** Impairment identified in Montana's integrated report, but not on 303(d) list for development of a TMDL.

*** Delisted in 2010 for impairment of the designated use "Fish and other Aquatic Biota" (warm water temperature and low dissolved oxygen) when Lake Sakakawea pool elevations recovered from drought conditions.

a. Fort Peck Reservoir

Fort Peck reservoir is not assigned a coldwater fishery use by the State of Montana in their water quality standards. However, the reservoir supports a stocked put-grow-take salmon fishery and a naturally reproducing lake trout (*Salvelinus namaycush*) and lake cisco fishery; all are considered coldwater species. Since a coldwater fishery is currently supported in Fort Peck reservoir, it is seemingly an existing use to be protected pursuant to the anti-degradation provisions of the Federal Clean Water Act (40 CFR 131.3).

Dissolved oxygen concentrations below Montana's 5 mg/L, 7-day mean minimum water quality standard were monitored at the Fort Peck powerplant for the first time in 2012. A special water quality study was conducted by NWO in 2012 to evaluate the situation. When monitored on September 25, the area immediately downstream of the dam to just beyond the energy dissipation structures was below 5 mg/L dissolved oxygen, while the area from just downstream of the energy dissipation structures through the dredge cuts area was just above 5 mg/L. During 2013-2018 dissolved oxygen in the water discharged through the Fort Peck powerplant has remained above the 5 mg/L minimum water quality standard with minimum instantaneous values of 5.4 mg/L (2013), 6.1 mg/L (2014), 5.9 mg/L (2015), 6.5 mg/L (2016), 6.4 mg/L (2017), and 9.9 mg/L (2018). The situation will continue to be evaluated to determine if corrective measures to meet State water quality standards may be needed.

b. Garrison Reservoir

The State of North Dakota's water quality standards classifies Garrison reservoir as a coldwater fishery. To protect the coldwater fishery use the State has promulgated the following water quality standards for Garrison reservoir--a water temperature criterion of ≤ 59 deg F (or 15 degrees C), a dissolved oxygen criterion of ≥ 5 mg/L, and a minimum reservoir volume of 500,000 AF (0.5 MAF) that meets these criteria.

Water temperature and dissolved oxygen depth profiles that were measured during water quality monitoring conducted at Garrison reservoir over the 2014-2018 5-year period were used to estimate the volume of water in the reservoir that meets the coldwater fishery habitat conditions defined by the State of North Dakota. ***Plate 3*** shows estimated reservoir and coldwater fishery habitat volumes, by year, for 2014 through 2018. Water quality monitoring in 2018 indicates that North Dakota's 0.5 MAF minimum water quality standards criterion for coldwater fishery habitat was seemingly met; however, temporal variability in data collected at Garrison does allow for some uncertainty in this measurement.

To better assess the occurrence and support of coldwater fishery habitat in Garrison reservoir the NWO is currently updating their CE-QUAL-W2 hydrodynamic and water quality modeling of the reservoir. A comprehensive water quality report of Garrison reservoir, including application of the CE-QUAL-W2 model and how Corps regulation of the dam and reservoir influence water quality conditions can be found at the Omaha District Water Quality Sections website.

Dissolved oxygen concentrations below North Dakota's 5 mg/L water quality standard have been monitored in late summer at the Garrison powerplant. To date, there is no evidence of current or past fish kills in the Garrison tailwaters. A Special Water Quality Study of the situation is being considered, and the situation will continued to be evaluated to determine if corrective measures to meet State water quality standards may be needed.

c. Oahe Reservoir

South Dakota's water quality standards protect Oahe for a Coldwater Permanent Fish Life Propagation (CPFLP) use (i.e., coldwater fishery). As such, a water temperature criterion of ≤ 65 deg F (or 18.3 degrees C) and a dissolved oxygen criterion of ≥ 6 mg/L have been promulgated by South Dakota to protect the coldwater fishery of Oahe.

The occurrence of coldwater fishery habitat (i.e. water temperature ≤ 18.3 degrees C and dissolved oxygen ≥ 6 mg/L) in Oahe was estimated from water quality monitoring conducted over the 5-year 2014-2018 period. ***Plate 4*** shows estimated reservoir and coldwater fishery habitat volumes, by year, for 2014 through 2018. At least 2 MAF of coldwater fishery habitat was present in Oahe for all years.

d. Big Bend Reservoir

The State of South Dakota classifies Big Bend for a CPFLP use and currently lists the designated coldwater fishery as impaired due to warm water temperatures and low dissolved oxygen levels, and targets the reservoir for development of a Total Maximum Daily Load (TMDL) in the near future. South Dakota should consider reclassification of Big Bend Reservoir from a coldwater fishery to a warmwater fishery based on a use attainability assessment of "natural conditions". Natural summer water temperatures of the Oahe powerplant discharge, especially during lower pool levels, do not meet the temperature requirements for a CPFLP use in Big Bend.

e. Fort Randall Reservoir

Hypolimnetic water is passed through Fort Randall Dam during power production in the summer and dissolved oxygen levels in the Fort Randall Dam tailwaters fall below South Dakota's water quality standards' minimum dissolved oxygen criterion of 5 mg/L for protection of the designated Warmwater Permanent Fish Life Propagation (WPFLP) use. The low dissolved oxygen levels in the tailwaters are not impairing the designated WPFLP use as regions of refugia exist in the impacted area, and there is no evidence of current or past summer fish kills in the tailwaters attributable to low dissolved oxygen levels. If warranted, low dissolved oxygen levels in the Fort Randall tailwaters, during periods of hypolimnetic releases, could be mitigated by spilling surface water with higher dissolved oxygen concentrations down the spillway. The situation will continue to be evaluated to determine if corrective measures to meet South Dakota’s water quality standards may be needed.

f. Gavins Point Reservoir

Gavins Point reservoir is currently identified as impaired by the State of Nebraska in their 303(d) listing of impaired waters. Nebraska identifies impairment to the use of aquatic life due to high chlorophyll-a levels. Of the six mainstem reservoirs, Gavins Point is exhibiting the most impact from nutrient loading and eutrophication. Eutrophication concerns at Gavins Point will likely increase as the reservoir continues to age. The current estimated volume loss of the Carryover Multiple Use Pool Zone (29 percent) in Gavins Point exceeds the State of Nebraska’s criterion (25 percent volume loss) for listing the reservoir as impaired for aesthetics. Gavins Point is not currently listed as impaired for sedimentation by the State of Nebraska.

5. Navigation

a. Barge Traffic

System releases provide navigation flow support in the Missouri River Bank Stabilization and Navigation Project (BSNP). Minimum navigation flow support, which is 6,000 cfs below full service, provides flow to ensure a minimum 8-foot channel depth. Full service navigation flow support provides flow to ensure a minimum 9-foot deep and 300-foot wide channel in the BSNP. Navigation flow support for the first half of the season is determined by the March 15 System storage check. Navigation flow support for the second half of the season, as well as season length, is determined by the July 1 System storage check. System releases are set to meet navigation target flows at four Missouri River locations – Sioux City, Omaha, Nebraska City and Kansas City.

Based on the March 15 System storage of 56.6 MAF, navigation flow support was at a full service level for the first half of the navigation season.

System storage on April 1 was 58.4 MAF, 2.3 MAF above the base of the Annual Flood Control and Multiple Use Zone. Based on the April 1 calendar year runoff forecast above Gavins Point, System and tributary storage, and Plate VI-1 of the Master Manual, the service level was increased, or expanded, from 40,000 cfs to 45,000 cfs. Although the service level was increased, release from Gavins Point ranged from 22,000 to 24,600 cfs during late March to reduce flood risk along the lower Missouri River while flows in tributaries downstream of Gavins point remained high. Gavins Point releases averaged 34,000 cfs in April.

The expanded service level was increased to 25,000 cfs above the full service level in late June. Based on the July 1 System storage of 67.8 MAF, the second half of the season included a 10-day extension to normal season length for flood storage evacuation.

On March 6, the year's first commercial load entered the Missouri River at St. Louis, MO. The Corps' Missouri River Project Office at Napoleon, MO recorded 31 loads into the Missouri River before April 1, when navigation flow supports begins. The last commercial tow taken off the Missouri River occurred on December 7.

b. Tonnage

Table 17 shows the final Missouri River tonnage data for 2013-17 compiled by the Waterborne Commerce Statistics Center (WCSC). Final navigation data is generally one year behind the summary report reporting year because the WCSC needs an extended period of time to compile the data. The 2017 total of 4.957 million tons includes 4.019 million tons for sand and gravel, 0.216 million tons for waterways materials, and 0.736 million tons for long-haul commercial tonnage. In 2017 the total tonnage increased by 0.301 million tons compared to 2016. The long-haul tonnage at 0.736 million tons is an increase of 0.177 million tons from 2016. The largest long-haul commercial tonnage, excluding sand, gravel and waterway material, occurred in 1977 at 3.34 million tons. ***Figure 23A*** shows total navigation tonnage on the Missouri River. ***Figure 23B*** shows the long-haul commercial navigation tonnage not including sand, gravel and waterway materials. The long-haul commercial tonnage in 2018 is estimated at 0.679 million tons, based on carrier interviews, towboat activity and barge counts from the Corps' daily boat reports. ***Figure 24A*** shows the navigation tonnage value of the commodities since 1960, using 2018 present-worth computations. ***Figure 24B*** shows the navigation tonnage value of long-haul commercial commodities since 1960. The 2018 commodity data is currently being gather and will computation will be completed. The ***Figures 23A***, ***23B***, ***24A*** and ***24B*** tonnages and tonnage values for 2018 are estimates and will change once final WCSC tabulations are available.

Navigation season target flows for past years are presented in ***Table 18***. ***Table 19*** shows the scheduled lengths of past System-supported navigation seasons, with total tonnage and ton-miles for each year. ***Figures 25A*** and ***25B*** present flows at the four navigation flow-target locations. There was no navigation support from the Kansas River projects in 2018.

Table 17
Missouri River Tonnage by Commodity (1,000 Tons)

Commodity Classification Group	**2013**	**2014**	**2015**	**2016**	**2017**
Farm Products	12	53	50	231	330
Corn	0	9	34	97	168
Wheat	0	0	3	2	3
Soybeans	12	44	13	133	140
Misc Farm Product	0	0	0	0	18
Nonmetallic Minerals	3,664	4,113	3,946	3,826	4,019
Sand/Gravel	3,609	4,072	3,901	3,807	4,004
Misc Nonmetallic	55	41	45	19	14
Food and Kindred	0	7	0	0	0
Pulp and Paper	0	0	0	0	0
Chemicals	53	64	72	140	125
Fertilizer	53	64	72	140	125
Other Chemicals	0	0	0	0	0
Petroleum (including coke)	54	44	13	68	73
Stone/Clay/Glass	71	85	83	98	98
Primary Metals	0	0	6	3	12
Waterway Materials	251	305	232	290	216
Other (Misc Mineral Prod)	0	0	0	0	84
Total Commercial	4,105	4,671	4,402	4,656	4,957
Total Long-Haul Commercial	245	293	269	559	736

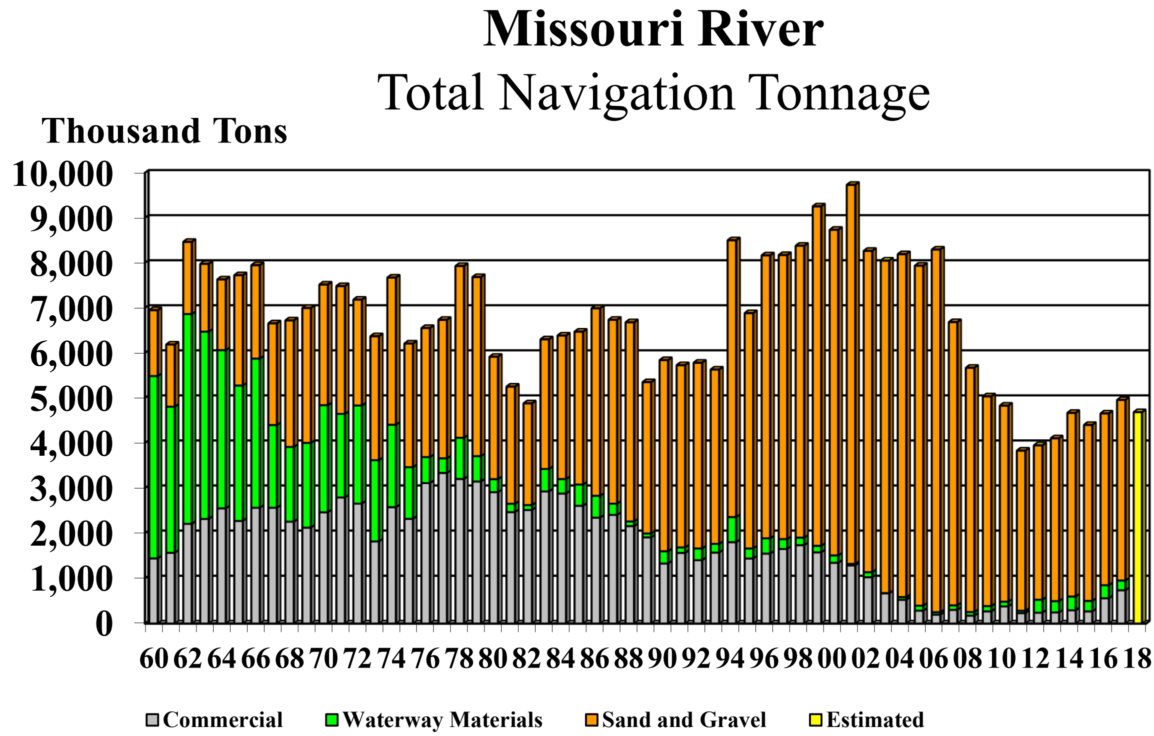


Figure 23A. Missouri River total navigation tonnage from 1960 to 2018 (estimated).

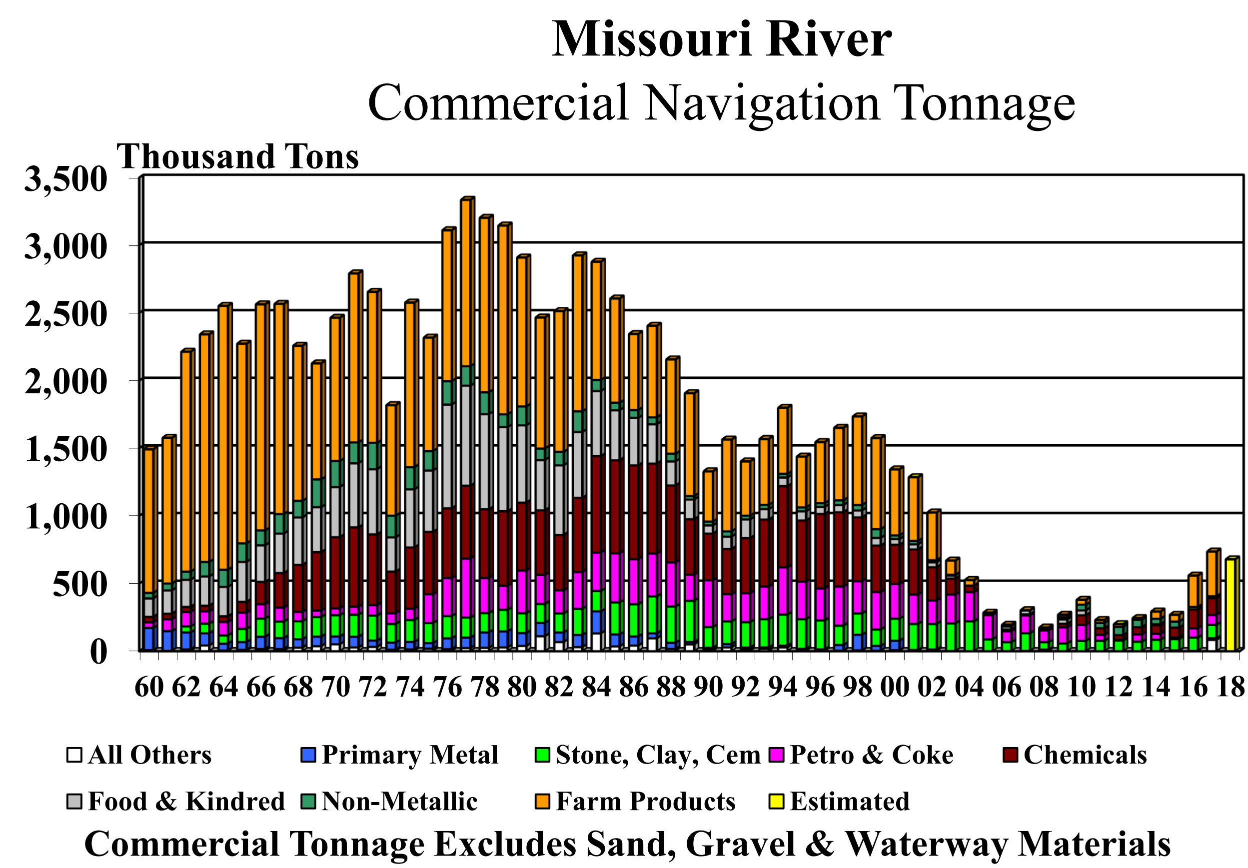


Figure 23B. Missouri River commercial navigation tonnage from 1960 to 2018 (estimated).

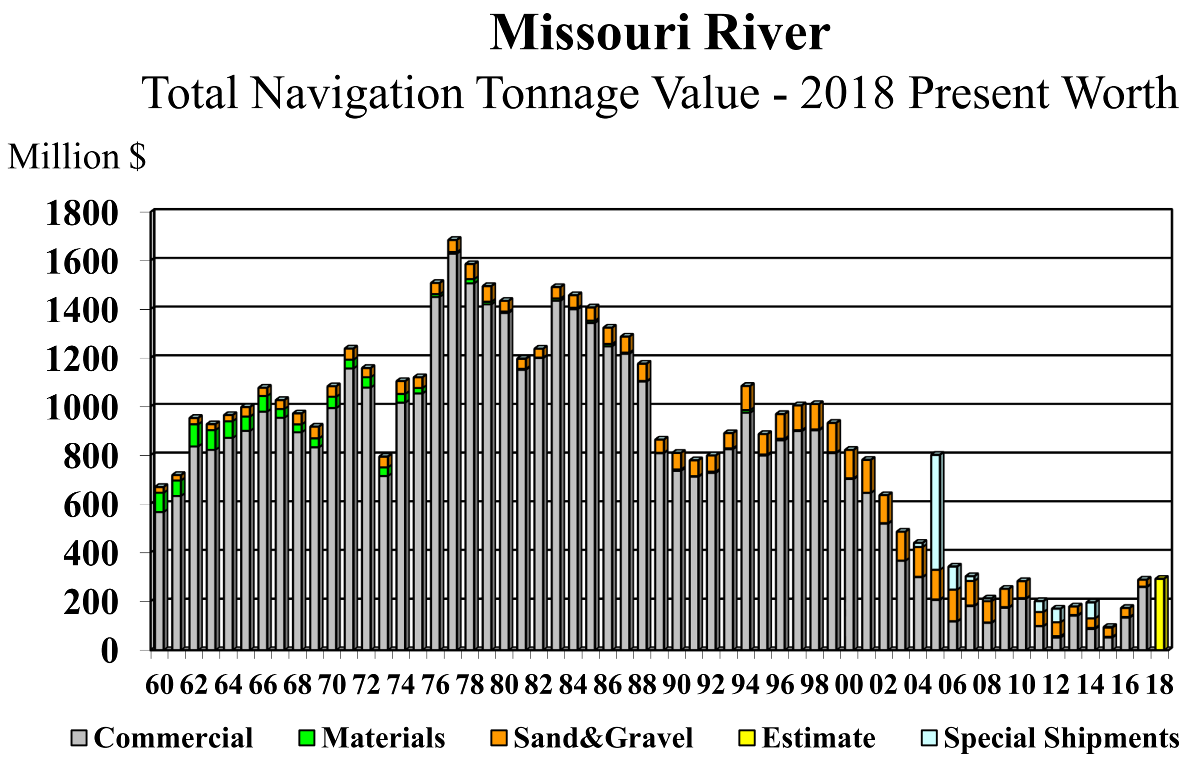


Figure 24A. Total navigation tonnage value using 2018 present worth computations.

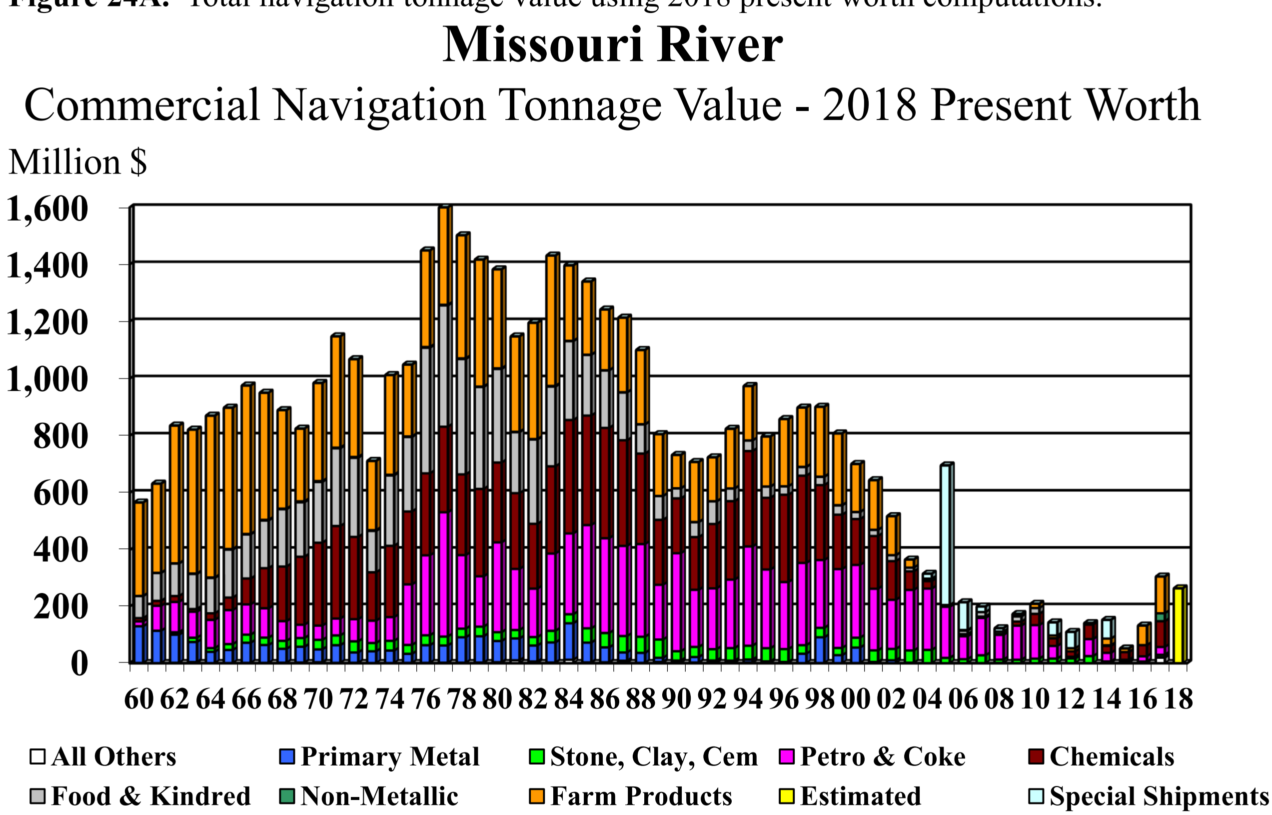


Figure 24B. Commercial navigation tonnage value using 2018 present worth computations.

Table 18
Navigation Season Target Flows
(1,000 cfs)

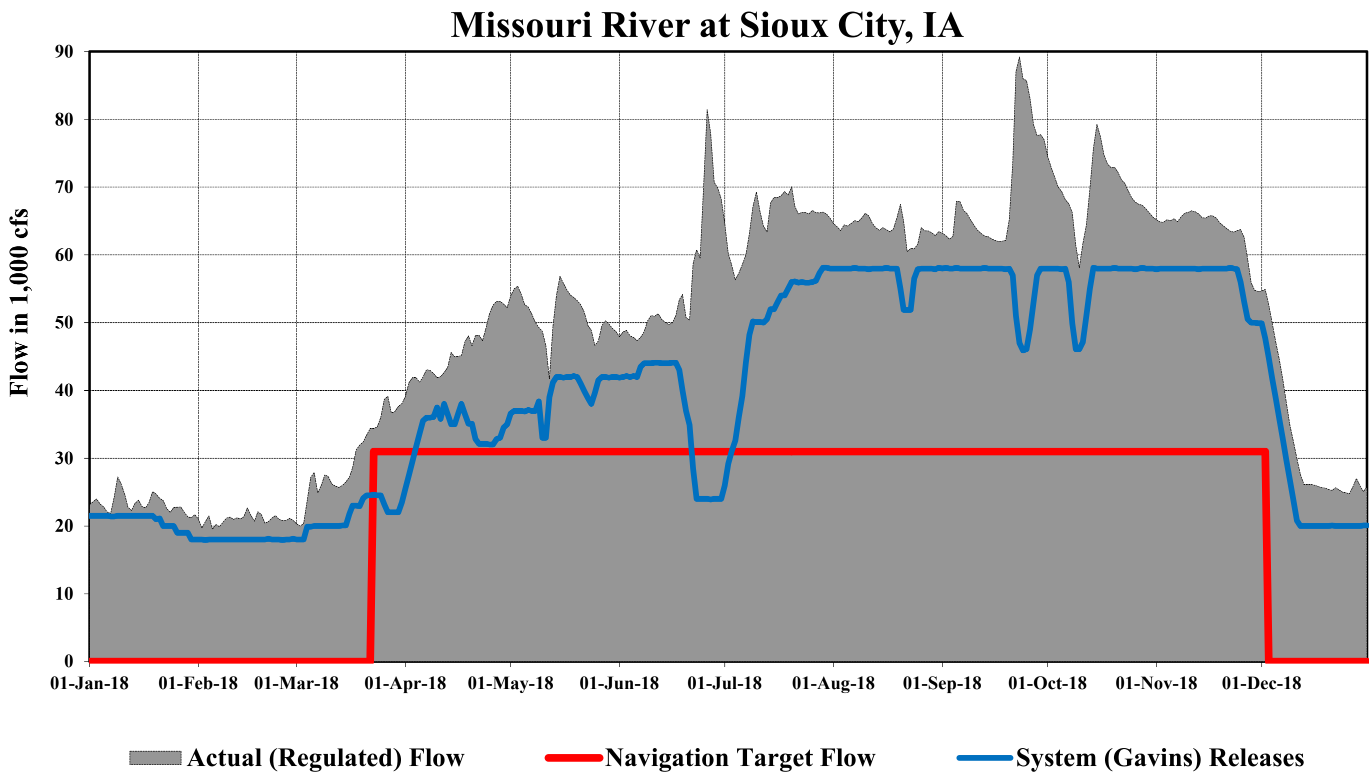
Year	Months	Sioux City	Omaha	Nebraska City	Kansas City
1967	Apr-Jun	28	28	34	38
	Jul-Nov	31	31	37	41
1968	Apr-Nov	31	31	37	41
1969	Apr-Jun(1)	35-40	35-40	41-46	45-50
	Jul(1)	36	36	42	46
	Aug-Sep(1)	50-55	50-55	55-60	55-60
	Oct-Nov(1)	40-45	40-45	45-50	50-55
1970	Apr-May	31	31	37	41
	May-Sep(1)	36	36	42	46
	Oct-Nov(1)	40	40	46	50
1971	Apr-May(1)	36	36	42	46
	May-Nov(1)	45-50	45-50	50-55	55-60
1972	Apr-Nov(1)	40-50	40-50	45-55	50-60
1973-74	Apr-Nov	31	31	37	41
1975	Apr	31	31	37	41
	May-Nov(1)	35-60	35-60	41-66	45-70
1976	Apr-Jul(1)	34-38	34-38	40-44	44-48
	Aug-Dec(1)	31-34	31-34	37-40	41-44
1977	Apr-Nov	31	31	37	41
1978	Apr	31	31	37	41
	May-Jul(1)	35-46	35-46	41-52	45-56
	Aug-Nov(1)	46-51	46-51	52-57	56-61
1979	Apr-Jul(1)	36-42	36-42	42-48	46-52
	Aug-Nov(1)	31-36	31-36	37-42	41-46
1980	Apr-Nov	31	31	37	41
1981	Apr-Nov(2)	31	31	37	41
1982	Apr-Sep	31	31	37	41
	Oct	31-36	31-36	37-42	41-46
	Nov-Dec(1)	36-46	36-46	42-52	46-56
1983	Apr-Jun	31	31	37	41
	Jul	31-36	31-36	37-42	41-46
	Aug-Nov(1)	36	36	42	46
1984	Apr-Jun	31	31	37	41
	Jul-Dec(1)	31-44	31-44	37-50	41-54
1985	Apr-Dec	31	31	37	41
1986	Apr(1)	36-41	36-41	42-47	46-51
	May-Dec(1)	41-46	41-46	47-52	51-56
1987	Apr-Nov	31	31	37	41
1988	Apr-Nov(2)	31	31	37	41
1989	Apr-Aug(3)	28	28	34	38
	Sep-Oct(3)	28	28	34	35
1990-93	Apr-Oct(4)	25	25	31	35
1994	Apr-Dec	31	31	37	41
1995	Apr-May	31	31	37	41
	Jun-Dec(1)	46-56	46-56	52-62	56-66
1996	Apr(1)	41	41	47	51
	May(1)	41-51	41-51	47-57	51-61
	Jun-Dec(1)	56	56	62	66
1997	Apr-Dec(5)	-	-	-	-
1998	Apr-Dec(5)	31	31	37	41
1999	Apr-Dec(1)	31-43	31-43	37-49	41-53
2000	Apr-Jun	31	31	37	41
	Jul-Dec(3)	29.5	29.5	35.5	39.5
2001	Apr-Dec(3)	28	28	34	38
2002	Apr-Jun(3)	27	27	33	37
	Jul-Dec(3)	25	25	31	35
2003	Apr-Nov(4)	25	25	31	35
2004-08	Apr-Oct(6)	25	25	31	35
2009	Apr-Nov(7)	25/31	25/31	31/37	35/41
2010	Apr-Dec(1)	31-43	31-43	37-49	41-53
2011	Apr(1)	31-41	31-41	37-47	41-51
	mid-Apr(1)	41-46	41-46	47-52	51-56
	May(1)	46-56	46-56	52-62	56-66
	mid-May(5)	-	-	-	-
2012	Apr-Dec	31	31	37	41
2013	Apr-Jun(6)	25	25	31	35
	Jul-Dec(3)	28	28	34	38
2014	Apr-Jun(3)	28	28	34	38
	Jul-Dec(1)	31-46	31-46	37-52	41-56
2015	Apr-Dec	31	31	37	41
2016	Apr-Dec	31	31	37	41
2017	Apr-Jun(1)	36	36	42	46
	Jul-Dec	31	31	37	41
2018	Apr-Jun(1)	36-56	36-56	42-62	46-66
	Jul-Dec(5)	-	-	-	-

(1) Downstream flow targets above full-service navigation level as a flood control storage evacuation measure.
(2) Full service flows provided for shortened season.
(3) Navigation targets below full service as a water conservation measure.
(4) Navigation targets at minimum service as a water conservation measure.
(5) Releases determined by flood control storage evacuation critiera and not adjusted to meet specific navigation targets.
(6) Minimum service targets at Sioux City and Omaha not met during periods when there was no navigation in those reaches.
(7) Minimum service targets at Sioux City were not met during periods when there was no navigation in those reaches.

Table 19
Missouri River Navigation
Tonnage and Season Length

Year	Reservoir System Supported Length of Season (Months)	Commercial (Tons) (1)	Total Traffic (Tons) (2)	Total Traffic (1,000 Ton-Miles) (2)
1967 (3)	8	2,562,657	6,659,219	1,179,235
1968	8 (4)	2,254,489	6,724,562	1,047,935
1969	8 (4)	2,123,152	7,001,107	1,053,856
1970	8 (5)	2,462,935	7,519,251	1,190,232
1971	8 (4)	2,791,929	7,483,708	1,329,899
1972	8 (4)	2,665,579	7,182,841	1,280,385
1973	8	1,817,471	6,370,838	844,406
1974	8	2,576,018	7,673,084	1,227,525
1975	8 (4)	2,317,321	6,208,426	1,105,811
1976	8 (4)	3,111,376	6,552,949	1,535,912
1977	8	3,335,780	6,734,850	1,596,284
1978	8 (4)	3,202,822	7,929,184	1,528,614
1979	8 (4)	3,145,902	7,684,738	1,518,549
1980	8	2,909,279	5,914,775	1,335,309
1981	7 1/4 (6)	2,466,619	5,251,952	1,130,787
1982	8 (4)	2,513,166	4,880,527	1,131,249
1983	8 (4)	2,925,384	6,301,465	1,300,000
1984	8 (4)	2,878,720	6,386,205	1,338,939
1985	8 (4) (7)	2,606,461	6,471,418	1,201,854
1986	8 (4) (7)	2,343,899	6,990,778	1,044,299
1987	8	2,405,212	6,735,968	1,057,526
1988	7 1/2	2,156,387	6,680,878	949,356
1989	6 3/4	1,906,508	5,352,282	796,799
1990	6 3/4	1,329,000	5,841,000	552,509
1991	6 3/4	1,563,000	5,729,000	537,498
1992	6 3/4	1,403,000	5,783,000	593,790
1993	8 (8)	1,570,000	5,631,000	615,541
1994	8	1,800,000	8,501,000	774,491
1995	8 (4)	1,439,000	6,884,000	604,171
1996	8 (4)	1,547,000	8,165,000	680,872
1997	8 (4)	1,651,000	8,172,000	725,268
1998	8 (4)	1,735,000	8,379,000	777,727
1999	8 (4)	1,576,000	9,252,000	699,744
2000	8	1,344,000	8,733,000	628,575
2001	8	1,288,000	9,732,000	566,150
2002	8 (9)	1,009,000	8,266,000	409,980
2003	8 (10)	667,000	8,050,000	256,788
2004	6 1/2 (11)	525,498	8,192,219	181,995
2005	6 1/2 (11)	284,641	7,935,747	129,882
2006	6 1/2 (11)	195,290	8,295,226	84,483
2007	6 3/4 (11)	302,769	6,684,625	119,177
2008	7 (11)	174,800	5,670,968	86,203
2009	8	269,563	5,035,744	114,865
2010	8(4)	379,492	4,829,714	132,747
2011	8(4)	230,439	3,831,925	62,253
2012	8	197,000	3,906,000	56,631
2013	8	244,576	4,104,505	110,280
2014	8(4)	293,125	4,670,661	89,932
2015	8	269,200	4,402,000	78,300
2016	8	559,020	4,655,884	201,943
2017	8	736,187	4,956,563	221,936
2018	8(4)		4,685,470 (12)	

(1) Includes commercial tonnage except for sand and gravel or waterway materials. Tonnage compiled by Waterborne Commerce Statistics Center (WCSC).
(2) Includes commodities; sand, gravel, and crushed rock; and waterway improvement materials. Tonnage by WCSC.
(3) Mainstem Reservoir System first reached normal operating storage level in 1967.
(4) 10-day extension of season provided.
(5) 10-day extension and 10-day early opening provided.
(6) Full service flows for shortened season in preference to reduced service.
(7) 10-day extension provided for 1985 season in trade for 10-day delayed support of 1986 season.
(8) Lower Missouri River closed: 57 days in 1993, 20 days in 1995, and 18 days in 1999.
(9) To protect endangered shore birds below Gavins Point Dam, the Corps did not support navigation from July 3 to August 14, 2002. Average days towing industry off the river was 23 days.
(10) 6-day shortening of season to follow CWCP. From Aug 11 to Sep 1 Corps did not support navigation flows to comply with lawsuit to follow 2000 Biological Opinion. Navigation industry left the river during this period.
(11) Season shortening; 47 days, 2004; 48 days, 2005; 44 days, 2006; 35 days, 2007; 30 days, 2008
(12) Estimated using WCSC preliminary projections.



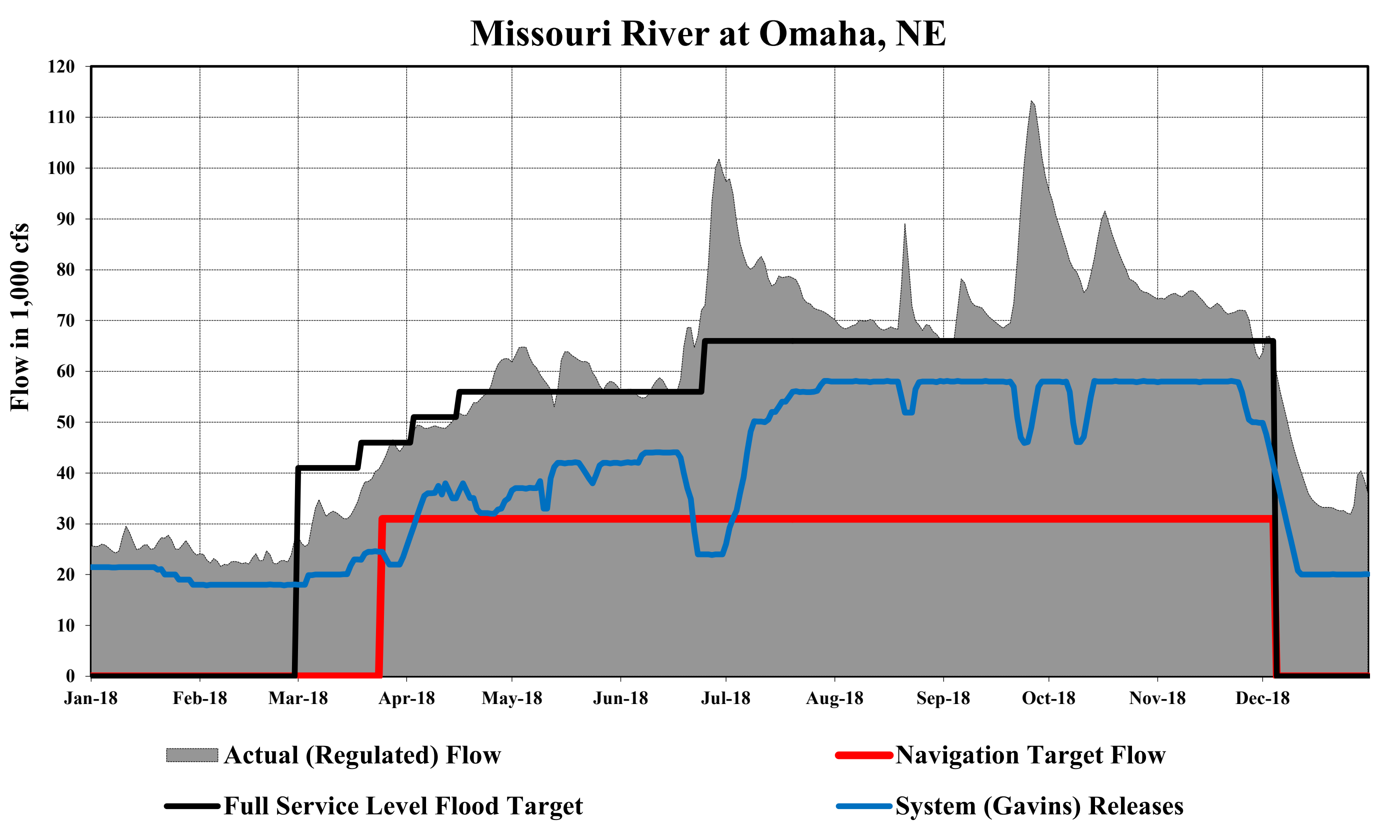
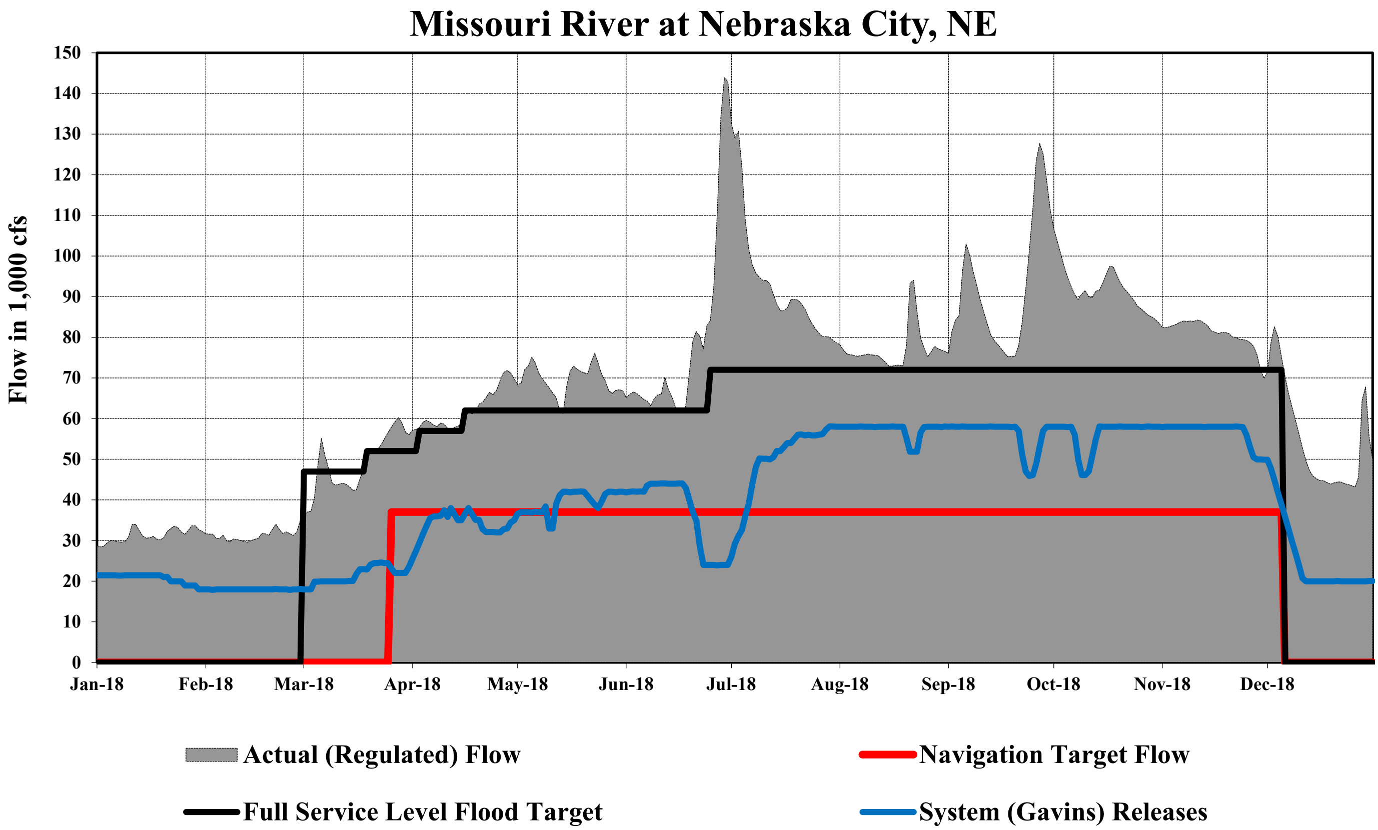


Figure 25A. Actual flow, System releases, navigation target flows, and service level flood target flows – Sioux City, IA and Omaha, NE (calendar year).



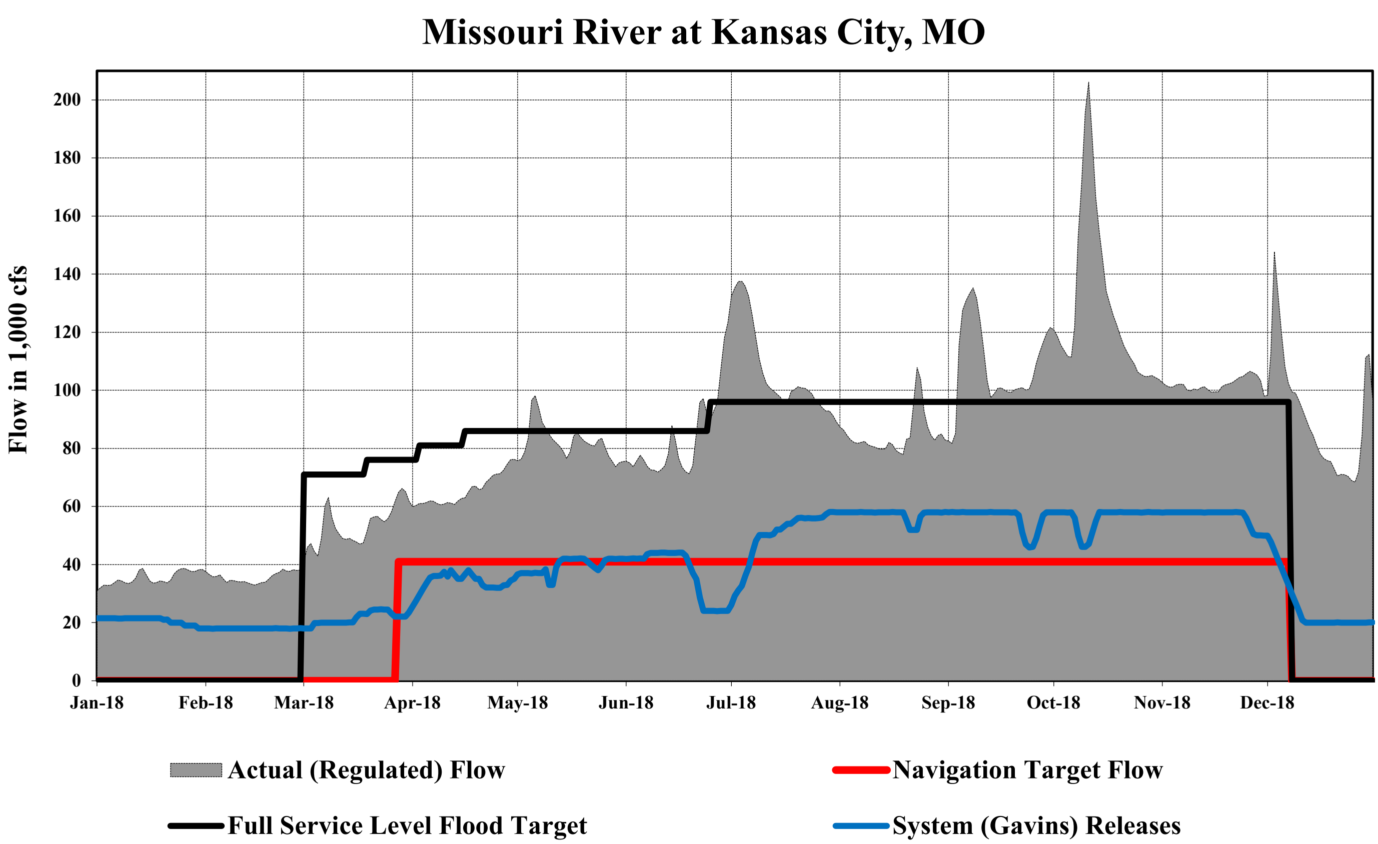


Figure 25B. Actual flow, System releases, navigation target flows, and service level flood target flows – Nebraska City, NE and Kansas City, MO (calendar year).

6. Power – Eastern Division, Pick-Sloan Missouri Basin Program (P-S MBP)

The hydropower energy generated by the system is transmitted over a Federal transmission system that traverses 7,875 circuit miles. On October 1, 2015 Western's transmission system became integrated with the Southwest Power Pool (SPP) regional transmission organization. During 2018, service was provided to over 350 wholesale customers. Customers receiving service include 200 municipalities, 2 federal agencies, 30 state agencies, 24 USBR projects, 5 irrigation districts, 36 rural electric cooperatives, 6 public utility districts, 9 private utilities, 25 Native American services and 18 power marketers. Additional marketing benefits have been realized with Western becoming an asset-owning market participant within the SPP integrated market place in 2017.

Per the Omaha Public Power District (OPPD) statistics, the average OPPD customer uses approximately 10,860 kilowatt hours (kWh) of energy annually. Based on the total System generation of 12.3 billion kWh, the energy generated in 2018 by this portion of the federal power system could have supplied all of the yearly needs of about 1,133,000 residential OPPD customers. In addition to the clean, renewable energy supplied to our customers, system hydropower provides an added measure of stability to the SPP regional power system. Large coal-fired and nuclear units are backed up by other SPP member resources and the federal hydropower generation. Members of the SPP market benefit by being able to call for reserves during emergency events. In addition, hydropower and other SPP generation are integrated with wind generation to provide balance to the SPP system.

The reliability of System hydropower helps to maintain adequate reserves in both the Northwest Power Pool in Western Area Power Administration, Upper Great Plains West (WAUW) and the SPP.

Hydropower generation in 2018 was 12.3 billion kWh, which was 132 percent of average since the System first filled in 1967 and the highest since 1997 when 14.6 billion kWh were generated. The 2018 generation was 2.8 billion kWh more than the 2017 generation of 9.5 billion kWh and 7.4 billion kWh more than the record low of 4.9 billion kWh, generated in 2008. Total generation was above average in 2018 due to the above-normal runoff year in the upper basin. Western purchased about 572 million kWh between January 1 and December 31, at a cost of $13.5 million, to supplement System hydropower production.

System generation, with individual project distribution for each calendar year in million megawatt hours (MWh) since 1954, is shown on ***Figure 26***. The total generation from the federal system (peak capacity and energy sales) for 2018 is shown in ***Table 20***. The tabulations in ***Table 21*** and ***Table 22*** summarize the peak and total gross generation for the Eastern Division, P-S MBP marketing area system for the past operating year. Actual settlement figures at the end of the billing periods differ somewhat from the calendar month figures shown.

Table 20
Gross Federal Power System Generation – January 2018 through December 2018

	Energy Generation 1000 kWh	**Peak Hour kW**	**Generation Date**
Corps Powerplants – Mainstem			
Fort Peck	1,274,484	194,000	November 9
Garrison	3,461,709	554,000	June 6
Oahe	3,700,530	737,000	August 10
Big Bend	1,375,957	374,000	August 22
Fort Randall	1,778,575	323,000	September 29
Gavins Point	738,692	118,000	July 1
Corps Subtotal	**12,329,947**	2,148,000	August 24
USBR Powerplants			
Canyon Ferry	370,553	56,000	May
Yellowtail*	524,706	121,000	July
USBR Subtotal	895,259		
Federal System Total	13,225,206		

* Includes only half of total Yellowtail generation, which is marketed by the Eastern Division, P-S MBP.

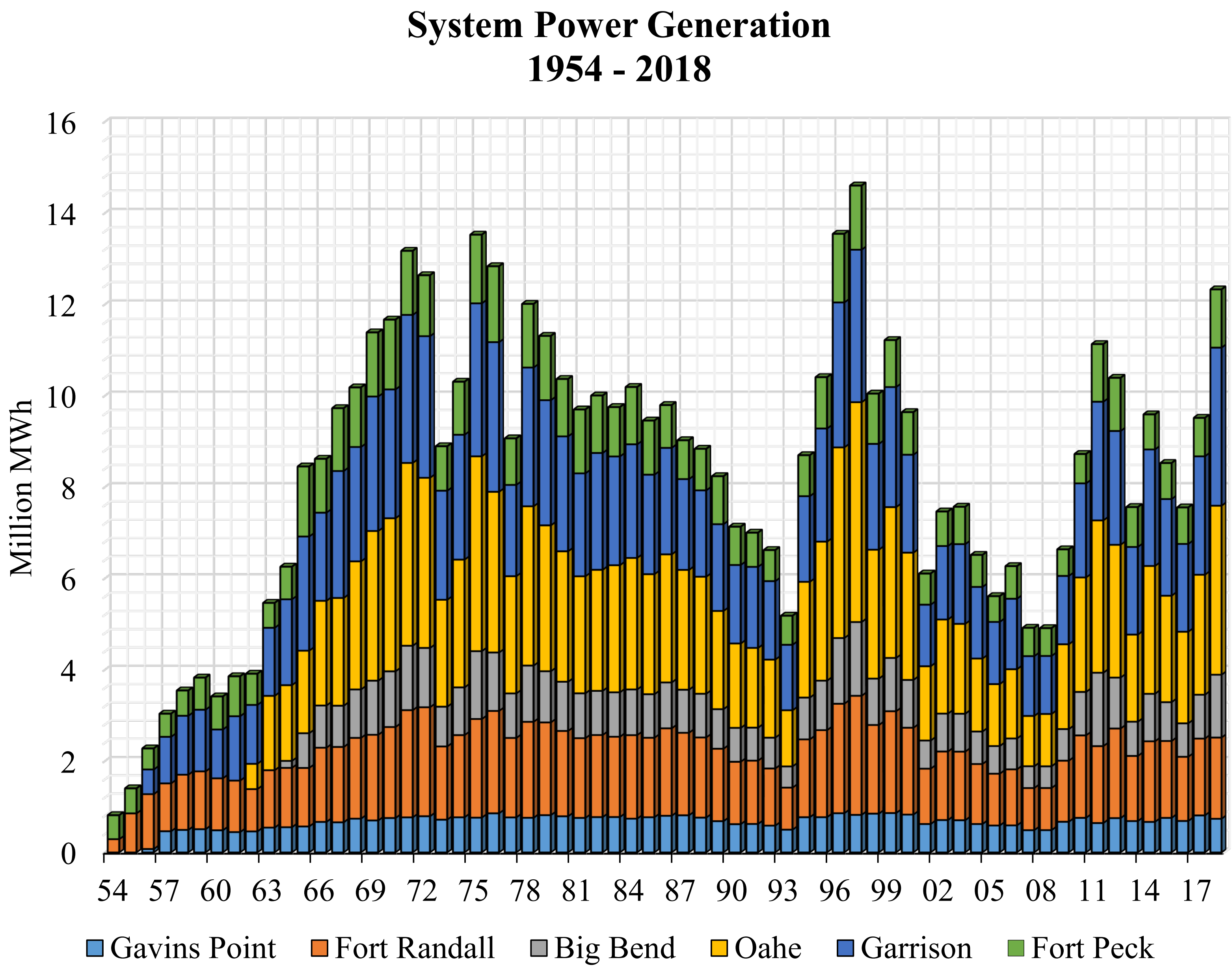


Figure 26. System power generation by project from 1954 to 2018.

Table 21
Historical Generation and Load Data – Peaks
Eastern Division, Pick-Sloan Missouri Basin Program*
Data at Plant (1000 kW)
January 1, 2018 through December 31, 2018

Period	Corps of Engineers Hourly Generation (Gross)**	(plus)	USBR Hourly Generation (Gross)**	(equals)	Federal Hour Generation (Gross)**	(plus)	Interchange and Purchases Received**	(equals)	Peak Total System Load	Peak Date	Peak Hour
January	1,544		103		1,647		94		1,741	Jan 15	1900
February	1,321		75		1,396		324		1,720	Feb 21	800
March	1,511		95		1,606		111		1,717	Mar 08	800
April	1,334		125		1,459		72		1,531	Apr 06	900
May	1,866		129		1,995		0		1,995	May 25	1600
June	1,862		123		1,985		0		1,985	Jun 28	1700
July	1,979		120		2,099		0		2,099	Jul 11	1600
August	2,123		101		2,224		0		2,224	Aug 09	1700
September	1,756		95		1,851		0		1,851	Sep 12	1700
October	1,597		71		1,668		0		1,668	Oct 15	800
November	1,736		97		1,833		0		1,833	Nov 26	1900
December	1,355		97		1,452		227		1,679	Dec 31	1800

* This tabulation summarizes the total gross generation and power operations for the Eastern Division marketing area system shown on Table 20.
** During hour of peak total system load.

Table 22
Historical Generation and Load Data – Total
Eastern Division, Pick-Sloan Missouri Basin Program*
Data at Plant (1000 kWh)
January 1, 2018 through December 31, 2018

Period	Corps of Engineers Generation (Gross)	(plus)	USBR Generation (Gross)	(equals)	Federal Generation (Gross)	(plus)	Scheduled Interchange and Purchases Received	(equals)	Total System Load
January	807,121		58,396		865,517		108,666		974,183
February	636,456		50,421		686,877		175,111		861,988
March	697,284		74,139		771,423		79,088		850,511
April	870,047		69,131		939,178		19,180		958,358
May	1,130,717		76,329		1,207,046		929		1,207,975
June	1,153,265		89,957		1,243,222		1,114		1,244,336
July	1,335,835		90,269		1,426,104		1,402		1,427,506
August	1,425,963		68,653		1,494,616		1,404		1,496,020
September	1,223,141		66,204		1,289,345		777		1,290,122
October	1,182,574		65,604		1,248,178		531		1,248,709
November	1,109,353		64,127		1,173,480		2,149		1,175,629
December	758,189		59,968		818,157		181,367		999,524

*Powerplants from Table 20.

7. Recreation

The System reservoirs provide outstanding opportunities for boating, fishing, swimming, camping and other outdoor recreation pursuits. Tourism related to the reservoirs is a major economic factor in all of the states adjoining the System. However, when the reservoirs are drawn down due to extended drought periods, as they were in some recent years, recreation may be adversely affected primarily due to access issues. Most of the recreational impacts of a drought are experienced at the upper three large reservoirs--Fort Peck, Garrison and Oahe. Due to the manner in which they are regulated, the lower three reservoirs are not significantly impacted by drought. Reservoir levels at the upper large reservoirs were higher than average during the 2018 recreation season due to high runoff in the upper basin. No accessibility problems were reported at mainstem projects' boat ramps.

Access areas at the upper three reservoirs include Corps-owned as well as Tribal, state and privately-owned facilities. In 2002, many of the Federal recreation areas and boat ramps in South Dakota were turned over in fee title to the State of South Dakota and the Bureau of Indian Affairs through the Title VI process. Since the land transfer, both the Federal treasury and the Corps have provided money to the South Dakota Game Fish and Parks, Cheyenne River Sioux Tribe and Lower Brule Sioux Tribe for operations and stewardship of the Title VI lands they received. Congress is also capitalizing a trust fund to cover these costs in the future.

The methodology used for the Corps to determine visitation hours was revised during 2013. No visitation data is available for 2013. Visitation data for 2014-18 is presented in ***Table 23***. The new methodology represents the number of unique individual visits for a specific activity or purpose that people used the reservoir and surrounding lands in any capacity. For example, a group of four people camping for the weekend counts as four visits. Four people pheasant hunting together counts as four visits per day. There are different weights and load factors assigned to different site types. The methodology also add in a certain ratio of dispersed use for areas that the Corps has no feasible way to monitor or meter.

Table 23
Visitation at System Reservoirs (Visits)

Project	2014	2015	2016	2017	2018*
Fort Peck	548,073	407,783	544,689	446,329	440,726
Garrison	1,351,900	1,488,471	1,590,185	1,765,337	2,039,783
Oahe	1,934,347	2,361,246	2,411,398	1,886,198	1,586,422
Big Bend	931,574	1,268,595	1,062,289	942,765	1,009,436
Fort Randall	896,671	896,847	836,647	808,772	738,883
Gavins Point	2,175,314	2,369,151	1,955,423	1,800,832	1,655,417
System Total	**7,837,879**	**8,792,093**	**8,400,631**	**7,650,233**	**7,470,667**

*Preliminary estimates.

8. Fish and Wildlife

a. Fish Management

Rainbow smelt are the primary forage species in both Garrison and Oahe reservoirs. Successful rainbow smelt reproduction is dependent on many factors including stable reservoir levels during the smelt spawning period, generally in April and early May. Most eggs are laid in water less than a foot deep and are subject to desiccation through wave action and slight drops in water level.

The above-average runoff in 2018 resulted in steady-to-rising pools in the Fort Peck, Garrison, and Oahe reservoirs throughout the spring and early summer. Evacuation of stored flood waters in 2018 may have displaced rainbow smelt and other game species to downstream locations.

b. Threatened and Endangered Species (T&E)

(1) Pallid Sturgeon

For detailed discussion on Missouri River activities for the pallid sturgeon, see the Missouri River Recovery Program (MRRP) 2018 Adaptive Management ESA Compliance Report (https://www.nwo.usace.army.mil/mrrp).

(2) Piping Plovers and Least Terns

Since 1986 the System has been regulated for the piping plover (plover, threatened) and least tern (tern, endangered), when they were federally listed as T&E species. The terns and plovers nest on sparsely vegetated sandbars, islands and shoreline of the Missouri River and the reservoirs. Real-time telemetered streamgaging stations have been installed along the Missouri River to monitor river stages and flows during the nesting season. These gages provide a check, as well as a stage history, throughout the season to help relate the effects of regulation and natural events at intervals along the river. The gage data must be supplemented with observations of nesting activities and conditions to provide the information that is needed for regulation of the reservoirs. A dynamic flow routing model has been developed to predict river stages along the river reaches downstream from the Fort Peck, Garrison, Fort Randall and Gavins Point dams for different combinations of daily and hourly power peaking. However, only the reach downstream of the Garrison dam has been updated with post-2011 flood cross section data.

Beginning in 1999, Omaha District created a computerized T&E species Data Management System (DMS). Report data, which is updated daily, includes nest records, census and productivity data, site descriptions, field journals and field observations. This database is a valuable tool in aiding regulation decisions benefiting the terns and plovers in years when the reservoirs are regulated to protect nesting terns and plovers.

Although the Corps prevented inundation of nests where possible and created habitat following the listing, fledging ratios continued to be lower than predicted by the USFWS 1990

Biological Opinion until 1998, when fledge ratios exceeded the goal for both species. Predation, habitat degradation, severe weather, nest inundation, record runoff and other factors contributed to the low fledging rates. The record fledging that occurred for both species between 1998 and 2005 is primarily attributed to the large amount of habitat created by the high runoff years of 1995, 1996 and 1997 and the declining reservoir levels during the 2000-2007 drought. The creation of additional habitat has also allowed greater flexibility in the release levels at Fort Randall and Gavins Point, the lower two System projects.

The above-average 2018 runoff resulted in rising reservoirs during the nesting season. The rising reservoir levels limited habitat and affected nest success. Known and presumed predation throughout the system along with nest inundation was the most common cause of nest failure in 2018. A detailed description of the factors affecting tern and plover nesting, fledge ratios and habitat conditions and creation activities by reservoir and river reach can be found in the MRRP 2018 Adaptive Management ESA Compliance Report (https://www.nwo.usace.army.mil/mrrp).

9. Cultural Resources

As acknowledged in the 2004 Programmatic Agreement (PA) for the Operation and Management of the Missouri River Main Stem System, wave action and the fluctuation of reservoirs levels results in erosion along the banks of the reservoirs. Shoreline erosion can have severe effects on cultural resources. During drought conditions, cultural resource sites are exposed as the pool levels decline.

The PA established a shared stewardship philosophy of protection of historic properties. The objective of a PA is to address "…potential adverse effects of complex projects or multiple undertakings…" and to collaboratively develop a preservation program that would avoid, minimize and mitigate the effects of the System regulation. All Tribes, whether signatory to the PA or not, may request government-to-government consultation on System regulation and the resulting effect on historic and cultural properties and other resources.

A Cultural Resource Program Five Year Plan was developed in consultation with Tribes, States, Agencies and interested parties. This plan outlines how the Corps will accomplish its responsibilities under the National Historic Preservation Act and the PA. The plan includes inventory, testing and evaluation, mitigation and other specific activities that will allow the Corps to avoid, minimize and mitigate the adverse effects to cultural sites on the Corps' lands within the System. The "Final Five Year Plan", dated February 2012 (see website http://www.nwo.usace.army.mil/Missions/CivilWorks/CulturalResources.aspx) is currently being implemented.

One consultation meeting on the PA was held during the 2018 reporting period. The purpose of consultation meetings is to engage in communications and discuss whether operational changes are likely to affect historic and cultural properties, identify those properties and discuss how to address those affects.

A letter, dated September 25, 2018, was sent to the Missouri River Basin Tribes offering consultation on the 2018-2019 AOP. To date, no Tribes have requested consultation nor provided verbal or written comments on the AOP. The Corps has semi-annual public meetings where basin stakeholders provide input on the upcoming year's reservoir operations. No Tribes were recorded participating in the fall AOP public meetings, which were held November 2018 in six locations throughout the basin.

The Corps actively addresses shoreline erosion which can damage or significantly alter cultural resource sites. During 2018, two Omaha District cultural resource protection projects were planned. One stabilization was completed at Lake Oahe. The planned project at Garrison was not completed in 2018 due to high water and it is now planned for completion in 2019, reservoir conditions permitting. There are also two projects planned or underway at Big Bend, scheduled for completion in 2019.

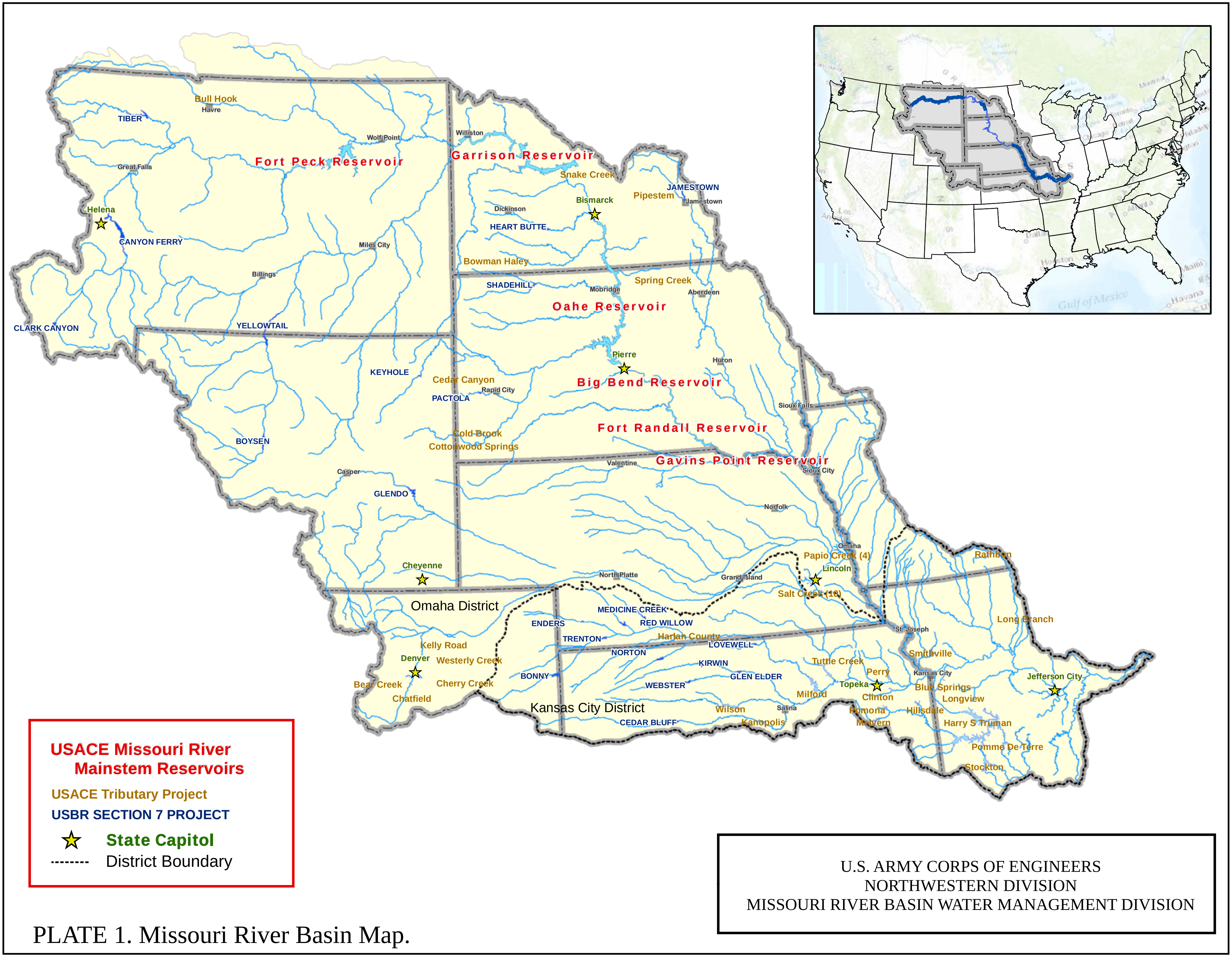


PLATE 1. Missouri River Basin Map.

Item No.	Summary of Engineering Data -- Missouri River Mainstem System Subject	Fort Peck Dam - Fort Peck Lake	Garrison Dam - Lake Sakakawea	Oahe Dam - Lake Oahe
1	Location of Dam	Near Glasgow, Montana	Near Garrison, ND	Near Pierre, SD
2	River Mile - 1960 Mileage	Mile 1771.5	Mile 1389.9	Mile 1072.3
3	Total & incremental drainage areas in square miles	57,500	181,400 (2) 123,900	243,490 (1) 62,090
4	Approximate length of full reservoir (in valley miles)	134, ending near Zortman, MT	178, ending near Trenton, ND	231, ending near Bismarck, ND
5	Shoreline in miles (3)	1520 (elevation 2234)	1340 (elevation 1837.5)	2250 (elevation 1607.5)
6	Average total & incremental inflow in cfs	10,200	25,600 15,400	28,900 3,300
7	Max. discharge of record near damsite in cfs	137,000 (June 1953)	348,000 (April 1952)	440,000 (April 1952)
8	Construction started - calendar yr.	1933	1946	1948
9	In operation (4) calendar yr.	1940	1955	1962
	Dam and Embankment			
10	Top of dam, elevation in feet msl	2280.5	1875	1660
11	Length of dam in feet	21,026 (excluding spillway)	11,300 (including spillway)	9,300 (excluding spillway)
12	Damming height in feet (5)	220	180	200
13	Maximum height in feet (5)	250.5	210	245
14	Max. base width, total & w/o berms in feet	3500, 2700	3400, 2050	3500, 1500
15	Abutment formations (under dam & embankment)	Bearpaw shale and glacial fill	Fort Union clay shale	Pierre shale
16	Type of fill	Hydraulic & rolled earth fill	Rolled earth filled	Rolled earth fill & shale berms
17	Fill quantity, cubic yards	125,628,000	66,500,000	55,000,000 & 37,000,000
18	Volume of concrete, cubic yards	1,200,000	1,500,000	1,045,000
19	Date of closure	24 June 1937	15 April 1953	3 August 1958
	Spillway Data			
20	Location	Right bank - remote	Left bank - adjacent	Right bank - remote
21	Crest elevation in feet msl	2225	1825	1596.5
22	Width (including piers) in feet	820 gated	1336 gated	456 gated
23	No., size and type of gates	16 - 40' x 25' vertical lift gates	28 - 40' x 29' Tainter	8 - 50' x 23.5' Tainter
24	Design discharge capacity, cfs	275,000 at elev 2253.3	827,000 at elev 1858.5	304,000 at elev 1644.4
25	Discharge capacity at maximum operating pool in cfs	230,000	660,000	80,000
	Reservoir Data (6)			
26	Max. operating pool elev. & area	2250 msl 245,000 acres	1854 msl 383,000 acres	1620 msl 386,000 acres
27	Max. normal op. pool elev. & area	2246 msl 240,000 acres	1850 msl 365,000 acres	1617 msl 362,000 acres
28	Base flood control elev & area	2234 msl 211,000 acres	1837.5 msl 308,000 acres	1607.5 msl 311,000 acres
29	Min. operating pool elev. & area	2160 msl 89,000 acres	1775 msl 125,000 acres	1540 msl 115,000 acres
	Storage allocation & capacity			
30	Exclusive flood control	2250-2246 971,000 a.f.	1854-1850 1,495,000 a.f.	1620-1617 1,107,000 a.f.
31	Flood control & multiple use	2246-2234 2,704,000 a.f.	1850-1837.5 4,211,000 a.f.	1617-1607.5 3,208,000 a.f.
32	Carryover multiple use	2234-2160 10,700,000 a.f.	1837.5-1775 12,951,000 a.f.	1607.5-1540 13,353,000 a.f.
33	Permanent	2160-2030 4,088,000 a.f.	1775-1673 4,794,000 a.f.	1540-1415 5,315,000 a.f.
34	Gross	2250-2030 18,463,000 a.f.	1854-1673 23,451,000 a.f.	1620-1415 22,983,000 a.f.
35	Reservoir filling initiated	November 1937	December 1953	August 1958
36	Initially reached min. operating pool	27 May 1942	7 August 1955	3 April 1962
37	Estimated annual sediment inflow	17,200 a.f./year 1073 yrs.	21,600 a.f./year 1,086 yrs.	14,800 a.f./year 1553 yrs.
	Outlet Works Data			
38	Location	Right bank	Right Bank	Right Bank
39	Number and size of conduits	2 - 24' 8" diameter (nos. 3 & 4)	1 - 26' dia. and 2 - 22' dia.	6 - 19.75' dia. upstream, 18.25' dia. downstream
40	Length of conduits in feet (8)	No. 3 - 6,615, No. 4 - 7,240	1529	3496 to 3659
41	No., size, and type of service gates	1 - 28' dia. cylindrical gate 6 ports, 7.6' x 8.5' high (net opening) in each control shaft	1 - 18' x 24.5' Tainter gate per conduit for fine regulation	1 - 13' x 22' per conduit, vertical lift, 4 cable suspension and 2 hydraulic suspension (fine regulation)
42	Entrance invert elevation (msl)	2095	1672	1425
43	Avg. discharge capacity per conduit & total	Elev. 2250 22,500 cfs - 45,000 cfs	Elev. 1854 30,400 cfs - 98,000 cfs	Elev. 1620 18,500 cfs - 111,000 cfs
44	Present tailwater elevation (ft msl)	2032-2036 5,000 - 35,000 cfs	1669-1677 15,000- 60,000 cfs	1422-1427 20,000-55,000 cfs
	Power Facilities and Data			
45	Avg. gross head available in feet (14)	194	161	174
46	Number and size of conduits	No. 1-24'8" dia., No. 2-22'4" dia.	5 - 29' dia., 25' penstocks	7 - 24' dia., imbedded penstocks
47	Length of conduits in feet (8)	No. 1 - 5,653, No. 2 - 6,355	1829	From 3,280 to 4,005
48	Surge tanks	PH#1: 3-40' dia., PH#2: 2-65' dia.	65' dia. - 2 per penstock	70' dia., 2 per penstock
49	No., type and speed of turbines	5 Francis, PH#1-2: 128.5 rpm, 1-164 rpm , PH#2-2: 128.6 rpm	5 Francis, 90 rpm	7 Francis, 100 rpm
50	Discharge cap. at rated head in cfs	PH#1, units 1&3 170', 2-140' 8,800 cfs, PH#2-4&5 170'-7,200 cfs	150' 41,000 cfs	185' 54,000 cfs
51	Generator nameplate rating in kW	1&3: 43,500; 2: 18,250; 4&5: 40,000	3 - 121,600, 2 - 109,250	112,290
52	Plant capacity in kW	185,250	583,300	786,030
53	Dependable capacity in kW (9)	181,000	388,000	534,000
54	Avg. annual energy, million kWh (12)	1,035	2,248	2,610
55	Initial generation, first and last unit	July 1943 - June 1961	January 1956 - October 1960	April 1962 - June 1963
56	Estimated cost September 1999 completed project (13)	$158,428,000	$305,274,000	$346,521,000

Summary of Engineering Data -- Missouri River Mainstem System

Big Bend Dam - Lake Sharpe	Fort Randall Dam - Lake Francis Case	Gavins Point Dam - Lewis & Clark Lake	Total	Item No.
21 miles upstream Chamberlain, SD	Near Lake Andes, SD	Near Yankton, SD		1
Mile 987.4	Mile 880.0	Mile 811.1		2
249,330 (1) 5,840	263,480 (1) 14,150	279,480 (1) 16,000		3
80, ending near Pierre, SD	107, ending at Big Bend Dam	25, ending near Niobrara, NE	755 miles	4
200 (elevation 1420)	540 (elevation 1350)	90 (elevation 1204.5)	5,940 miles	5
28,900	30,000 1,100	32,000 2,000		6
440,000 (April 1952)	447,000 (April 1952)	480,000 (April 1952)		7
1959	1946	1952		8
1964	1953	1955		9
1440	1395	1234		10
10,570 (including spillway)	10,700 (including spillway)	8,700 (including spillway)	71,596	11
78	140	45	863 feet	12
95	165	74		13
1200, 700	4300, 1250	850, 450		14
Pierre shale & Niobrara chalk	Niobrara chalk	Niobrara chalk & Carlile shale		15
Rolled earth, shale, chalk fill	Rolled earth fill & chalk berms	Rolled earth & chalk fill		16
17,000,000	28,000,000 & 22,000,000	7,000,000	358,128,000 cu. yds	17
540,000	961,000	308,000	5,554,000 cu. yds.	18
24 July 1963	20 July 1952	31 July 1955		19
Left bank - adjacent	Left bank - adjacent	Right bank - adjacent		20
1385	1346	1180		21
376 gated	1000 gated	664 gated		22
8 - 40' x 38' Tainter	21 - 40' x 29' Tainter	14 - 40' x 30' Tainter		23
390,000 at elev 1433.6	620,000 at elev 1379.3	584,000 at elev 1221.4		24
270,000	508,000	345,000		25
1423 msl 62,000 acres	1375 msl 102,000 acres	1210 msl 29,000 acres	1,206,000 acres	26
1422 msl 60,000 acres	1365 msl 94,000 acres	1208 msl 25,000 acres	1,146,000 acres	27
1420 msl 58,000 acres	1350 msl 76,000 acres	1204.5 msl 21,000 acres	984,000 acres	28
1415 msl 51,000 acres	1320 msl 36,000 acres	1204.5 msl 21,000 acres	437,000 acres	29
1423-1422 61,000 a.f.	1375-1365 986,000 a.f.	1210-1208 54,000 a.f.	4,674,000 a.f.	30
1422-1420 118,000 a.f.	1365-1350 1,306,000 a.f.	1208-1204.5 79,000 a.f.	11,626,000 a.f.	31
	1350-1320 1,532,000 a.f.		38,536,000 a.f.	32
1420-1345 1,631,000 a.f.	1320-1240 1,469,000 a.f.	1204.5-1160 295,000 a.f.	17,592,000 a.f.	33
1423-1345 1,810,000 a.f.	1375-1240 5,293,000 a.f.	1210-1160 428,000 a.f.	72,428,000 a.f.	34
November 1963	January 1953	August 1955		35
25 March 1964	24 November 1953	22 December 1955		36
3,445 a.f./year 525 yrs.	15,800 a.f./year 334 yrs.	2,700 a.f./year 159 yrs.	77,400	37
	Left Bank			38
None (7)	4 - 22' diameter	None (7)		39
	1013			40
	2 - 11' x 23' per conduit, vertical lift, cable suspension			41
1385 (11)	1229	1180 (11)		42
	Elev 1375			43
	32,000 cfs - 128,000 cfs			
1351-1355(10) 25,000-100,000 cfs	1228-1237 10,000-60,000 cfs	1153-1161 15,000-60,000 cfs		44
70	117	48	764 feet	45
None: direct intake	8 - 28' dia., 22' penstocks	None: direct intake		46
	1,074		55,083	47
None	59' dia, 2 per alternate penstock	None		48
8 Fixed blade, 81.8 rpm	8 Francis, 85.7 rpm	3 Kaplan, 75 rpm	36 units	49
67' 103,000 cfs	112' 44,500 cfs	48' 36,000 cfs		50
67,275 (15)	40,000	44,100		51
517,470	320,000	132,300	2,501,200 kw	52
497,000	293,000	74,000	1,967,000 kw	53
975	1,720	724	9,336 million kWh	54
October 1964 - July 1966	March 1954 - January 1956	September 1956 - January 1957	July 1943 - July 1966	55
$107,498,000	$199,066,000	$49,617,000	$1,166,404,000	56

Remarks

(1) Includes 4,280 square miles of non-contributing areas.
(2) Includes 1,350 square miles of non-contributing areas.
(3) With pool at base of flood control.
(4) Storage first available for regulation of flows.
(5) Damming height is height from low water to maximum operating pool. Maximum height is from average streambed to top of dam.
(6) Based on latest available storage data.
(7) River regulation is attained by flows over low-crested spillway and through turbines.
(8) Length from upstream face of outlet or to spiral case.
(9) Based on 8th year (1961) of drought drawdown (From study 8-83-1985).
(10) Affected by level of Lake Francis case. Applicable to pool at elevation 1350.
(11) Spillway crest.
(12) 1967-2016 Average
(13) Source: Annual Report on Civil Works Activities of the Corps of Engineers. Extract Report Fiscal Year 1999.
(14) Based on Study 8-83-1985
(15) 67,275 kW on per unit basis 64,684 kW on facility basis

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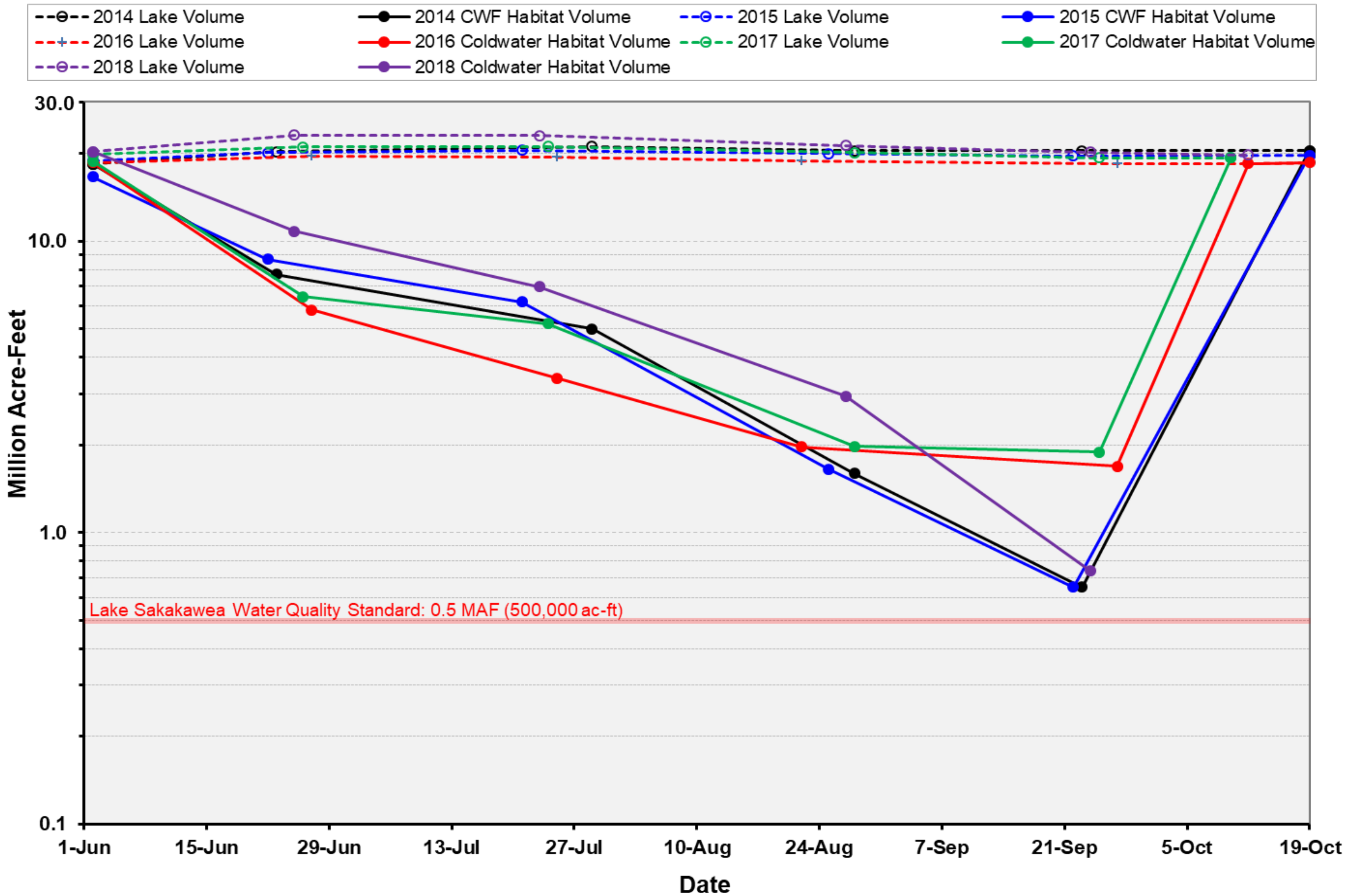

Plate 3. Garrison Reservoir - estimated reservoir and coldwater fishery (CWF) habitat 2014 through 2018.

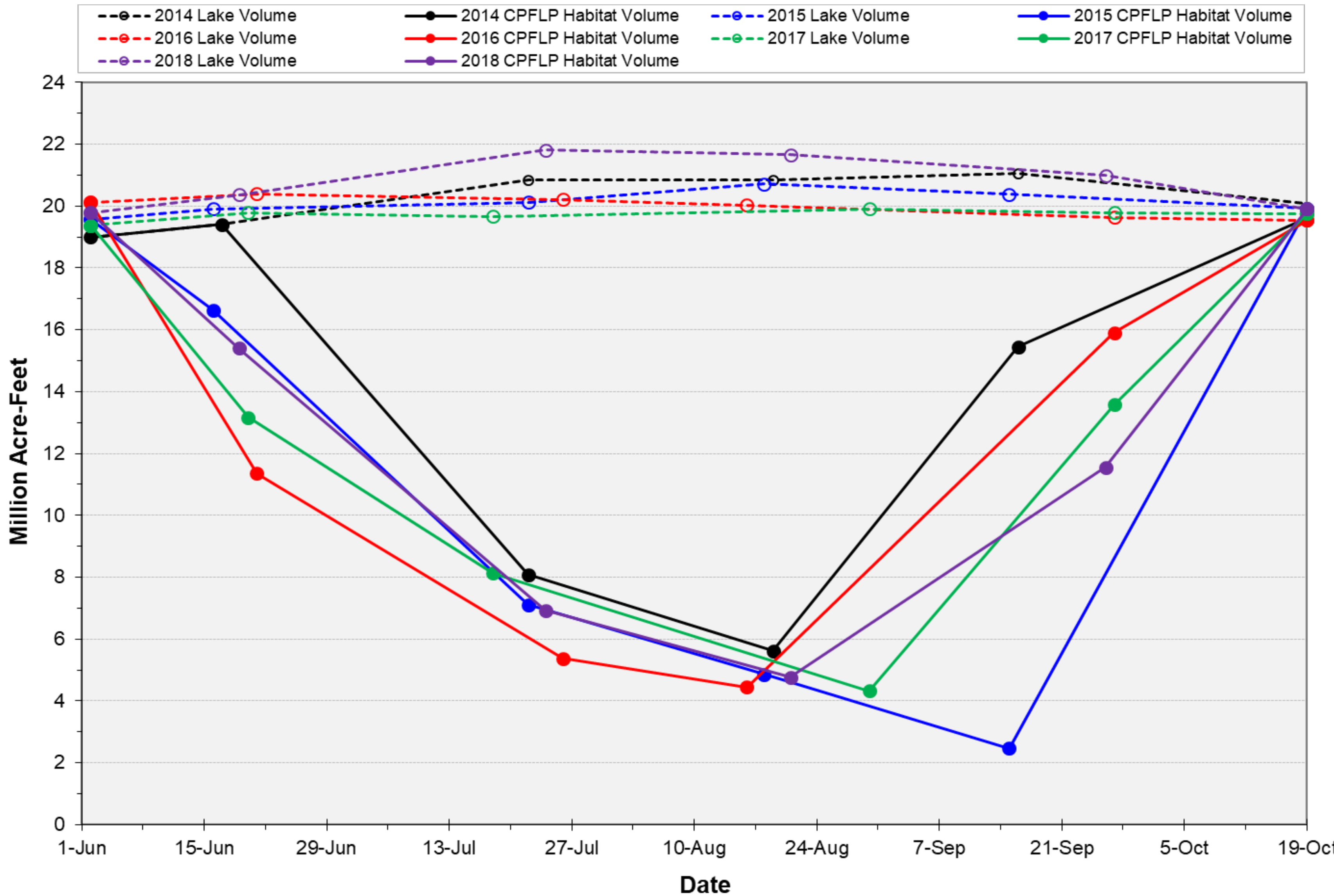

Plate 4. Oahe Reservoir - estimated reservoir and coldwater fishery (CWF) habitat 2014 through 2018.