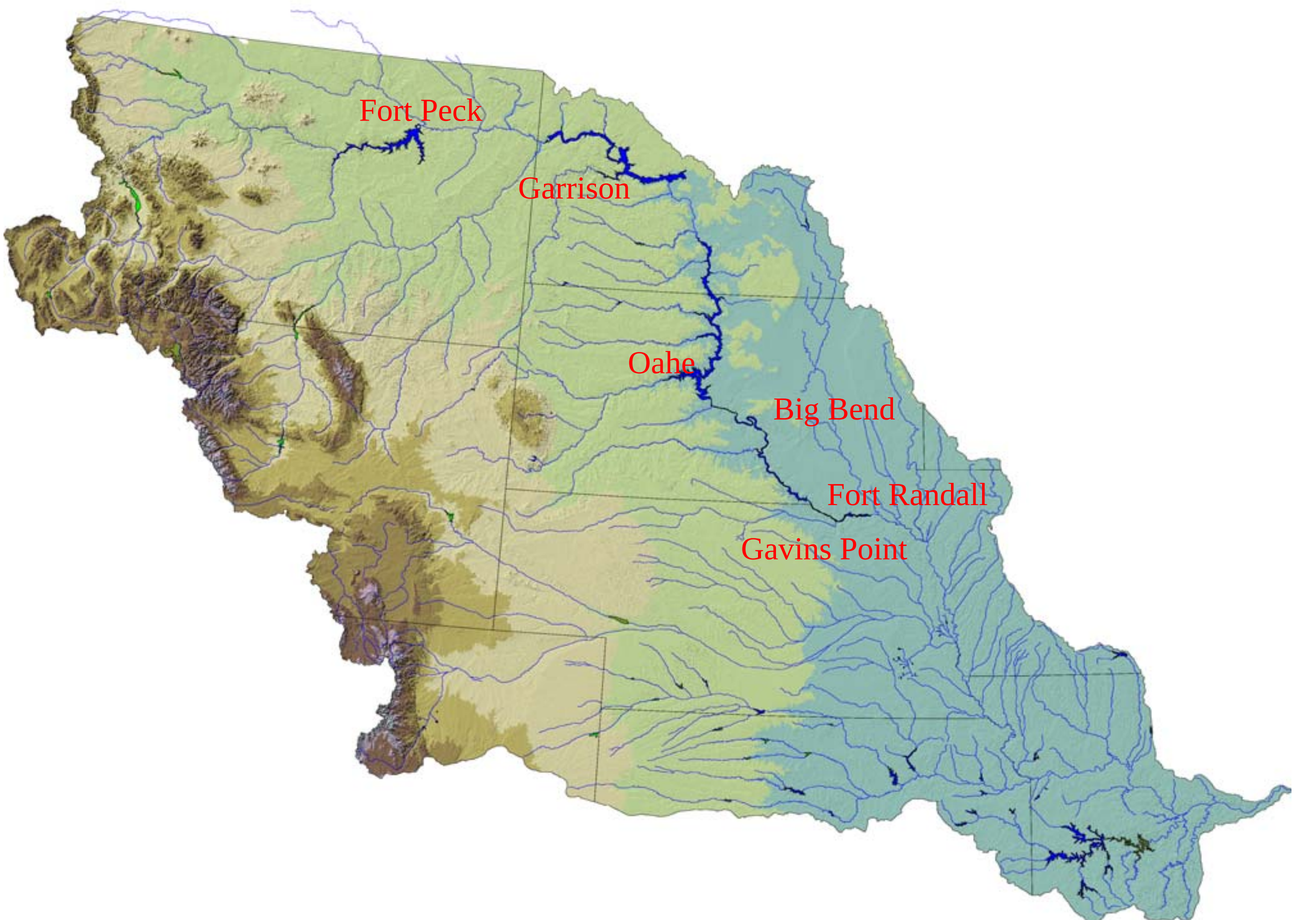
US Army Corps
of Engineers

Northwestern Division

Missouri River Mainstem Reservoir System

Summary of Actual 2016 Regulation

Missouri River Basin



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

June 2017

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 Nino Southern Oscillation
EOM	End of Month
Five Year Plan	Cultural Resources Program Five Year Plan
FTT	Flow to Target
ft	feet
ft msl	feet above mean sea level
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
msl	mean sea level
MV	motor vessel
MVD	Corps' Mississippi Valley Division
MW	megawatt
MWh	megawatt hour
M&I	municipal and industrial
NDEQ	Nebraska Department of Environmental Quality
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-NWS	National Oceanic and Atmospheric Administration - National Weather Service
NOHRSC	National Operational and Hydrologic Remote Sensing Center

LIST OF ABBREVIATIONS AND ACRONYMS (cont'd)

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
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 2016 Regulation

I. FOREWORD

This document contains a summary of the actual regulation of the Missouri River Mainstem Reservoir System (System) for the 2016 Calendar Year (CY). Two other reports related to System regulation are also available, the ***System Description and Regulation*** and ***Final 2015-2016 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 2016

A. General

This report summarizes the System regulation as it pertains to all eight congressionally-authorized purposes. During 2016 the System was regulated in accordance with the Master Water Control Manual (Master Manual) and the applicable provisions of the Final 2015-16 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 2016

Plains snowpack, mountain snowpack and general weather conditions in the Missouri River Basin during the 2016 calendar year are discussed in the following sections. The reference period for average conditions for plains and mountain snowpack, precipitation and temperature is 1981-2010.

1. Plains Snowpack

Plains snowpack during the 2015-2016 winter was generally low and of short duration. As is typical during an El Niño winter, temperatures in the Northern Plains from December 2015 through February, the climatological winter, were above normal (***Figure 1***). While precipitation

(***Figure 2***) was well-above normal in parts of South Dakota, Nebraska, Kansas, Missouri and Iowa from December 2015 through February, much of the upper Basin received below- to near-normal precipitation. Despite the above-normal precipitation in parts of the Basin, well-above normal temperatures limited snowpack formation and duration.

Prior to the first accumulations of the 2015-2016 winter plains snowpack, soil moisture conditions were generally in the 30^{th} to 70^{th} percentile ranking (normal) in Montana, North Dakota and much of Wyoming (see ***Figure 3***). Soil moisture was greater than the 70^{th} percentile ranking (above normal) in eastern Wyoming, western and southeastern South Dakota, Nebraska and Iowa. Fall soil moisture is significant in its relation to spring runoff. During the onset of the winter freeze, much of this moisture is locked up in frozen soil moisture and is then released during the spring thaw. Furthermore, soil moisture typically does not change during the winter; therefore, high fall precipitation and high soil moisture typically establishes wet spring soil moisture conditions.

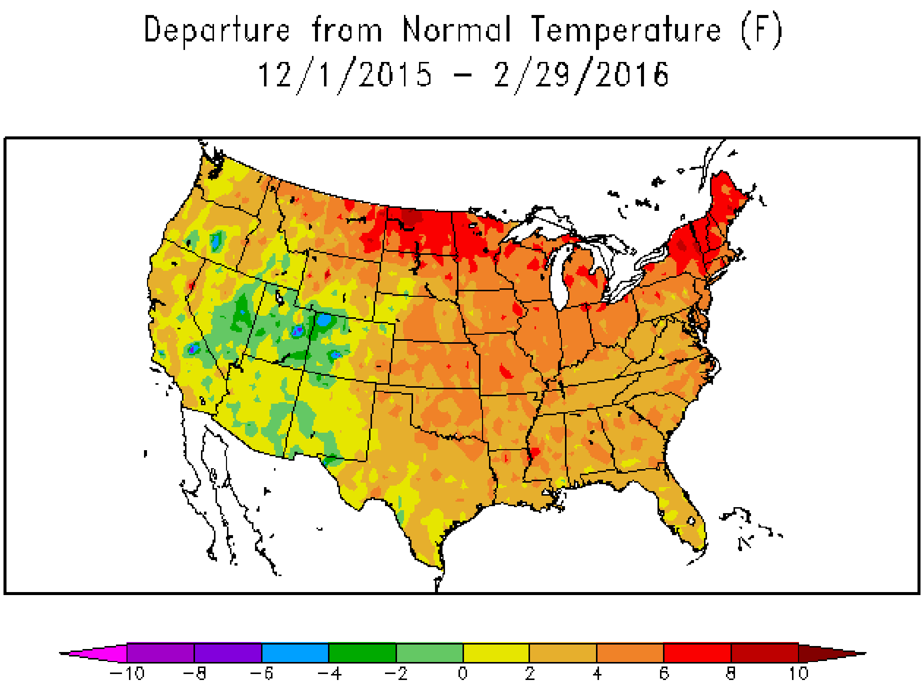


Figure 1. December 2015 – February 2016 departure from normal temperature (degrees Fahrenheit). Source: High Plains Regional Climate Center (HPRCC).

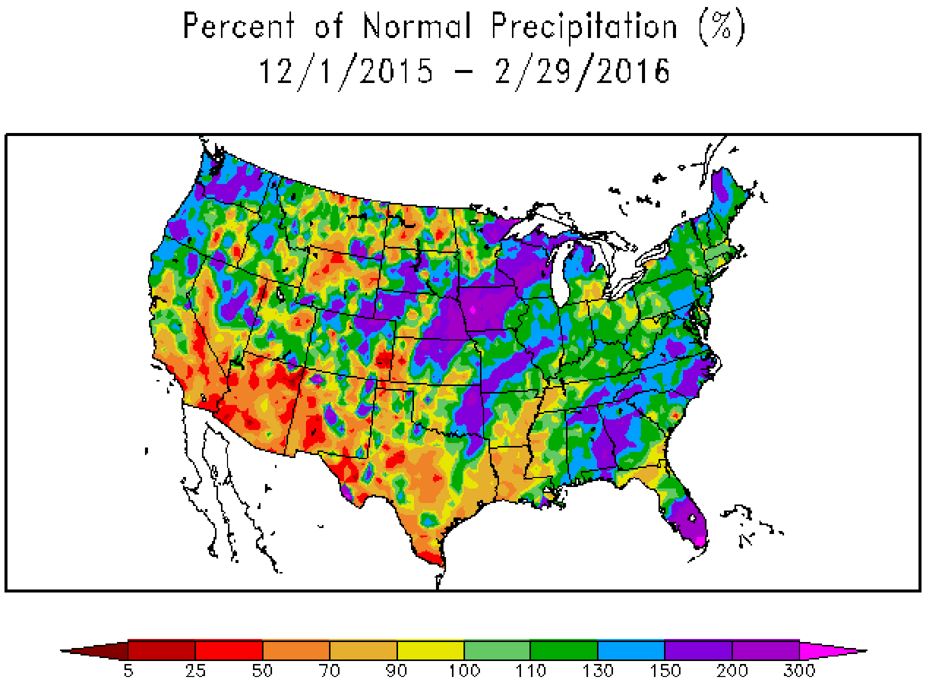


Figure 2. December 2015 – February 2016 percent of normal precipitation. Source: HPRCC.

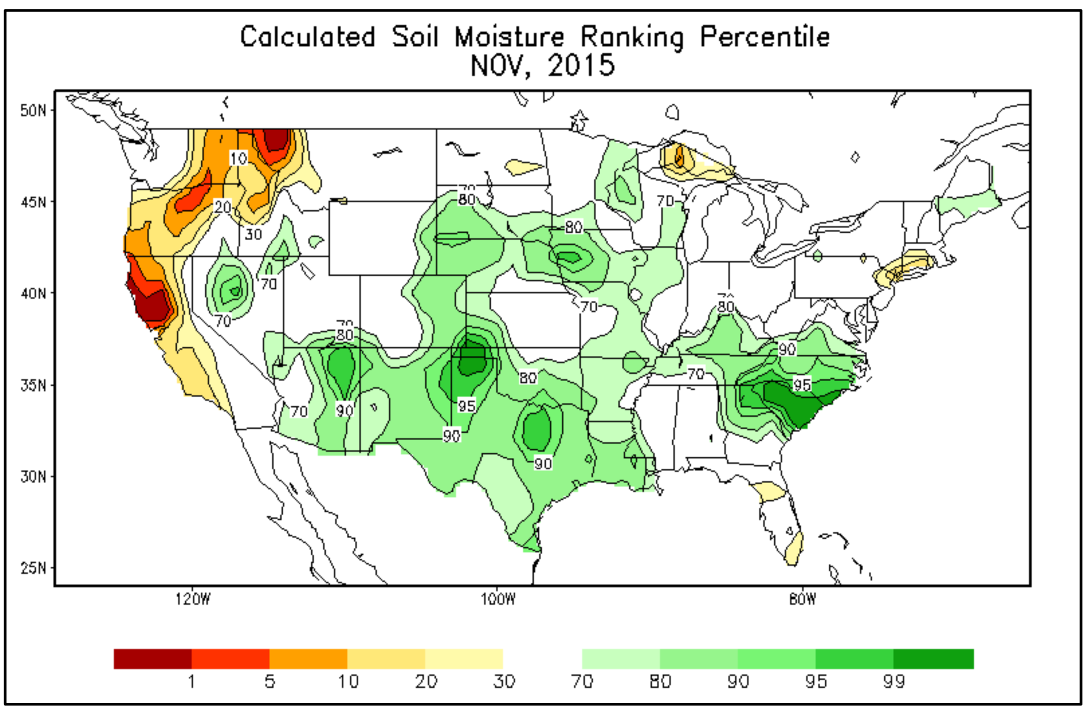


Figure 3. Soil moisture percentile ranking, November 2015. Source: NOAA CPC

The snowpack across the Northern and Central Plains began accumulating primarily in Wyoming, South Dakota, and northern Iowa at the end of November 2015. Above-normal precipitation was able to overcome the warmer-than-normal temperatures in central and eastern portions of the Basin to form some plains snowpack. Some significant daily snowfall amounts during November 2015 were 7.2 inches on November 20 and 8.7 inches on November 30 at

Sioux Falls, SD; and, 5.7 inches on November 20 and 6.6 inches on November 30 at Sioux City, IA. As of December 5, 2015, shallow accumulations were present in Montana, Wyoming, South Dakota, eastern North Dakota and northwest Iowa (see ***Figure 4***).

December precipitation accumulations were well-above-normal in western Montana, central North Dakota, South Dakota and most of the lower Basin, but temperatures were above-normal across most of the Basin. Monthly temperature departures ranged from 1 to 3 degrees Fahrenheit (deg F) above normal in Montana, and ranged from 5 to 8 deg F above normal in North Dakota and South Dakota. Due to the widespread above-normal precipitation in the Basin, plains snowpack developed across most of the upper Basin and portions of the lower Basin (see ***Figure 5***). Significant monthly snowfall amounts during December 2015 were 15.5 inches at Great Falls, MT; 13.7 inches at Billings, MT; 12.8 inches at Glasgow, MT; 12.8 inches at Bismarck, ND; 11.5 inches at Aberdeen, SD; 19.1 inches at Sioux Falls, SD; 11.8 inches at Sioux City, IA; and 12.3 inches at Omaha, NE. Snowpack depths as of January 3 generally ranged from 4 to 8 inches in areas of the upper Basin as shown in ***Figure 5***.

In contrast to December 2015, January was the opposite in terms of precipitation. Snowfall during January was below average in areas of North Dakota and South Dakota. Much of the plains region of the Dakotas received less than 75 percent of normal precipitation, and some areas received less than 25 percent of normal precipitation. Monthly snowfall amounts during January were 3.0 inches at Bismarck, ND; 2.3 inches at Aberdeen, SD; 6.9 inches at Sioux Falls, SD; 4.9 inches at Sioux City, IA; and 6.9 inches at Omaha, NE. Temperatures during the second half of January were well-above normal in Montana, northern Wyoming, North Dakota and northern South Dakota. Daytime high temperatures reached 55 and 58 deg F on January 27 and 28 at Great Falls, MT and Billings, MT, respectively. The daytime high temperature reached 47 deg F at Bismarck, ND on January 27; and, temperature departures ranged from 10 to 20 deg F above normal during the last week of January. As of January 30, most of the plains snowpack that developed in December had melted or ablated in Montana, eastern Wyoming, western and central South Dakota, and much of North Dakota. Shallow amounts of plains snow remained in portions of northeastern Montana, eastern South Dakota and northern Iowa (see ***Figure 6***). At the end of January, Billings, MT, Great Falls, MT, Bismarck, ND and Aberdeen, SD reported only trace amounts of snow. Glasgow, MT reported 5 inches of snow depth; Sioux Falls, SD reported 3 inches of snow depth; and, Sioux City, IA reported 4 inches of snow depth.

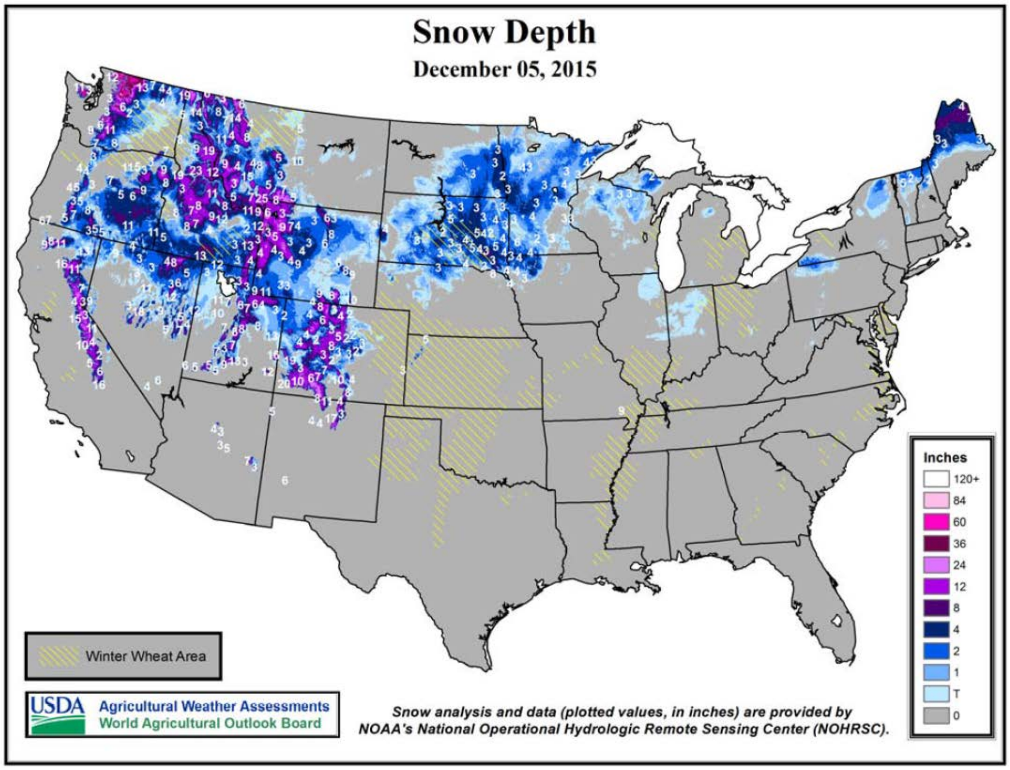


Figure 4. Snow depth in inches on December 5, 2015.

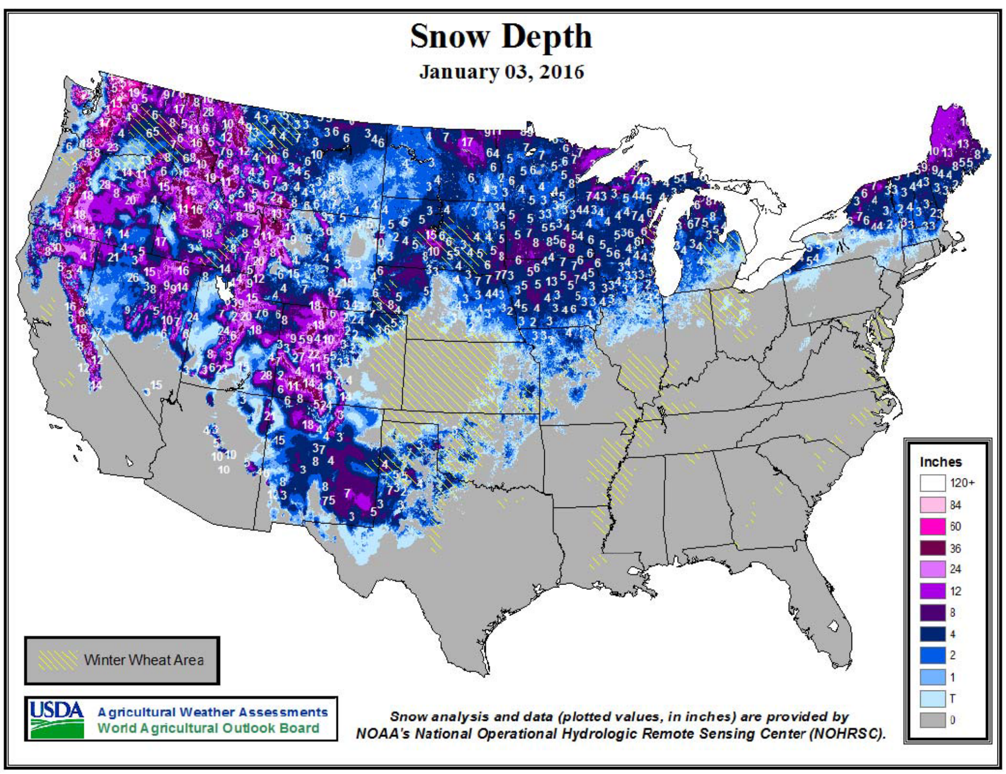


Figure 5. Snow depth in inches on January 3, 2016.

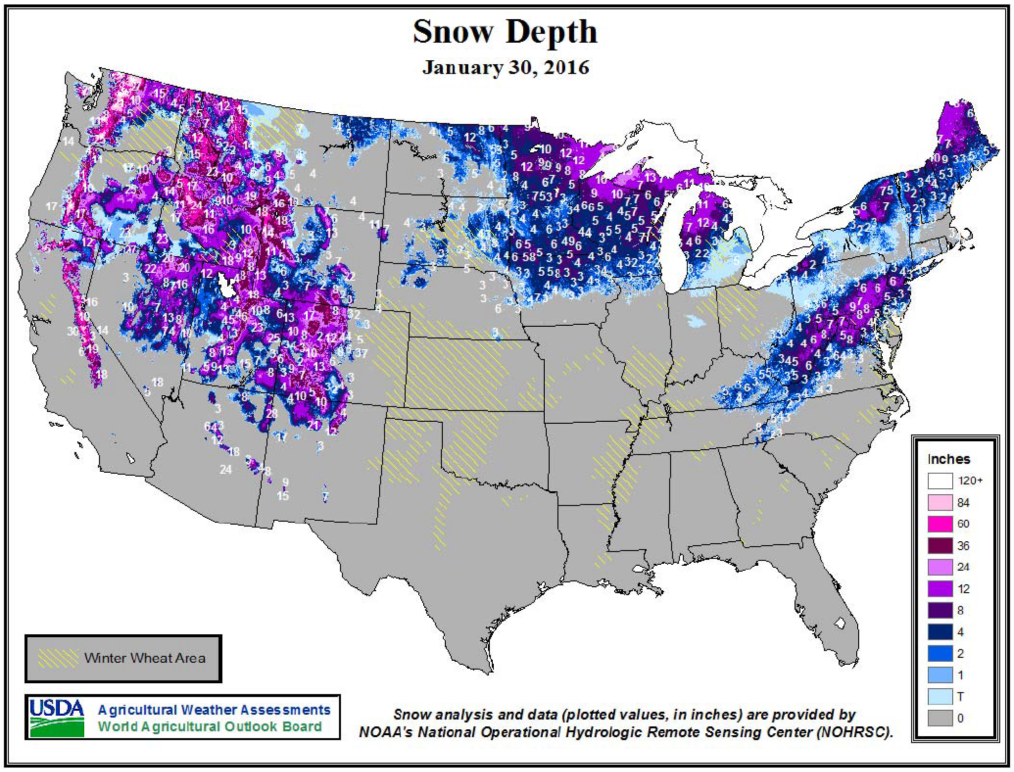


Figure 6. Snow depth in inches on January 30, 2016.

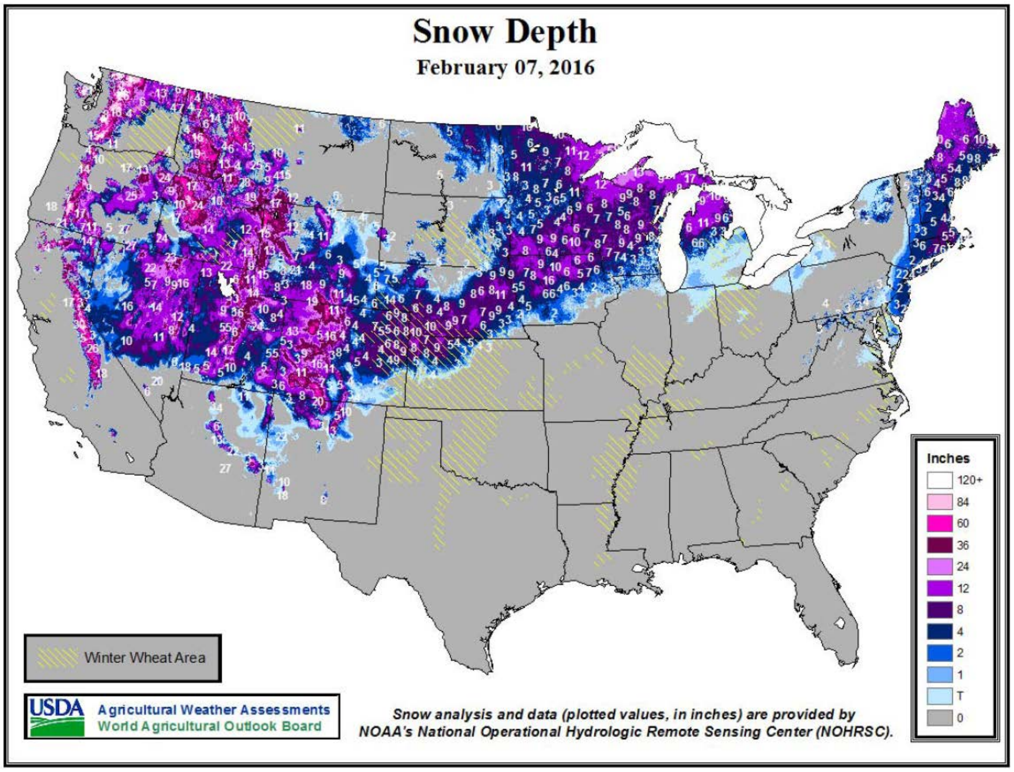


Figure 7. Snow depth in inches on February 7, 2016.

February plains snowfall was very sparse in Montana and North Dakota. Monthly snowfall amounts in February were 0.2 inches at Billings, MT; 0.1 inches at Great Falls, MT; 2.1 inches at Glasgow, MT; and 3.0 inches at Bismarck, ND. Eastern South Dakota, Nebraska, and Iowa received above-normal snowfall during February. On February 2, a significant winter storm produced 4.2 inches of snow at Sioux Falls, SD; 12.4 inches at Sioux City, IA; and 4.9 inches at Omaha, NE. The 12.4 inches on February 2 tied the seventh highest daily snowfall total on record at Sioux City. On February 7, there was no plains snowpack over much of the upper Basin, while there was measurable snow cover from the early February storm over much of Wyoming, Colorado, Nebraska and Iowa (see ***Figure 7***).

February precipitation was generally below normal across the Basin with the exception of eastern Montana, northwestern North Dakota, and the snow-covered areas shown in ***Figure 7***, which received well-above normal precipitation. Average monthly temperature departures during February ranged from 9 to 12 deg F above normal in much of Montana, North Dakota, and South Dakota. For the remainder of the upper Basin, temperature departures ranged from 6 to 9 deg F above normal, while lower Basin temperature departures ranged from 3 to 6 deg F above normal (***Figure 8***). As a result of the dry and warm weather conditions, there was no plains snowpack remaining at the end of February (see ***Figure 9***). Several small snowfall events occurred in March and April in the upper Basin, but the resulting snowpack melted within a few days of occurrence.

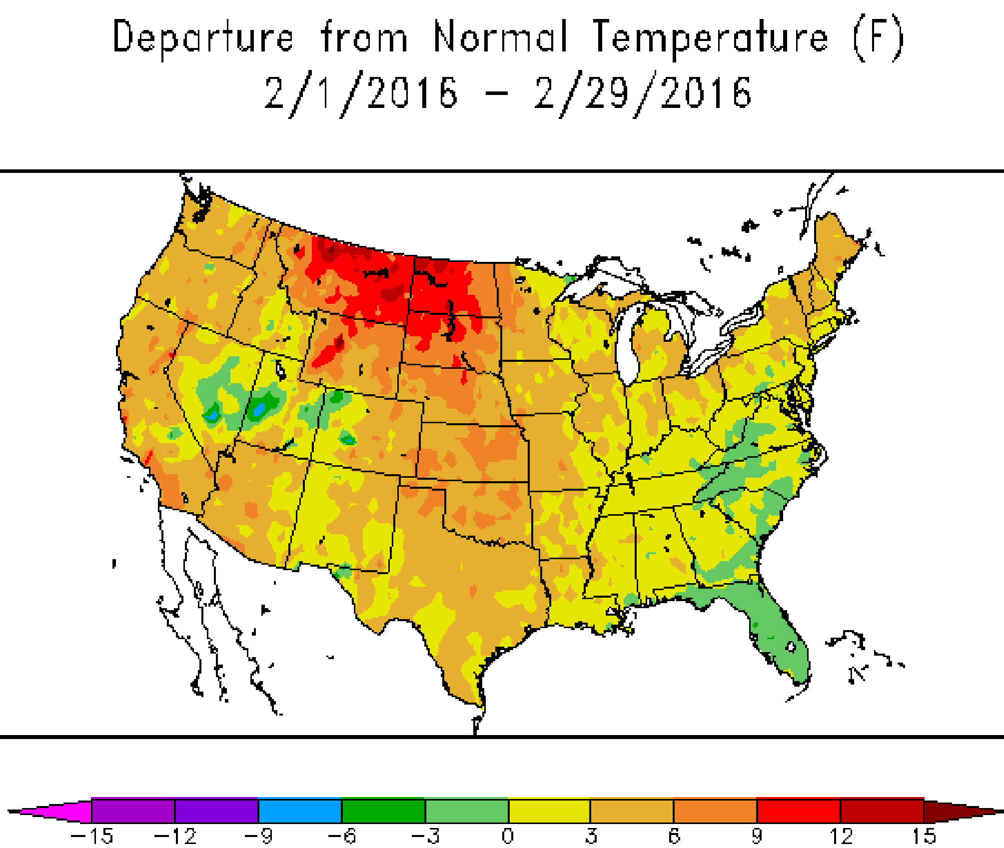


Figure 8. February 2016 departure from normal temperature (deg F). Source: HPRCC.

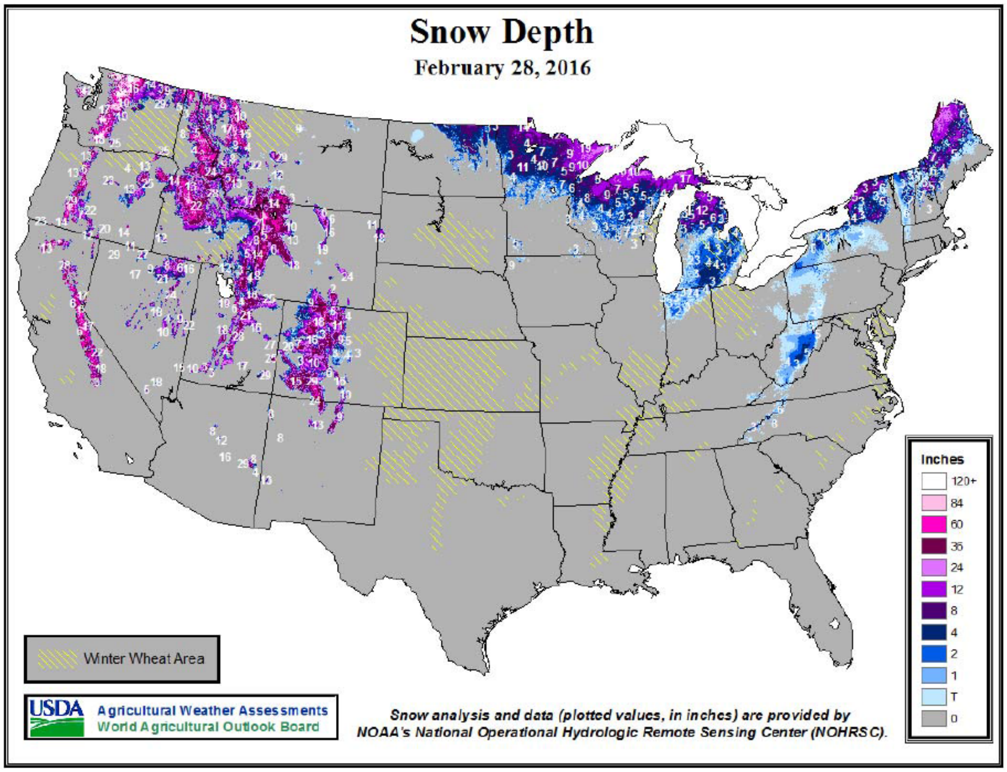


Figure 9. Snow depth in inches on February 28, 2016.

The peak plains snowpack coverage and SWE occurred from December 26, 2015 to January 9. In the upper Basin, the peak snowpack and SWE had developed by December 26 and persisted until January 9 (shown in ***Figure 10***). In southeastern South Dakota, eastern Nebraska and western Iowa, the heaviest plains SWE had accumulated by January 9. The greatest SWE amounts ranged from 1 to 2 inches with some greater amounts ranging from 2 to 3 inches.

Annual plains snowfall totals for locations in the plains (July 2015 to June 2016) and the previous season are listed in ***Table 1***. All locations in the upper Basin, with the exception of Sioux Falls, SD and Sioux City, IA, received well-below average annual snowfall. Billings, MT and Bismarck, ND received about one-half of their annual average snowfall. Sioux Falls and Sioux City received above-average snowfall, while Omaha, NE was above average. Due to much warmer-than-normal temperatures, Kansas City, MO received only 5.9 inches of snow.

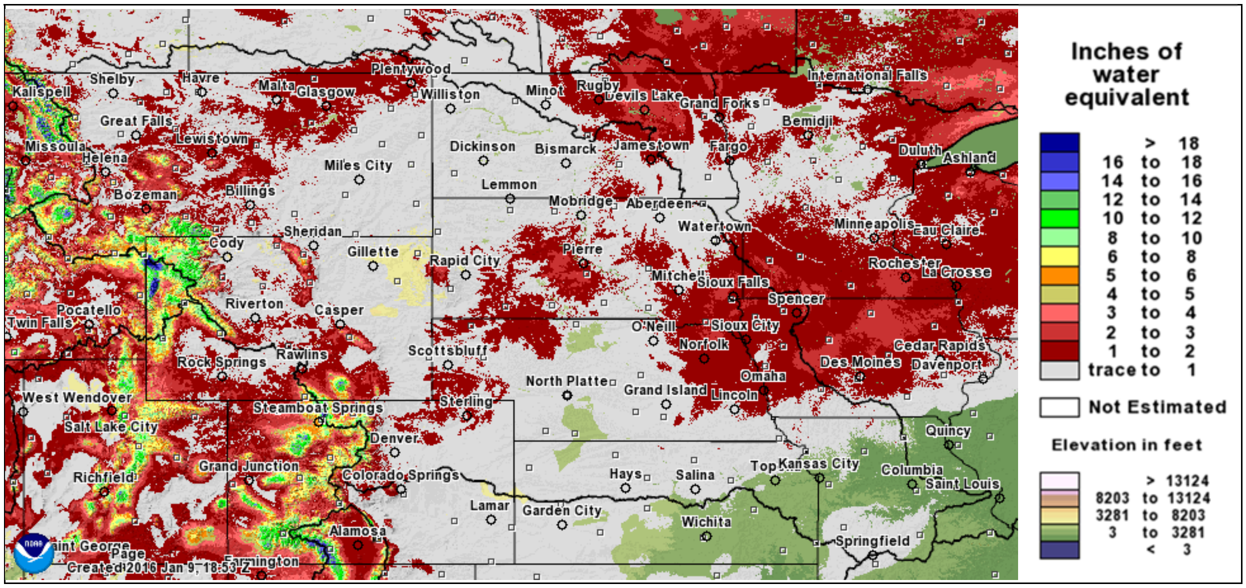


Figure 10. Missouri River Basin snowpack and SWE on January 9, 2016. Source: NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC).

Table 1
Missouri River Basin - Plains Snowfall Totals (inches)

Location	2014-15 Total	2015-2016 Total	Annual Average (1981-2010)
Billings, MT	55.4	28.1	55.1
Glasgow, MT	43.2	27.6	34.6
Great Falls, MT	57.9	46.9	63.2
Bismarck, ND	24.1	24.1	51.2
Aberdeen, SD	20.2	26.5	38.1
Sioux Falls, SD	31.9	68.5	44.5
Watertown, SD	25.3	28.7	35.9
Sioux City, IA	21.5	57.6	34.8
Omaha, NE	13.8	27.4	26.4
Kansas City, MO	14.2	5.9	18.8

*Maximum of record
Source: NOAA Online Weather Data (NOWData). Totals represent total snowfall from July 1 to June 30 of the following year.

2. Mountain Snowpack

Mountain snowpack is monitored by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service's (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. The 2015-16 mountain snowpack accumulation and melt pattern for each of the two reaches is illustrated in ***Figure 11***. Mountain SWE is discussed in the following paragraphs 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 2***.

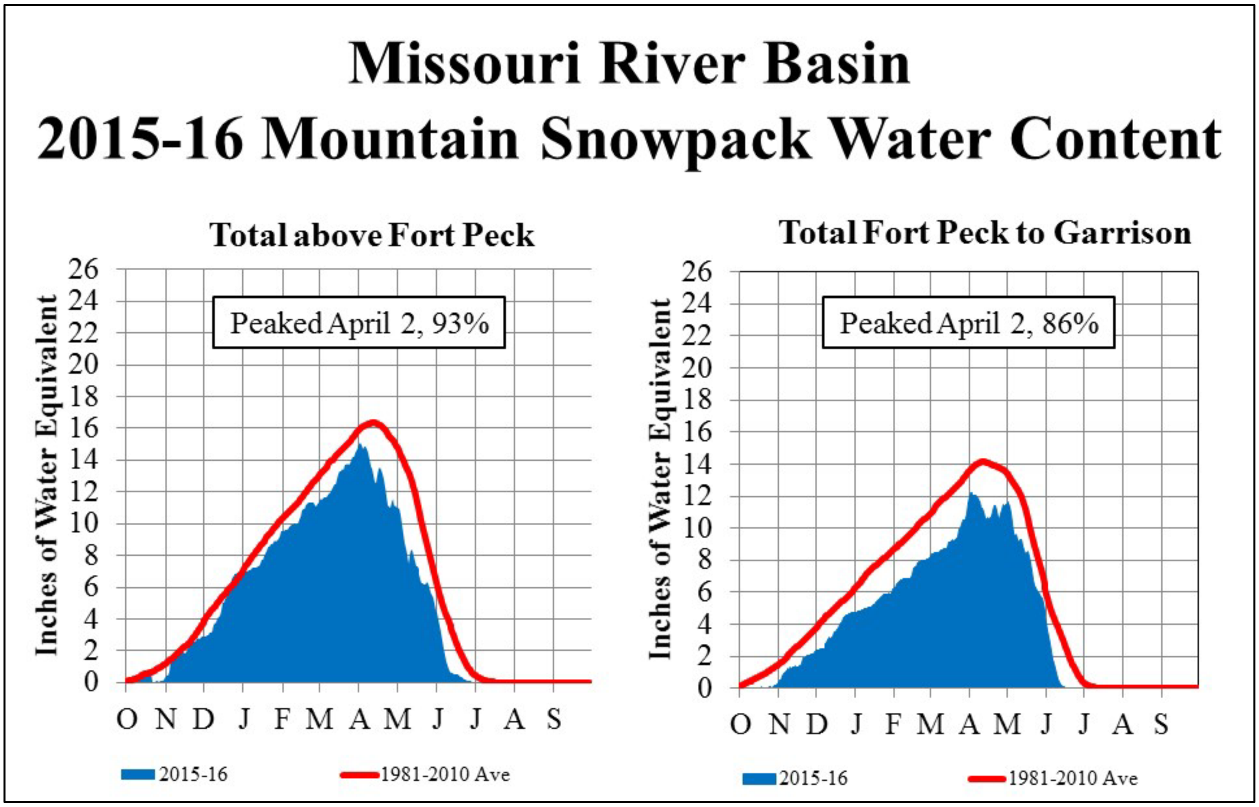


Figure 11. Missouri River Basin 2015-16 mountain SWE. Data Source: USDA-NRCS National Water and Climate Center.

In both reaches, the mountain snowpack was generally below average from October through July. In the Fort Peck reach (Total above Fort Peck in ***Figure 11***), the average mountain snowpack was near to slightly below normal from November through the end of December. From January through July it was below normal. Mountain snowpack peaked in the Fort Peck reach on April 2 at 93 percent of the 1981-2010 average SWE, which typically occurs in mid-April (see ***Table 2***). Following the peak accumulation, Fort Peck mountain snowpack declined rapidly, though some periodic mountain snowfall events caused short-term breaks in the overall mountain snowmelt. By June 1, mountain snowpack SWE was 72 percent of the June 1 normal snowpack and 26 percent of the normal April 15 peak accumulation. By July 2, all mountain snowpack in this reach, as monitored by the SNOTEL network, had melted.

In the Fort Peck to Garrison reach (Total Fort Peck to Garrison in ***Figure 11***), the average mountain snowpack was below normal during the entire mountain snowpack season from October through July. At no time during the season did the mountain snowpack reach normal levels in the Fort Peck to Garrison reach. Mountain snowpack peaked in the Fort Peck to Garrison reach on April 2 at 86 percent of the 1981-2010 average peak SWE, which typically occurs in mid-April (see ***Table 2***). Following the peak accumulation, Fort Peck to Garrison mountain snowpack declined, but a large mountain snowfall event in the Garrison reach caused the snowpack to accumulate to a lesser, second peak of 82 percent of the 1981-2010 average peak SWE on about May 1. Mountain snowpack melted rapidly following the May 1 second peak. By June 1, mountain snowpack SWE was 69 percent of the June 1 normal snowpack and 29 percent of the normal April 15 peak accumulation. All mountain snowpack in this reach, as monitored by the SNOTEL network, had melted by July 2.

Table 2
Mountain SWE Accumulation, 2015-2016

Month	Above Fort Peck Percent of Normal	Fort Peck to Garrison Percent of Normal	Average Percent of Actual Peak Accumulation
November 1	33	32	9
December 1	73	60	26
January 1	97	75	44
February 1	92	72	64
March 1	88	76	79
April 1	94	89	97
Peak	April 2, 93	April 2, 86	100
May 1*	74 / 67	87 / 82	92
June 1*	72 / 26	69 / 29	39
July 1*	7 / 0	12 / 0	3
Melt-out	July 2	July 2	

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

3. Weather Conditions

The Basin experienced above-normal precipitation and much warmer-than-normal temperatures during 2016. January-December precipitation and temperature statewide rankings for the past 122 years are shown in ***Figure 12*** and ***Figure 13***, respectively. Percent of normal monthly precipitation maps and departure from normal 3-month maps are shown on ***Figure 14*** and ***Figure 15***, respectively. ***Figure 16*** shows the National Drought Mitigation Center's drought maps in 3-month intervals. ***Table 3*** and ***Table 4*** show seasonal precipitation totals and departures from normal.

a. January – March

The year began with much warmer- and drier-than-normal weather conditions in much of the Basin from January to March. Precipitation was below normal in eastern Montana, North Dakota, South Dakota, southern Nebraska, Kansas and Missouri. In contrast, some localized areas received above-normal precipitation, highlighted by more than 150 percent of normal precipitation over much of Wyoming in March. Temperatures during the January – March period ranged from 6 to 10 deg F above normal in northeastern Montana, North Dakota and northern South Dakota, and 4 to 6 deg F above normal in the remainder of the upper Basin. Temperatures in the lower Basin ranged from 2 to 6 deg F above normal. Moderate (D1) Drought in the upper Basin in early January (***Figure 16***) was present in western Montana, north-central Wyoming, south-central Montana and south-central South Dakota. Due to warmer-than-normal temperatures in the upper Basin, the limited plains snowpack melted in early February, resulting in 170 percent of average February runoff in the upper Basin (***Table 6***). The lack of snowpack and below normal precipitation in the plains in March resulted in 62 percent of average runoff during March. The accumulated runoff for the upper Basin above Sioux City by the end of March was 4.5 MAF, 93 percent of average.

b. April – June

By early April, drought conditions (***Figure 16***) in western Montana had improved and only a small region of D1 Drought was present. Severe (D2) Drought developed in north-central Wyoming and south-central Montana, and D1 Drought developed in southwestern North Dakota.

The weather during the April – June period began with several large precipitation events in April and early May, but ended with a very dry June. Precipitation accumulations were 200 to 400 percent of normal over much of the Basin in April with the exception of southwestern Montana and northwestern Wyoming (***Figure 14***). As a result of April precipitation, April runoff (***Table 6***) was above average in the Fort Randall, Gavins Point and Sioux City reaches. In May above-normal precipitation continued in northern and central Montana, central Wyoming, southeastern South Dakota, northwestern Iowa and eastern Nebraska, while below-average precipitation (less than 50 percent of average) occurred over a region covering southeastern Montana, southwestern North Dakota and western South Dakota. As a result May runoff was above average in all reservoir reaches except the Oahe reach (***Table 6***). June precipitation was well-below normal throughout the Basin, punctuated by areas receiving less than 50 percent of normal precipitation. Conditions were especially dry in southern Montana, Wyoming, southern

Nebraska and Kansas. April–June temperatures (***Figure 15***) were generally 0 to 2 deg F above normal over most of the Basin with temperature departures ranging from 2 to 4 deg F above normal in southern Montana, northern Wyoming, South Dakota and eastern Nebraska. Warmer-than-normal temperatures resulted in an early mountain snowpack peak and early melting. The June runoff summation for the upper Basin was below average (***Table 6***).

c. July – September

Due to dry conditions in northeastern Wyoming, southeastern Montana and western South Dakota in May and June, the drought intensity degraded to Extreme (D3) Drought on July 5 (***Figure 16***). However, drought conditions improved in western Montana, North Dakota, western Wyoming, and Kansas by July 5, while Abnormally Dry (D0) conditions had developed in southeastern Nebraska.

Although month-to-month precipitation as a percent of normal varied in the Basin, overall precipitation accumulations were above normal. During July, precipitation was above normal from central Montana to North Dakota, in Kansas and Missouri. Precipitation was less than 70 percent of average over much of Wyoming, southern Montana and eastern South Dakota. Despite the above-normal precipitation in July, runoff in the Oahe reach was above average. During August precipitation was above normal in southeastern Montana, southeastern North Dakota, eastern South Dakota and much of the lower Basin. August runoff was above average runoff occurred in the Oahe, Fort Randall and Sioux City reaches.

September precipitation was more than 150 percent of normal in Montana, much of Wyoming, North Dakota, southeastern South Dakota, eastern Iowa and Nebraska. Much of the precipitation in Montana, Wyoming and North Dakota occurred from September 21-25. In contrast, precipitation was below normal in western and northeastern South Dakota and western Nebraska. September runoff was below average in the Fort Peck, Garrison and Oahe reaches, but it was above average in the Fort Randall, Gavins Point and Sioux City reaches. Temperatures were average to slightly below normal in Montana and Wyoming from July-September; however, temperatures were above normal in the Dakotas and much of the lower Basin below Sioux City, IA.

d. October – December

In October, precipitation was above normal in western Wyoming, western and central Montana due to a large rain storm (***Figure 14***) that caused flooding in north-central Montana. Precipitation was well below normal in the remainder of the Basin. In November dry conditions prevailed throughout much of the western portion of the Basin, while above-normal precipitation occurred in the central and eastern Dakotas. Precipitation accumulations were more than 200 percent of normal over much of the upper Basin in December, due to several winter storms that produced rain and heavy snowfall. December precipitation totals (departures) were: 1.7 inches (1.2 inches above average) at Billings, MT; 2.1 inches (1.6 inches above average) at Bismarck, ND; 2.3 inches (1.9 inches above average) at Mobridge, SD; and, 1.9 inches (1.2 inches above average) at Sioux Falls, SD. Temperatures during the October–December period were about normal in Montana, northern Wyoming, but temperatures were 2 to 4 deg F above normal in much of the remainder of the Basin.

e. Significant Precipitation Events

Although heavy seasonal precipitation occurred in the Basin during all 3-month periods, precipitation occurring from April–May and from September–October resulted in the highest unregulated peak flows on the Missouri River, which was attenuated by the six Mainstem dams on the Missouri River. Plots of the natural or unregulated flow versus the actual or regulated flow are shown in ***Figure 17A***, ***Figure 17B*** and ***Figure 17C***. ***Figure 17C*** indicates unregulated Missouri River flows at Hermann exceeding 500,000 cfs in early January. This late December and early January event is discussed in the ***Summary of Actual 2015 Regulation*** report.

April brought heavy precipitation to the Basin and record precipitation to several locations in the upper Basin. Two large storm systems moved through the Missouri Basin April 15-21 and April 24-30. These storm systems were responsible for a majority of the April precipitation shown in ***Figure 14*** and listed in ***Table 3***. April precipitation totals ranged from 2.8 to 4.6 inches in the upper Basin. Riverton, WY and Miles City, MT received record April precipitation totals. In the lower Basin, April rainfall totals (departures) listed in ***Table 3*** ranged from 5.1 inches (2.5 inches above normal) in Grand Island, NE to 7.9 inches (5.1 inches above normal) in Manhattan, KS. In May heavy rainfall in north-central Montana and central Wyoming combined with mountain snowpack to cause above average runoff in all System reaches except the Oahe reach (***Table 6***). Heavy rainfall also occurred in the lower Basin in central Nebraska, eastern Kansas and western Missouri.

Regulation of tributary and mainstem projects resulted in a reduction of Missouri River flows at Wolf Point, MT from a 53,000-cfs unregulated or natural peak flow to a 16,000-cfs actual or regulated flow on May 15 (***Figure 17A***). At Bismarck, ND, a 68,000-cfs unregulated peak flow was reduced to a 22,000-cfs actual flow on May 23. At Sioux City, IA, a 90,000-cfs unregulated peak flow was reduced to a 36,000-cfs actual flow on May 31.

In the lower Basin, System regulation had less effect on flood peaks, such as those shown in ***Figure 17B*** at St. Joseph, MO. Heavy rainfall occurred in May in eastern Kansas and northwest Missouri. Due to System and tributary regulation, the unregulated peak flow of 161,000 cfs at St. Joseph, MO was reduced to 135,000 cfs on May 12. The unregulated peak flow of 368,000 cfs at Hermann, MO was reduced to 254,000 cfs on June 1.

In addition, heavy July–August precipitation totals (departure from normal) in the Basin included 10.5 inches (5.0 inches above normal) at Jamestown, ND; 9.5 inches (3.7 inches above normal) at Watertown, SD; 15.2 inches (6.2 inches above normal) at St. Joseph, MO; and, 18.0 inches (9.6 inches above normal) at Kansas City, MO. See ***Figure 17A*** through ***Figure 17C*** to see how regulation of the System and tributary reservoirs effected downstream flows.

Heavy rainfall occurred in the upper Basin from mid-September to early October. ***Table 4*** contains significant September and October precipitation totals and departures in many locations in the Upper Basin. Heavy rainfall occurred in a large area spanning Montana, central and northern Wyoming, and northern Montana from October 2-5, causing widespread flooding in the Milk River basin in north central Montana. Significant October totals (departure from normal) include 6.8 inches (6.0 inches above normal) near Malta, MT; 5.5 inches (4.7 inches above normal) near Saco, MT; 5.6 inches (4.4 inches above normal) at Lake Yellowstone, MT; and 7.6 inches (3.2 inches above normal) at Sioux Falls, SD. Significant September–October precipitation totals (departure from normal) in north-central Montana included 9.5 inches (7.4 inches above normal) at Malta, MT; 8.2 inches (6.2 inches above normal) at Saco, MT; 7.0 inches (3.5 inches above normal) at Yellowtail Dam, MT; and 10.7 inches (4.1 inches above normal) at Sioux Falls, SD. Regulation of Fort Peck and tributary projects resulted in a reduction of flows at Wolf Point, MT from a 55,000-cfs unregulated peak flow to a 13,300-cfs actual flow on October 9 (***Figure 17A***). Regulation of Fort Peck, Garrison and tributary projects resulted in a reduction of the unregulated peak flow of 55,000-cfs at Bismarck, ND to a 13,800-cfs actual flow on October 17.

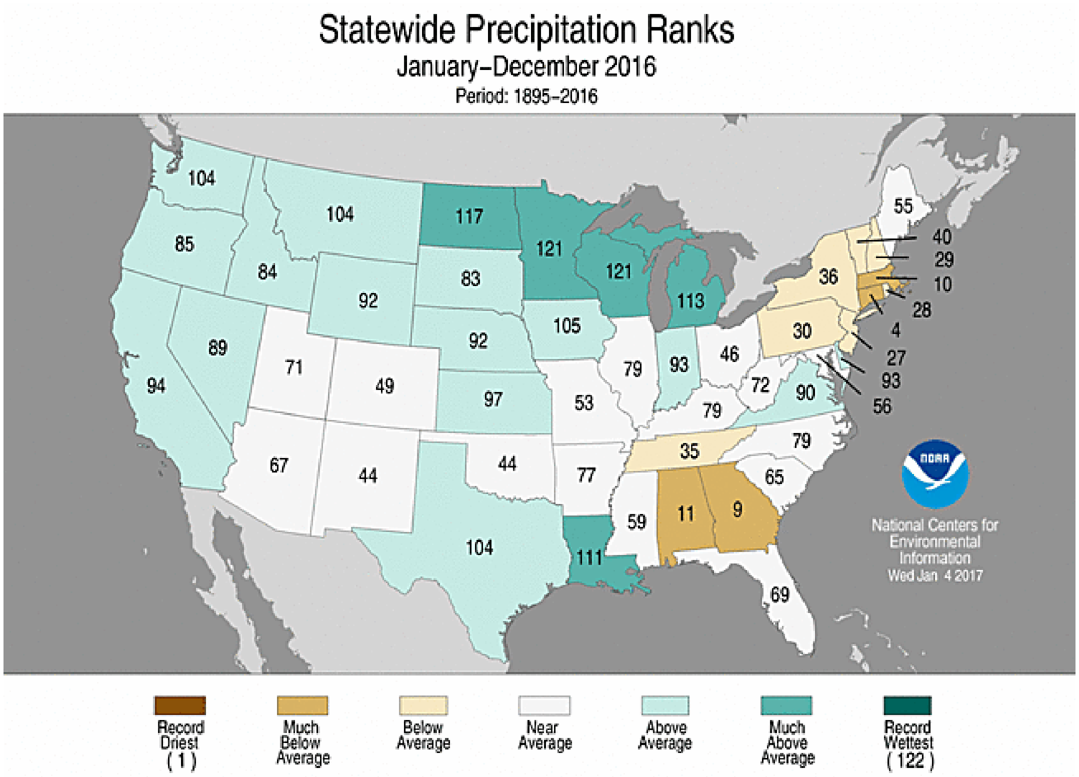


Figure 12a. January-December 2016 Statewide Precipitation Ranks (Source: NOAA/NCDC).

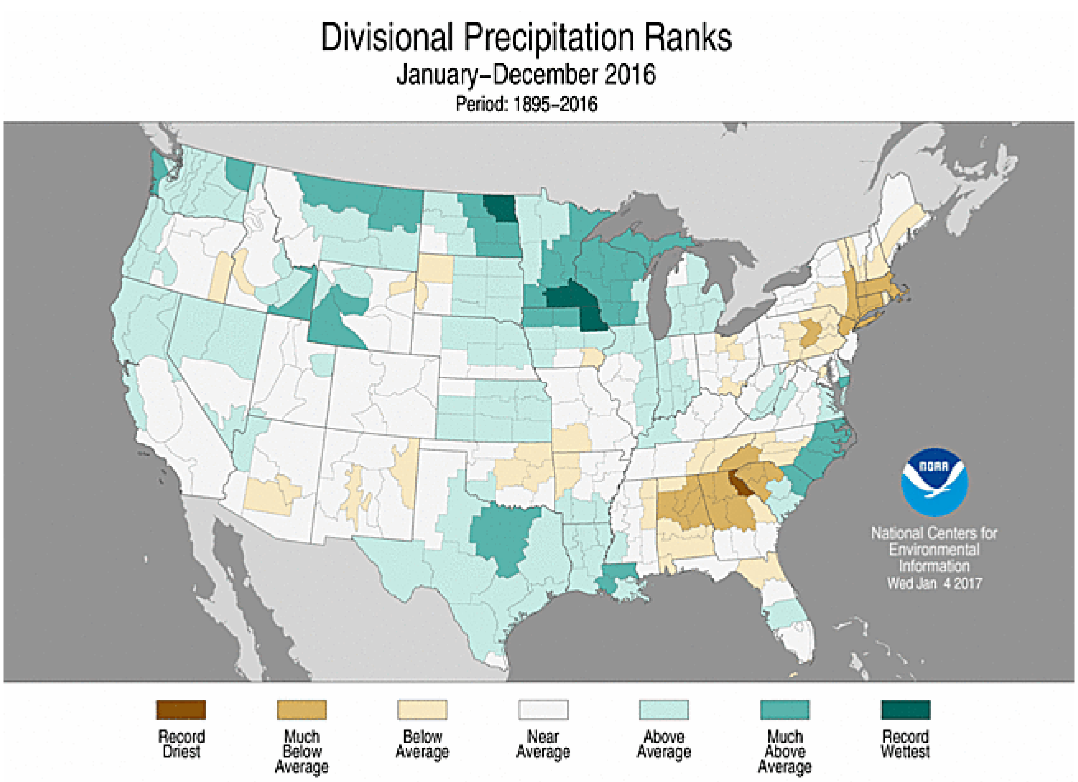


Figure 12b. January-December 2016 Divisional Precipitation Ranks (Source: NOAA/NCDC).

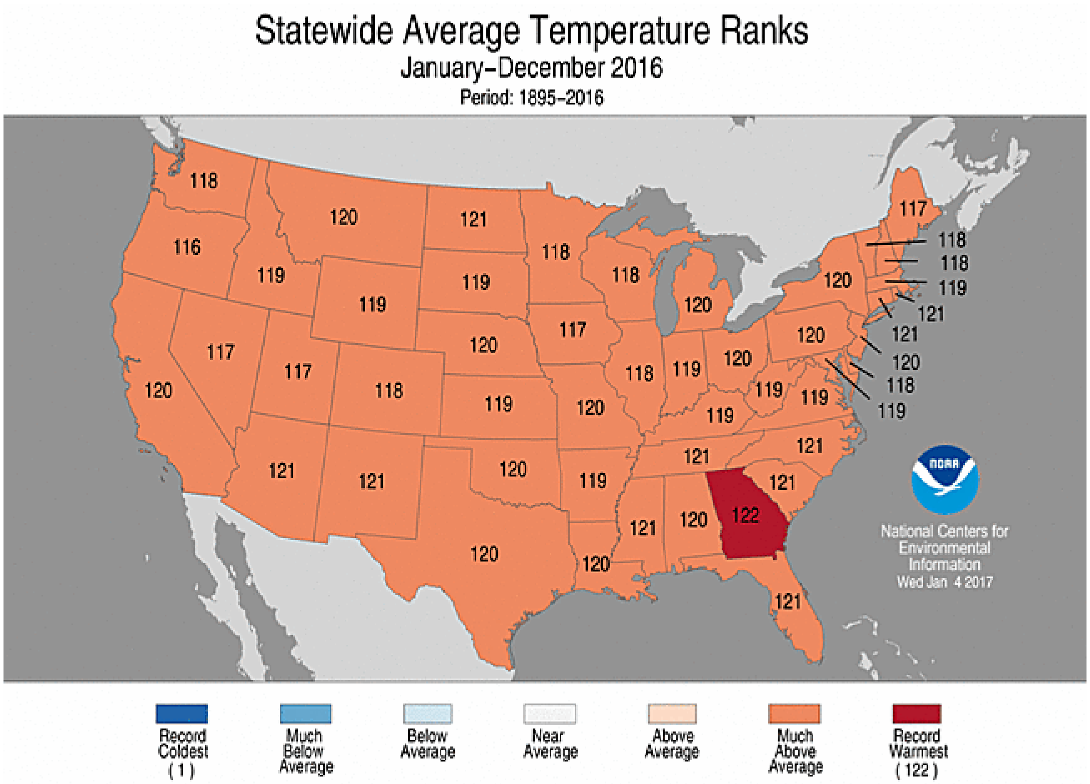


Figure 13a. January-December 2016 Statewide Temperature Ranks (Source: NOAA/NCDC).

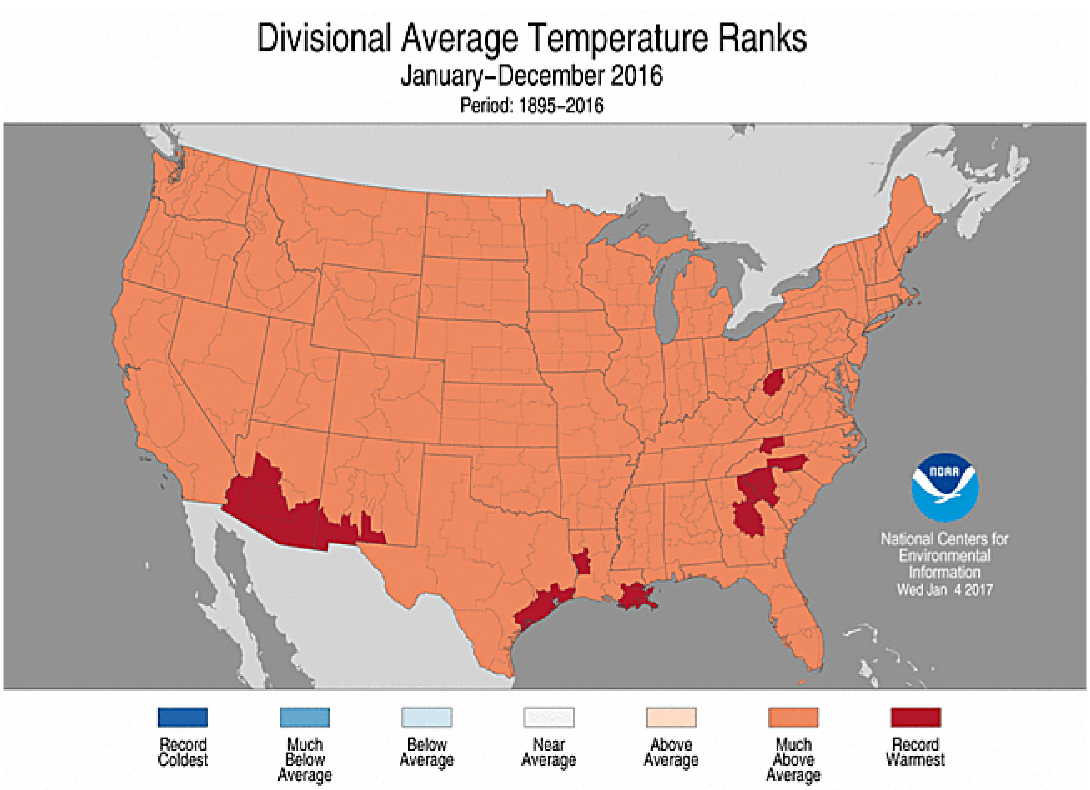


Figure 13b. January-December 2016 Divisional Temperature Ranks (Source: NOAA/NCDC).

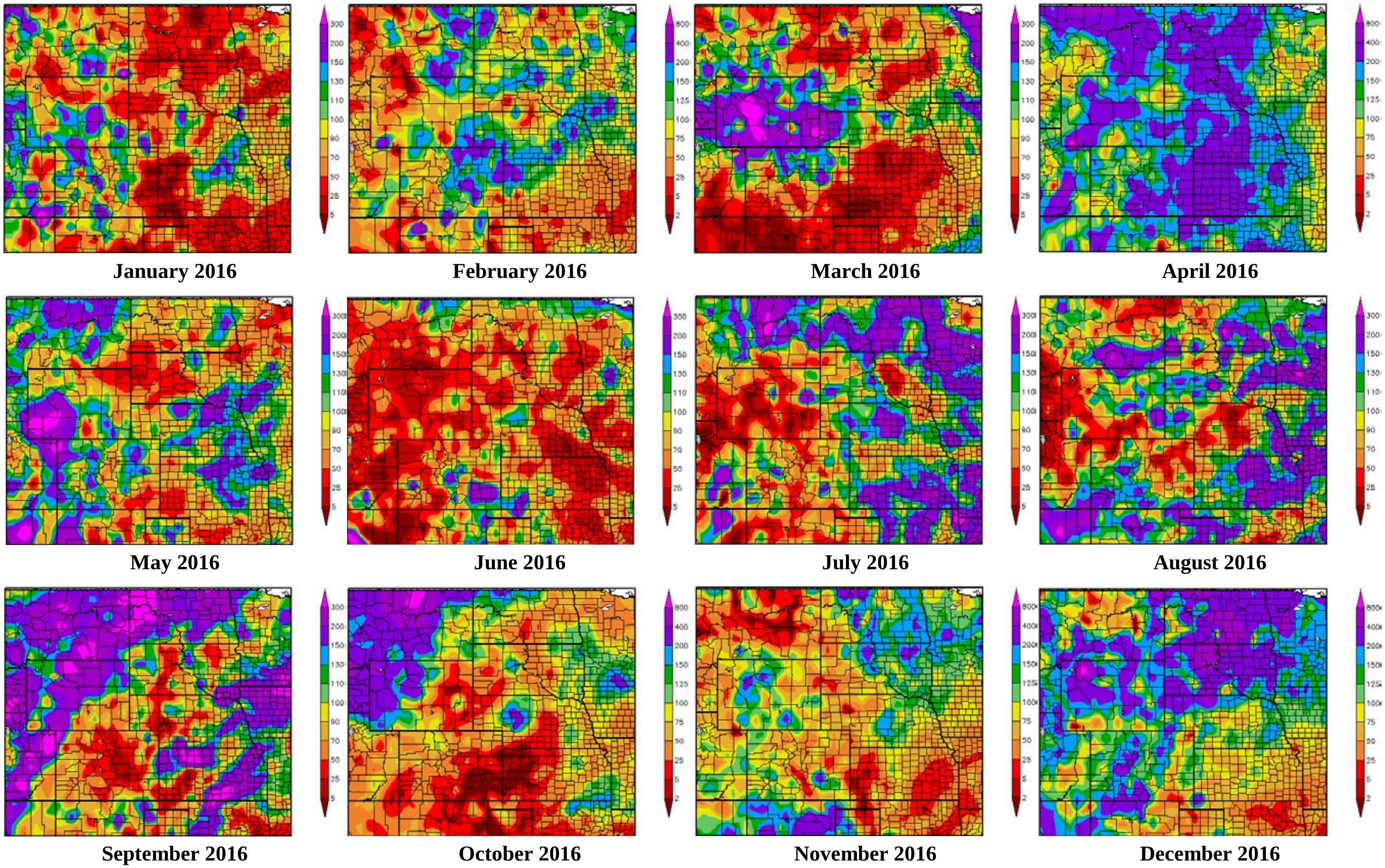


Figure 14. Percent of normal precipitation maps for 2016, by month. Reformatted from the High Plains Regional Climate Center Climate Summary Maps.

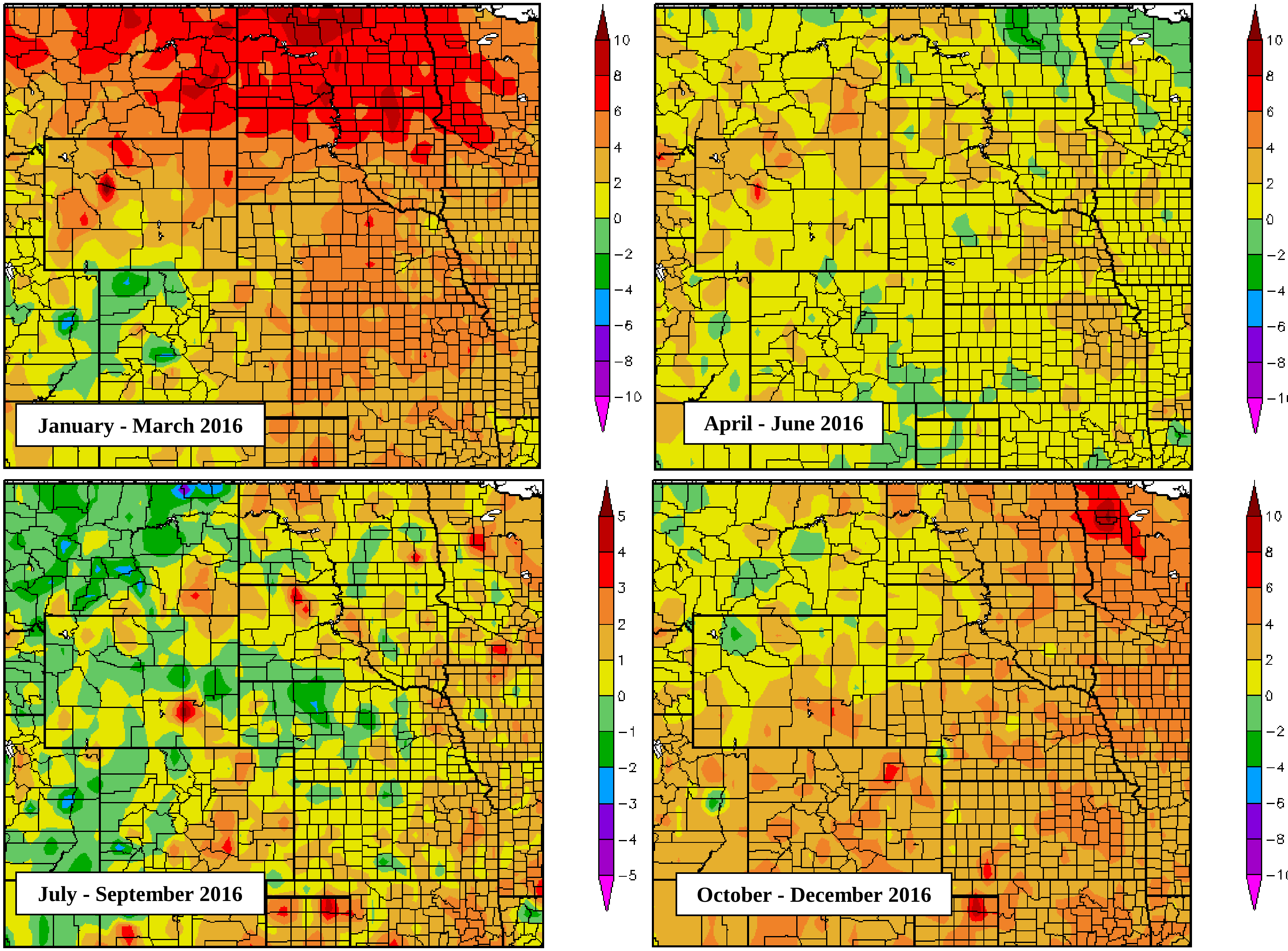


Figure 15. Departure from normal temperature (degrees F) for the 2016 three-month periods: January-March, April-June, July-September and October-December. Reformatted from the High Plains Regional Climate Center Climate Summary Maps.

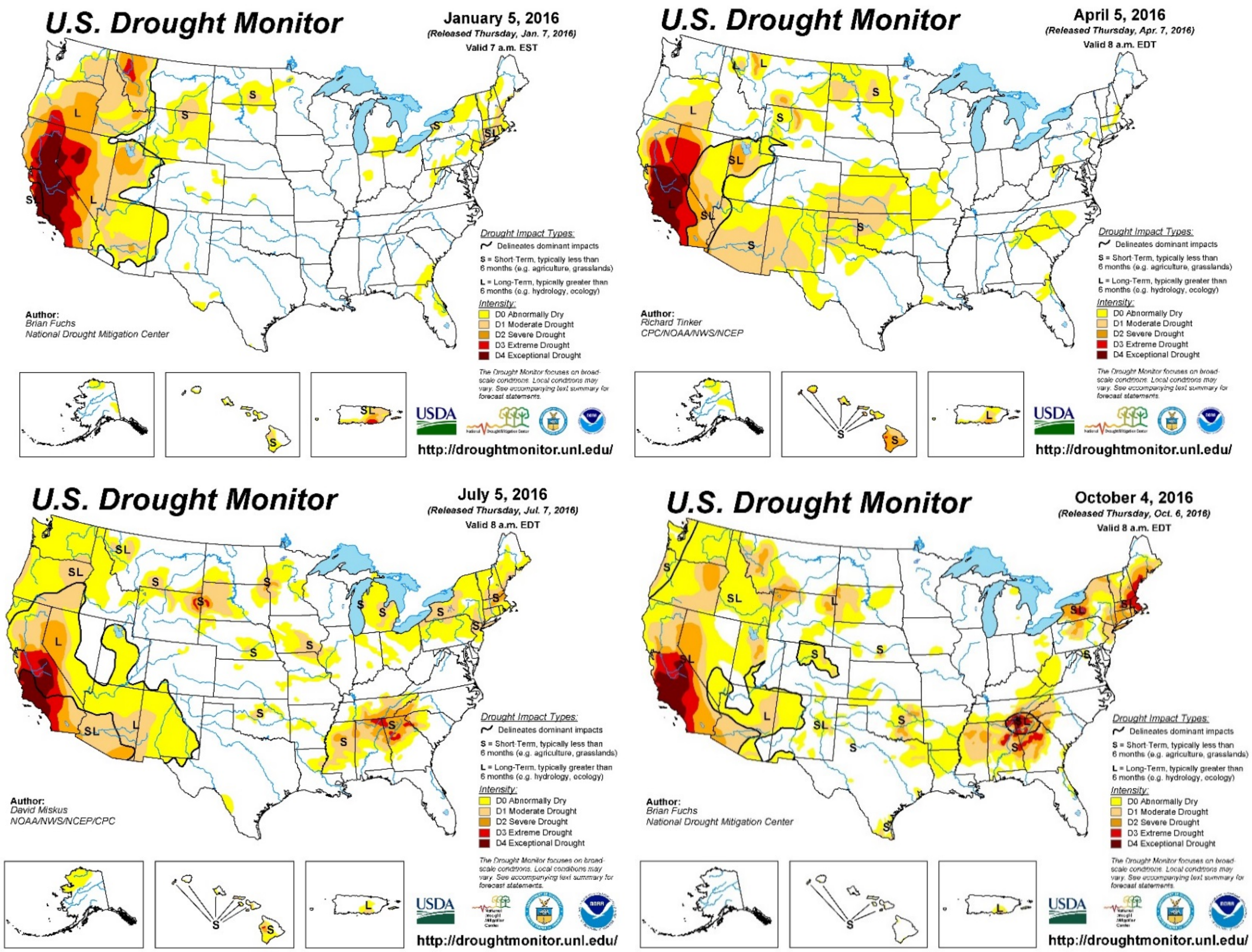


Figure 16. The National Drought Mitigation Center's drought maps for early January, April, July and October 2016.

Table 3. April – May 2016 precipitation totals and departures from normal.

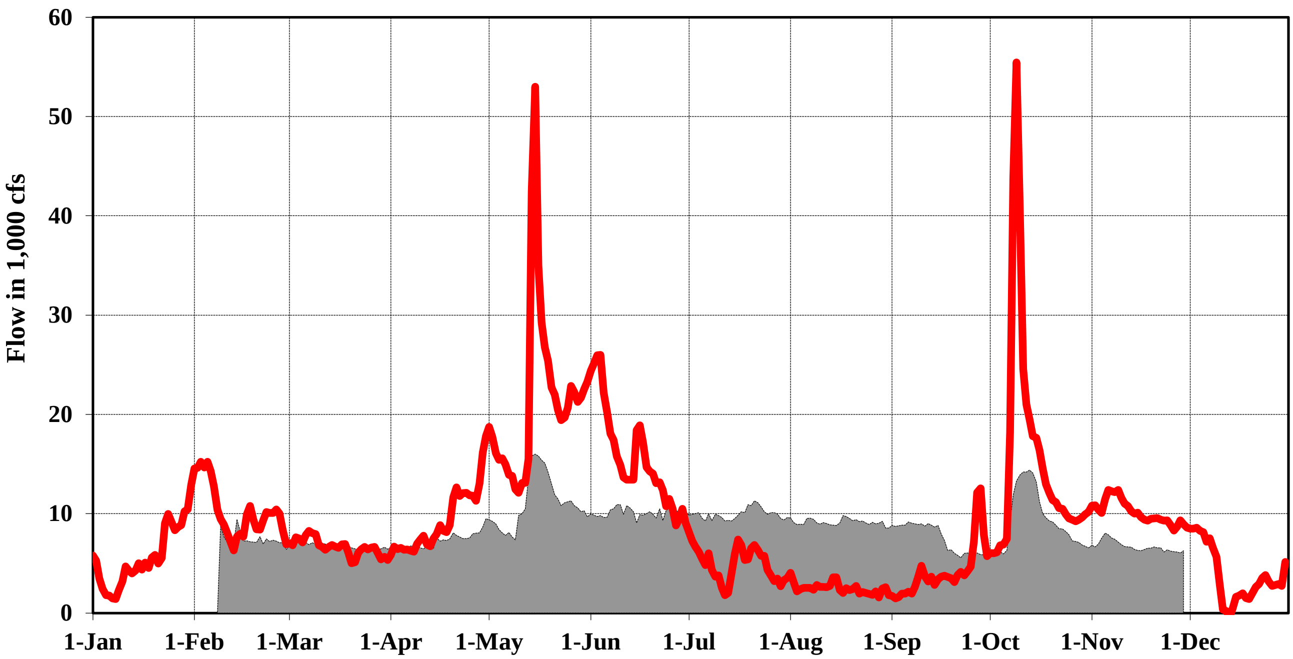
City, State	April		May		April-May	
	Total inches	Departure inches	Total inches	Departure inches	Total inches	Departure inches
Great Falls, MT	2.8	1.4	2.4	-0.4	5.2	1.0
Havre, MT	3.6	2.7	3.5	1.7	7.1	4.4
Miles City, MT	4.4*	3.0	2.4	0.3	6.8	3.3
Glasgow, MT	2.6	1.8	4.5	2.5	7.1	4.3
Riverton, WY	3.3*	2.0	2.8	1.1	6.1	3.1
Lander, WY	4.6	2.7	5.0	2.8	9.6	5.5
Sheridan, WY	3.4	1.8	1.1	-1.3	4.5	0.5
Bismarck, ND	4.2	2.9	2.0	-0.4	6.2	2.5
Jamestown, ND	2.6	1.4	2.8	0.1	5.4	1.5
Pierre, SD	3.9	2.1	1.2	-2.0	5.1	0.1
Sioux City, IA	5.8	2.9	5.2	1.3	11.0	4.2
Grand Island, NE	5.1	2.5	6.8	2.4	11.9	4.9
Omaha, NE	5.4	2.4	4.8	0.1	10.2	2.5
Manhattan, KS	7.9	5.1	5.9	1.4	13.8	6.5
Topeka, KS	6.9	3.4	8.8	3.9	15.7	7.3
Kansas City, MO	7.2	3.5	9.5	4.3	16.7	7.8

*Monthly record.

Table 4. September-October 2016 precipitation totals and departures from normal.

City, State	September		October		September-October	
	Total inches	Departure inches	Total inches	Departure inches	Total inches	Departure inches
Dillon, MT	1.5	0.6	2.2	1.5	3.7	2.1
Great Falls WFO, MT	2.4	0.9	1.8	1.0	4.2	1.9
Malta 7 E, MT	2.7	1.4	6.8	6.0	9.5	7.4
Saco 1 NNW, MT	2.7	1.5	5.5	4.7	8.2	6.2
Lewistown AP, MT	2.4	1.1	4.0	2.9	6.4	4.0
Billings, MT	1.6	0.3	3.5	2.3	5.1	2.6
Livingston, MT	1.6	0.4	3.3	2.1	4.9	2.5
Glendive, MT	3.8	2.5	0.8	-0.3	4.6	2.2
Glasgow, MT	1.7	0.7	3.1	2.4	4.8	3.1
Wolf Point, MT	2.3	1.3	3.3	2.1	5.6	3.4
Livingston AP, MT	1.6	0.4	3.3	2.1	4.9	2.5
Lake Yellowstone, WY	2.4	0.9	5.6	4.4	8.0	5.3
Yellowtail Dam, MT	3.9	2.2	3.1	1.3	7.0	3.5
Sheridan, WY	3.7	2.3	1.5	0.0	5.2	2.3
Williston, ND	3.5	2.5	1.1	0.1	4.6	2.6
Watford City, ND	5.3	4.3	1.2	0.2	6.5	4.5
Sioux Falls, SD	7.6	3.2	3.1	0.9	10.7	4.1

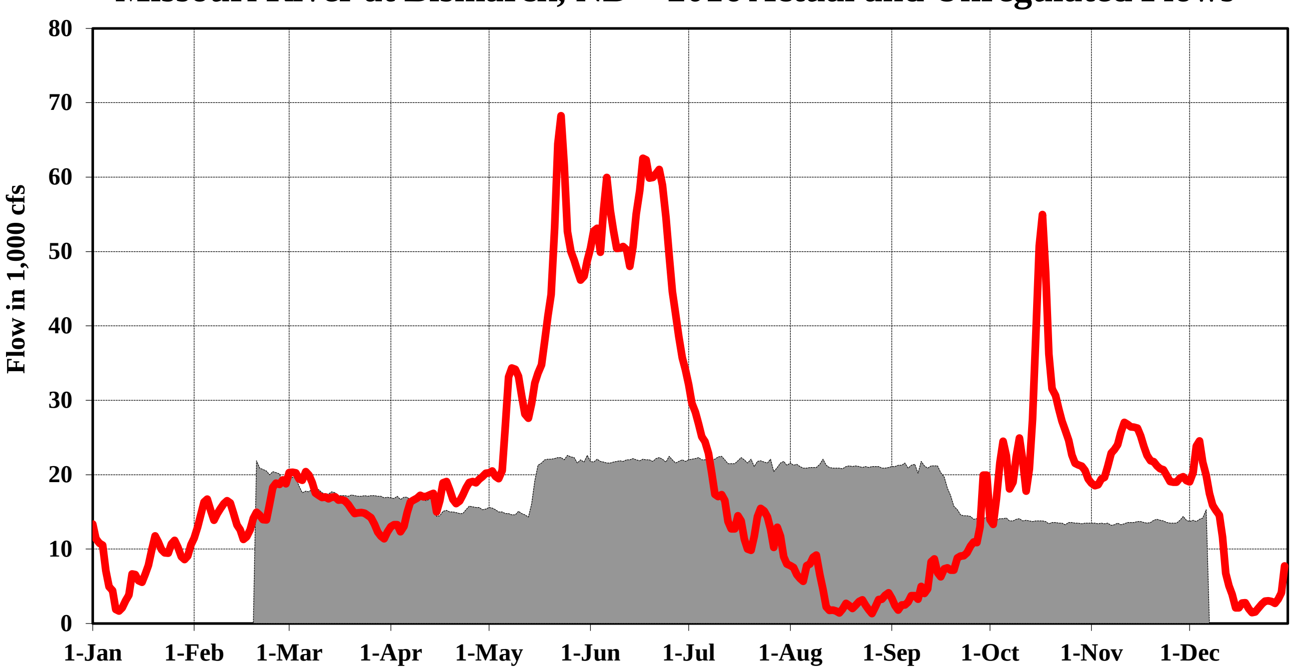
Missouri River at Wolf Point, MT – 2016 Actual and Unregulated Flows



Actual (Regulated) Flow* Unregulated (Natural) Flow

*Actual flow prior to February 9, 2016 and after December 6, 2016 is ice affected.

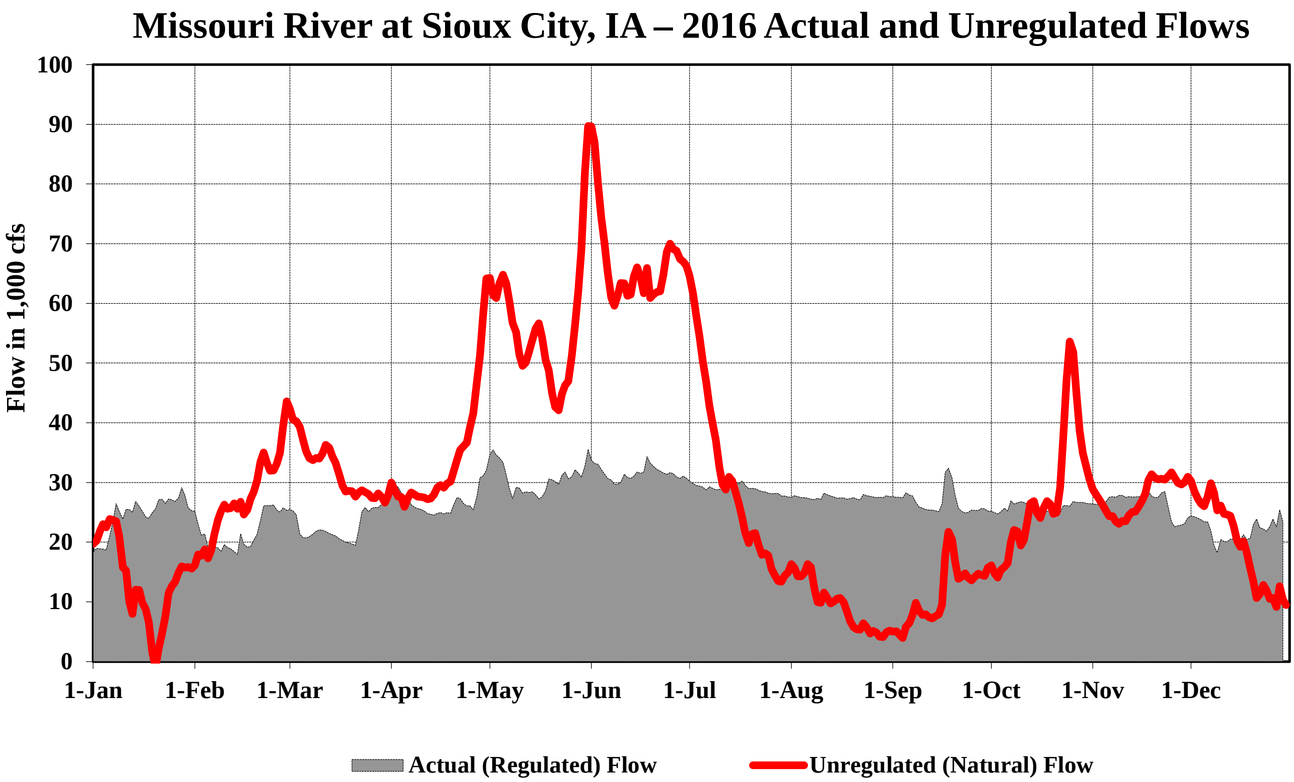
Missouri River at Bismarck, ND – 2016 Actual and Unregulated Flows



Actual (Regulated) Flow** Unregulated (Natural) Flow

**Actual flow prior to February 20, 2016 and after December 6, 2016 is ice affected.

Figure 17A. 2016 actual and unregulated flows – Wolf Point, MT and Bismarck, ND.



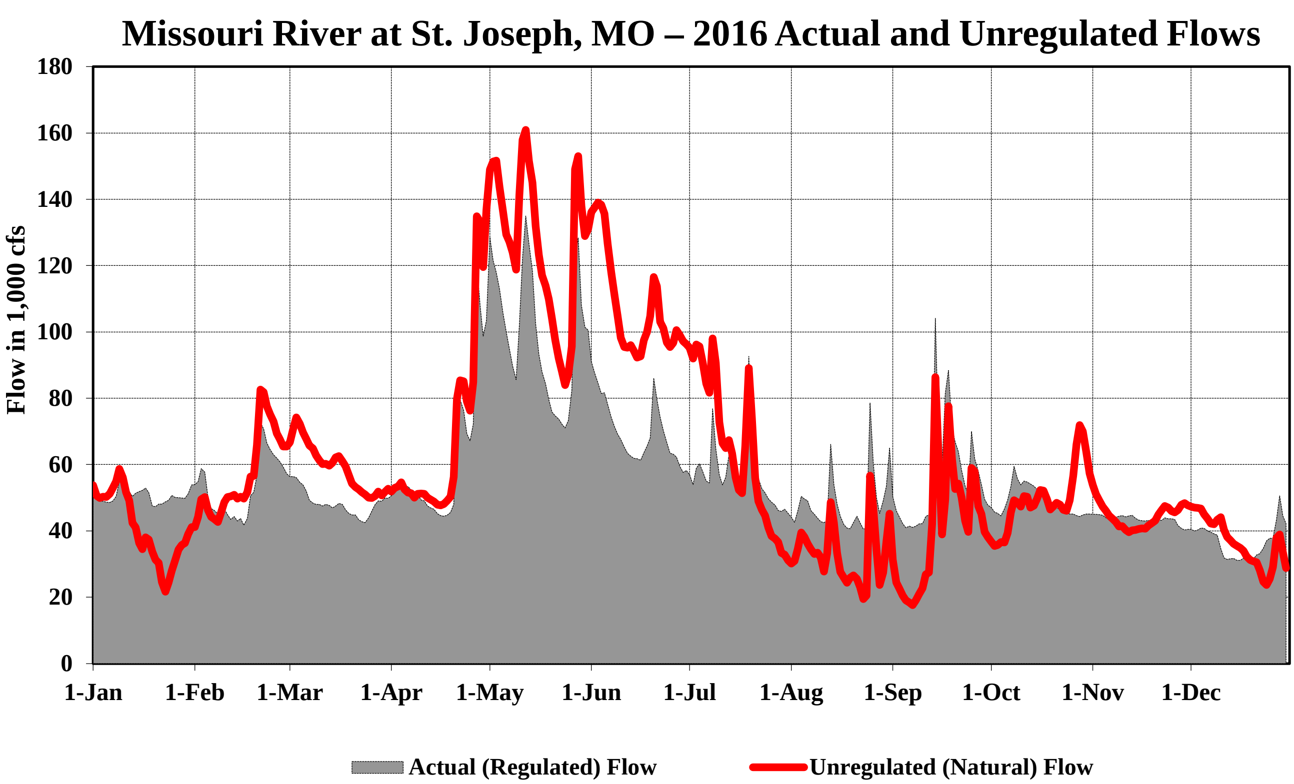
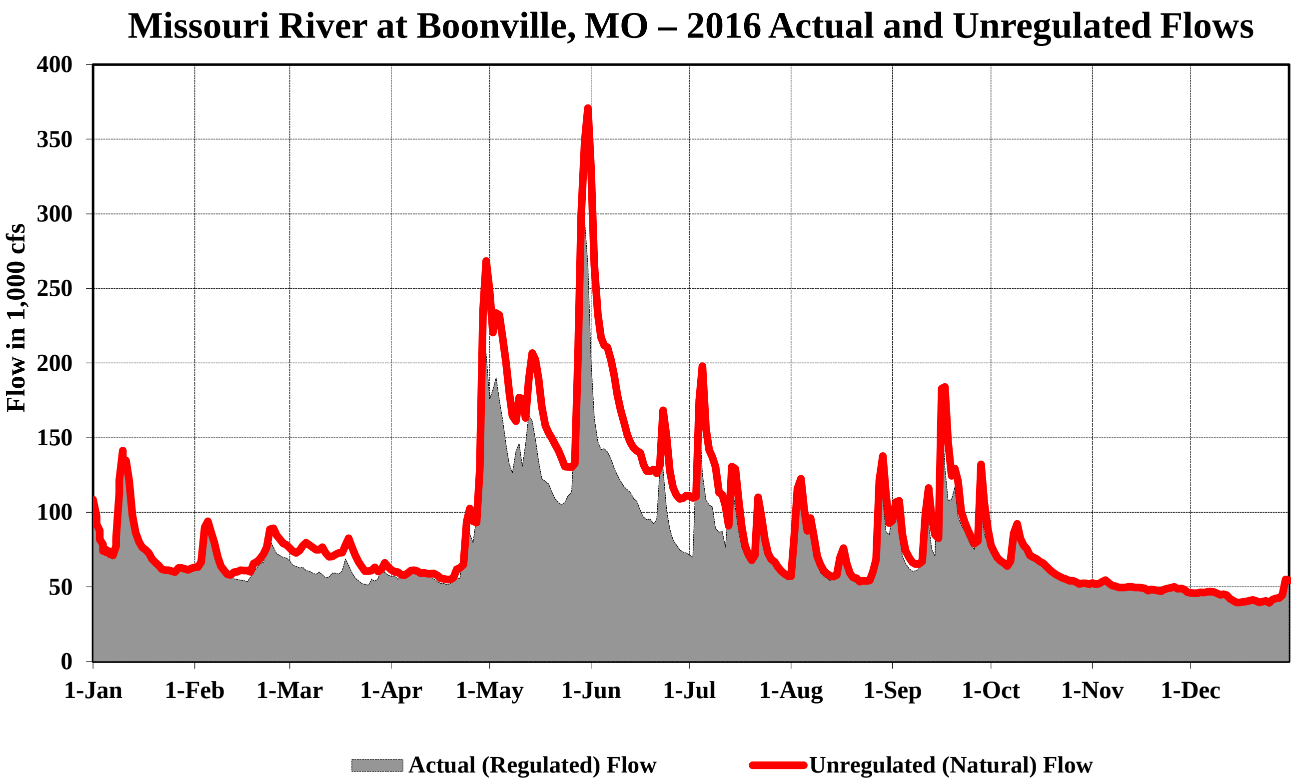


Figure 17B. 2016 actual and unregulated flows – Sioux City, IA and St. Joseph, MO.



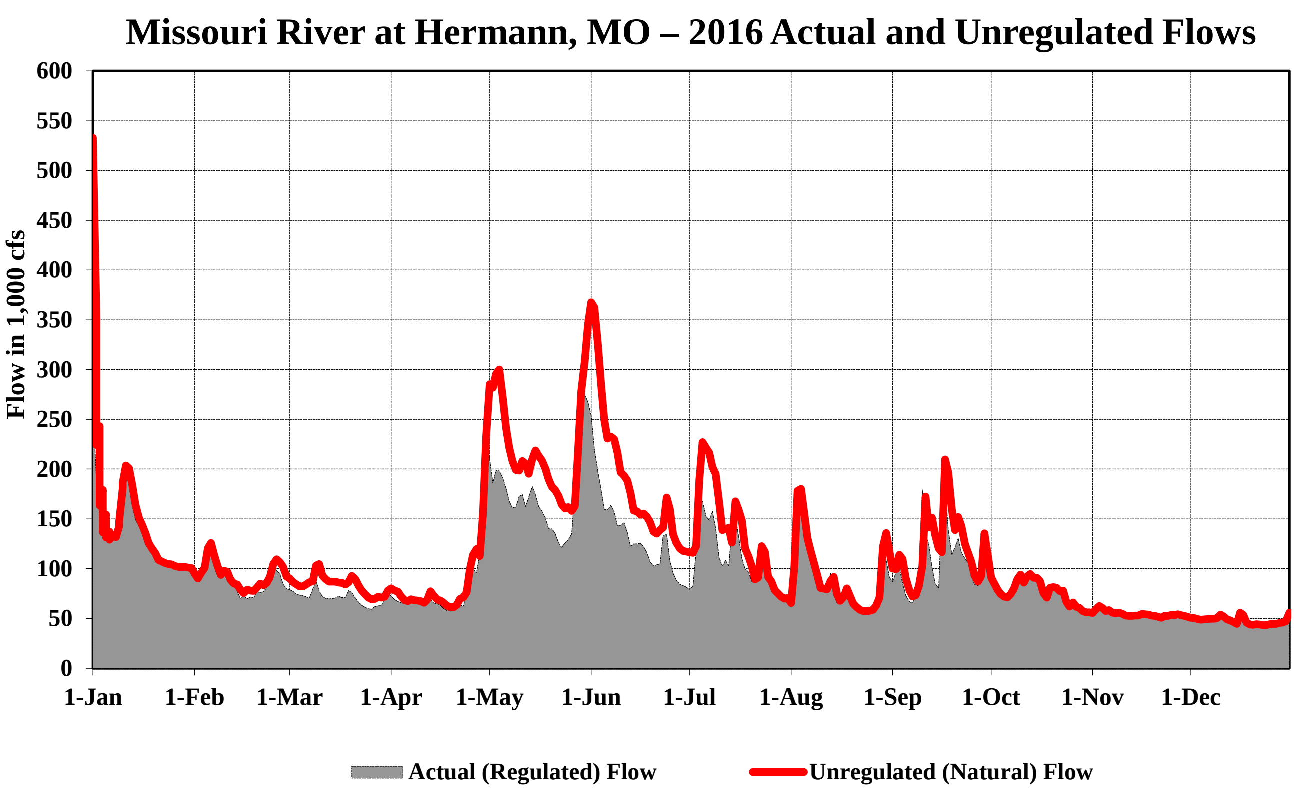


Figure 17C. 2016 actual and unregulated flows – Boonville, MO and Hermann, MO.

4. 2016 Calendar Year Runoff

The 2016 unregulated runoff volume for the upper Basin above Sioux City, IA totaled 24.1 million acre-feet (MAF), 95 percent of average, based on the historical period of 1898-2015, as shown in ***Table 5*** and ***Figure 18***. ***Table 6*** lists the runoff for the upper Basin by month and reach and is the adjusted compilation of the runoff into the System. As the year progresses, this table is filled in with observed monthly runoff data for those months that have occurred and with forecasted runoff data for the remaining months in the year. 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. As the season progresses, more of the actual runoff is accumulated, and the estimate of annual runoff volume becomes more reliable. The majority of the annual runoff has usually occurred by the end of July, and the remainder of the year can be estimated with a greater degree of accuracy. ***Table 5*** compares 2016 monthly and calendar year totals to the 1898-2015 historic period of record.

Total runoff in the lower Basin, from Sioux City, IA to Hermann, MO totaled 50.7 MAF, 116 percent of average (see ***Table 5***). Of the six reaches in the Basin above Sioux City outlined in ***Table 5***, runoff was below average in the upper three and above average in the lower three. Of the three reaches in the lower Basin, the reaches between Sioux City and Kansas City, MO experienced above average runoff while below-average runoff occurred in the lowermost Kansas City to Hermann reach.

Figure 19 illustrates the monthly variation of the runoff summation above Sioux City, IA compared to the long-term average variation of runoff based on the 1898-2015 historic period. Runoff in January and February was above average with warmer-than-normal temperatures that resulted in an early melting of the plains snowpack. Runoff in March and April were much below normal due to lack of precipitation as well as lack of plains snow. Several rainfall events throughout the upper Basin during May resulted in above-average monthly inflow. Less-than-average mountain snowpack and average precipitation resulted in below-average runoff in June and July. Inflows were about average in August and September. Above-normal precipitation in October and November resulted in above-average inflows during the last three months of the year.

Table 5
2016 CY Runoff Volumes for Selected Reaches (1,000 acre-feet)

Reach	**1898-2015 Average Runoff**	**2016 CY Runoff**	**% of Average Runoff**
Above Fort Peck	7,231	5,880	81
Fort Peck to Garrison	10,742	8,939	83
Garrison to Oahe	2,501	1,949	78
Oahe to Fort Randall	911	1,127	124
Fort Randall to Gavins Point	1,692	1,906	113
Gavins Point to Sioux City	2,244	4,288	191
TOTAL ABOVE SIOUX CITY	**25,321**	**24,089**	**95**
	1967-2015 Average Runoff	**2016 CY Runoff**	**% of Annual Runoff**
Sioux City, IA to Nebraska City, NE*	7,880	15,009	190
Nebraska City, NE to Kansas City, MO*	11,480	15,500	135
Kansas City, MO to Hermann, MO*	24,210	20,207	83
TOTAL BELOW SIOUX CITY*	**43,570**	**50,716**	**116**

** 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 1967-2015.*

Table 6
Missouri River Basin
2016 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 2016	259	206	-86	157	61	188	597	785	785
AVERAGE*	313	264	13	29	101	52	720	771	771
DEPARTURE	-54	-58	-99	128	-40	136	-123	14	14
% OF AVE	83%	78%	-656%	545%	60%	363%	83%	102%	102%
FEB 2016	413	491	303	195	177	299	1,579	1,878	2,663
AVERAGE	363	359	97	55	132	101	1,006	1,106	1,878
DEPARTURE	50	132	206	140	45	198	574	772	785
% OF AVE	114%	137%	312%	356%	134%	297%	157%	170%	142%
MAR 2016	355	544	222	93	167	443	1,381	1,824	4,487
AVERAGE	597	1,001	584	213	210	324	2,605	2,928	4,806
DEPARTURE	-242	-457	-362	-120	-43	119	-1,224	-1,104	-319
% OF AVE	59%	54%	38%	44%	80%	137%	53%	62%	93%
APR 2016	515	567	303	378	185	469	1,948	2,417	6,904
AVERAGE	639	1,077	504	143	179	382	2,542	2,923	7,729
DEPARTURE	-124	-510	-201	235	6	87	-594	-506	-825
% OF AVE	81%	53%	60%	265%	103%	123%	77%	83%	89%
MAY 2016	1,096	1,364	318	259	409	804	3,446	4,250	11,154
AVERAGE	1,079	1,263	326	148	185	321	3,001	3,321	11,051
DEPARTURE	17	101	-8	111	224	483	446	929	104
% OF AVE	102%	108%	98%	175%	221%	251%	115%	128%	101%
JUN 2016	968	2,193	217	44	204	518	3,626	4,144	15,298
AVERAGE	1,636	2,725	451	163	185	325	5,160	5,484	16,535
DEPARTURE	-668	-532	-234	-119	19	193	-1,534	-1,340	-1,237
% OF AVE	59%	80%	48%	27%	110%	159%	70%	76%	93%
JUL 2016	556	1,191	223	24	119	296	2,113	2,409	17,707
AVERAGE	829	1,819	191	59	138	247	3,035	3,282	19,817
DEPARTURE	-273	-628	32	-35	-19	49	-922	-873	-2,110
% OF AVE	67%	65%	117%	41%	86%	120%	70%	73%	89%
AUG 2016	304	421	180	46	97	201	1,048	1,249	18,956
AVERAGE	360	613	78	42	116	151	1,208	1,359	21,176
DEPARTURE	-56	-192	102	4	-19	50	-160	-110	-2,220
% OF AVE	84%	69%	231%	110%	84%	133%	87%	92%	90%
SEP 2016	200	353	101	49	121	306	824	1,130	20,086
AVERAGE	330	452	112	38	110	110	1,042	1,152	22,328
DEPARTURE	-130	-99	-11	11	11	196	-218	-22	-2,242
% OF AVE	61%	78%	90%	130%	110%	278%	79%	98%	90%
OCT 2016	594	902	0	-83	122	265	1,535	1,800	21,886
AVERAGE	379	528	72	5	119	90	1,103	1,193	23,521
DEPARTURE	215	374	-72	-88	3	175	432	607	-1,635
% OF AVE	157%	171%	0%	--	103%	294%	139%	151%	93%
NOV 2016	427	510	58	-36	142	214	1,101	1,315	23,201
AVERAGE	380	390	68	5	118	83	961	1,044	24,564
DEPARTURE	47	120	-10	-41	24	131	140	271	-1,363
% OF AVE	112%	131%	85%	--	120%	258%	115%	126%	94%
DEC 2016	193	197	110	1	102	285	603	888	24,089
AVERAGE	328	252	4	13	100	60	697	757	25,321
DEPARTURE	-135	-55	106	-12	2	225	-94	131	-1,233
% OF AVE	59%	78%	--	8%	102%	475%	86%	117%	95%
Calendar Year Totals									
	5,880	8,939	1,949	1,127	1,906	4,288	19,801	24,089	
AVERAGE	7,231	10,742	2,501	911	1,692	2,244	23,077	25,321	
DEPARTURE	-1,351	-1,803	-552	216	214	2,044	-3,276	-1,233	
% OF AVE	81%	83%	78%	124%	113%	191%	86%	95%	

*1898-2015

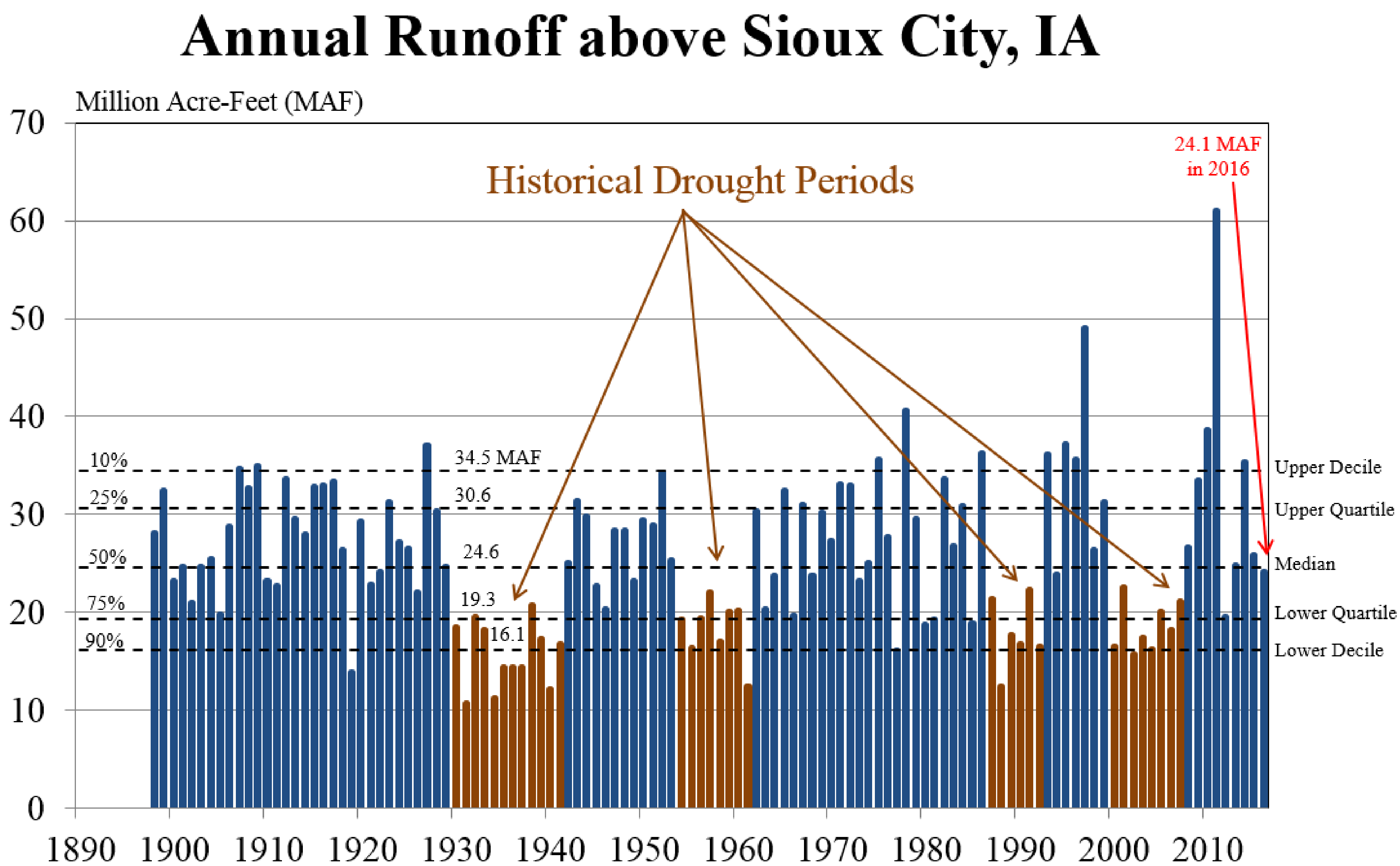


Figure 18. Missouri River Basin annual runoff above Sioux City, IA.

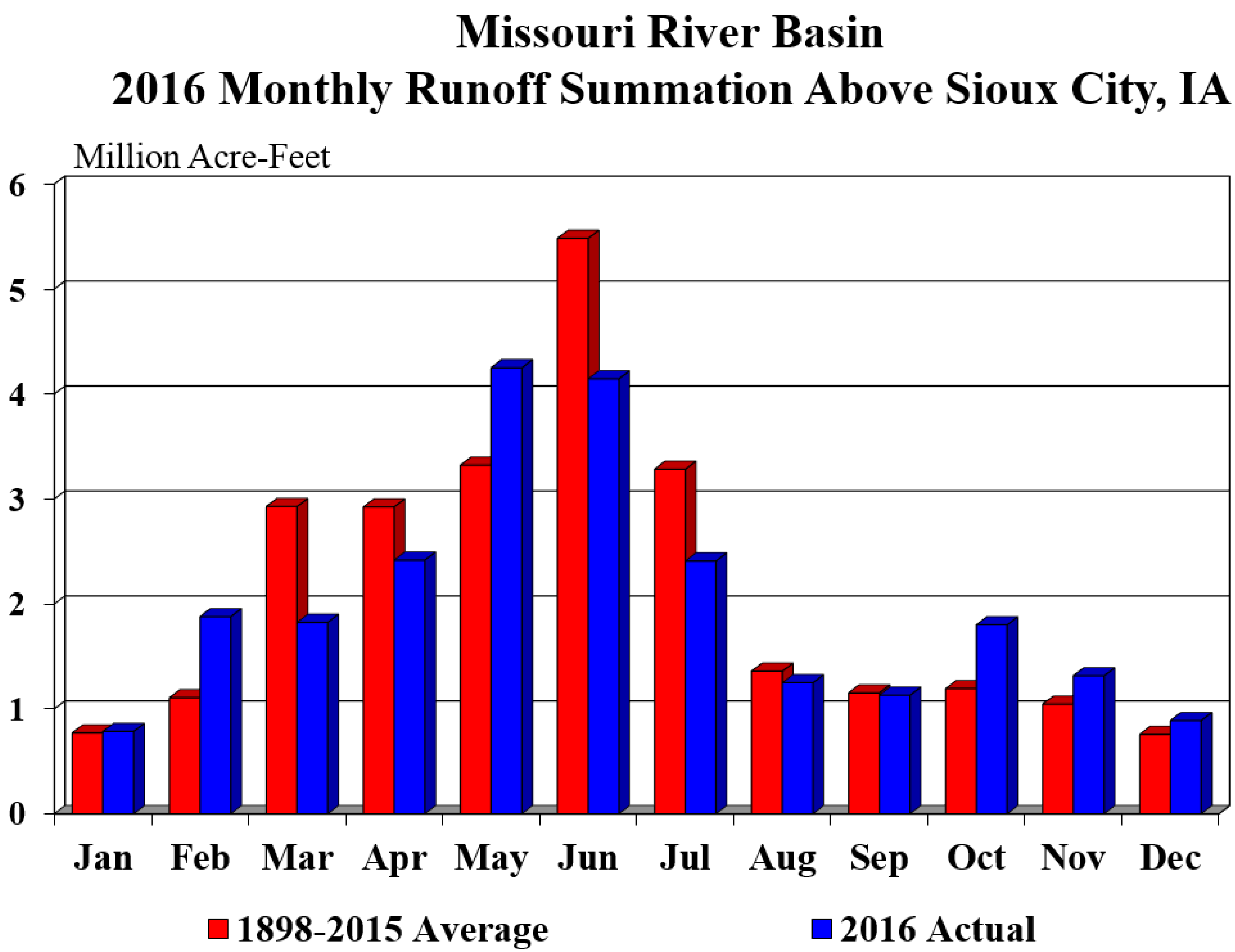


Figure 19. Missouri River Basin 2016 monthly runoff summation above Sioux City, IA.

C. <u>System Regulation – January to December 2016</u>

1. Basin Conditions and System Regulation

Runoff above Sioux City, Iowa in 2016 was 24.1 MAF, 95 percent of average (***Table 6***). This followed 2015, which had produced 25.8 MAF of runoff, 102 percent of average. Runoff in 2016 allowed System storage to remain within the Annual Flood Control and Multiple Use Zone almost the entire year and provide good service to all authorized purposes.

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 27. The 2016 runoff season started in late January when warmer-than-normal temperatures in the upper Basin resulted in some melting of the plains snow. Runoff was above average in January and February. On February 1 mountain SWE was near average in the Fort Peck reach and well-below average in the Garrison reach (see ***Table 2***).

b. Conditions on March 1

On March 1 the System storage was 56.8 MAF, 0.7 MAF above the base of the Annual Flood Control and Multiple Use Zone, but 0.3 MAF less than March 1, 2015. There was very light plains snow cover on March 1 due to recent snowfall. End-of-February soil moisture conditions were mixed in the upper Basin (***Figure 20***). Very wet soil moisture conditions were present in north central Montana, while localized wet conditions were scattered throughout Montana, South Dakota, Nebraska and Iowa. Dry soil moisture conditions were present in localized regions of Wyoming, North Dakota, Kansas and Missouri (***Figure 20***). March-April runoff was expected to be below average in the upper Basin since much of the plains snow had melted in January and February (***Table 6***) and very limited plains snowpack existed on March 1. By March 1, mountain SWE declined to 88 percent of average in the Fort Peck reach, and increased slightly to 76 percent of average in the Garrison reach. The March 1 annual runoff forecast was 21.6 MAF, 85 percent of average. Per the Master Manual, the March 15 System storage check of 57.0 MAF set navigation flow support to the full service level for the first half of the navigation season. System releases were increased to 20,000 cfs beginning on March 21 to begin full service flow support on the Missouri River in river reaches where commercial navigation was present and anticipated.

c. Conditions on April 1

System storage on April 1 was 56.9 MAF, 0.8 MAF above the base of the Annual Flood Control and Multiple Use Zone. Precipitation during the January-March period was generally below average in the upper Basin (***Figure 14***), while temperatures during the January-March period were well-above average in the upper Basin (***Figure 15***). The March runoff summation (***Table 6***) above Sioux City was 1.8 MAF, 62 percent of average, and the accumulated 2016 runoff through March was 4.5 MAF, 93 percent of average.

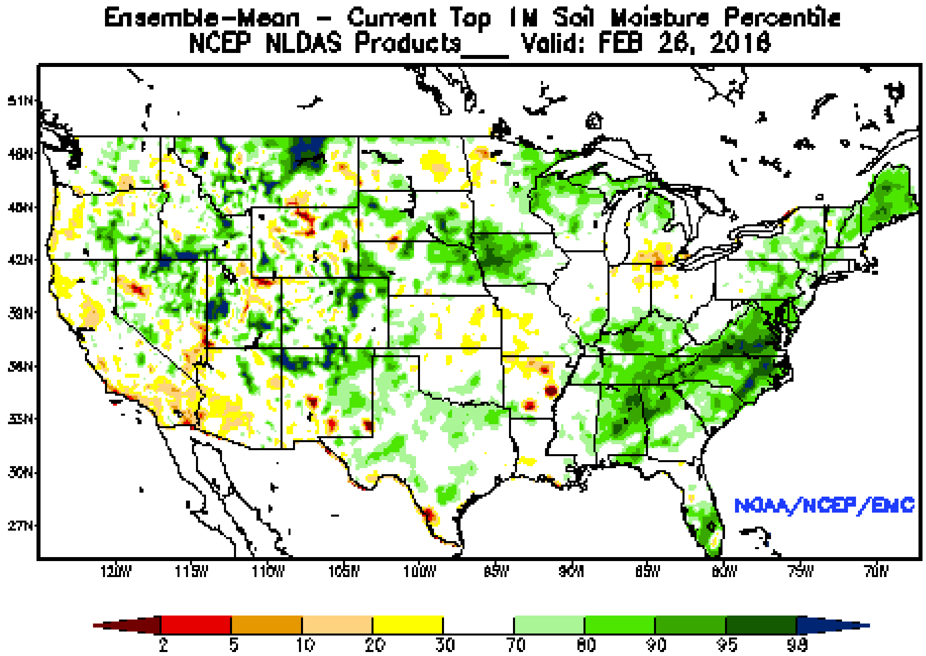


Figure 20. Soil moisture ranking percentile, February 26, 2016. Source: NOAA National Centers for Environmental Prediction, North American Land Data Assimilation Systems.

On April 1, the mountain SWE was 94 percent of the April 1 average above Fort Peck and 89 percent of average in the Fort Peck to Garrison reach. The April 1 annual runoff forecast was 21.7 MAF, 86 percent of average. The mountain SWE peaked on April 2 at 93 percent of the average peak above Fort Peck and peaked on April 2 at 86 percent of the average peak from Fort Peck to Garrison (***Table 2***). As of April 5, 2016 (***Figure 16)*** Abnormally Dry (D0) drought conditions were present in portions of the Basin. Moderate Drought (D1) conditions had developed in northwestern and southern Montana, northern Wyoming and North Dakota.

April precipitation in the upper Basin was well-above average in Montana, Wyoming, North Dakota and South Dakota (***Figure 14***). Precipitation was also well-above average in Nebraska and Kansas. Soil moisture increased throughout the Missouri Basin due to the above-average precipitation. Since all the plains snowpack had melted in January and February, the April runoff was due to rainfall runoff only. April runoff was 2.4 MAF, 83 percent of average.

d. Conditions on May 1

On May 1, the mountain SWE above Fort Peck was 74 percent of the May 1 average SWE, and it was 87 percent of the May 1 average SWE from Fort Peck to Garrison. The May 1 annual runoff forecast was increased to 22.5 MAF, 89 percent of average, due to above-average May precipitation and increased soil moisture in the upper Basin. System storage on May 1 was 57.7 MAF, 1.6 MAF above the base of the Annual Flood Control and Multiple Use Zone.

May precipitation was variable across the Basin (***Figure 14***). Precipitation was above average in northern Montana and portions of the lower Basin. Precipitation was below average in North Dakota, central and western South Dakota and northeastern Wyoming. Basin temperatures were cooler than average and May runoff was 4.3 MAF, 128 percent of average. The above-average runoff was due to the late-April precipitation runoff entering the reservoirs in early May and above average May precipitation in specific reaches (see ***Figure 14***).

e. Conditions in June and July

System storage continued to increase to a June 1 level of 59.4 MAF, 3.3 MAF above the base of the Annual Flood Control and Multiple Use Zone. The June 1 annual runoff forecast was 25.3 MAF, 100 percent of average. June precipitation was well below average (***Figure 14***) and temperatures were above average in the Basin. June runoff was 4.1 MAF, 76 percent of average due to the below-average June precipitation and below-average mountain snowpack that completely melted in June (***Figure 11***). System storage peaked on June 22 at 60.1 MAF, occupying 4.0 MAF of the 16.3 MAF flood storage zone.

As of July 1, System storage was 60.0 MAF, 3.9 MAF above the base of the Annual Flood Control and Multiple Use Zone. The July 1 System storage check resulted in the continuation of full service navigation flow support for the second half of the navigation season. The July 1 annual runoff forecast was reduced to 23.0 MAF, 91 percent of average, due to the rapid decline of the mountain snowpack in June. Accumulated July precipitation was above average in parts of Montana, North Dakota and Nebraska, but it was below average in southern Montana, Wyoming and eastern South Dakota. July runoff was 2.4 MAF, 73 percent of average, and was affected most from the low runoff volumes in the Fort Peck and Garrison reaches.

f. Conditions from August through December

August 1 System storage was 59.4 MAF, 3.3 MAF above the base of the Annual Flood Control and Multiple Use Zone. The August 1 annual runoff forecast was 22.7 MAF, 89 percent of average. August precipitation was above average in localized areas of the upper Basin and the lower Basin, but it was below average in the mountains. August runoff was 1.2 MAF, 92 percent of average.

September 1 System storage was 58.1 MAF, 2.0 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 and October 1 annual runoff forecasts were 22.4 MAF, 89 percent of average, and 22.7 MAF, 90 percent of average, respectively. Heavy rainfall occurred at the end of September and beginning of October across Montana and Wyoming (***Figure 14***). The abundant rainfall increased soil moisture in these regions and produced above-average runoff in the Fort Peck and Garrison reaches. October runoff was 157 percent of average in the Fort Peck reach, 171 percent of average in the Garrison reach and 151 percent of average in the upper Basin. The Dakotas, eastern Montana and the remainder of the lower Basin received below-average precipitation in October, and runoff was below average in the Oahe and Fort Randall reaches in October and November. Runoff in the Sioux City reach increased in September and October to more than 200 percent of average due to areas of heavy rainfall from late summer to early fall.

November 1 System storage was 57.2 MAF, 1.1 MAF above the base of the Annual Flood Control and Multiple Use Zone. The November 1 annual runoff forecast was 24.1 MAF, about 1.4 MAF more than the October 1 forecast due to above-average runoff in October. November precipitation in the upper Basin was generally below average in Montana, eastern Wyoming and the western Dakotas. Precipitation was above average in the central and eastern Dakotas. Precipitation in the lower Basin was below average (***Figure 14***). From November 23 to November 25, the System release from Gavins Point Dam was reduced from 25,000 cfs to 18,000 cfs to end navigation flow support at the mouth of the Missouri River on December 1. An 18,000 cfs release rate was maintained to continue evacuating some stored water in the Annual Flood Control and Multiple Use Zone.

November runoff was 1.3 MAF, 126 percent of average, due to above-average runoff continuing in the Fort Peck, Garrison, Gavins Point and Sioux City reaches. Above-average precipitation occurred in December as rain and snow in the upper Basin. Cold winter temperatures eventually froze rivers and streams in the upper Basin causing runoff to drop below average in the Fort Peck, Garrison, Oahe and Fort Randall reaches. Above-average precipitation and warmer-than-average temperatures resulted in above-average runoff in the Gavins Point and Sioux City reaches. December runoff was 0.9 MAF, 117 percent of average. The 2016 annual runoff was 24.1 MAF, 95 percent of average (***Table 6***). All stored flood waters were evacuated from the System when the System storage reached 56.1 MAF on December 18. The December 31 System storage was 56.1 MAF, at the base of the Annual Flood Control and Multiple Use Zone.

2. Fort Peck Regulation – January to December 2016

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 7 lists the average monthly inflows and releases and the end-of-month (EOM) pool elevation for Fort Peck for 2015 and 2016 as well as the averages since the System first filled in 1967.

Table 7
Fort Peck – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2016	2015	1967-2015	2016	2015	1967-2015	2016	2015	1967-2015
January	5,400	8,800	7,200	6,800	6,200	10,500	2233.8	2234.2	2227.4
February	7,200	10,900	8,600	6,200	6,900	10,800	2234.1	2235.2	2226.8
March	5,900	9,000	11,700	6,000	6,900	7,800	2233.9	2235.7	2227.9
April	7,600	7,300	10,200	6,500	6,800	7,300	2234.2	2235.8	2228.6
May	13,600	9,200	15,500	7,400	7,700	9,000	2235.9	2236.0	2230.3
June	9,400	13,000	19,500	8,600	8,800	10,400	2235.8	2236.9	2232.8
July	6,900	6,800	12,100	8,300	8,100	10,500	2235.1	2236.2	2232.8
August	5,500	6,100	8,000	8,000	7,900	10,100	2233.8	2235.3	2231.7
September	6,400	6,400	7,700	6,300	6,200	8,900	2233.4	2234.8	2230.9
October	11,000	6,300	7,300	4,600	4,700	7,800	2234.8	2234.8	2230.3
November	7,000	5,300	7,100	4,900	4,800	8,200	2235.0	2234.6	2229.7
December	4,800	5,500	6,600	6,500	5,400	9,300	2234.1	2234.3	2228.6

b. Winter Season 2015-16

The Fort Peck reservoir level was at elevation 2234.3 feet on January 1 at midnight, 0.3 foot above the base of the Annual Flood Control and Multiple Use Zone and 0.8 foot above the previous year's level.

c. Winter River and Ice Conditions below Fort Peck

No special release reductions were required due to ice-jam flooding downstream of Fort Peck. Releases from Fort Peck were below average during December 2015, and January and February 2016. Sub-zero (deg F) temperatures were experienced at the end of December 2015 and early January. Ice-cover formation on the Missouri River downstream from Fort Peck resulted in the Missouri River stage rising about 5 feet at the Wolf Point streamgaging site on December 28, 2015. The stage leveled off near 15 feet and then remained in the 15- to 16-foot range through January before dropping to just under 11 feet on February 10. The peak winter stage at Wolf Point was 16.4 feet on January 13, 6.6 feet below the 23-foot flood stage. No reports of ice-affected flooding on the Missouri River below Fort Peck were recorded during the 2015-16 winter season. The Fort Peck reservoir froze over on January 18 and was free of ice on March 17.

d. Spring Open Water Season 2016

Both inflows and releases from Fort Peck were below average from April-June. Average monthly inflows to the reservoir were 7,600 cfs (75 percent of average) in April, 13,600 cfs (88 percent of average) in May and 9,400 cfs (48 percent of average) in June. Fort Peck releases were 6,500 cfs (89 percent of average) in April, 7,400 cfs (82 percent of average) in May, and 8,600 cfs (83 percent of average) in June. Fort Peck reservoir rose 1.9 feet from its April 1 elevation of 2233.9 feet to 2235.8 feet near the end of June, 1.8 feet above the base of the Annual Flood Control and Multiple Use Zone. Fort Peck reservoir rose 2.0 feet during the critical fish spawning period from 2233.9 feet (April 1) to 2235.9 feet (May 31).

e. Summer Open Water Season 2016

Average monthly release rates from Fort Peck continued to be below average (77 percent of the July-September average) during the summer with 8,300, 8,000, and 6,300 cfs in July, August, and September, respectively. Inflows for that same 3-month period were also below average (68 percent) with 6,900 cfs, 5,500 cfs, and 6,400 cfs, respectively. Over the 3-month period the reservoir level steadily decreased 2.4 feet from 2235.8 feet (June 30) to 2233.4 feet (September 30).

f. Fall Open Water Season 2016

Releases during the fall continued to be below average. Average monthly releases were 4,600 cfs in October (59 percent of average), 4,900 cfs in November (60 percent of average) and 6,500 cfs in December (70 percent of average). The lower-than-average releases were made to balance storage in the upper three reservoirs. Inflows were well above average with 11,000 cfs in October (151 percent of average). Inflows receded during November and December, averaging 7,000 cfs (99 percent of average) and 4,800 cfs (73 percent of average), respectively. The pool elevation rose 0.7 foot over the 3-month period from 2233.4 feet (September 30) to 2234.1 feet (December 31), 0.1 foot above the base of the Annual Flood Control and Multiple Use Zone.

g. Summary

The highest 2016 Fort Peck midnight pool elevation occurred on June 16 at 2236.2 feet, 2.2 feet above the base of the Annual Flood Control and Multiple Use Zone. The lowest 2016 midnight pool elevation was 2233.2 feet on September 19, 0.8 feet below the base of the Annual

Flood Control Zone. The 2016 average daily inflow of 7,600 cfs was 75 percent of average. The 2016 average daily release of 6,700 cfs was 73 percent of average.

3. Garrison Regulation – January to December 2016

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 8 lists the average monthly inflows and releases and the EOM pool elevation for Garrison for 2015 and 2016 as well as the averages since the System first filled in 1967.

Table 8
Garrison – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation(feet)		
	2016	2015	1967-2015	2016	2015	1967-2015	2016	2015	1967-2015
January	11,500	14,100	15,200	17,400	19,600	22,400	1838.8	1839.4	1832.0
February	15,100	20,400	18,500	19,100	23,100	23,500	1838.1	1838.8	1831.0
March	14,200	23,200	26,600	16,100	19,400	19,100	1837.9	1839.4	1832.5
April	15,200	16,800	22,900	14,900	21,100	18,800	1837.6	1838.6	1833.1
May	29,300	23,600	29,600	18,100	22,800	21,600	1840.0	1838.5	1834.6
June	34,300	53,700	48,100	20,900	21,000	25,000	1841.9	1844.3	1838.8
July	17,700	21,600	33,300	20,300	20,800	25,900	1841.2	1844.2	1839.9
August	12,100	13,500	18,600	20,100	20,200	25,000	1839.1	1842.6	1838.2
September	15,100	14,400	17,000	16,900	16,400	20,900	1838.4	1841.6	1837.0
October	18,400	13,300	17,200	13,000	13,400	18,900	1839.1	1841.1	1836.3
November	17,400	12,400	15,800	13,100	12,900	19,700	1839.5	1840.7	1835.2
December	10,500	12,500	13,800	15,700	14,600	19,800	1838.1	1840.0	1833.7

b. Winter Season 2015-16

The Garrison reservoir level was at elevation 1840.0 feet on January 1, 0.4 foot below the previous year's level. This elevation was 2.5 feet above the base of the Annual Flood Control and Multiple Use Zone. Releases from the Garrison were below average during December 2015, January, and February. The reservoir level declined throughout the winter season and ended February at 1838.1 feet, 0.9 foot below the previous year's elevation and 0.6 foot above the base of the Annual Flood Control and Multiple Use Zone. The Garrison reservoir froze over on January 13 and was free of ice on April 1.

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 28-30, 2015 during the season's first river ice formation. This type of rise in stage during river ice formation is normal. The river ice-cover conditions were generally continuous from late December 2015 through early February. The peak winter ice-affected Missouri River stage at Bismarck was 12.8 feet on February 14. This was 1.7 feet below the Bismarck flood stage of 14.5 feet and 0.2 foot below the Corps' winter freeze-in maximum stage target of 13 feet. The peak stage was preceded by warm temperatures and a reduction in ice in the main channel, resulting in a drop in stages. A short cold spell followed, causing ice blocks to stack up against each other filling the channel from bank to bank. This lasted about two days and then broke up quickly on the third day, February 17, as temperatures again warmed. From January 29 through February 13 there was an open channel along the right bank of the Missouri River while the left bank remained ice-covered. The Missouri River was free of ice after February 19. No reports of ice-affected flooding on the Missouri River below Garrison were recorded during the 2015-16 winter season.

d. Spring Open Water Season 2016

Below-average mountain and plains snowpack resulted in below-average March-April inflows. Above-normal precipitation during May in Montana and the Dakotas reversed this with inflows being near normal in May. Earlier melting of the below-normal mountain snowpack and below-normal rainfall in June resulted in below-normal inflows during June. Releases from Garrison were below normal from March through June. Even with below-average inflows the Garrison pool level increased 4.0 feet, from 1837.9 feet (April 1) to 1841.9 feet at the end of June, 4.4 feet above the base of the Annual Flood Control and Multiple Use Zone. Garrison reservoir rose 2.1 feet during the critical fish spawning period from 1838.9 feet (April 1) to 1837.9 feet (May 31). Inflows were 15,200 cfs (66 percent of average) in April, 29,300 cfs (99 percent of average) in May and 34,300 cfs (71 percent of average) in June. Releases were 14,900 cfs in April (79 percent of average), 18,100 cfs in May (84 percent of average), and 20,900 cfs in June (84 percent of average).

e. Summer Open Water Season 2016

Inflows into Garrison reservoir remained below average during July (17,700 cfs; 53 percent of average), August (12,100 cfs; 65 percent of average), and September (15,100 cfs; 89 percent of average). Below-normal releases were made during the 3-month period. During the 3-month period, the pool crested at 1842.4 feet on June 25, 4.9 feet into the 12.5-foot Annual Flood Control and Multiple Use Zone. Following the crest, the Garrison pool slowly declined 4.0 feet to 1838.4 feet at the end of September. A daily peaking pattern was established at Garrison from May 13 through September 2 to protect endangered birds nesting on sandbars below the project.

f. Fall Open Water Season 2016

Inflows increased during the fall with near average inflows in October and November of 18,400 cfs (107 percent of average) and 17,400 cfs (110 percent of average), respectively, before receding in December to 10,500 cfs (76 percent of average). Releases were below average in October (13,000 cfs; 69 percent of average) and November (13,100 cfs, 66 percent of average). Releases were increased in December (15,700 cfs, 79 percent of average) to provide more winter hydropower generation and in anticipation of the freeze-in of the Missouri River between Washburn and Bismarck, ND, which occurred on December 10. The December 31 Garrison pool elevation was 1838.1 feet, 0.6 foot 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 1843.5 feet in the fall.

h. Summary

The Garrison pool elevation peaked at 1842.2 feet on June 25 at midnight, 4.7 feet above the base of the Annual Flood Control and Multiple Use Zone. The lowest Garrison midnight pool level during 2016 occurred on April 14 at 1837.0 feet or 0.5 foot below the base of the Annual Flood Control and Multiple Use Zone. The average annual inflow of 17,600 cfs was 77 percent of average. The average annual release of 17,100 cfs was 79 percent of average.

4. Oahe and Big Bend Regulation – January to December 2016

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 9 lists the average monthly inflows and releases and the EOM pool elevation for Oahe for 2015 and 2016 as well as the averages since the System first filled in 1967.

Table 9
Oahe – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2016	2015	1967-2015	2016	2015	1967-2015	2016	2015	1967-2015
January	16,100	20,800	22,800	24,800	21,500	20,800	1607.5	1607.3	1599.0
February	23,700	26,300	26,900	17,600	20,100	18,200	1608.7	1608.2	1600.6
March	17,900	23,600	30,900	16,200	23,500	18,200	1609.0	1608.1	1603.1
April	20,900	21,400	27,100	17,700	26,800	21,100	1609.3	1607.3	1604.1
May	20,500	37,100	28,400	8,700	21,500	22,100	1611.7	1609.9	1605.1
June	22,300	37,500	31,100	16,900	20,700	26,800	1612.2	1612.7	1605.5
July	21,500	24,500	28,500	23,500	20,800	31,000	1611.7	1613.3	1604.7
August	20,800	22,500	26,600	24,500	24,100	33,600	1610.4	1612.5	1602.7
September	18,400	19,100	22,500	18,800	23,800	29,800	1609.8	1611.1	1600.8
October	13,500	13,900	20,600	12,700	17,200	24,000	1609.7	1610.0	1599.7
November	14,600	15,100	21,100	15,400	16,900	22,700	1609.1	1609.6	1599.1
December	17,100	15,500	20,100	18,300	14,600	20,600	1608.4	1609.2	1598.8

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 2016 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 lists the average monthly inflows and releases and the EOM pool elevation for Big Bend for 2015 and 2016 as well as the averages since the System first filled in 1967.

Table 10
Big Bend – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2016	2015	1967-2015	2016	2015	1967-2015	2016	2015	1967-2015
January	23,400	19,900	20,400	22,500	19,600	20,300	1421.1	1420.8	1420.5
February	16,600	18,500	18,200	16,900	18,800	18,200	1420.7	1420.4	1420.4
March	14,800	21,800	18,900	15,100	21,600	18,800	1420.2	1420.4	1420.4
April	17,900	24,900	21,300	17,200	24,700	21,000	1420.7	1420.6	1420.5
May	8,300	21,000	22,300	8,000	20,000	22,100	1420.8	1421.2	1420.4
June	15,300	21,300	27,000	15,700	21,500	26,700	1420.1	1420.7	1420.3
July	21,700	19,200	30,300	20,900	19,600	29,900	1420.6	1419.8	1420.2
August	23,100	22,500	32,900	22,700	21,200	32,300	1420.3	1420.5	1420.2
September	17,800	21,700	29,200	17,300	21,300	28,800	1420.1	1420.2	1420.3
October	11,800	16,300	23,700	11,000	15,600	23,200	1420.8	1420.8	1420.5
November	14,800	16,100	23,800	14,700	16,000	22,300	1420.7	1420.6	1420.4
December	16,900	13,800	20,300	16,900	14,100	20,100	1420.6	1420.2	1420.5

b. Winter Season 2015-16

No ice-induced flooding problems were experienced downstream of the two projects during the 2015-16 winter. No minimum generation or release was implemented at Oahe during the winter season. When necessary, a one unit minimum ensures that water is always flowing in the river downstream of Oahe Dam to reduce river ice formation directly below the dam. The Missouri River conditions were closely monitored by the Corps staff.

The Oahe reservoir remained open all winter and did not form an ice cover during the 2015-16 winter season. This was the ninth winter season that an ice-free state was experienced on the reservoir. The last time this occurred was the 2011-12 winter season. No reports of ice-affected flooding on the Missouri River below Oahe or Big Bend were recorded during the 2015-16 winter season.

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 0 cfs and 31,900 cfs. The Big Bend reservoir froze over on December 29, 2015 and was free of ice on March 11.

c. Spring Open Water Season 2016

Oahe inflows for March were below normal due to a light plains snowpack and less-than-normal precipitation in March. During April, above-normal precipitation caused inflows to increase but remained below normal through May. March and April average monthly inflows were 17,900 cfs (58 percent of average) and 20,900 cfs (77 percent of average), respectively. May inflows were 20,500 cfs (72 percent of average). Oahe releases were below average in

March-May with a combined average of 14,200 cfs (69 percent of average). Oahe reservoir rose 2.7 feet during the critical fish spawning period from 1609.0 feet (April 1) to 1611.7 feet (May 31).

d. Summer Open Water Season 2016

Oahe inflows remained below average for June through September. Oahe's 2016 peak elevation was 1612.7 feet on June 17, 5.2 feet above the base of the 9.5-foot Annual Flood Control and Multiple Use Zone. June releases were 16,900 cfs, 63 percent of average; July releases were 23,500 cfs, 76 percent of average; August releases were 24,500 cfs, 73 percent of average; and September releases were 18,800 cfs, 63 percent of average. The reservoir pool declined 2.9 feet from its June 17 peak to 1609.8 feet on September 30.

e. Fall Open Water Season 2016

Inflows and releases were below average for October through December. Inflows in October were 13,500 cfs (65 percent of average), 14,600 cfs in November (69 percent of average), 17,100 cfs in December (85 percent of average). Average monthly releases for October were 12,700 cfs (53 percent of average), 15,400 cfs in November (68 percent of average) and 18,300 cfs in December (89 percent of average). The December 31 pool elevation was 1608.4 feet, 0.9 foot above the base of the Annual Flood Control and Multiple Use Zone.

f. Summary

The highest 2016 Oahe midnight reservoir level of 1612.6 feet occurred on June 17, 5.1 feet above the base of the Annual Flood Control Zone. The 2016 minimum midnight pool elevation of 1607.4 feet occurred on February 5, 0.1 feet below the base of the Annual Flood Control Zone. Oahe's 2016 average annual inflow was 18,900 cfs, 74 percent of average. Oahe's 2016 average annual release was 17,900 cfs, 74 percent of average. Big Bend's annual minimum midnight pool elevation of 1419.7 feet was recorded on September 2 and the annual maximum midnight pool elevation of 1421.3 feet was recorded on December 5.

5. Fort Randall Regulation – January to December 2016

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 11 lists the Fort Randall average monthly inflows and releases in cfs and the EOM pool elevation in feet for 2015 and 2016 as well as the historic averages since the System was first filled in 1967.

Table 11
Fort Randall – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2016	2015	1967-2015	2016	2015	1967-2015	2016	2015	1967-2015
January	26,600	22,800	21,900	20,800	17,600	15,200	1345.4	1346.1	1347.0
February	21,400	21,300	20,100	13,900	16,300	13,400	1351.2	1349.7	1351.9
March	17,900	23,800	21,700	13,800	19,800	15,800	1354.2	1352.8	1356.0
April	23,700	27,200	23,700	15,600	22,900	21,300	1359.6	1355.8	1357.6
May	12,300	25,900	25,100	13,200	25,100	25,200	1358.8	1356.0	1357.3
June	17,600	28,500	29,800	20,900	21,800	28,600	1356.3	1360.2	1357.8
July	22,800	23,300	31,500	23,900	25,300	32,800	1355.2	1358.4	1356.7
August	24,800	24,100	34,000	24,200	25,500	35,000	1355.1	1356.9	1355.4
September	19,100	24,400	30,000	20,800	27,000	34,800	1353.4	1354.4	1351.3
October	10,500	16,100	23,500	20,500	27,500	32,400	1344.7	1344.7	1343.3
November	14,700	17,500	22,300	20,400	22,700	28,700	1338.8	1339.4	1336.9
December	18,400	15,500	21,300	16,300	15,000	17,200	1340.9	1339.8	1341.0

b. Winter Season 2015-16

No reports of ice-affected flooding on the Missouri River below Fort Randall were recorded during the 2015-16 winter season. Fort Randall's average daily winter release ranged from 11,900 cfs to 23,100 cfs. The Fort Randall reservoir froze over on January 9 and was free of ice on March 7.

c. Spring Open Water Season 2016

The Fort Randall pool elevation was 1354.2 feet on March 1. The pool level rose to its typical spring and summer pool level of 1355.2 feet by mid-April. 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 13,800 cfs was 87 percent of average and the average April release of 15,600 cfs was 73 percent of average. These releases corresponded with inflows of 17,900 cfs in March (82 percent of average) and 23,700 cfs in April (100 percent of average). During May, Fort Randall average inflows were 12,300 cfs (49 percent of average) and releases averaged 13,200 cfs (52 percent of average).

d. Summer Open Water Season 2016

Inflows averaged 17,600 cfs in June (59 percent of average), 22,800 cfs in July (72 percent of average), and 24,800 cfs in August (73 percent of average). Releases from Fort Randall averaged 20,900 cfs in June (73 percent of average), 23,900 cfs in July (73 percent of average), and 24,200 cfs in August (69 percent of average). September releases averaged 20,800 cfs (64 percent of average) to back up System releases from Gavins Point. September inflows averaged 19,100 cfs (64 percent of average). The Fort Randall reservoir reached its annual peak elevation of 1362.0 feet on May 13. The reservoir was above its typical elevation of 1355 during May due to low Fort Randall releases and high runoff in the Fort Randall reach.

A daily hydropower peaking pattern was established at Fort Randall during the nesting season to provide flexibility to regulate over a range of releases while minimizing impacts to endangered birds nesting below the project. Hydropower peaking started on May 24. Because two hydropower units were not available for use at the start of the nesting season, peaking was limited to 270 MW for a continuous 8-hour time frame. The hydropower peaking pattern was maintained until September 10, at which time all restrictions were lifted.

e. Fall Open Water Season 2016

Normal regulation of Fort Randall includes the lowering of the pool level at the end of the navigation season to 1337.5 feet, 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 below average from October-December. On September 1, the pool level was 1353.4 feet. The lowering of Fort Randall pool started after Labor Day and reached its lowest 2016 level on December 15.

f. Summary

The highest 2016 Fort Randall midnight reservoir level of 1361.6 feet occurred on May 13. The lowest 2016 midnight reservoir level was 1336.4 feet on December 14. The average annual inflow was 19,100 cfs, 75 percent of average, and the average annual release was 18,700 cfs, 75 percent of average.

6. Gavins Point Regulation – January to December 2016

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 msl. 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 12 lists the Gavins Point average monthly inflows and releases in cfs and the EOM pool elevation in feet msl for 2015 and 2016 as well as the historic averages since the System was first filled in 1967.

Table 12
Gavins Point – Inflows, Releases and Elevations

Month	Monthly Inflow (cfs)			Monthly Release (cfs)			EOM Elevation (feet)		
	2016	2015	1967-2015	2016	2015	1967-2015	2016	2015	1967-2015
January	21,800	19,900	17,300	22,400	19,100	17,200	1206.1	1208.1	1207.5
February	17,100	18,600	16,500	17,000	19,000	17,300	1206.2	1206.8	1205.8
March	16,300	21,800	19,700	16,200	21,900	19,700	1206.3	1206.4	1205.7
April	19,500	24,900	25,100	19,200	24,900	24,900	1206.8	1206.2	1205.8
May	19,300	27,700	28,800	18,800	27,400	28,500	1207.7	1206.5	1206.1
June	23,300	24,700	31,900	23,900	24,600	31,600	1206.2	1206.2	1206.2
July	25,200	27,200	34,900	25,000	27,000	34,500	1206.2	1206.4	1206.7
August	25,400	26,600	36,700	25,000	26,400	36,300	1206.6	1206.2	1207.2
September	22,600	28,800	36,800	22,200	28,100	36,400	1207.2	1207.4	1207.6
October	22,600	28,900	34,600	22,000	28,500	34,400	1208.4	1207.8	1207.8
November	23,000	25,200	31,100	23,100	25,200	31,100	1208.0	1207.6	1207.6
December	18,000	17,100	19,300	18,000	17,000	19,300	1207.9	1207.4	1207.4

* monthly minimum of record ** monthly maximum of record

b. Winter Season 2015-16

The Gavins Point average daily release was below average in December 2015 and February and above average in January. Winter releases varied from 15,000 cfs to 19,000 cfs in December, from 17,000 cfs to 24,200 cfs in January, and from 16,900 cfs to 17,900 cfs in February. The Gavins Point reservoir froze over on December 31, 2015 and was free of ice on March 10.

c. Winter River and Ice Conditions below Gavins Point

The lowest Sioux City, IA stage recorded during the 2015-16 winter season was 8.2 feet on February 14, 2016, which was 2.0 feet higher than the previous year's low of 6.1 feet. This drop in stage followed two nights of single-digit temperatures and four days of maximum air temperatures that were below freezing. These conditions normally result in the formation of ice in the lower Missouri River. The first ice reports for the Missouri below Gavins Point indicating floating ice were noted on January 4. From Omaha, NE downstream to Nebraska City, NE, ice pans were estimated to be about 5 to 10 feet in diameter and the river was about 10 percent covered with floating ice. Reports of floating ice were reported in the Sioux City, IA area during two different periods, January 4-21 and February 4-12. Ice reports indicated pan sizes ranging from 3 to 20 feet and river ice covering 10 to 50 percent of the river. The cold weather that started at the end of December lingered through January 26, with the exception of three above-freezing days from January 13-15. As a result of the cold weather, ice observers noted 10 to 75 percent floating ice with pan sizes ranging from 3 to 30 feet from Sioux City, IA downstream to the Chamois Power Plant in Missouri. Beginning on January 5 the Gavins Point release was increased from 17,000 cfs to 24,000 cfs over a 3-day period. The increase in System releases was made because of the higher-than-expected December runoff and to complete the evacuation of water stored in the annual flood control pool. The higher releases also reduced impacts to Missouri River downstream stages as the tributary flows declined during the cold snap. The Gavins Point release was maintained at 24,000 cfs until January 27 to complete the evacuation of the stored 2015 flood waters. From January 27 to February 1, the Gavins Point release was reduced to 17,000 cfs. No reports of ice-affected flooding or lack of water supply on the Missouri River below Gavins Point were recorded during the 2015-16 winter season.

d. Spring Open Water Season 2016

The bimodal spring pulse from Gavins Point was not conducted in 2016. 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 Management Plan/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 2016 Missouri River operating season and that this suspension was not likely to have an adverse effect on the listed species.

Per the Master Manual, the March 15 System storage check of 57.0 MAF set navigation flow support to the full service level for the first half of the navigation season. Since no commercial navigation was expected to occur on the Missouri River above Nebraska City, NE during the early part of the navigation season, the full service target was not initially met at Sioux City, IA. The initial Gavins Point release of 20,000 cfs to support navigation was reached on March 23.

Flow support for the 2016 navigation season began on 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.

Due to below-average runoff in March and early April and the forecast for below average runoff during the 2016 calendar year, the Gavins Point release was reduced to 18,000 cfs on April 22 to conserve System storage, while maintaining full service navigation target levels at all target locations except Sioux City. From April 29 to May 7, the Gavins Point release was reduced to 14,000 cfs in accordance with the minimum service flood targets at Nebraska City and Kansas City, in order to reduce potential downstream flood risk (***Figure 25AB***). The minimum service flood target during full service navigation flow support is 57,000 cfs at Nebraska City and 101,000 cfs at Kansas City according to Table VII-8 of the Master Manual. When flows exceed these flood targets, the Gavins Point release may be modified to provide minimum service flow at the other target locations. The Gavins Point release was increased to 17,000 cfs on May 8 as the Missouri River at Nebraska City and Kansas City discharges fell below their respective minimum service flood targets.

The Gavins Point release was increased to a steady rate of 23,000 cfs on May 18 in order to encourage the threatened least tern and endangered piping plover birds to nest on the higher elevation areas of downstream sandbars in the Gavins Point to Sioux City reach. On May 27, additional downstream flood concerns prompted the decision to cycle Gavins Point flows from 23,000 cfs to 20,000 cfs for a few days. Cycling of releases has been conducted in previous years in May to encourage the threatened and endangered (T&E) birds to nest on the higher elevation areas of downstream sandbars in the reach. This allows for future System release increases to support navigation while providing for downstream flood risk reduction. Cycling, however, was ceased on May 30 at a release of 20,000 cfs because the combined flow of the James River and Gavins Point release was providing the 23,000 cfs steady discharge in the reach from the mouth of the James River to Sioux City. As tributary flows receded in the Gavins Point to Sioux City reach and the Missouri River flow fell below flood targets, the Gavins Point release was increased to a steady release of 25,000 cfs by June 10.

e. Summer Open Water Season 2016

Based on the July 1 System storage check of 60.0 MAF, full service navigation support was continued during the second half of the navigation season. In addition, the July 1 System storage check called for a normal 8-month navigation season length. The Gavins Point release was maintained at 25,000 cfs to provide full service navigation flow support on the Missouri River below Omaha, NE. Full to minimum service flow support was provided at Sioux City since there was no commercial navigation traffic between Sioux City and Omaha.

f. Fall Open Water Season 2016

Based on the September 1 System storage check of 58.1 MAF the winter release rate from Gavins Point was set at a minimum 17,000 cfs. The 25,000 cfs steady release was maintained until early September, the end of the T&E bird season. On September 22, the Gavins Point release was adjusted to a 22,000 cfs flow-to-target release to provide minimum service navigation flow support at Sioux City and full service navigation flow support at all other target locations.

During the time period from September through the end of November, Gavins Point releases were reduced temporarily from September 17-24 and October 7-21 to conserve water in the System while Missouri River tributaries provided additional water to meet navigation flow targets. Due to above-average runoff and increased System storage in mid-October, the Gavins Point release was increased to 23,000 cfs on October 23 and to 25,000 cfs on November 5 to evacuate stored flood waters from the Annual Flood Control and Multiple Use Zone. The end-of-navigation season release reductions began on November 23, and a Gavins Point release of 18,000 cfs was reached on November 25.

g. Summary

System releases during the 2016 navigation season served a full length navigation season with full service flows in Missouri River reaches where commercial navigation was present, which was typically below Nebraska City, NE. System storage was conserved by limiting flow support to river reaches serving commercial navigation traffic throughout the season. Also, flood control was served by reducing Gavins Point releases in late April and late May. Gavins Point steady releases from early June through early September protected T&E birds nesting on sandbar habitat in the Missouri River reach from Gavins Point to Ponca, NE. After the storage peaked in late June, stored flood waters were gradually evacuated from the System throughout the year.

The highest Gavins Point midnight reservoir level in 2016 was 1208.5 feet, reached on November 28. The lowest midnight reservoir level in 2016 was 1205.7 feet, reached on January 20. The average annual inflow to Gavins Point was 21,200 cfs, 6,600 cfs below the average inflow of 27,800 cfs. The average annual System release was 21,100 cfs, 6,600 cfs below the average release of 27,700 cfs.

D. Non-Routine Regulation and Other Items Pertaining to System Regulation

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. The trial began in Kansas City for the first group of plaintiffs on March 6, 2017.

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 U.S. Bureau of Reclamation (Reclamation) 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 September 4, 2015, the U.S. District Court granted plaintiffs' motion to issue a preliminary injunction, prohibiting the Corps and Reclamation from proceeding with construction of a proposed fish by-pass channel at the Intake Dam on the Yellowstone River. On January 5, 2016, the U.S. District court approved the parties joint motion/agreement to stay (or put on hold) the litigation while the Corps and Reclamation complete an Environmental Impact Statement (EIS) on proposed fish passage at Intake dam, to include consideration of an open water fish passage alternative. The Final Environmental Impact Statement was issued in October 2016, and the Record of Decision was signed in December 2016. Plaintiffs and the agencies are currently negotiating briefing schedules for litigation path forward.

E. Reservoir Elevations and Storage

Reservoir elevations and storage levels of the System reservoirs at the end of July 2016 are presented in ***Table 13*** and the same information for the end of December 2016 is presented as ***Table 14***. 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 all were lower than the previous year, ranging from 1.1 to 2.9 feet lower. By the end of December, all three remained above the base of their respective Annual Flood Control and Multiple Use zones, ranging from 0.2 to 0.9 foot above their bases.

Table 13
Reservoir Levels and Storages – July 31, 2016

Project	Reservoir Elevation		Reservoir Storage in 1,000 AF		
	Elevation (feet msl)	12-Month Change (feet)	Total	Above Min. Level*	12-Month Change
Fort Peck	2235.1	-1.1	15,022	10,934	-245
Garrison	1841.3	-2.9	18,951	14,157	-1,001
Oahe	1611.6	-1.7	19,996	14,681	-580
Big Bend	1420.6	0.8	1,664	33	42
Fort Randall	1355.2	-3.2	3,427	1,958	-280
Gavins Point	1206.2	-0.2	331	36	-5

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

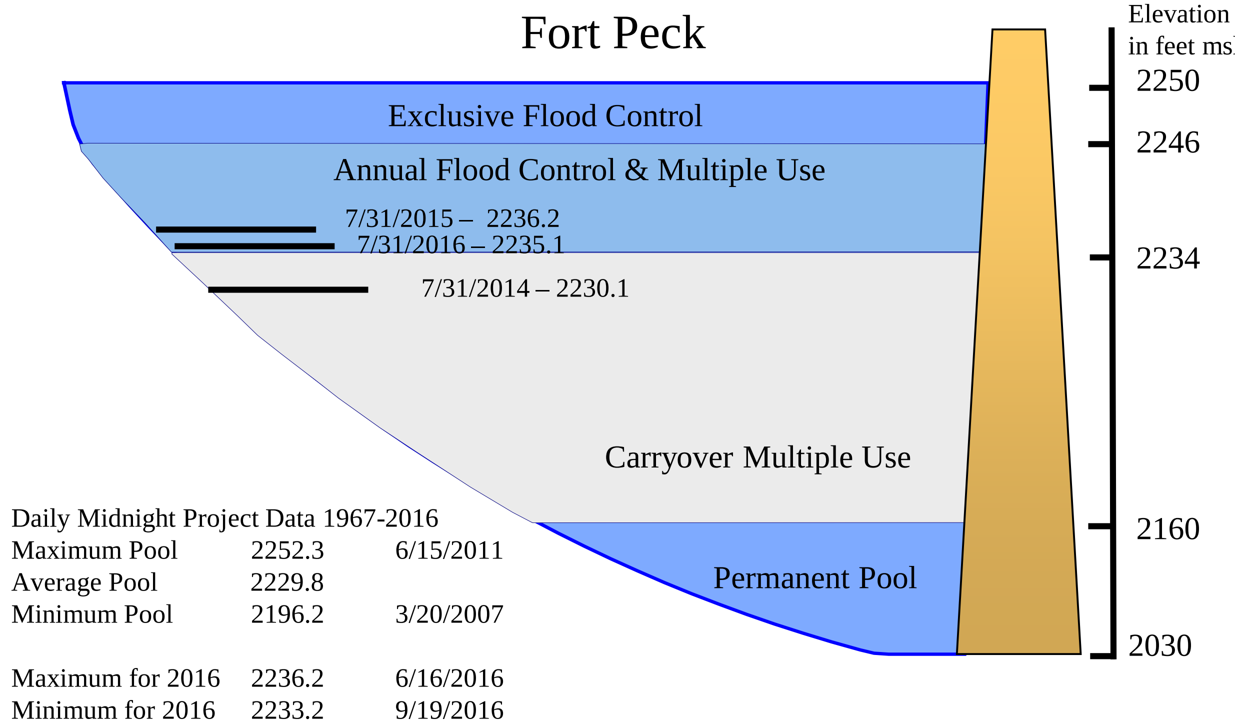
Table 14
Reservoir Levels and Storages – December 31, 2016

Project	Reservoir Elevation		Reservoir Storage in 1,000 AF		
	Elevation (feet msl)	12-Month Change (feet)	Total	Above Min. Level*	12-Month Change
Fort Peck	2234.2	+0.1	14,828	10,740	+26
Garrison	1838.1	-1.9	17,934	13,140	-595
Oahe	1608.4	-0.8	18,962	13,647	-253
Big Bend	1420.7	+0.5	1,670	39	+26
Fort Randall	1340.9	+1.1	2,382	913	+65
Gavins Point	1207.9	+0.2	372	77	+4

*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 2014 through 2016. 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



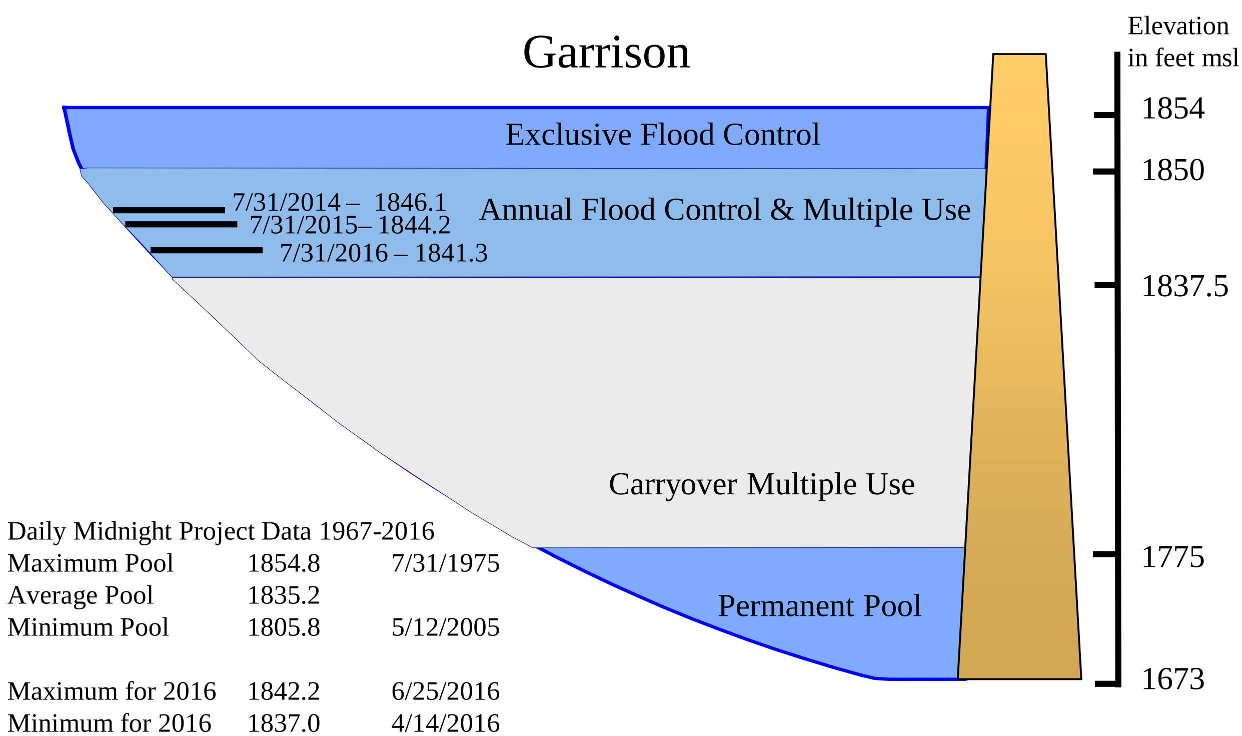
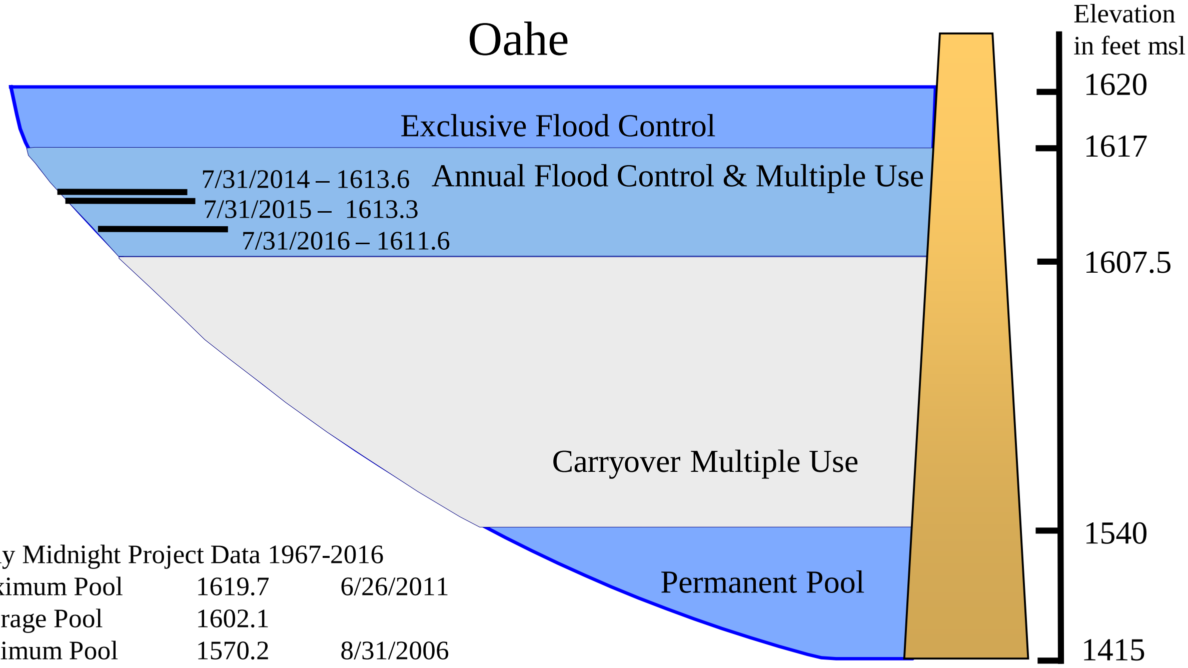
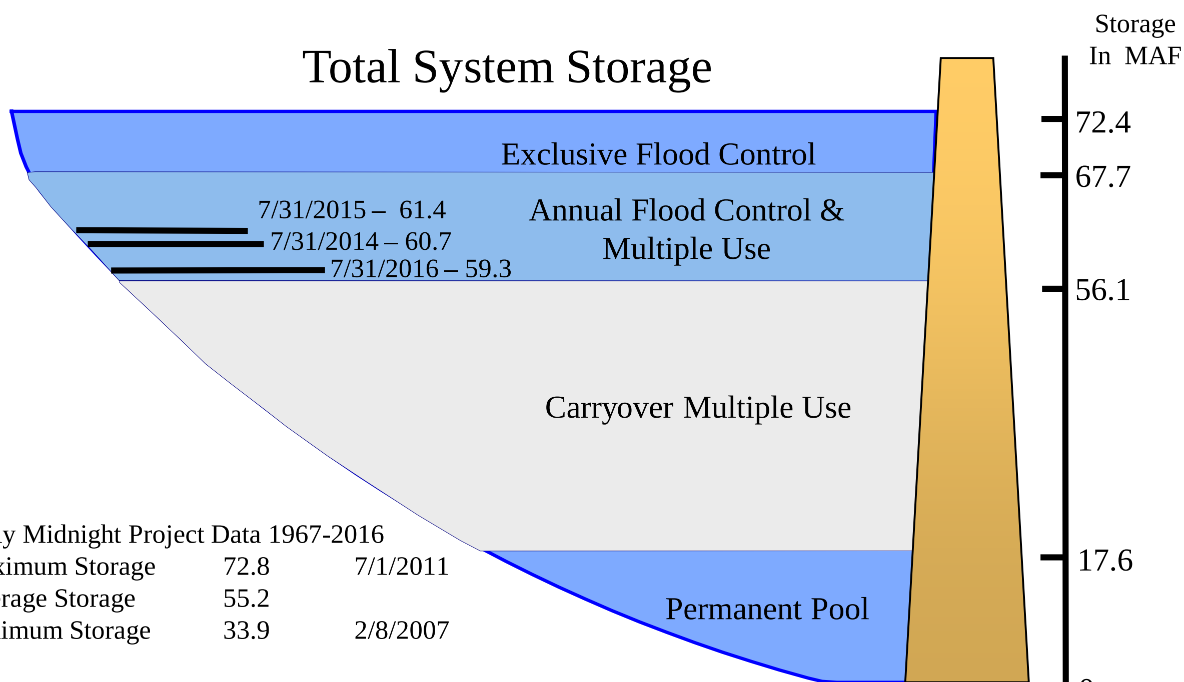


Figure 21A. End-of-July pool elevations for Fort Peck and Garrison.

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



Daily Midnight Project Data 1967-2016		
Maximum Pool	1619.7	6/26/2011
Average Pool	1602.1	
Minimum Pool	1570.2	8/31/2006
Maximum for 2016	1612.6	6/17/2016
Minimum for 2016	1607.4	2/5/2016



Daily Midnight Project Data 1967-2016		
Maximum Storage	72.8	7/1/2011
Average Storage	55.2	
Minimum Storage	33.9	2/8/2007
Maximum for 2016	60.1	6/22/2016
Minimum for 2016	56.0	12/23/2016

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

F. <u>Summary of Results</u>

1. Flood Control

The March 15 and July 1 System storages were 57.0 and 60.0 MAF, respectively. Per the criteria outlined in the Master Manual, full service flow support was provided for the first half and second half of the 8-month navigation season during 2016. Operation of Federal projects during significant runoff events in June (Omaha District) and May, June and July (Kansas City District) resulted in flood damage reduction. As shown on ***Figures 17A*** through ***17C***, 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 2016 were estimated to be nearly $3.1 billion ($109 million Omaha District; $3.0 billion Kansas City District). Flood damages prevented by the System reservoirs during 2016 were estimated to be $680 million ($83 million Omaha District; $597 million Kansas City District). The System flood damages prevented indexed to the September 2016 price level is illustrated in ***Figure 22A.*** Since 1938, the total flood control damages prevented by the System were $60.0 billion, an annual average of $759 million, indexed to September 2016 price levels. The total un-indexed flood damages prevented at the original price levels is $35.5 billion, an annual average of $450 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 2016 price levels, the dams cost approximately $26.7 billion, whereas the original un-indexed cost was $1.2 billion.

Figures 17A through ***17C*** show the 2016 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.

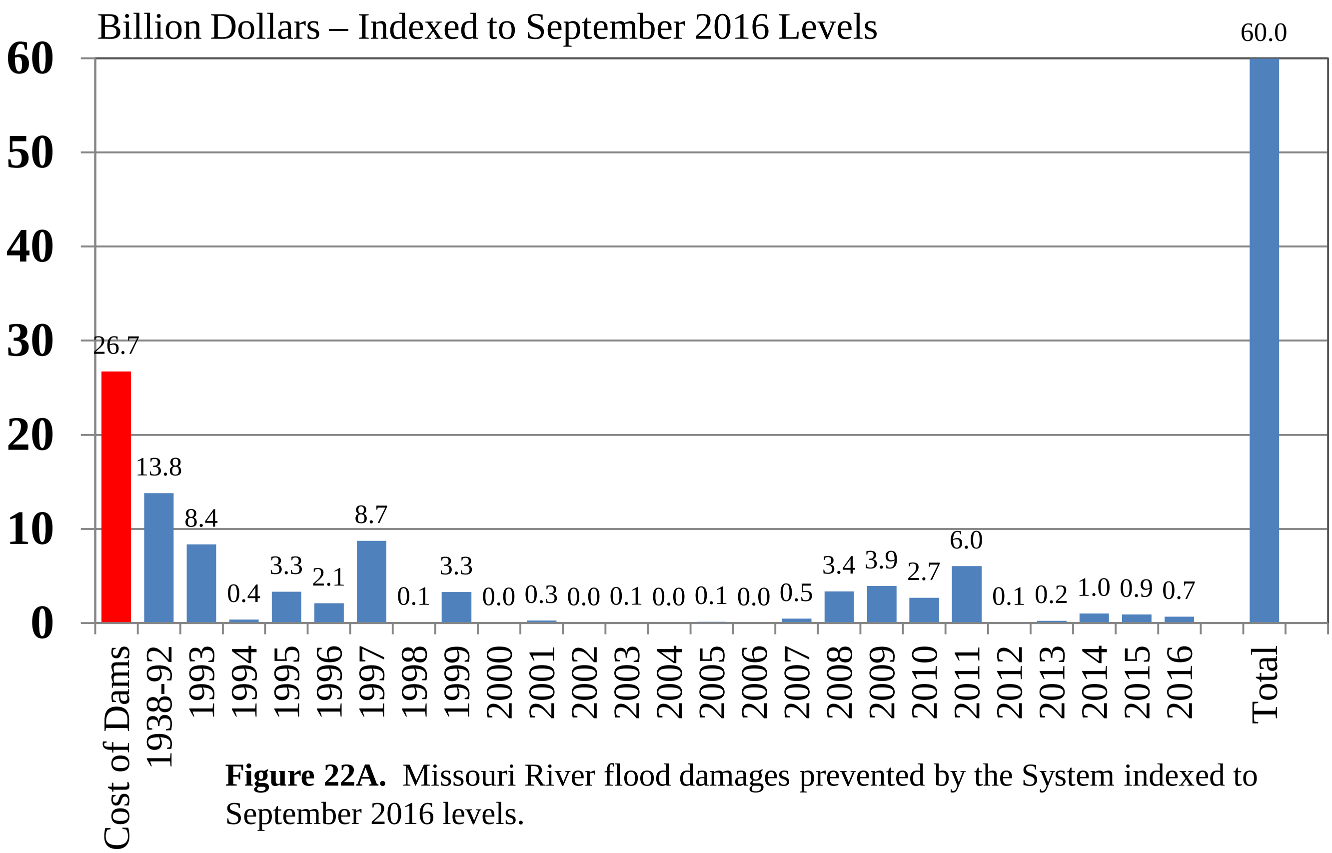


Figure 22A. Missouri River flood damages prevented by the System indexed to September 2016 levels.

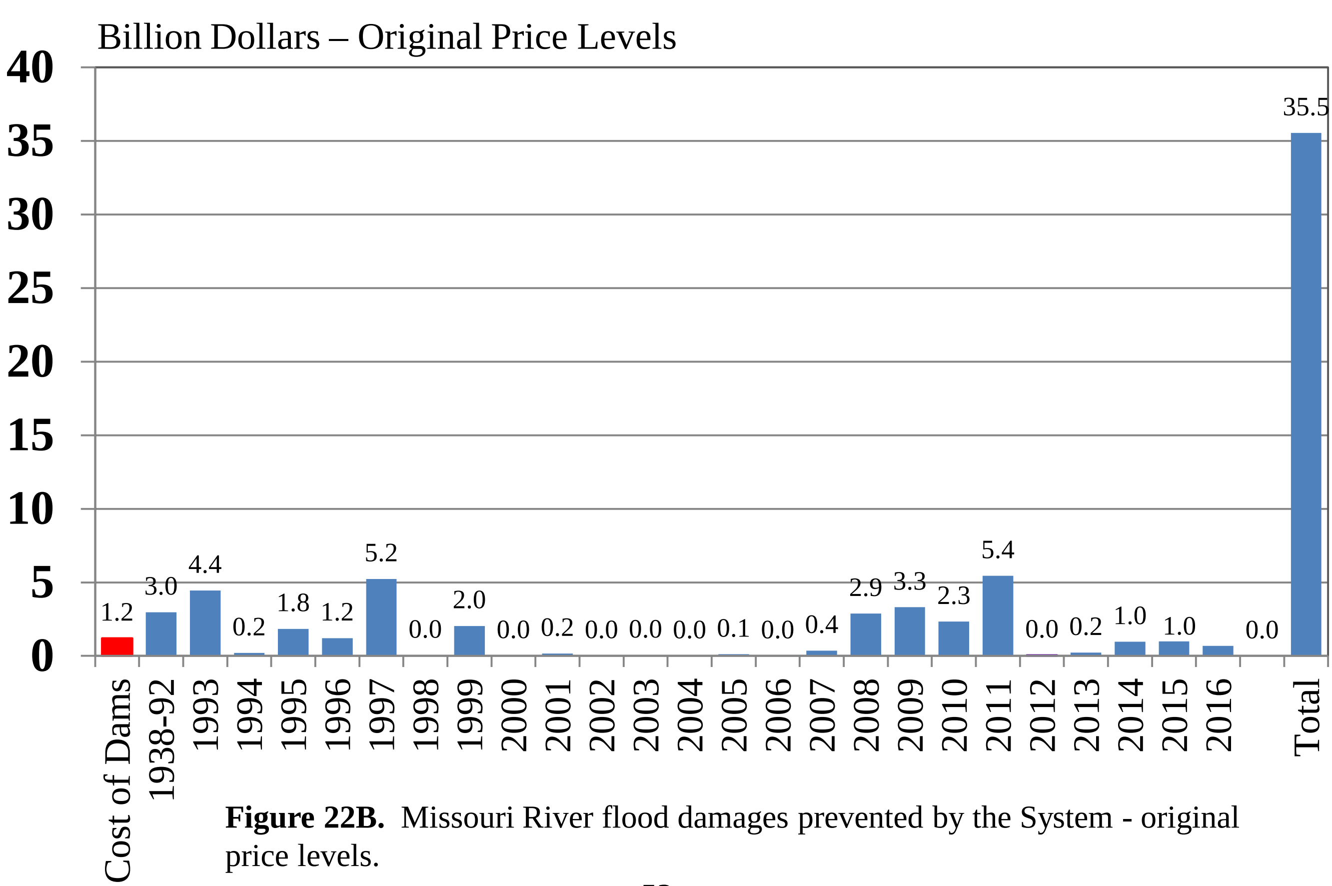


Figure 22B. Missouri River flood damages prevented by the System - original price levels.

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.

Due to the historic releases in 2011, stretches of the Missouri River, specifically reaches directly downstream of the projects, experienced significant channel degradation. During the 2012-13 and 2013-14 winters, minimum releases required some additional coordination with downstream intake owners to ensure that their intakes were operational. The September 1 storage check indicated a winter release of no less than 17,000 cfs, which did not result in any intake access issues.

4. Water Quality Control

a. Overview

During 2016 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:

- 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.
- Evaluate how eutrophication is progressing in the mainstem reservoirs, especially regarding the expansion of hypoxic conditions in the hypolimnion during summer stratification.
- 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.
- 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.
- 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 projects].
- Identify existing and potential surface water quality problems at NWO projects and develop and implement appropriate solutions.
- Evaluate surface water quality conditions and trends at NWO projects.

Table 15 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

Table 15
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	No	Yes	Mercury	Fish consumption advisory also issued by the State of North Dakota and Cheyenne River Sioux Tribe for Lake Oahe within their jurisdictions.
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, SD)	Warmwater Aquatic Life (NE) Warmwater Perm. Fish Life (SD) Fish/Wildlife Propagation (SD) Recreation (SD) Stock Watering (SD)	Mercury in Fish Tissue (NE, SD)	No	Yes (NE, SD)	Mercury	---
Gavins Point • Lewis and Clark Lake	Yes (NE, SD)	Aquatic Life (NE) Warmwater Perm. Fish Life (SD) Fish/Wildlife Propagation (SD) Recreation (SD) Stock Watering (SD)	Chlorophyll-a (NE) Mercury in Fish Tissue (SD)	No	Yes (SD)	Mercury	Sedimentation. Emergent aquatic vegetation.
• Missouri River, Gavins Point Dam to the Big Sioux River	Yes (SD)	Warmwater Perm. Fish Life (SD) Fish/Wildlife Propagation (SD) Recreation (SD) Stock Watering (SD)	Mercury in Fish Tissue	No	Yes (SD)	Mercury	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	*E. coli*	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	*E. coli*	Yes (NE)	No	---	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, 2017.

** 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.

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.

c. 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, run-of-the-river reservoirs and water drawn into the powerplants is usually fairly well mixed through the reservoir water column.

d. 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 antidegradation 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 2013-2016 dissolved oxygen in the water discharged through the Fort Peck powerplant 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), and 6.5 (2016). The situation will continue to be evaluated to determine if corrective measures to meet State water quality standards may be needed.

e. 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 5-year period 2012 through 2016 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 2012 through 2016. Water quality monitoring in 2016 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, is planned for completion by mid-2017.

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.

f. 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 period 2012 through 2016. ***Plate 4*** shows estimated reservoir and coldwater fishery habitat volumes, by year, for 2012 through 2016. At least 2 MAF of coldwater fishery habitat was present in Oahe for all years.

g. 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 2029. 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.

h. 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.

i. Gavins Point Reservoir

Gavins Point reservoir is currently identified as impaired by the States of South Dakota and Nebraska in their 303(d) listing of impaired waters. South Dakota identifies impairment to the designated uses of WPFLP, Fish/Wildlife Propagation, Recreation, and Stock Watering due to elevated mercury levels in fish tissue. 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 Carry Over Multiple Use Pool Zone (28 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 57.0 MAF, navigation flow support was at a full service level for the first half of the navigation season. Based on the July 1 System storage of 60.0 MAF, System releases were maintained to provide full service flow support for the second half of the season with a normal 8-month season length.

On January 20, the year's first commercial load entered the Missouri River at St. Louis, MO. The load was carried by the *Motor Vessel (MV) Jamie Leigh,* which is operated by the Jefferson City River Terminal (JCRT). The *MV Jamie Leigh,* which was towing the *MV Marge I* and five barge loads of cement with an 8.5-foot draft, was headed for the JCRT at River Mile (RM) 143.3. The Corps' Missouri River Project Office at Napoleon, MO recorded 60 loads and 2 empties brought into the Missouri River before April 1, the start of the navigation season. The last commercial tow taken off the Missouri River in 2016 was the *MV Gerald F Engemann* of Hermann Sand and Gravel Company on December 16.

b. Tonnage

Table 16 shows the final Missouri River tonnage data for 2011-2015 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 2015 total of 4.402 million tons includes 3.901 million tons for sand and gravel, 0.232 million tons for waterways materials, and 0.269 million tons for long-haul commercial tonnage. In 2015 the total tonnage decreased by 0.269 million tons compared to 2014. The long-haul tonnage at 0.269 million tons decreased by 0.024 million tons from 2014. 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 2016 is estimated at 0.276 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 2016 present-worth computations. ***Figure 24B*** shows the navigation tonnage value of long-haul commercial commodities since 1960. The ***Figures 23A***, ***23B***, ***24A*** and ***24B*** tonnages and tonnage values for 2016 are estimates and will change once final WCSC tabulations are available.

Navigation season target flows for past years are presented in ***Table 17***. ***Table 18*** shows the scheduled lengths of past System-supported navigation seasons, with total tonnage and ton-miles for each year. ***Figure 25*** presents flows at the four navigation flow-target locations. There was no navigation support from the Kansas River projects in 2016.

Table 16
Missouri River Tonnage by Commodity (1,000 Tons)

Commodity Classification Group	2011	2012	2013	2014	2015
Farm Products	21	20	12	53	50
Corn	6	0	0	9	34
Wheat	0	0	0	0	3
Soybeans	15	20	12	44	13
Misc Farm Product	0	0	0	0	0
Nonmetallic Minerals	3,588	3,479	3,664	4,113	3,946
Sand/Gravel	3,548	3,421	3,609	4,072	3,901
Misc Nonmetallic	39	61	55	41	45
Food and Kindred	0	0	0	7	0
Pulp and Paper	0	0	0	0	0
Chemicals	49	34	53	64	72
Fertilizer	49	34	53	64	72
Other Chemicals	0	0	0	0	0
Petroleum (including coke)	44	6	54	44	13
Stone/Clay/Glass	77	79	71	85	83
Primary Metals	0	0	0	0	6
Waterway Materials	53	288	251	305	232
Other	0	0	0	0	0
Total Commercial	3,832	3,906	4,105	4,671	4,402
Total Long-Haul Commercial	230	197	245	293	269

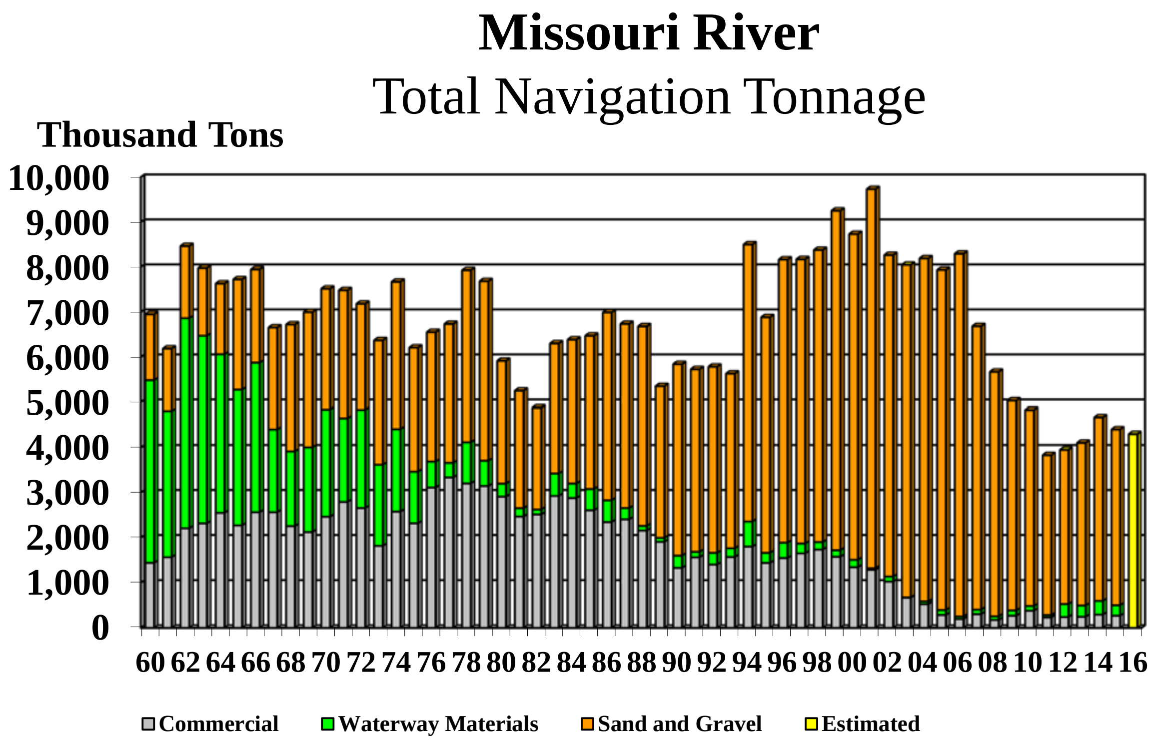


Figure 23A. Missouri River total navigation tonnage from 1960 to 2016 (estimated).

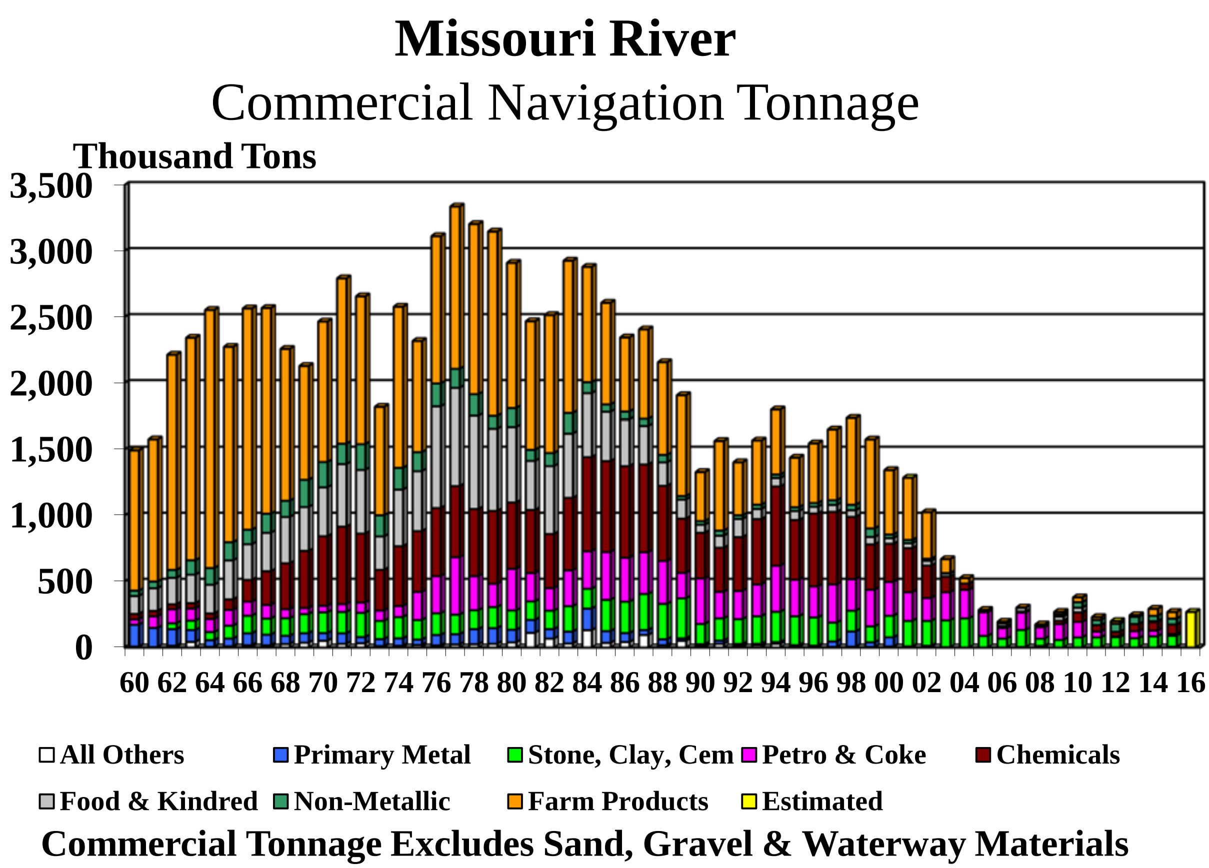


Figure 23B. Missouri River commercial navigation tonnage from 1960 to 2016 (estimated).

Missouri River

Total Navigation Tonnage Value - 2016 Present Worth

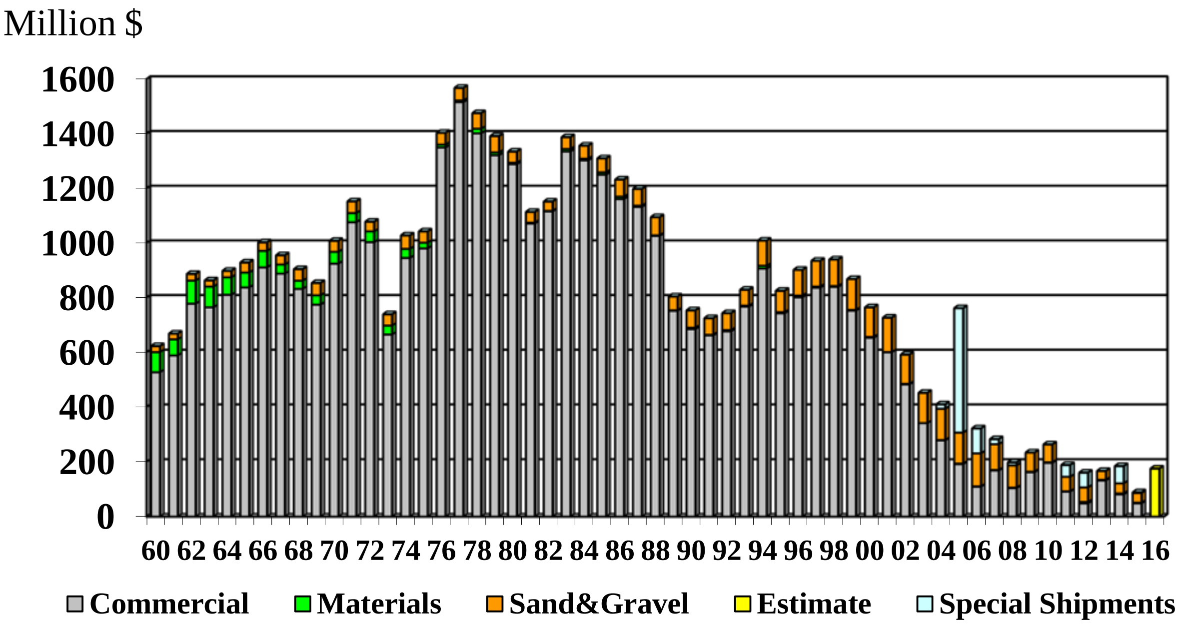
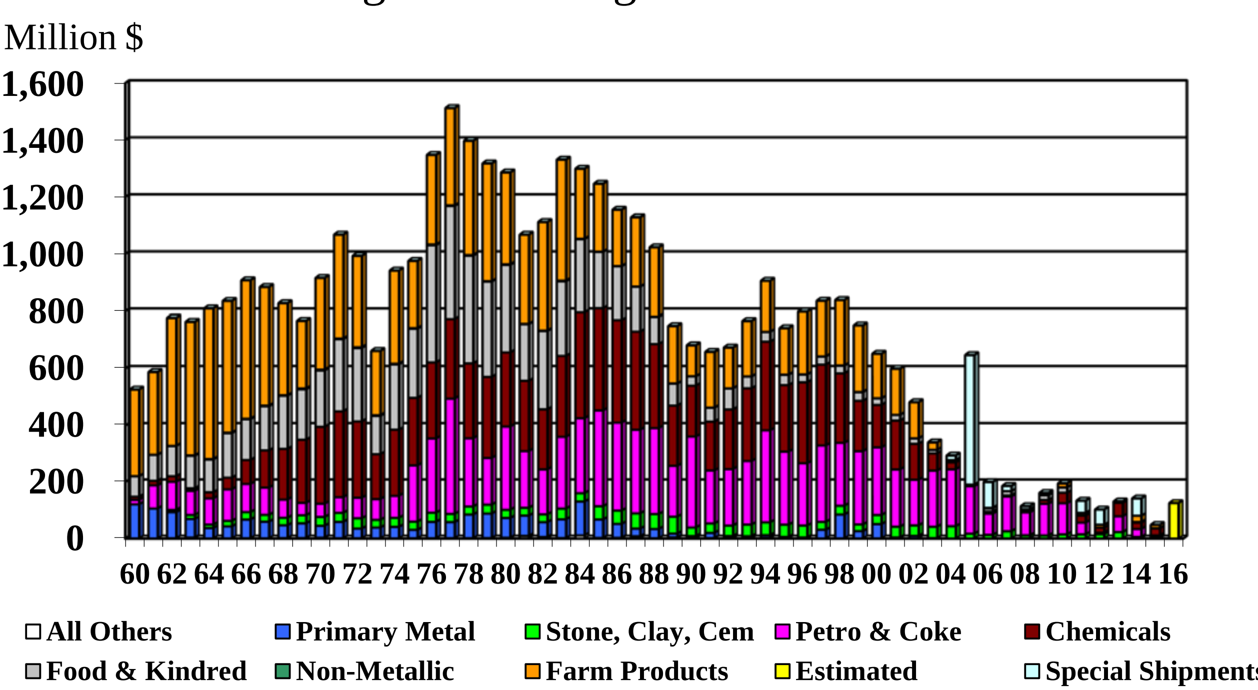


Figure 24A. Total navigation tonnage value using 2016 present worth computations.

Missouri River

Commercial Navigation Tonnage Value - 2016 Present Worth



Commercial Value Excludes Sand, Gravel and Waterway Materials

Figure 24B. Commercial navigation tonnage value using 2016 present worth computations.

Table 17
Navigation Season Target Flows
(1,000 cfs)

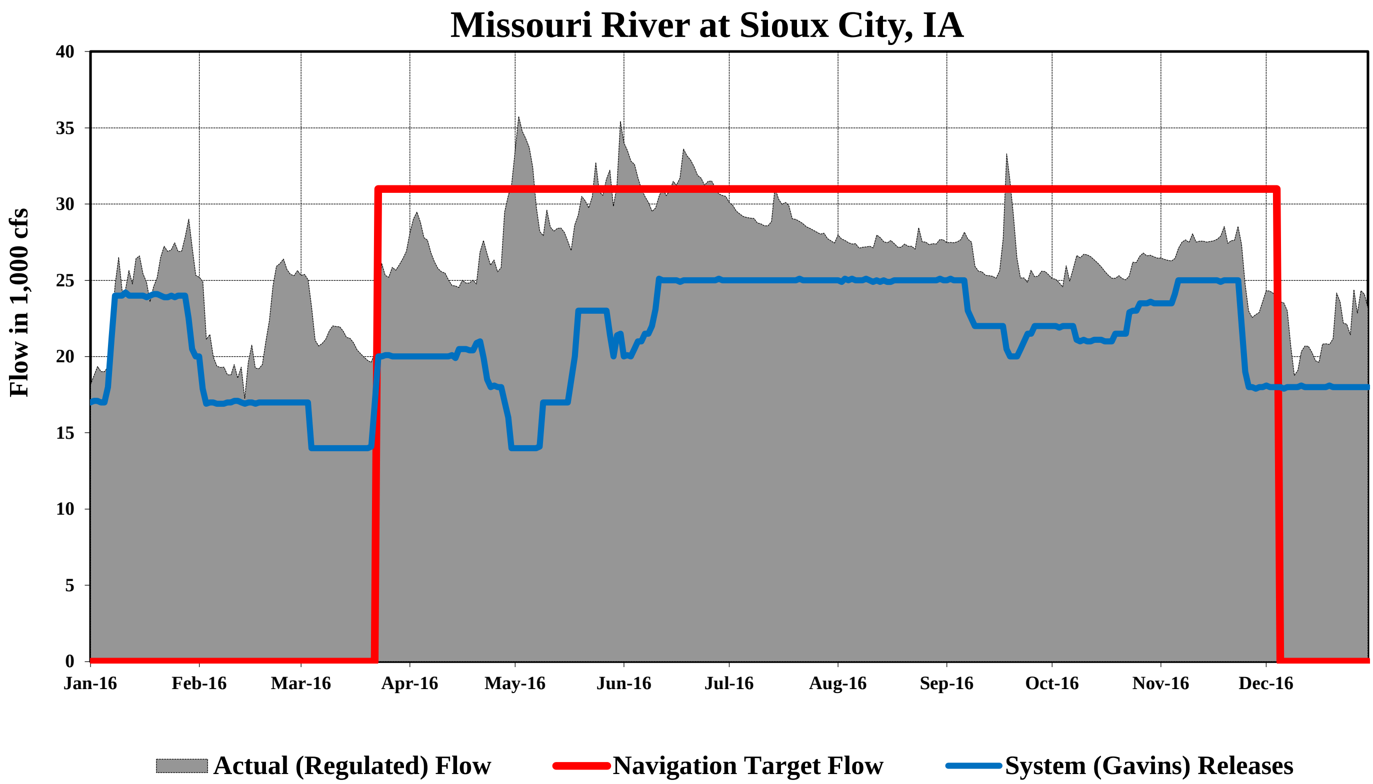
Year	Months	Sioux City	Omaha	Nebraska City	Kansas City
1967	Apr-Jun	28	28	34	38
	Jul-Nov	31	31	37	41
1968	Apr-Nov	31	31	37	41
1969	Apr-Jun(1)	35-40	35-40	41-46	45-50
	Jul(1)	36	36	42	46
	Aug-Sep(1)	50-55	50-55	55-60	55-60
	Oct-Nov(1)	40-45	40-45	45-50	50-55
1970	Apr-May	31	31	37	41
	May-Sep(1)	36	36	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

(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 18
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	261,000 (12)	4,290,800 (12)	88,400 (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 boat report barge counts.



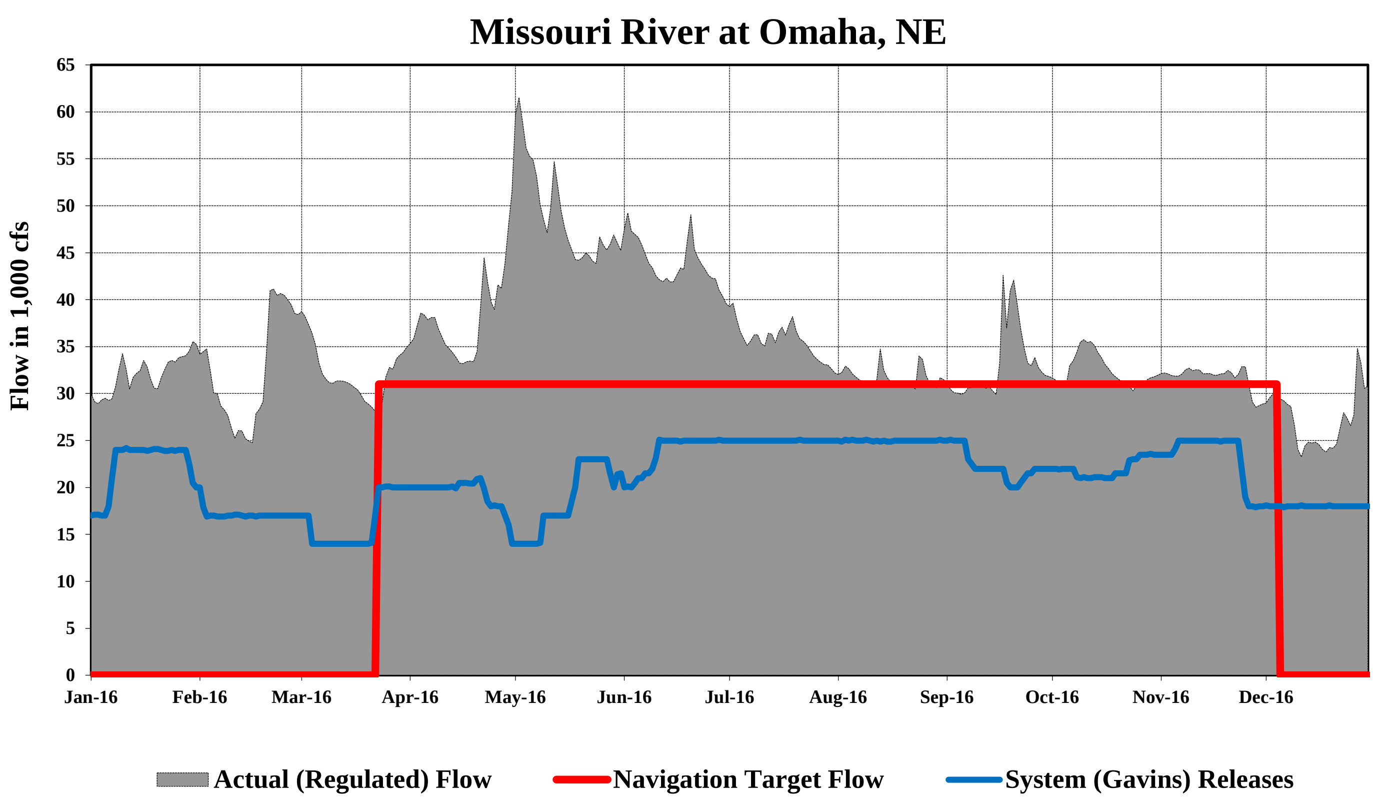
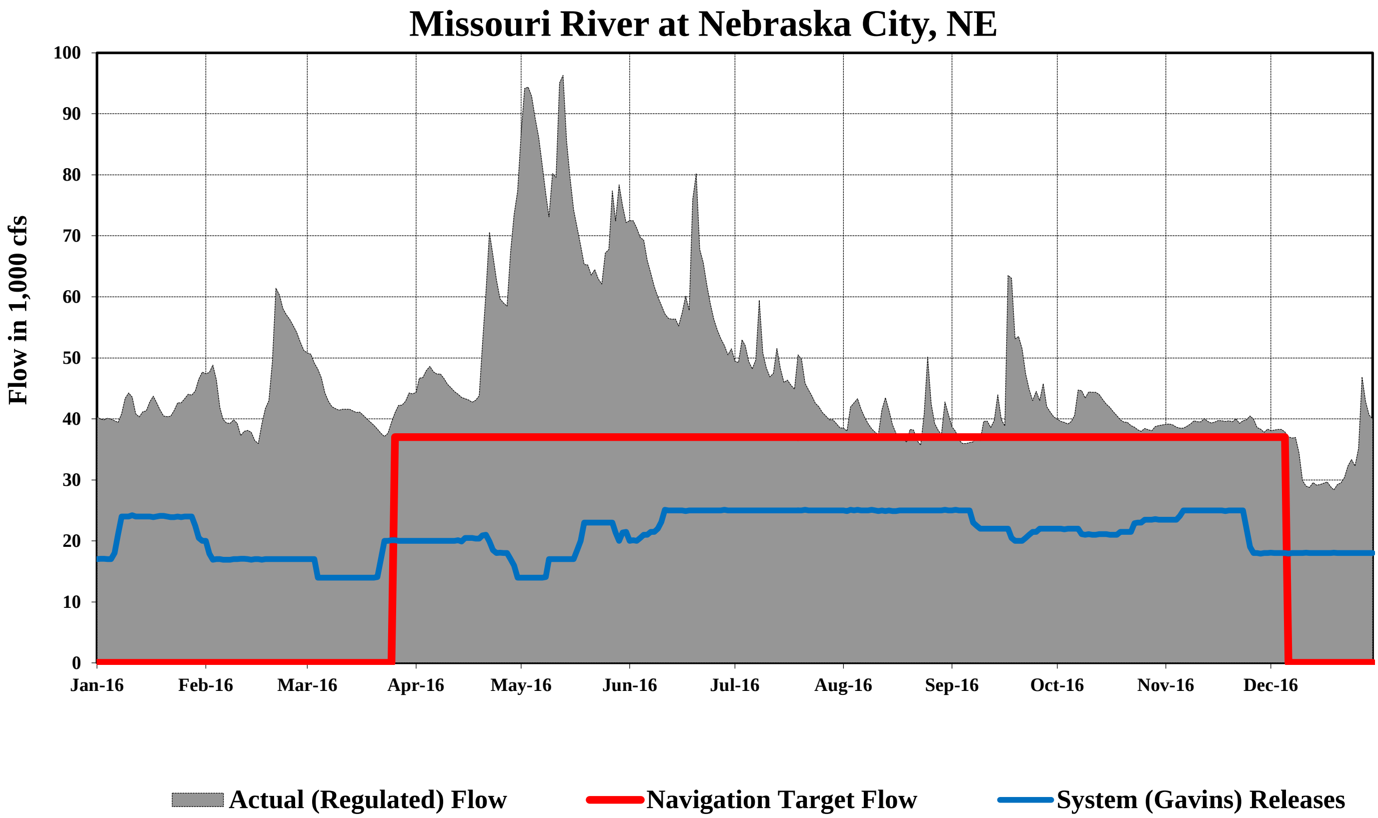


Figure 25A. Actual flow, System releases and navigation target flows – Sioux City, IA and Omaha, NE (calendar year).



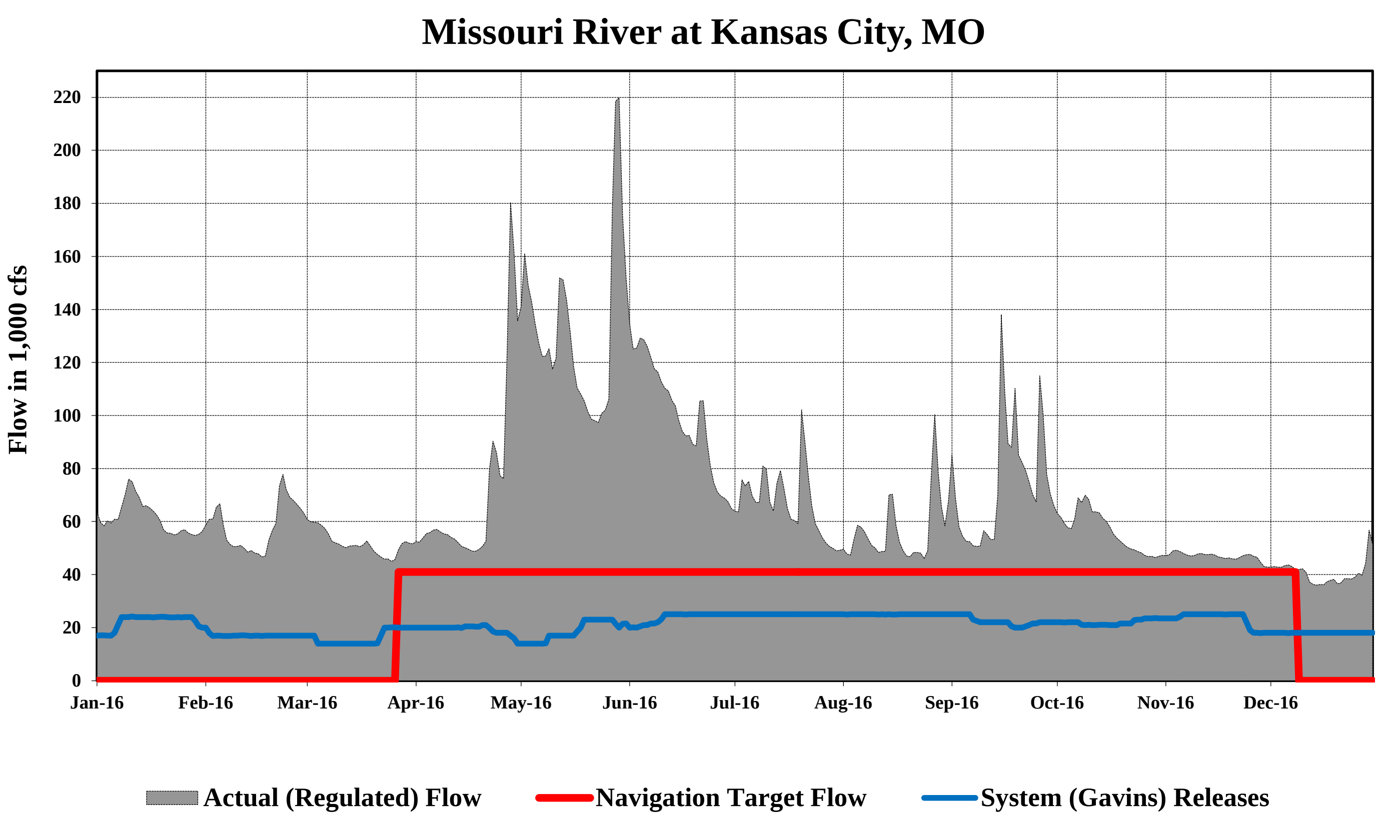


Figure 25B. Actual flow, System releases and navigation target flows –Nebraska City, NE and Kansas City, MO (calendar year).

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 2016, 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 2016.

Per the Omaha Public Power District (OPPD) statistics, the average OPPD customer uses approximately 11,650 kilowatt hours (kWh) of energy annually. Based on the total System generation of 7.6 billion kWh, the energy generated in 2016 by this portion of the Federal power system could have supplied all of the yearly needs of about 649,000 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 2016 was 7.6 billion kWh, which was 82 percent of average since the System first filled in 1967. The 2016 generation was 0.9 billion kWh less than the 2015 generation of 8.5 billion kWh and 2.7 billion kWh more than the record low of 4.9 billion kWh, set in 2008. Total generation was below average in 2016 despite runoff being near average for the upper basin. The difference in generation versus runoff was primarily due to the distribution of runoff. Runoff was above normal in the Fort Randall and Sioux City reaches and below normal in the Fort Peck, Garrison, and Oahe reaches. In addition less-than-average Gavins Point releases were required to meet downstream navigation target flows. Western purchased about 1.6 billion kWh between January 1 and December 31, at a cost of $29 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 2016 is shown in ***Table 19***. The tabulations in ***Table 20*** and ***Table 21*** 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 19
Gross Federal Power System Generation – January 2016 through December 2016

	Energy Generation 1000 kWh	**Peak Hour kW**	**Generation Date**
Corps Powerplants – Mainstem			
Fort Peck	799,149	167,000	June 15
Garrison	1,922,431	381,000	June 30
Oahe	2,005,781	534,000	January 26
Big Bend	732,525	317,000	August 16
Fort Randall	1,405,543	283,000	August 18
Gavins Point	690,302	98,000	November 18
Corps Subtotal	**7,555,731**	1,677,000	August 16
USBR Powerplants			
Canyon Ferry	311,255	56,000	May, June & November
Yellowtail*	346,553	97,000	June
USBR Subtotal	**657,808**		
Federal System Total	**8,213,539**		

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

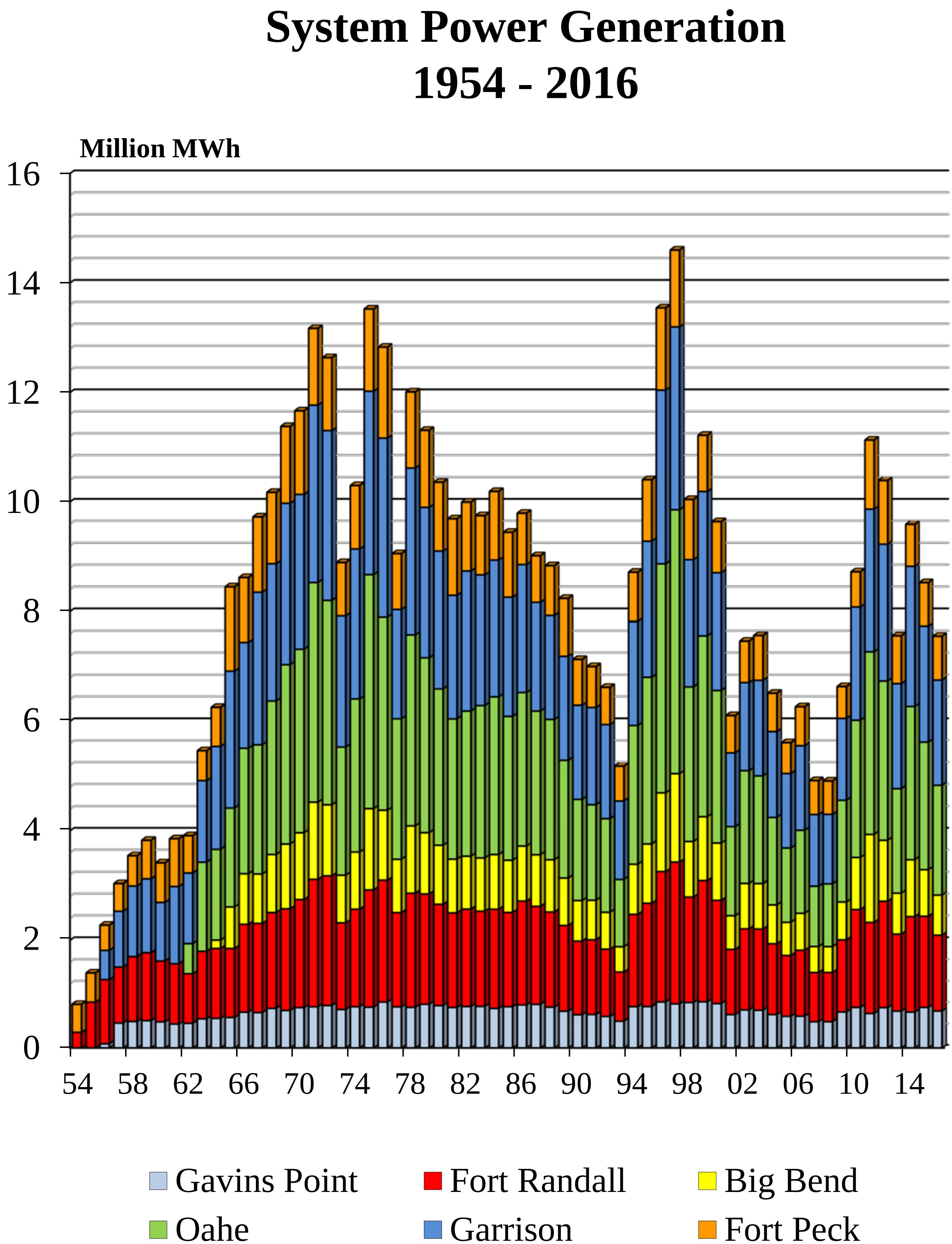


Figure 26. System power generation by project from 1954 to 2016

Table 20
Historical Generation and Load Data – Peaks
Eastern Division, Pick-Sloan Missouri Basin Program*
Data at Plant (1000 kW)
January 1, 2016 through December 31, 2016

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	1,198		72		1,270		427		1,697	Jan 12	900
February	1,135		75		1,210		466		1,676	Feb 12	900
March	920		64		984		444		1,428	Mar 01	700
April	1,304		68		1,372		79		1,451	Apr 08	900
May	880		86		966		290		1,256	May 06	1500
June	1,277		125		1,402		97		1,499	Jun 10	1700
July	1,510		83		1,593		41		1,634	Jul 22	1700
August	1,448		78		1,526		3		1,529	Aug 11	1800
September	1,312		71		1,383		0		1,383	Sep 06	1700
October	937		80		1,017		170		1,187	Oct 31	2000
November	1,006		74		1,080		312		1,392	Nov 21	1800
December	1,223		86		1,309		368		1,677	Dec 14	1900

* This tabulation summarizes the total gross generation and power operations for the Eastern Division marketing area system shown on Table 19.
** During hour of peak total system load.

Table 21
Historical Generation and Load Data – Total
Eastern Division, Pick-Sloan Missouri Basin Program*
Data at Plant (1000 kWh)
January 1, 2016 through December 31, 2016

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	741,009		38,501		779,510		143,984		923,494
February	565,361		35,157		600,518		246,550		847,068
March	555,738		32,881		588,619		180,582		769,201
April	574,200		39,682		613,882		153,952		767,834
May	504,494		67,892		572,386		141,305		713,691
June	693,631		72,277		765,908		40,628		806,536
July	809,556		48,249		857,805		27,788		885,593
August	820,148		45,306		865,454		44,594		910,048
September	640,473		38,442		678,915		81,315		760,230
October	517,679		44,920		562,599		146,071		708,670
November	538,626		43,735		582,361		160,538		742,899
December	594,816		42,403		637,219		228,602		865,821

*Powerplants from Table 19.

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 were at near normal levels through the 2016 recreation season and 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 has been under revision since 2013. The new methodology will leverage metered data that is collected as vehicles enter and exit the recreation areas. Since 1992, all Corps projects, including the mainstem projects, report visitation using the Visitation Estimation Reporting System (VERS). Currently no visitation data is available since 2012. The annual visitation data for 2013 to current will be updated in future summary reports when it becomes available. Another change to the data reporting is attributed to the associated with the South Dakota Title VI land transfer mentioned previously. Since the land transfer occurred, the Corps has not collected visitation data consistent with previous years at the recreation sites in South Dakota. The visitation data in South Dakota reported in future reports will reflect water-related use on the reservoirs but not the visitation at the campgrounds that were turned over to the State of South Dakota and the Tribes.

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.

Except for a brief period in early April, the slightly below average 2016 runoff resulted in steady-to-rising pools in the Fort Peck, Garrison, and Oahe reservoirs throughout the spring and early summer.

b. Threatened and Endangered Species (T&E)

(1) Pallid Sturgeon

This was the 12th year of operating for the endangered pallid sturgeon (pallid sturgeon) per the revised Master Manual. The bimodal spring pulse from Gavins Point was not conducted in 2016, as detailed in section II.C.6.d. of this report.

(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 Garrison dam has been updated with post-2011 Flood cross-sectional 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 combination of near-average 2016 runoff and lower-than-average releases resulted in rising pools during the nesting season, limiting habitat on the reservoirs. Lower, stable releases from the System contributed to nesting success in 2016. Avian predation throughout the system was higher in 2016, limiting fledge ratios. 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 Missouri River Recovery Program 2016 Annual Report (*www.moriverrecovery.org*).

The population distribution and productivity for terns and plovers for 2000 through 2016 are shown in ***Table 22*** and ***Table 23***, respectively. Data for the period 1986 - 1999 can be found in earlier ***Summary of Actual Regulation Reports***. Productivity estimates for these birds on the Missouri River do not include terns and plovers raised in captivity from 1995 to 2002. Adult bird totals listed in ***Table 22*** and ***Table 23*** are considered breeders even though they may not have had nesting success. The term "fledglings/pair" refers to the number of young birds produced per breeding pair. The fledge ratio is an estimate, as the fate of every single fledgling is impossible to ascertain. Numbers for 2013 were not comparable to the numbers in this table because of the change in survey methodology. However, the estimates can be found in the MRRP 2013 Annual Report.

Table 22
Missouri River System - Interior Least Tern Survey Data

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013***	2014	2015	2016
Fort Peck Lake																		
	Adults	0	0	0	2	0	0	2	2	0	0	0	0	0		0	0	0
	Fledglings/Pair	0	0	0	0	0	0	3	0	0	0	0	0			0	0	0
Fort Peck to Lake Sakakawea																		
	Adults	13	39	34	38	48	34	36	77	22	46	26	0	0		8	12	10
	Fledglings/Pair	0.15	0.97	0.59	0.63	0.50	2.18	1.17	1.38	1.45	0.87	1.00	0.00	0.00		0.00	0.00	0
Lake Sakakawea																		
	Adults	10	34	21	25	16	26	48	53	14	15	11	3	14		19	18	52
	Fledglings/Pair	0.20	0.76	0.86	0.56	0.88	0.31	0.71	0.72	2.57	1.07	0.00	0.00	0.29		0.11	0.89	0.38
Garrison to Lake Oahe																		
	Adults	105	125	126	144	142	157	139	123	73	108	134	0	105		131	157	213
	Fledglings/Pair	1.03	1.26	1.83	1.28	1.13	0.73	0.81	1.06	1.34	0.48	1.36	0.00	0.99		0.55	1.06	0.24
Lake Oahe/Lake Sharpe																		
	Adults	85	94	106	70	73	131	128	186	111	71	48	39	100		89	93	87
	Fledglings/Pair	1.01	1.34	1.32	1.20	1.26	0.87	1.14	0.48	0.58	0.96	0.17	1.33	1.06		0.29	0.49	0.25
Ft. Randall to Niobrara																		
	Adults	72	71	84	50	71	76	55	74	58	23	10	0	87		99	155	138
	Fledglings/Pair	1.26	0.14	0.71	0.92	0.37	0.47	0.69	0.30	1.14	0.43	0.00	0.00	1.10		0.73	1.63	1.41
Lake Lewis and Clark																		
	Adults	44	58	46	46	13	4	0	85	225	214	272	231	211		131	164	145
	Fledglings/Pair	0.38	1.17	1.04	0.39	0.00	0.00	0.00	1.58	0.67	0.76	1.01	0.15	1.43		0.52	1.46	0.98
Gavins Point to Ponca																		
	Adults	149	232	314	366	359	476	383	410	278	211	159	0	209		243	318	416
	Fledglings/Pair	1.72	1.09	1.32	0.75	1.04	1.34	0.63	0.59	1.14	1.00	1.17	0	1.2		0.79	1.46	0.98
Total Adults		551	653	731	741	722	904	802**	1,010	781	696	650	273	726		720	917	1061
Fledglings/Pair		1.22	1.04	1.27	0.87	0.95	1.09	0.80**	0.75	0.98	0.80	1.02	0.32	1.19		0.6	1.31	0.8

- Data not collected
* Partial Survey Results
{} No Birds Found
+ Subsampling of Selected Nesting Areas
** Includes adults and fledglings from Lake Francis Case
*** 2013 data is not added due to survey methodology change. See 2013 MRRP Annual Report for additional information.

Notes: The data do not include least terns and piping plovers raised in captivity from 1995 to 2002. The data represent only wild fledged birds.
From 1990 to 2003 the 10-Year Least Tern Fledge Ratio was 0.70 (1990 and 2000 Biological Opinions).
From 2004 to current 5-year running average goal is 0.94 (2003 Amended Biological Opinion)
Data in this table may differ from previous reports. As information becomes available, this table is updated.
Refer to previous MRBWM Summary Reports for 1986-1999 data.

Table 23
Missouri River System - Piping Plover Survey Data

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013**	2014	2015	2016
Fort Peck Lake																		
	Adults	0	4	2	17	9	26	20	16	9	12	3	2	0		0	4	2
	Fledglings/Pair	0	1	2	0.35	2.22	1.08	1.2	0.5	0.22	0.33	0	0	0		0	0	0
Fort Peck to Lake Sakakawea																		
	Adults	4	3	2	6	0	2	5	0	0	0	0	0	0		0	0	0
	Fledglings/Pair	0	1.33	0	2.67	0	4	0.4	0	0	0	0	0	0		0	0	0
Lake Sakakawea																		
	Adults	277	424	469	528	738	746	430	399	363	85	38	24	200		155	252	400
	Fledglings/Pair	1.61	1.25	1.65	1.06	1.5	0.89	0.61	0.7	0.68	0.21	0.89	1.67	1.4		0.48	0.73	1
Garrison to Lake Oahe																		
	Adults	99	149	119	149	164	220	175	222	218	275	287	0	98		221	392	336
	Fledglings/Pair	1.41	1.53	2.03	1.66	1.16	0.8	0.77	0.97	1.37	0.94	0.84	0	1		2.05	1.26	0.36
Lake Oahe/Lake Sharpe																		
	Adults	141	184	203	301	372	364	331	273	281	158	44	20	125		210	251	227
	Fledglings/Pair	1.45	1.41	2.16	1.84	1.41	1.21	0.99	0.62	0.9	0.47	0.1	0.4	1.76		0.45	0.49	0.56
Ft. Randall to Niobrara																		
	Adults	62	38	35	37	42	42	37	21	26	16	6	0	43		106	145	173
	Fledglings/Pair	0.87	0.74	1.03	1.46	0.71	0.81	0.38	0	1	1	0	0	1.81		1.08	2.34	1.69
Lake Lewis and Clark																		
	Adults	28	34	44	14	0	24	4	20	57	122	152	134	179		186	188	124
	Fledglings/Pair	0.5	0.71	1.68	1.57	0	0.17	0.5	1.8	1.37	1.8	1.25	0.22	1.35		0.57	1.37	1.05
Gavins Point to Ponca																		
	Adults	186	218	260	286	262	340	309	300	320	238	74	2	137		238	380	570
	Fledglings/Pair	2.17	1.85	2.29	1.9	1.87	1.97	0.78	0.39	1.39	1.09	1.86	0	1.82		1.73	2.23	1.69
Total Adults		797	1054	1134	1338	1587	1764	1311	1251	1274	906	604	182	782		1116	1612	1832
Fledglings/Pair		1.58	1.41	1.91	1.5	1.49	1.15	0.78	0.66	1.06	0.94	1.01	0.43	1.49		1.12	1.4	1.12

- Data not collected
* Partial Survey Results
{} No Birds Found
+ Subsampling of Selected Nesting Areas
** 2013 data is not added due to survey methodology change. See 2013 MRRP Annual Report for additional information.

Notes: The data do not include least terns and piping plovers raised in captivity from 1995 to 2002. The data represent only wild fledged birds.
From 1990 to 2000 the 15-Year Piping Plover Fledge Ratio Goal was 1.44 (1990 Biological Opinion).
From 2001 to 2003 the goal was 1.13 (2000 Biological Opinion)
From 2004 to current the 10-year running average goal is 1.22 (2003 Amended Biological Opinion)
Data in this table may differ from previous reports. As information becomes available, this table is updated.
Refer to previous MRBWM Summary Reports for 1986-1999 data.

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 2016 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 7, 2016, was sent to the Missouri River Basin Tribes offering consultation on the 2016-2017 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. One Tribe was recorded participating in the fall AOP public meetings in October 2016.

The Corps actively addresses shoreline erosion which can damage or significantly alter cultural resource sites. During the 2016 reporting period, Omaha District awarded two contracts for large cultural resource shoreline protection projects at Gavins Point and Garrison and anticipates the completion of these two projects in 2017.

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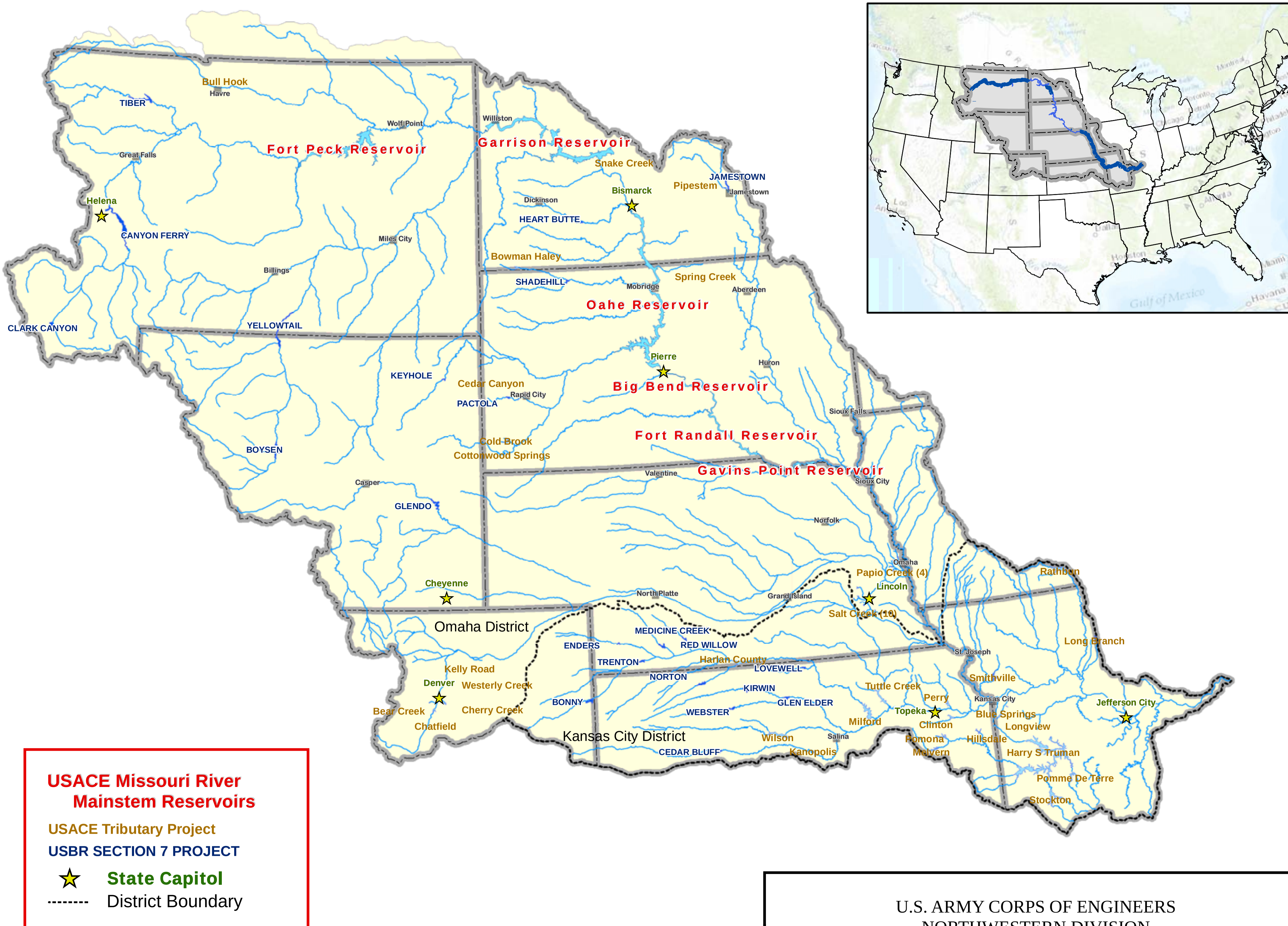

U.S. ARMY CORPS OF ENGINEERS
NORTHWESTERN DIVISION
MISSOURI RIVER BASIN WATER MANAGEMENT DIVISION

PLATE 1. Missouri River Basin Map.

Summary of Engineering Data -- Missouri River Mainstem System

Item No.	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	2,254	2,622
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
1351-1355(10) 25,000-100,000 cfs	32,000 cfs - 128,000 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
3 - 67,276, 5 - 58,500	40,000	44,100		51
494,320	320,000	132,300	2,501,200 kw	52
497,000	293,000	74,000	1,967,000 kw	53
980	1,726	725	9,342 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) 1967-2015 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

Corps of Engineers, U.S. Army
Compiled by
Northwestern Division
Missouri River Region
October 2016

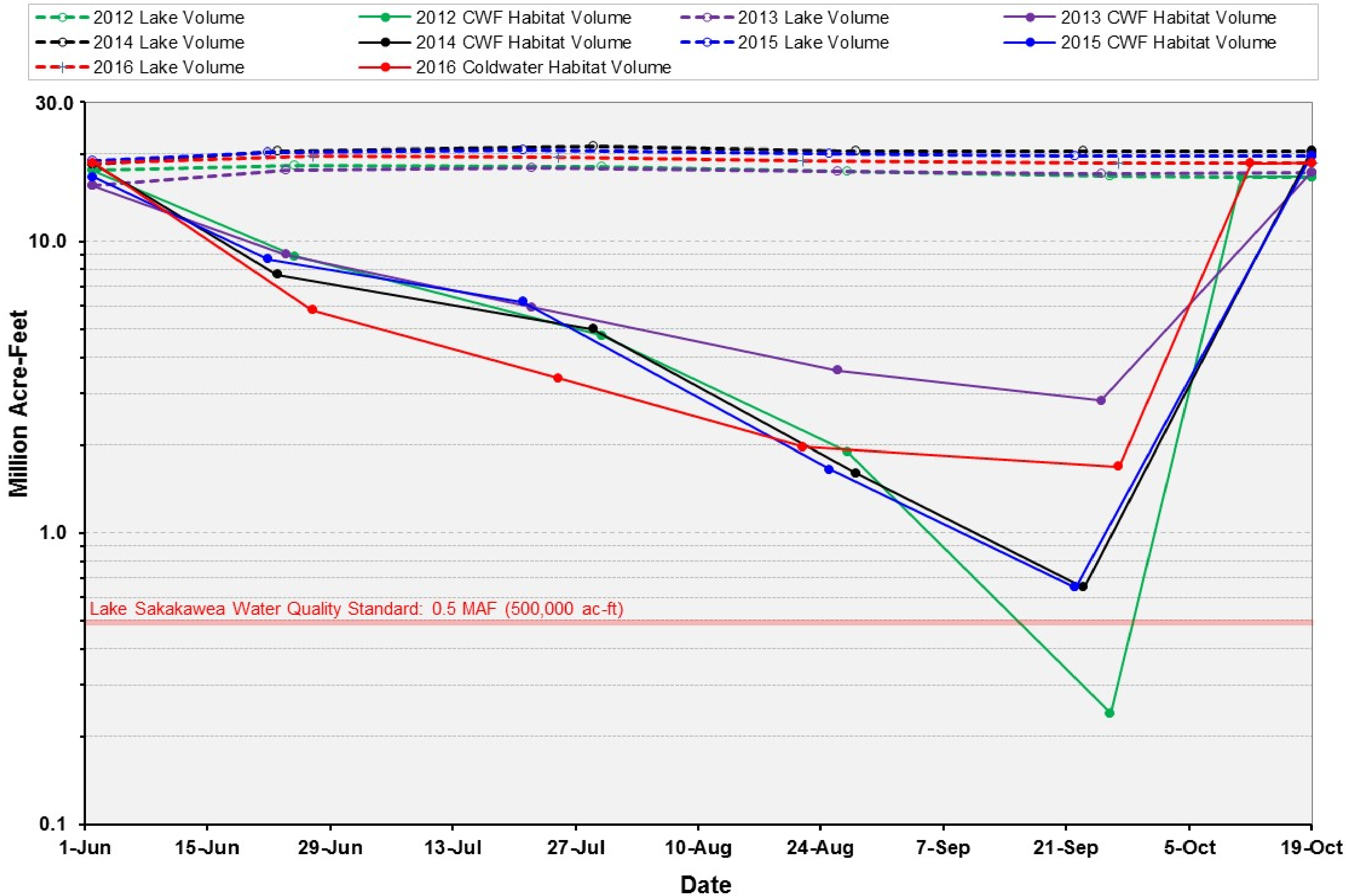

Plate 3. Garrison Reservoir - estimated reservoir and coldwater fishery (CWF) habitat 2012 through 2016.

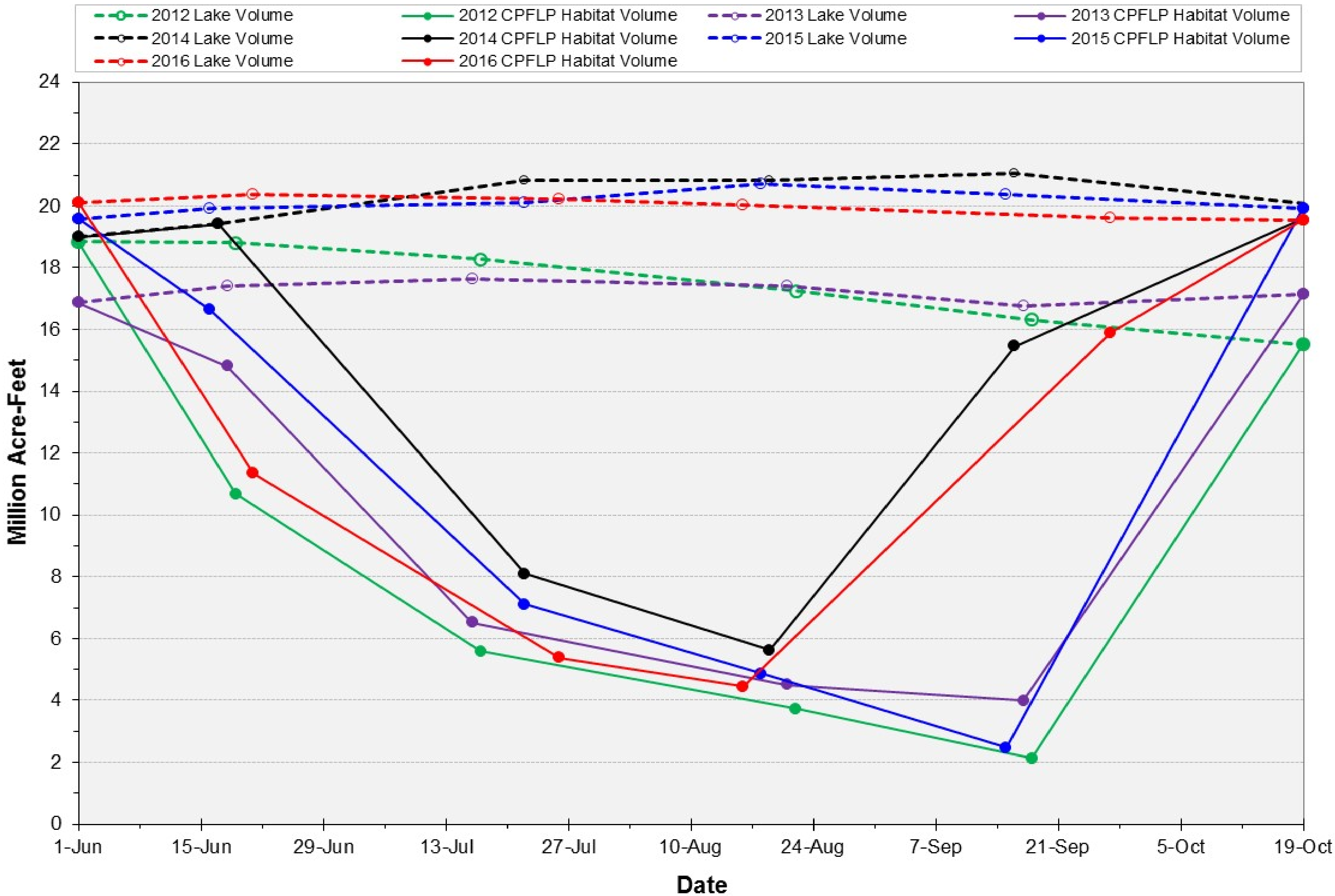

Plate 4. Oahe Reservoir - estimated reservoir and coldwater fishery (CWF) habitat 2012 through 2016.

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