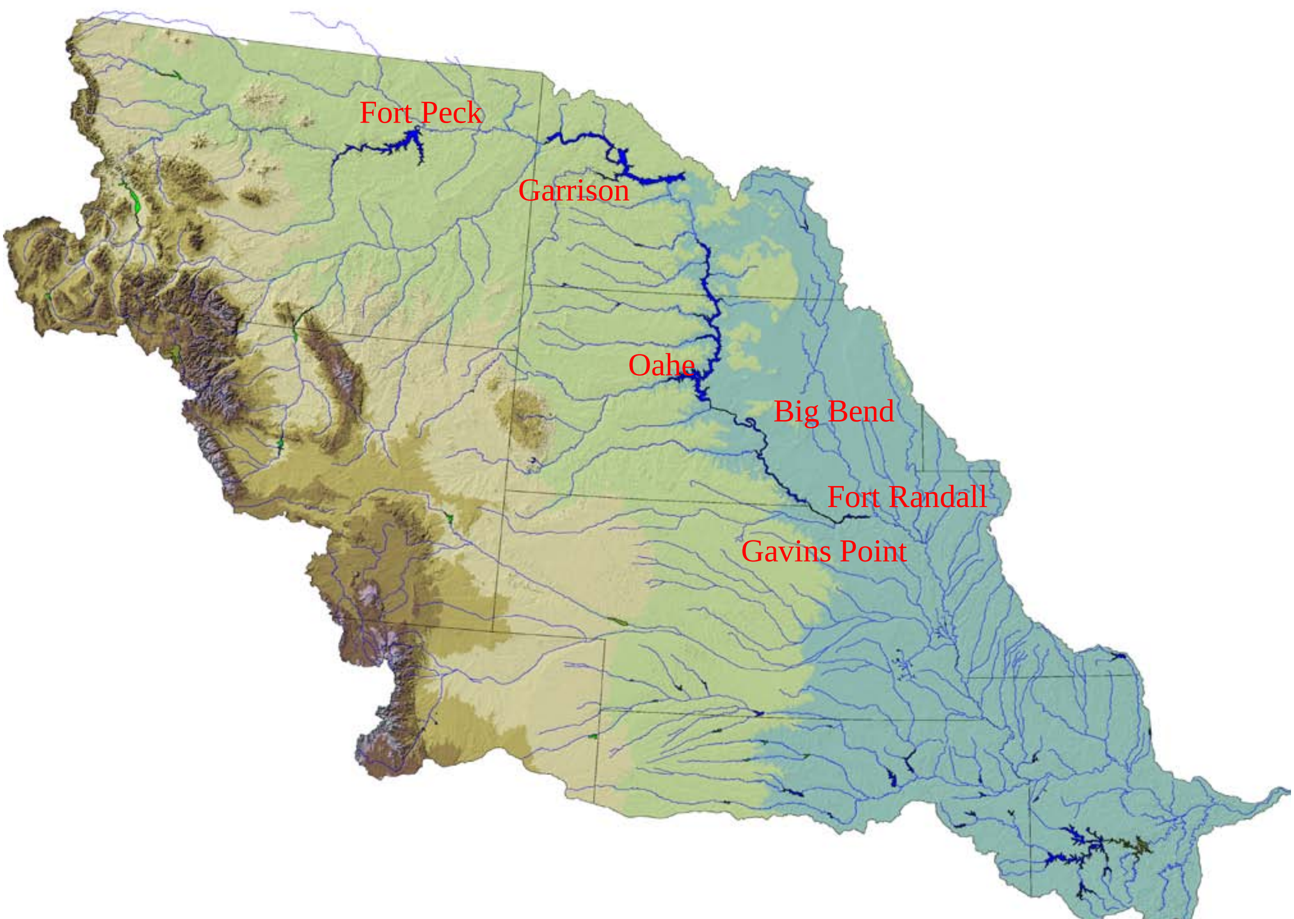
US Army Corps
of Engineers

Northwestern Division

Missouri River Mainstem Reservoir System

Summary of Actual 2011 Regulation

Missouri River Basin



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

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Missouri River Mainstem Reservoir System

Summary of Actual 2011 Regulation

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LIST OF ABBREVIATIONS AND ACRONYMS

ACHP	Advisory Council on Historic Preservation
AOP	annual operating plan
AF	acre-feet
cfs	cubic feet per second
CPC	National Oceanic and Atmospheric Administration Climate Prediction Center
CY	calendar year (January 1 to December 31)
DMS	Data Management System
^{o} C	degrees Centigrade
^{o} F	degrees Fahrenheit
EA	Environmental Assessment
ENSO	El Nino Southern Oscillation
EOM	End of Month
ft	feet
ft msl	feet above mean sea level
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
NOAA-NWS	National Oceanic and Atmospheric Administration – National Weather Service
NOHRSC	National Operational and Hydrologic Remote Sensing Center
NRCS-SNOTEL	Natural Resources Conservation Service SNOwpack TELemtry
NWD	Corps' Northwestern Division
NWK	Corps' Kansas City District
NWO	Corps' Omaha District
OPPD	Omaha Public Power District
PA	2004 Programmatic Agreement

LIST OF ABBREVIATIONS AND ACRONYMS (cont'd)

plover	piping plover
P-S MBP	Pick-Sloan Missouri Basin Program
RM	river mile
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
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

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 2011 Regulation

I. FOREWORD

This document contains a summary of the actual regulation of the Missouri River Mainstem Reservoir System (System) for the 2011 Calendar Year (CY). Three other reports related to System regulation are also available, the ***System Description and Regulation***, ***Final 2010-2011 Annual Operating Plan*** and ***Summary Report on Regulation – 2011 Flood***. All four 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 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 2011

A. General

This report summarizes the System regulation as it pertains to all eight congressionally-authorized purposes. The Missouri River Basin "Flood of Record" occurred during 2011. A separate report, ***Summary Report on Regulation – 2011 Flood*** chronologically discusses the flood control regulation of the System during the Flood of 2011 in much more detail than contained in this report.

During 2011 the System was regulated in accordance with the Master Water Control Manual (Master Manual) and the applicable provisions of the Final 2010-2011 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. A summary of the significant events during 2011 follows.

B. Precipitation and Water Supply Available in 2011

The 2011 runoff year was the highest runoff year of record in the upper Missouri River basin since 1898, resulting in a total annual runoff of 61.0 million acre-feet (MAF), 246% of normal. It also marked the fourth consecutive year of above-average runoff conditions in the Missouri River basin, immediately following the drought of 2000-2007. Runoff is discussed in more detail in Section II.B.4 of this report. The reference period for average conditions for plains and mountain snowpack, precipitation and temperature is 1971-2000.

1. Plains Snowpack

At the end of 2010, nearly the entire Missouri River basin, with the exception of a majority of the State of Missouri, was covered by plains snowpack as a result of heavy late November and December snowfall and colder-than-normal temperatures across the northern plains. Monthly and seasonal snowfall at National Oceanic and Atmospheric Administration-National Weather Service (NOAA-NWS) monitoring locations is provided in ***Table 1***. November through December snowfall totals, as of December 31, 2010, were 39.1 inches at Billings, MT; 37.3 inches at Glasgow, MT; 44.1 inches at Great Falls, MT; 31.2 inches at Bismarck, ND; 50.4 inches at Williston, ND; and 31.0 inches at Watertown, SD.

Table 1
Winter of 2010-2011 Monthly, Seasonal Total and Seasonal Average Snowfall (inches)

Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Seasonal Total	Seasonal Average
Billings, MT	0.0	23.3	15.8	3.3	13.8	5.9	9.8	71.9	55.9
Glasgow, MT	1.2	12.6	24.7	41.6	13.8	11.4	3.3	108.6	29.9
Great Falls, MT	0.0	19.5	24.6	6.1	32.6	4.1	20.7	107.6	56.9
Bismarck, ND	3.4	10.1	21.1	18.2	5.5	13.7	13.4	85.4	49.8
Williston, ND	4.1	15.1	35.3	20.5	5.9	13.7	12.6	107.2	42.2
Aberdeen, SD	0.3	1.7	24.6	16.5	21.0	9.7	5.5	79.3	38.6
Mobridge, SD	1.7	1.4	16.0	18.0	16.7	13.1	8.7	75.6	33.4
Pierre, SD	1.5	0.3	18.2	12.9	19.0	8.3	4.8	65.0	29.5
Sioux Falls, SD	0.0	1.1	17.9	14.8	7.9	3.0	0.9	45.6	40.6
Watertown, SD	0.1	2.0	29.0	20.4	21.5	5.4	1.0	79.4	31.2

Source: NOAA-NWS.

On December 31, 2010 modeled plains snow water equivalent (SWE) provided by NOAA's National Operational and Hydrologic Remote Sensing Center (NOHRSC) estimated an area of 1 to 4 inches of SWE north of a line extending from Sioux City, IA to north central Montana (see ***Figure 1***). Two to 3 inches of SWE existed in much of the Missouri River basin in North Dakota and northeast Montana; while areas of 3 to 4 inches covered the upper Big Sioux River, the upper James River above Jamestown, ND and a stretch of the Missouri River from Williston, ND to Bismarck, ND.

Snowfall continued at above-average rates in January and February. Notable monthly accumulations during January included 41.6 inches at Glasgow, MT; 20.5 inches at Williston, ND; and 20.4 inches at Watertown, SD. Notable monthly accumulations during February included 32.6 inches at Great Falls, MT; 21.0 inches at Aberdeen, SD; and 21.5 inches at Watertown, SD. February accumulation rates were less than January due to a brief warm period during February 13-17, 2011, which consolidated snow in many areas and melted snow in locations such as Pierre, SD and Aberdeen, SD. A very large snow storm that occurred during February 19-21, 2011 quickly caused snow depths and SWE to rebound to even higher levels than were seen earlier in the month despite the earlier snowmelt.

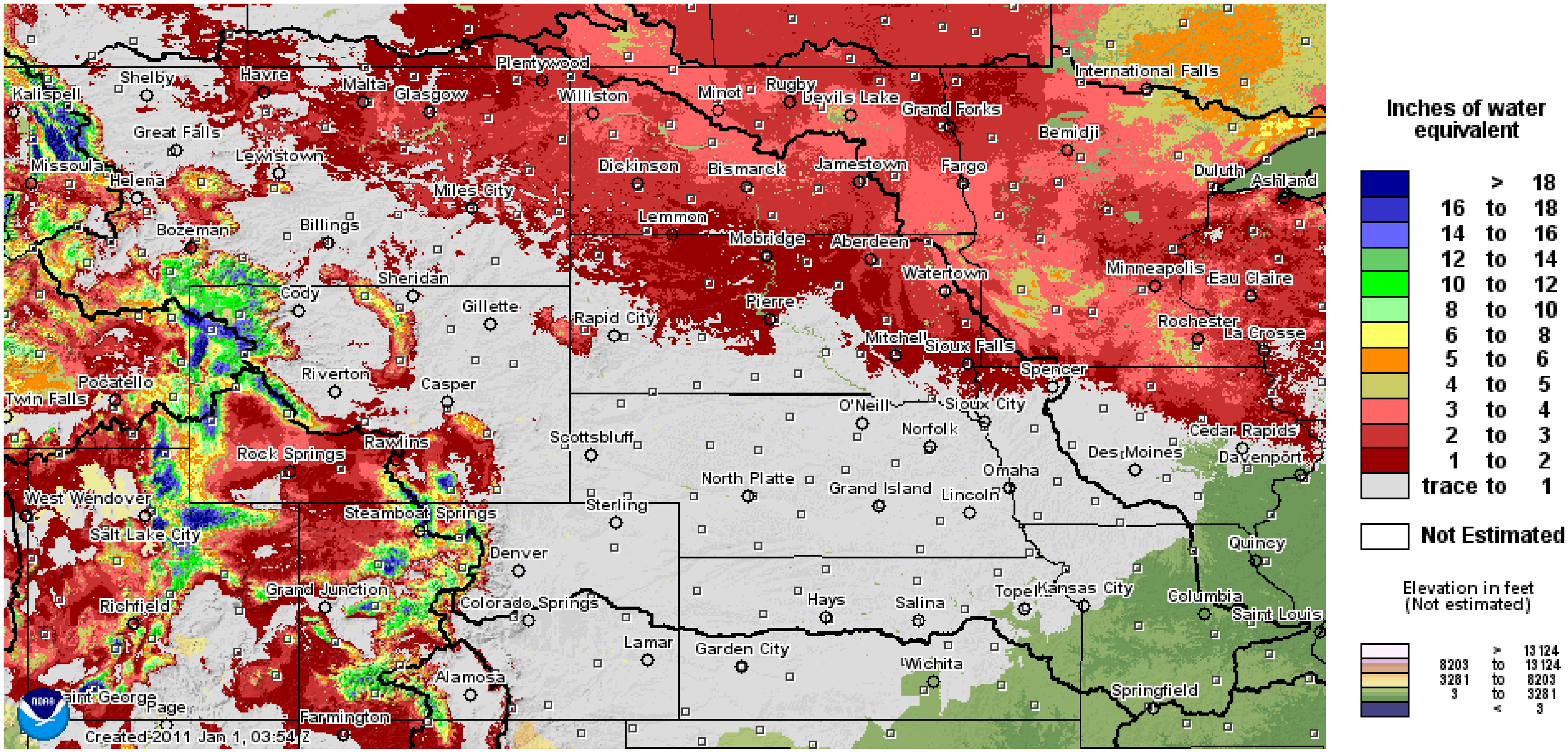


Figure 1. December 31, 2010 plains snow water equivalent (inches) modeled by NOAA NOHRSC.

By February 25, 2011, the date of estimated peak snow coverage, NOHRSC's modeled SWE product indicated more than 4 inches of SWE north and east of a line from Sioux Falls, SD to Glasgow, MT and westward to Havre, MT (see ***Figure 2***). Greater amounts, ranging from 5 to 8 inches, existed from northeast South Dakota into northeast Montana. SWE amounts in excess of 1 inch had accumulated southward into southern South Dakota, while almost the remainder of the Missouri River basin contained trace to 1-inch amounts of SWE. Plains snow did not expand in coverage after February 25, yet light accumulations continued in early March until March 14 when average daily temperatures rose above freezing, causing plains snow to begin melting in most locations throughout the upper basin. Above-freezing temperatures persisted for about 10 days in South Dakota, resulting in complete melt of snow in much of South Dakota, with the exception of northern and northeastern portions of the state. As of April 1, North Dakota and northeast Montana still maintained a heavy snowpack (see ***Figure 3***), though warm temperatures quickly melted the snow in Bismarck, ND; Aberdeen, SD and Glasgow, MT within the first week of April, while snow in Williston, ND melted by April 10.

Over the winter of 2010-2011, SWE data gathered across the upper Missouri River basin by plains snow survey observers (a team established by MRBWM in 2010 consisting of staff from the Corps, NOAA, the U.S. Geological Survey (USGS), States of South Dakota and North Dakota, various local and county emergency managers and private citizens) were used by MRBWM to develop the March and April runoff forecasts for the System. In addition, these data were provided to the NOAA NOHRSC office to adjust and verify the modeled snow product. At their respective peak accumulations, a number of locations verified very high amounts of SWE that had accumulated in the upper Missouri River basin. Some notable maximum SWE amounts measured in the basin include: 5.0 inches at Wolf Point, MT; 6.1 inches at New Rockford, ND; 6.4 inches at Lake City, SD; and 5.9 inches at Watertown, SD.

2. Mountain Snowpack

a. November-December 2010

Mountain snow accumulations were first detectable at Natural Resources Conservation Service SNOwpack TELemetry (NRCS SNOTEL) stations as early as October. By mid-October, wide-spread accumulations began to build. For purposes of monitoring the mountain snowpack and forecasting spring and summer runoff from the Rocky Mountains, the snowpack in the reach above Fort Peck and the Fort Peck to Garrison reach is depicted as an average SWE of all contributing SNOTEL stations versus time, as shown in ***Figure 4***.

Weather in the Rocky Mountain portion of the Missouri Basin was being influenced by La Nina conditions in the equatorial Pacific, which usually result in greater-than-average mountain snow accumulations and lower-than-normal winter temperatures. On November 1, average mountain SWE in the reach above Fort Peck and the Fort Peck to Garrison reach were 73% and 74% of the normal accumulation, respectively. Normally, 8% of the peak SWE accumulation occurs by November 1. This percentage is based on the 1971-2000 snowpack records.

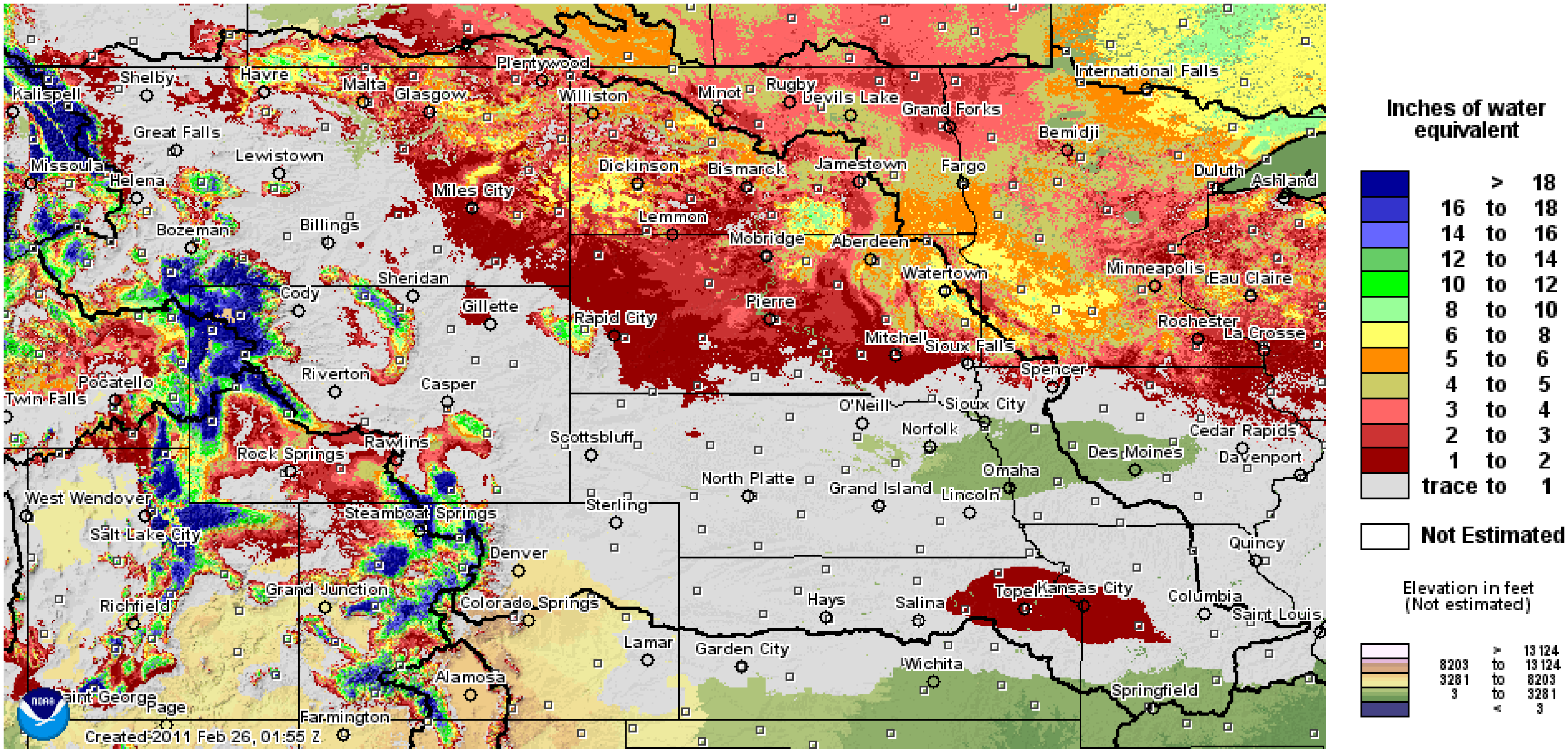


Figure 2. February 25, 2011 plains snow water equivalent (inches) modeled by NOAA NOHRSC.

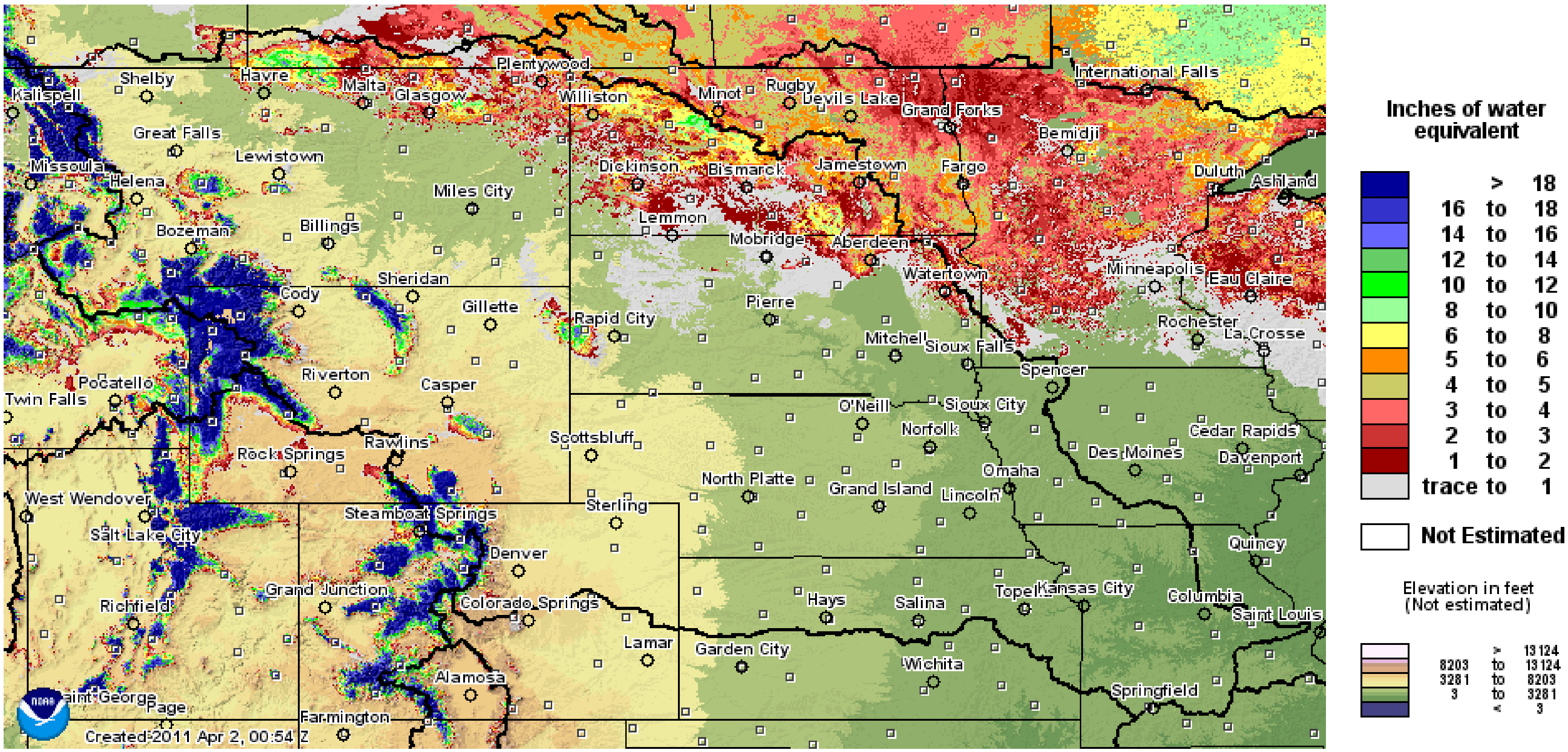
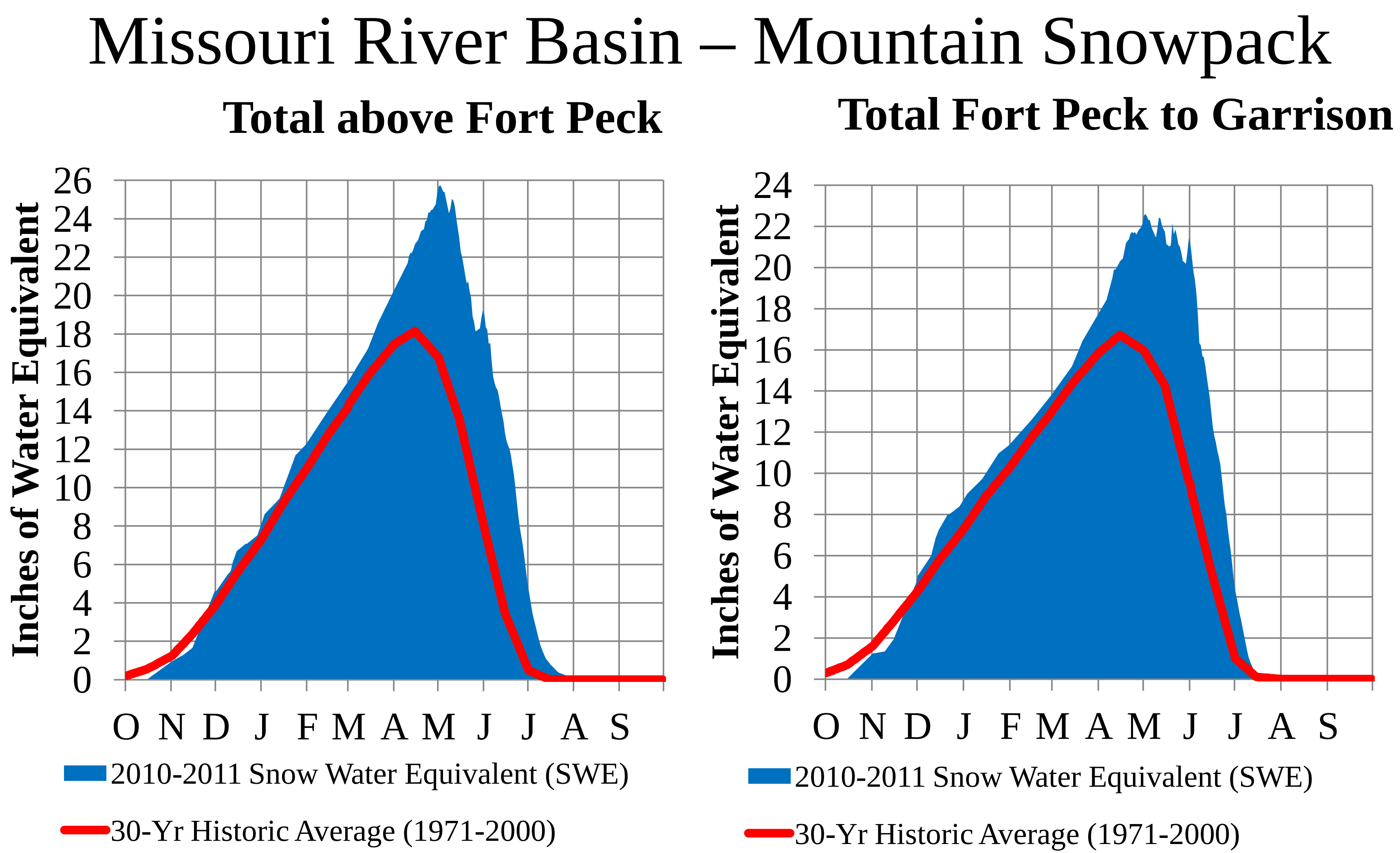


Figure 3. April 1, 2011 plains snow water equivalent (inches) modeled by NOAA NOHRSC.



The mountain snowpack in the reach above Fort Peck peaked at 141% of the normal peak accumulation on May 2. The mountain snowpack in the reach between Fort Peck and Garrison peaked at 136% of the normal peak accumulation on May 2. The Missouri River basin mountain snowpack normally peaks near April 15.

Figure 4. Missouri River Basin mountain snowpack water content 2010–2011.

During November, La Nina conditions were reaching their peak. Mountain SWE accumulations increased to above normal during the middle of November. By December 1, 116% of the normal mountain SWE had accumulated in the reach above Fort Peck and 103% of the normal mountain in the Fort Peck to Garrison reach. Normally, 24% of the peak SWE accumulation occurs by December 1. Snowfall continued at an above-average rate, and by December 29 110% of the normal SWE accumulation above Fort Peck and 111% of the normal SWE accumulation in the Fort Peck to Garrison reach had occurred.

b. January 2011

In January, though snow was not as extensive across the upper basin, a number of smaller mountain snowstorms continued to produce snow in the Rocky Mountains in spite of warmer-than-normal monthly temperatures. By January 31, 2011 the SWE accumulation was 112% of normal above Fort Peck and 111% of normal in the Fort Peck to Garrison reach. Normally, 61% of the peak accumulation of snow occurs by February 1.

c. February 2010

Precipitation in the Rocky Mountains continued at a steady pace in February, with mountain snowstorms producing moderate snow in the higher elevations and lesser amounts at the lower elevations. Negative temperature departures of 5 to 10 degrees Fahrenheit (^{o}F) enhanced the snow accumulations in the mountains. As a result, mountain snowpack continued at about the same pace as previous months. On February 28, mountain SWE was 110% of normal above Fort Peck and 107% of normal in the Fort Peck to Garrison reach. Normally, 79% of the peak accumulation of snow occurs by March 1.

d. March 2011

Historically during March, weather systems begin bringing in more moisture to the basin, thus producing greater amounts of precipitation in the Rocky Mountains and the plains. During March 2011 these areas of the basin experienced higher amounts of precipitation compared to February, and average temperatures continued to be several degrees below normal, aiding the accumulation of mountain snow. Normally at the end of March, mountain snow accumulation rates begin to decline, but in March 2011, the colder temperatures caused accumulations to continue to the end of the month at a higher rate than normal. On March 31, the mountain SWE increased to 116% of normal above Fort Peck and increased to 112% of normal in the Fort Peck to Garrison reach. Normally, 96% of the peak accumulation of snow occurs by April 1.

e. April 2011

In April 2011, precipitation was well-above normal in the high elevations of the Rocky Mountains while temperatures were generally 3 to 4 ^{o}F below normal, and as a result mountain snowpack continued to rapidly increase through the end of the month. April 15 is the average date of historical peak snow accumulation. By April 15, mountain SWE had reached 126% of the normal peak accumulation in the reach above Fort Peck. In the Fort Peck to Garrison reach the SWE accumulation had reached 121% of the normal peak accumulation. After April 15, accumulations continued to climb through the rest of April.

f. May 2011

On May 2, 2011, the mountain SWE accumulation in both reaches peaked. As a percent of the normal accumulation on May 2, mountain SWE was 156% of normal above Fort Peck and 143% of normal in the Fort Peck to Garrison reach. The MRBWM office historically refers to peak percentage as it relates to the historic April 15 peak. For 2011, that would be 141% and 136% for the reach above Fort Peck and the Fort Peck to Garrison reach, respectively.

Continued colder-than-normal conditions combined with above-normal precipitation in the mountains were responsible for a late decline in the mountain snowpack. By June 1, 2011 mountain SWE was 104% of the normal peak accumulation (April 15) above Fort Peck and 127% of the normal peak accumulation (April 15) in the Fort Peck to Garrison reach.

g. June-July 2011

The mountain SWE melted gradually throughout the months of June and July. On June 15, mountain SWE was 70% of the normal peak accumulation (April 15) above Fort Peck and 78% of the normal peak accumulation (April 15) in the Fort Peck to Garrison reach. By July 1, mountain SWE was 26% of the normal peak accumulation (April 15) in both the Fort Peck and Garrison reaches. By July 25, all snow had melted from the SNOTEL stations used to determine the mountain SWE in the reach above Fort Peck. By August 1, all snow had melted from the SNOTEL stations used to determine mountain SWE in the Fort Peck to Garrison reach. It should be noted that some mountain snow did not melt, which is not uncommon.

h. Summary

Over the course of the winter season, the mountain snowpack began accumulating at a below-average rate until late November when snowfall accumulations increased as a result of increased precipitation. The snowpack remained slightly above the 30-year historic average (1971-2000) through much of the winter until April when accumulations increased rapidly in both the reach above Fort Peck and the Fort Peck to Garrison reach as a result of increased precipitation and much-cooler-than-normal temperatures. Snowpack continued to increase until it peaked on May 2 at 141% of the average April 15 historic peak accumulation above Fort Peck and 136% of the average April 15 historic peak accumulation in the Fort Peck to Garrison reach. The late mountain snowpack peak and cooler-than-normal temperatures in late spring and early summer delayed the end of the melt season until August 1, 2011. The 2010-2011 mountain snow accumulation and melt for the reaches above Fort Peck and Fort Peck to Garrison are illustrated in ***Figure 4***.

3. Weather Conditions

Wet and cool weather conditions were dominant factors influencing the upper Missouri River basin during the 2011 CY. These conditions were a continuation of the very wet and generally cooler-than-normal weather pattern that dominated the upper basin in 2010. During 2010 much of the upper basin received over 120% of normal precipitation, especially from northeast Montana through eastern South Dakota. Precipitation ranged from 130 to 175% of normal, and temperatures were generally several degrees below normal in the western Dakotas and in eastern and northern Montana. Furthermore, La Nina conditions developed in the equatorial Pacific during the June-July-August period of 2010, and then strengthened to a moderate La Nina by the fall of 2010. During La Nina episodes, the upper Missouri River basin can experience cooler-than-normal temperatures during the December through February period, accompanied by wetter-than-normal conditions in the northern Rocky Mountains. A negative Arctic Oscillation also influenced weather in early 2011 that allowed cold air from the Arctic to move farther southward than normal. The combination of these factors contributed to the unusually moist and cold conditions that dominated the 2011 CY weather.

Figure 5 depicts percent of normal precipitation for the 3-month periods of January-March, April-June, July-September, and October-December 2011 in the central U.S. The January-March precipitation was above normal in a large portion of the plains, while above-normal precipitation during the April-June period was highlighted by greater than 150% of normal precipitation over western North Dakota, most of Montana and northern Wyoming. Montana alone received 200-300% of normal precipitation over the 3-month period, a majority of which was due to unprecedented widespread rain in May. During the July-September period, Montana and Wyoming received below-normal precipitation accumulations ranging from 25-70% of normal, while the above-normal precipitation pattern continued in the most of the plains region, with the exception of the Gavins Point to Sioux City reach where precipitation was less than 75% of normal. During the October-December period, the wetter-than-normal pattern shifted westward into concentrated areas of Wyoming and Montana, while below-normal precipitation accumulations expanded throughout eastern Montana, the Dakotas and northwest Iowa.

Figure 6 reveals a temperature pattern throughout the upper Missouri River basin that began with colder-than-normal temperatures during the first half of the 2011 CY, but changed to warmer-than-normal temperatures during the second half of the CY. January-March temperatures ranged from 2 to 10 ^{o}F below normal across much of the upper basin, allowing for the formation of deep plains snowpack and development of thick ice cover on the Missouri River mainstem and tributaries. The coldest temperatures covered much the Dakotas and northern Montana with departures, ranging from 6 to 10 ^{o}F below normal. The colder-than-normal pattern continued into the April-June period with temperatures ranging from 2 to 5 ^{o}F below normal over most of the upper Missouri River basin. These colder temperatures prolonged the accumulation of mountain snowpack, with the peak accumulation occurring on May 2.

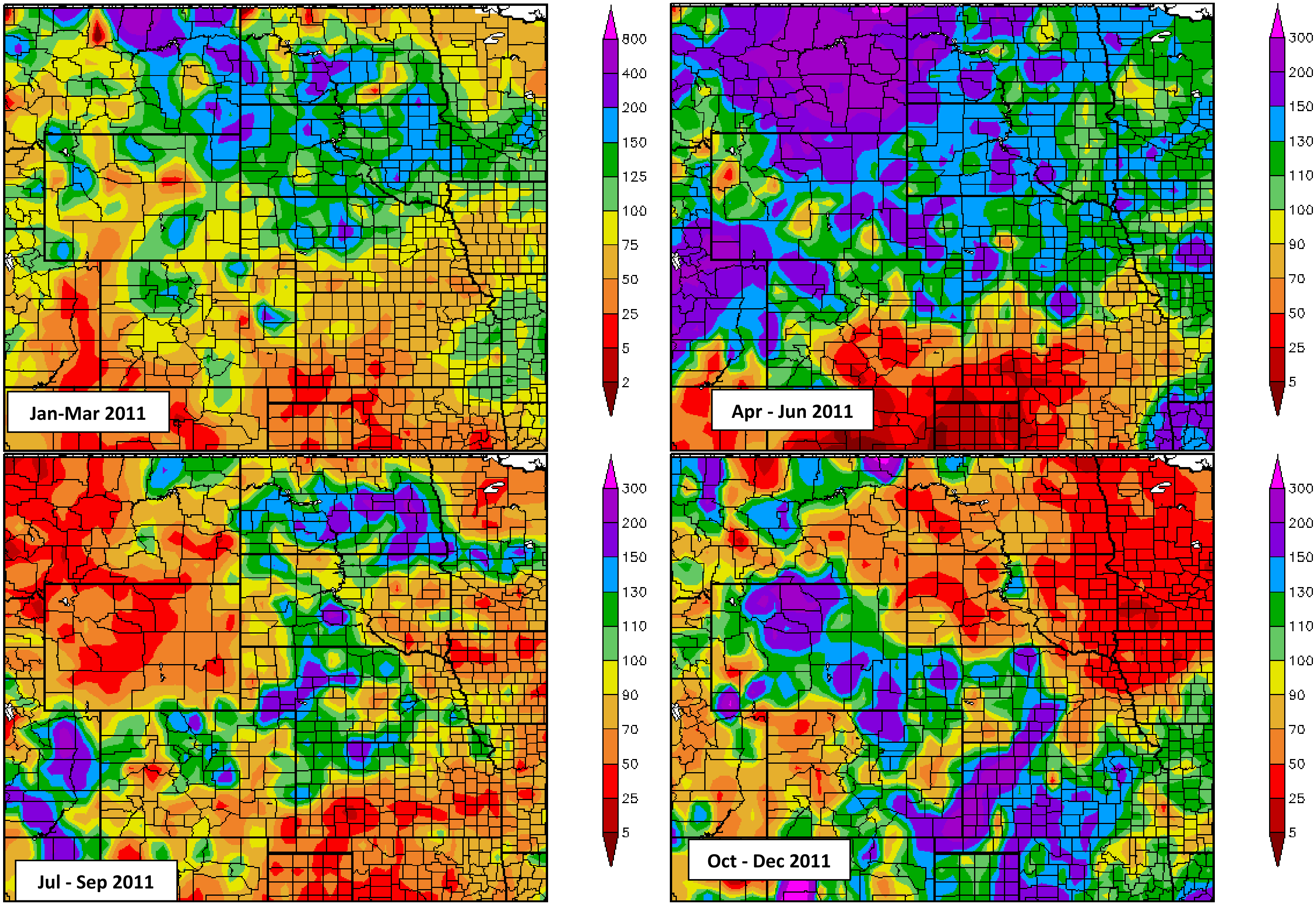


Figure 5. Percent of normal precipitation maps for the 2011 3-month periods: Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec. Reformatted from the High Plains Regional Climate Center Climate Summary Maps.

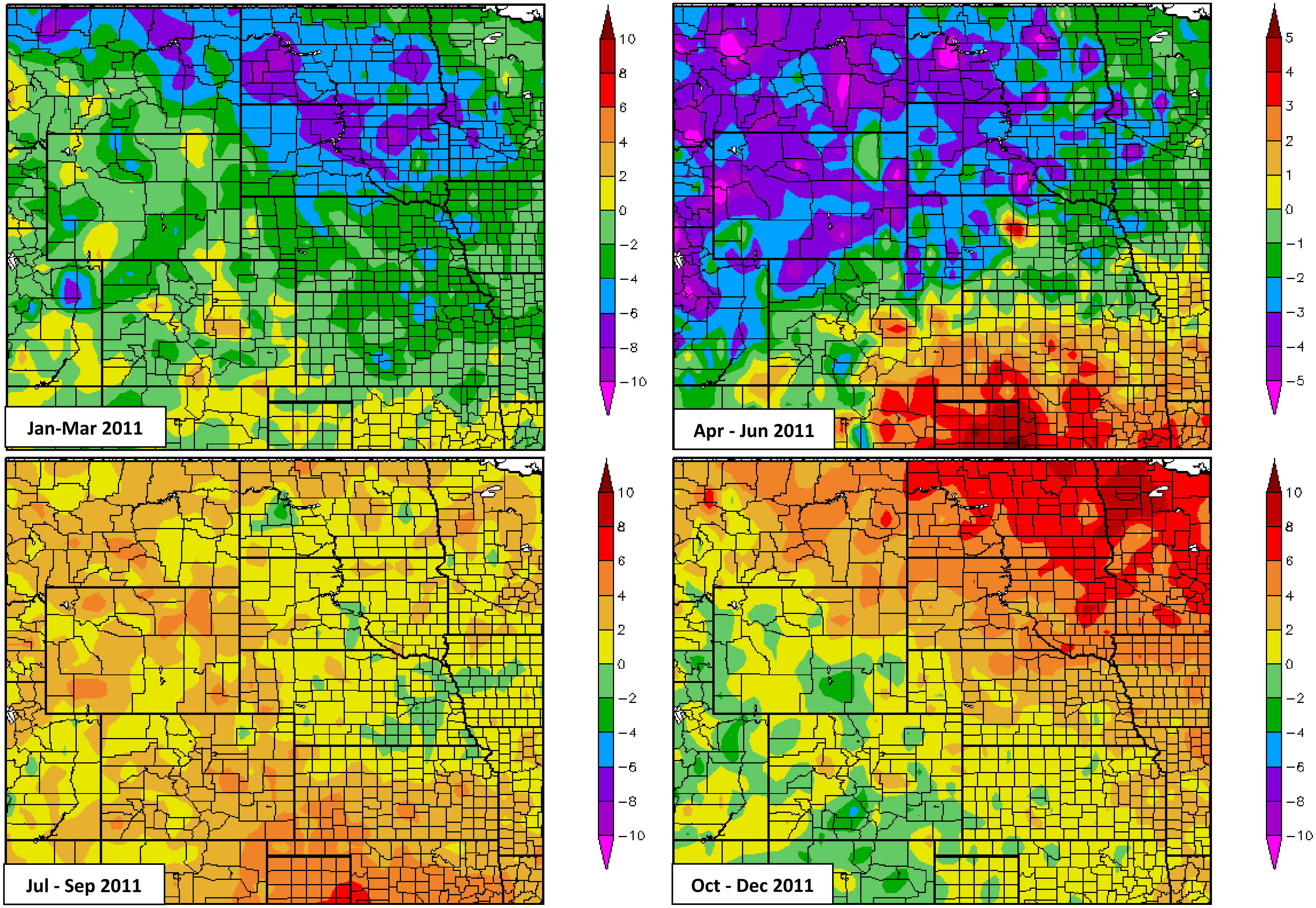


Figure 6. Departure from normal temperature (^{o}F) for the 2011 3-month periods: Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec. Reformatted from the High Plains Regional Climate Center Climate Summary Maps.

Figure 7 depicts drought magnitudes as defined by the National Drought Mitigation Center in January, April, July and October 2011. On both the January 4, 2011 and April 5, 2011 drought monitor maps, Abnormally Dry (D0) conditions were present in central Wyoming, while no drought conditions were present anywhere else in the upper Missouri River basin. Due to the abnormally wet and cool conditions that occurred throughout the winter and spring, all traces of drought were no longer present by July 5, 2011. During the summer and fall, areas of below-normal rainfall and unseasonably warm temperatures caused Abnormally Dry areas to form in western Montana, eastern South Dakota, northeast Nebraska and western Iowa. Areas of Moderate Drought (D1) also developed in eastern South Dakota and northwestern Iowa. More detailed precipitation and temperature conditions are described on a month-by-month basin in the following sections.

a. January

January precipitation in the Missouri River basin was above normal in the Gavins Point to Sioux City reach and large portions of the Garrison and Oahe reaches with departures ranging from 1-2 inches above normal (200-400% of normal). Heavy snow occurred throughout the upper basin highlighted by 41.6 inches of snowfall in Glasgow, MT. Temperatures were 2-4 ^{o}F warmer than normal in the Rocky Mountains; however temperatures in the plains were normal to below normal in eastern South Dakota, eastern Nebraska and western Iowa, and Missouri, where they were 2-6 ^{o}F below January normal temperatures.

b. February

February was another wet month in the Missouri River basin with precipitation departures ranging from 0.75-1.0 inch above normal (200-400% of normal) from western Montana through eastern South Dakota. In eastern Kansas and Missouri, departures ranged from 1.5 to 3.0 inches above normal (200-400% of normal). Snowfall was above normal throughout the plains and mountains as described previously in this report. Temperatures were 6-8 ^{o}F below normal over a very large portion of the upper basin, while in the lower basin temperatures ranged from 2 to 4 ^{o}F below normal.

c. March

March precipitation, which occurred mostly as snow in the upper basin, was 0.5-2 inches above normal (150-300% of normal) in portions of central North Dakota, Montana and Wyoming. In contrast the lower basin received precipitation that was 0.75-2.25 inches below normal (50% of normal). Temperatures in the Rocky Mountains were near average; however, departures in northern Montana, North Dakota, and much of South Dakota ranged from 6 to10 ^{o}F below normal, inhibiting the melting of plains snow and ice breakup on the rivers. Temperatures in the lower basin were normal.

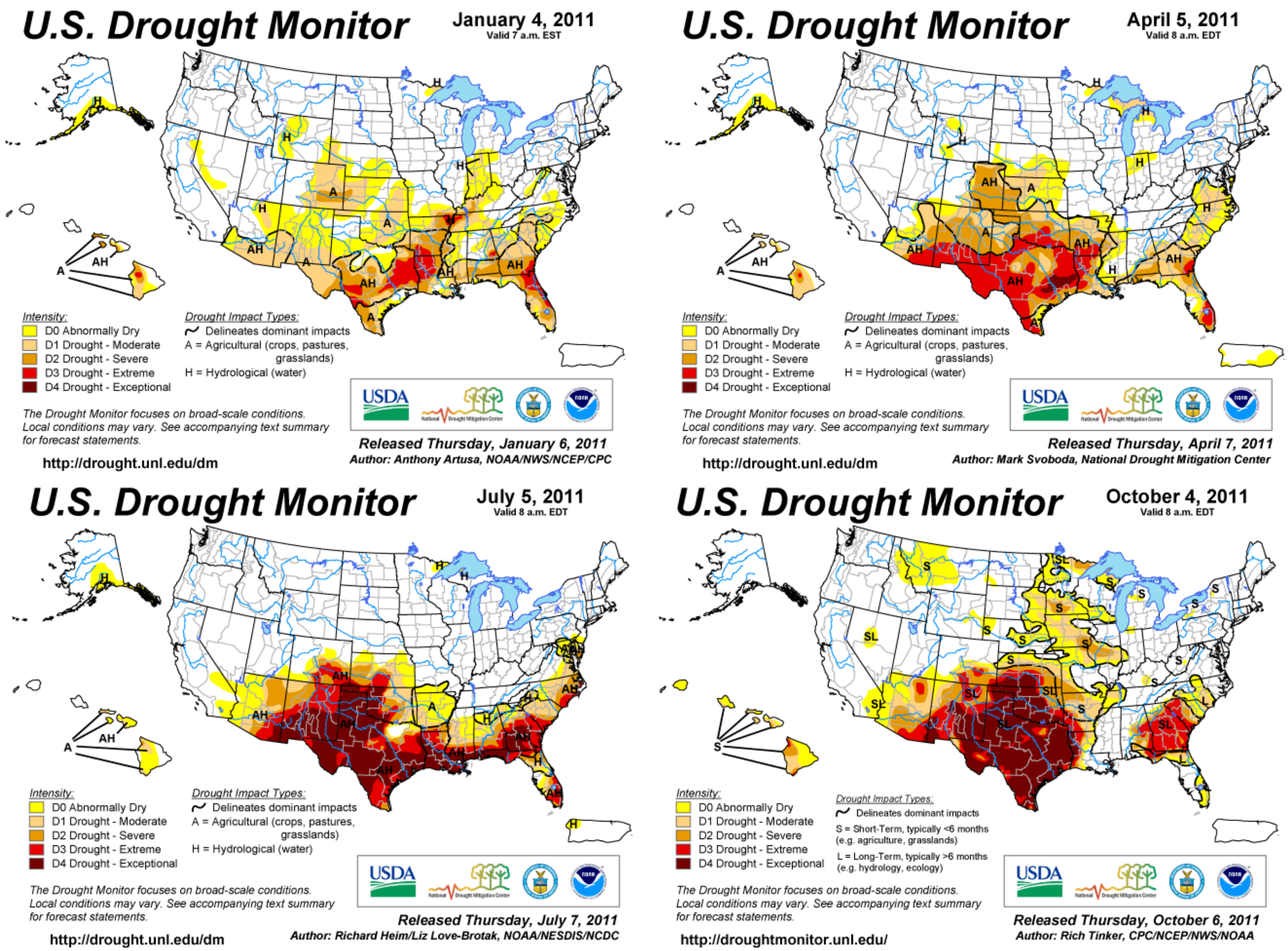


Figure 7. The National Drought Mitigation Center's drought maps for early January, April, July and October 2011.

d. April

Overall, April-May-June temperature and precipitation conditions were cooler than normal and much wetter than normal, thus contributing greatly to the flood conditions that developed during this time period. Beginning in April, the storm pattern continued to be very active across the upper basin and in the lower basin in Missouri, resulting in precipitation departures ranging from 1 to 3 inches above normal (150-400% of normal) in the plains of Montana and North Dakota and similar departures through the Rocky Mountains of the Missouri River basin. Each day during April greater than 0.5 inches of precipitation occurred somewhere in the basin. In April monthly temperature departures were 2-6 ^{o}F below normal across much of Montana and North Dakota. Combined with a very active storm pattern, these temperatures allowed significant amounts of snow to accumulate throughout the Rocky Mountains past the normal peak accumulation date of April 15. Two significant lower basin events included a large area of 1.5-2.5 inches of rainfall that covered Nebraska and Missouri on April 15-16, and repeated rounds of heavy rain totaling 5-12 inches in extreme southern portions of the lower basin in Missouri. This second event, which occurred during the last week of April, contributed to the severe spring flooding on the Mississippi River.

e. May

The wet weather pattern intensified following the first week of May, resulting in a series of four large, intense spring rain events that generated heavy rain over the entire Missouri River basin, with the heaviest amounts focused in Montana, Wyoming and the western Dakotas. These rainfall events were the driving force behind the record high runoff year for the System reservoirs and the highest runoff year of record.

Normal May rainfall in the upper basin can range from 2 to 4 inches in the plains and 3 to 6 inches in the mountains. In May 2011, rainfall totals varied across the upper basin, but plains regions received 3-10 inches, while accumulations in the mountains ranged from 5 to 15 inches. Compared to past May precipitation, Montana and Wyoming both received the third highest May precipitation amounts in 117 years of record. Expressed as departures from normal, large areas in Montana, northern Wyoming and North Dakota received greater than 4.5 inches of precipitation above normal May amounts. Within Montana in the Bighorn and lower Yellowstone basins, areas received greater than 7.5 inches of precipitation above normal May amounts. Several notable rainfall amounts that occurred in May include 9.5 inches at Billings, MT (7.1 inches above normal), 9.4 inches at Miles City, MT (7.2 inches above normal) and 11.0 inches at Yellowtail Dam. As a percent of normal, May rainfall in the aforementioned areas of Montana, Wyoming and the Dakotas was 150 to 300% of normal, while nearly the entire eastern half of Montana, a portion of northern Wyoming and areas in northwest North Dakota received greater than 300% of normal May precipitation. Temperatures were much cooler than normal throughout the upper basin, ranging from 4 to 8 ^{o}F below normal in the aforementioned areas, resulting in some continued accumulation of mountain snow, a peak accumulation delayed until May 2 and delayed mountain snowmelt. Although El Nino Southern Oscillation (ENSO) conditions went from a weak La Nina to ENSO-neutral conditions during the March-April-May 3-month period according to the NOAA Climate Prediction Center (CPC), La Nina weather conditions (cooler and wetter than normal) continued through May into June.

Refer to the ***Summary Report on Regulation – 2011 Flood*** report for detailed descriptions of the four major rainfall events that occurred in the upper basin during May.

f. June

The June storm pattern across the Missouri River basin continued to be very active, especially in Montana, North Dakota, South Dakota and north central Nebraska. Precipitation anomalies ranged from 1.5 to 3 inches above normal (150-300% of normal) in these locations, while northeast Montana and central/southern South Dakota received 3-6 inches in excess of normal June precipitation (300-400% of normal). Two notable precipitation totals in June included 8.3 inches at Pierre, SD (4.8 inches above normal) and 5.2 inches at Glasgow, MT (3.0 inches above normal). During June monthly temperature departures of 2-4 ^{o}F below normal occurred throughout most of the upper basin, while some deviations of 4-6 ^{o}F below normal occurred in several regions in Montana.

g. July

July precipitation in the Rocky Mountains was below normal in Montana and Wyoming, with many locations receiving less than 75% of normal precipitation. In the plains of Montana, North Dakota, South Dakota and Nebraska, precipitation accumulations continued at above-normal rates. An area of 150-200% of normal rainfall (1-4 inches above normal) extended from northeast Montana through southeast North Dakota, with similar amounts in central South Dakota and western Nebraska. In the lower basin, precipitation was less than 75% of normal, especially in Iowa and Missouri, where it was less than 50% of normal precipitation. Temperatures were 0-4 ^{o}F warmer than normal in Montana and Wyoming, while in the Dakotas and Nebraska temperatures were 2-6 ^{o}F above normal. In Kansas and Missouri, monthly temperatures were 4-8 ^{o}F above normal.

h. August

August precipitation accumulations followed a pattern similar to July precipitation. Precipitation in the mountains of Montana and Wyoming was less than 50% of normal, while precipitation was 150-300% of normal throughout much of the plains in the upper and lower basins. The exception was less than 50% of normal precipitation in northeast and eastern South Dakota. Temperatures were normal in the plains, while in mountainous regions temperatures were 2-6 ^{o}F above normal. Also beginning in August, weak La Nina conditions had developed according to the NOAA CPC.

i. September

September was a very dry month throughout the entire basin. Much of Montana and Wyoming received less than 50% of normal precipitation. A second large region of less than 50% of normal precipitation occurred in the eastern Dakotas and most of the lower Missouri River basin. Precipitation departures ranged from 1 to 3 inches below normal with the greatest departures (3-4 inches below normal) occurring in northern Missouri. Temperature departures were similar to August in the upper basin, with the greatest departures ranging from 4 to 6 ^{o}F above normal. Departures in the lower basin were opposite, ranging from 2 to 5 ^{o}F below normal in eastern Nebraska, Iowa and Missouri.

j. October

October precipitation was greater than 200% of normal in portions of the Rocky Mountains and in Montana and Wyoming, although precipitation was generally less than 75% of normal in most other locations of the basin. The driest areas were in the eastern Dakotas, which received less than 75% of normal precipitation, and in eastern Nebraska and Kansas, Iowa and Missouri, where less than 25% of normal precipitation occurred. Temperatures in the upper basin were 2-4 ^{o}F above normal, while in the lower basin temperatures were 0-2 ^{o}F above normal.

j. November

November was highlighted by very dry conditions in the Dakotas and Nebraska, while several areas in the upper and lower basin were wet. Precipitation in much of North Dakota, eastern South Dakota and northeast Nebraska was less than 25% of normal. In contrast, northeast Montana and central Wyoming, including the Bighorn Mountain range, received 150-300% of normal precipitation with departures of 0.5-2 inches above normal. Temperatures in these regions were 1-2 ^{o}F above normal. A third wet area occurred in the lower basin in tributary areas downstream of Nebraska City, NE, where 150-300% of normal precipitation occurred with departures of 1-4 inches. Temperature departures were 1-2 ^{o}F below normal in the upper Yellowstone River and adjacent basins. Temperatures were generally 2-6 ^{o}F above normal in all other areas.

k. December

December precipitation was as low as 1.5 inches below normal (50% of normal) in the upper basin. In southeast Nebraska, Iowa, Kansas and western Missouri several winter storms occurring December 2-3, 13-14 and 19-20, producing 2-4 inches of total precipitation and resulting in monthly departures of 1-3 inches (150-300% of normal). Temperatures continued to be 4-10 ^{o}F above normal in the northern plains, particularly in Montana and North Dakota, while lower basin temperatures were 2-6 ^{o}F above normal.

4. 2011 Calendar Year Runoff

This report includes a brief summary of runoff into the System during the 2011 flood of record. For more details regarding the record runoff into the System during 2011, refer to the ***Summary Report on Regulation – 2011 Flood*** report.

The final unregulated runoff volume for the period January through December 2011 for the basin above Sioux City, IA totaled 61.0 MAF, 246% of normal runoff, based on the historical period of 1898-2009, as shown in ***Table 2***, which also breaks down this runoff volume by reach. The 61.0 MAF in 2011 represents the highest runoff in 114 years of record (1898-2011), as shown on ***Figure 8***. Monthly runoff during 2011 above Sioux City, IA varied from a low of

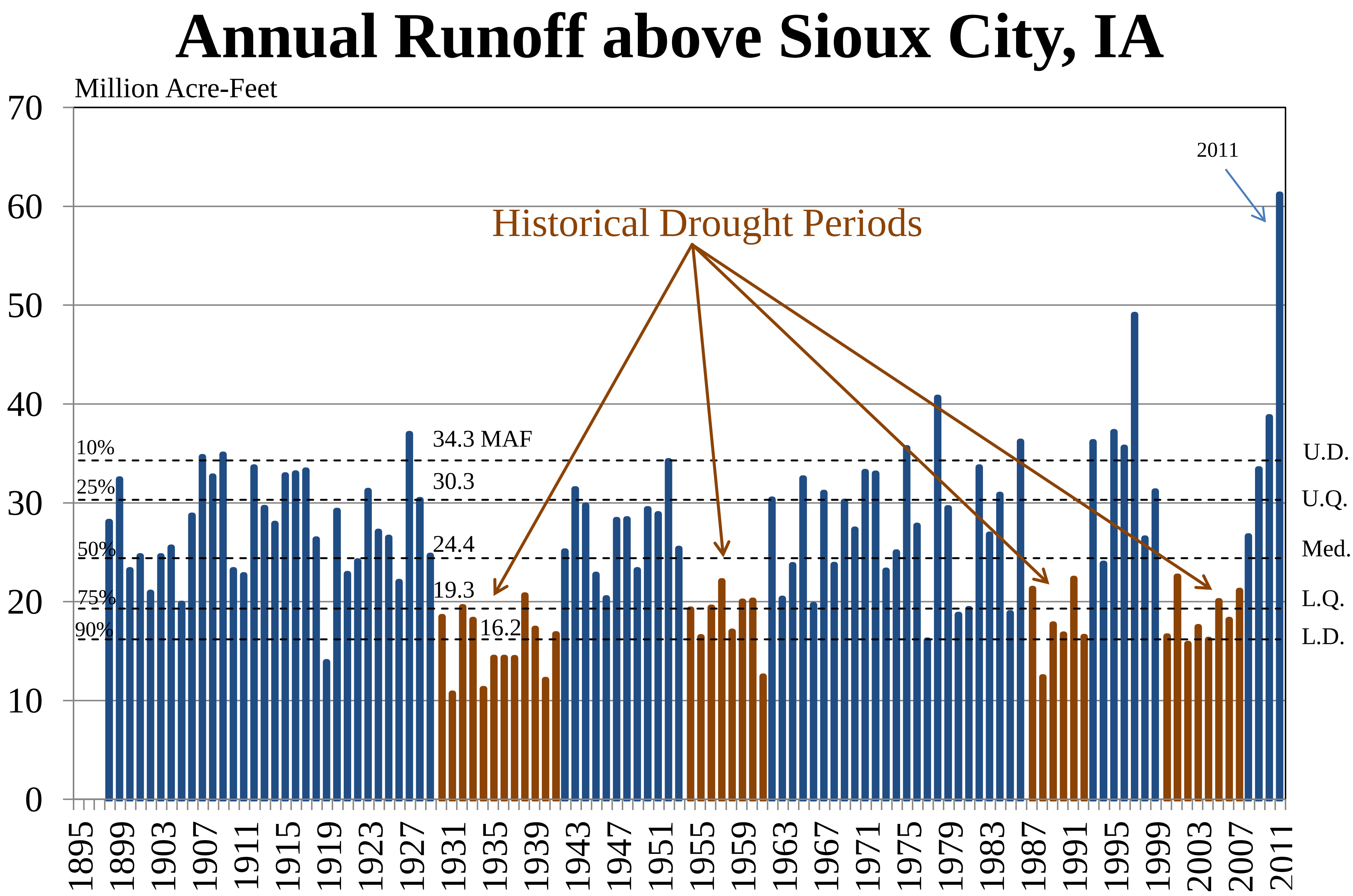


Figure 8. Missouri River annual runoff above Sioux City, IA

Table 2
2011 CY Runoff for Selected Reaches (1000 acre-feet)

Reach	1898-2009 Average Runoff Volume*	2011 CY Runoff Volume	% of Annual Runoff
Above Fort Peck	7,213	14,477	201
Fort Peck to Garrison	10,612	24,512	231
Garrison to Oahe	2,373	6,574	277
Oahe to Fort Randall	883	3,161	358
Fort Randall to Gavins Point	1,681	2,030	121
Gavins Point to Sioux City	2,023	10,250	507
TOTAL ABOVE SIOUX CITY	**24,785**	**61,004**	**246**
	1967-2011 Average Runoff	**2011 CY Runoff Volume**	**% of Annual Runoff**
Sioux City, IA to Nebraska City, NE**	7,700	12,370	161
Nebraska City, NE to Kansas City, MO**	11,900	8,730	73
Kansas City, MO to Hermann, MO**	24,200	22,070	91
TOTAL BELOW SIOUX CITY**	**43,800**	**43,170**	**99**

** These averages will be updated to 2011 as part of the update to the RCC Technical Report – Runoff Volumes for Annual Operating Studies.*
*** 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 1967-2011.*

118% in November to a record high of 320% in July. ***Figure 9*** indicates the monthly variation of runoff for CY 2011.

The runoff in the reach above Fort Peck was 14.5 MAF, more than 2 times normal. This was a record runoff, exceeding the previous record of 13.8 MAF set in 1975.

The runoff in the reach between Fort Peck and Garrison was 24.5 MAF, nearly matching the average annual runoff above Sioux City of 24.8 MAF. This amount of runoff, more than 2.3 times normal, was also a record, easily eclipsing the previous record of 17.4 MAF, set in 1997.

The runoff in the reach between Garrison and Oahe was 6.6 MAF, almost 2.8 times normal. This amount of runoff was third highest in 114 years of record, just behind the 7.7 MAF and 7.4 MAF received in 2009 and 1997, respectively.

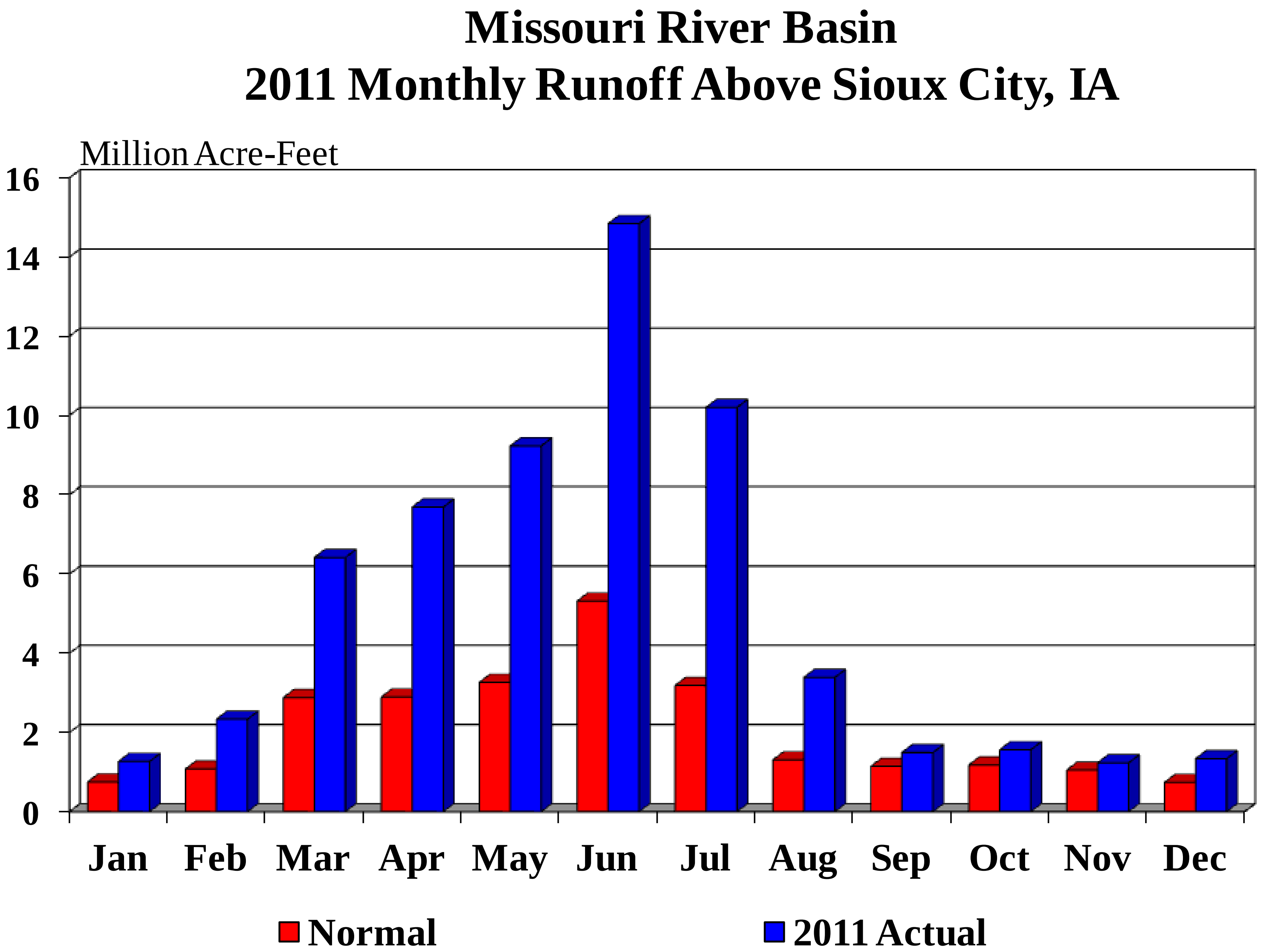


Figure 9. Missouri River Basin 2011 monthly runoff above Sioux City, IA.

The runoff in the reach between Oahe and Fort Randall was 3.2 MAF, 3.6 times normal. This amount of runoff was second highest in 114 years of record, with the highest being 3.4 MAF in 1997.

The runoff in the reach between Fort Randall and Gavins Point was 2.0 MAF, 1.2 times normal.

The runoff in the reach between Gavins Point and Sioux City, IA was 10.3 MAF, 5 times normal. This was the highest runoff for this reach in 114 years of record.

Total runoff below Sioux City, IA was 108% of normal and ranged from a high of 161 % of normal from Sioux City, IA to Nebraska City, NE to a low of 79% of normal in the Nebraska City, NE to Kansas City, MO reach. Total inflow from Kansas City, MO to Hermann, MO was 104% of normal. These near-normal runoffs downstream from Nebraska City, NE were fortunate given the very high System releases and prevented even greater damages on the lower reaches of the Missouri River.

The adjusted final monthly runoffs for 2011 from Fort Peck downstream to Sioux City, IA by major river reach are presented in ***Table 3***. The table lists the runoff 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 data for those months that have passed and with estimated forecasted data for the remaining months in the year. This forecast forms a basis for intrasystem 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 forecast 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. The figures that are accumulated each month are adjusted at the end of the CY such that the numbers shown in ***Table 3*** are somewhat different than those used each month during 2011 for the monthly System regulation studies.

C. System Regulation – January to December 2011

1. System Regulation January to December 2011

This report includes a brief summary of regulation of the System during the 2011 flood of record. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report.

System runoff in 2011 was 61.0 MAF, the highest on record and nearly 2.5 times normal. May (9.2 MAF), June (14.8 MAF) and July (10.2 MAF) had the highest inflows for their respective months in the 114-year period of record. The 34.3 MAF of runoff received during that 3-month period exceeded the total annual runoff in 102 of the previous 113 years.

Table 3
Missouri River Basin
CY 2011 Runoff above Sioux City, Iowa

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
				Values in 1000 Acre Feet					
	(Actual)								
JAN 2011	398	331	90	78	61	310	958	1,268	1,268
NORMAL	312	261	12	25	100	40	710	750	750
DEPARTURE	86	70	78	53	-39	270	248	518	518
% OF NORM	128%	127%	750%	312%	61%	775%	135%	169%	169%
FEB 2011	577	460	282	213	232	571	1,764	2,335	3,603
NORMAL	360	356	90	49	130	92	985	1,077	1,827
DEPARTURE	217	104	192	164	102	479	779	1,258	1,776
% OF NORM	160%	129%	313%	435%	178%	621%	179%	217%	197%
MAR 2011	1,010	1,436	1,727	647	375	1,224	5,195	6,419	10,022
NORMAL	596	1,003	567	209	206	299	2,581	2,880	4,707
DEPARTURE	414	433	1,160	438	169	925	2,614	3,539	5,315
% OF NORM	169%	143%	305%	310%	182%	409%	201%	223%	213%
APR 2011	891	2,666	1,600	248	184	2,104	5,589	7,693	17,715
NORMAL	649	1,080	481	144	180	360	2,534	2,894	7,601
DEPARTURE	242	1,586	1,119	104	4	1,744	3,055	4,799	10,114
% OF NORM	137%	247%	333%	172%	102%	584%	221%	266%	233%
MAY 2011	2,408	3,887	912	303	76	1,642	7,586	9,228	26,943
NORMAL	1,081	1,245	312	147	186	292	2,971	3,263	10,864
DEPARTURE	1,327	2,642	600	156	-110	1,350	4,615	5,965	16,079
% OF NORM	223%	312%	292%	206%	41%	562%	255%	283%	248%
JUN 2011	4,825	6,485	1,080	855	436	1,159	13,681	14,840	41,783
NORMAL	1,612	2,667	423	152	178	286	5,032	5,318	16,182
DEPARTURE	3,213	3,818	657	703	258	873	8,649	9,522	25,601
% OF NORM	299%	243%	255%	563%	245%	405%	272%	279%	258%
JUL 2011	2,228	5,566	399	355	263	1,389	8,811	10,200	51,983
NORMAL	819	1,776	179	57	137	218	2,968	3,186	19,368
DEPARTURE	1,409	3,790	220	298	126	1,171	5,843	7,014	32,615
% OF NORM	272%	313%	223%	623%	192%	637%	297%	320%	268%
AUG 2011	635	1,542	206	243	135	631	2,761	3,392	55,375
NORMAL	353	604	65	39	115	131	1,176	1,307	20,675
DEPARTURE	282	938	141	204	20	500	1,585	2,085	34,700
% OF NORM	180%	255%	317%	623%	117%	482%	235%	260%	268%
SEP 2011	279	666	55	123	72	297	1,195	1,492	56,867
NORMAL	333	452	111	38	111	99	1,045	1,144	21,819
DEPARTURE	-54	214	-56	85	-39	198	150	348	35,048
% OF NORM	84%	147%	50%	324%	65%	300%	114%	130%	261%
OCT 2011	380	721	79	0	66	318	1,246	1,564	58,431
NORMAL	385	523	66	5	120	78	1,099	1,177	22,996
DEPARTURE	-5	198	13	-5	-54	240	147	387	35,435
% OF NORM	99%	138%	120%	--	55%	408%	113%	133%	254%
NOV 2011	416	368	38	12	78	323	912	1,235	59,666
NORMAL	384	398	67	6	118	76	973	1,049	24,045
DEPARTURE	32	-30	-29	6	-40	247	-61	186	35,621
% OF NORM	108%	92%	57%	200%	66%	425%	94%	118%	248%
DEC 2011	430	384	106	84	52	282	1,056	1,338	61,004
NORMAL	329	247	0	12	100	52	688	740	24,785
DEPARTURE	101	137	106	72	-48	230	368	598	36,218
% OF NORM	131%	155%	--	700%	52%	542%	153%	181%	246%
				Calendar Year Totals					
	14,477	24,512	6,574	3,161	2,030	10,250	50,754	61,004	
NORMAL	7,213	10,612	2,373	883	1,681	2,023	22,762	24,785	
DEPARTURE	7,264	13,900	4,201	2,278	349	8,227	27,991	36,218	
% OF NORM	201%	231%	277%	358%	121%	507%	223%	246%	

a. Conditions on March 1

The winter of 2011 marked the third consecutive year of significant plains snowpack. The mountain SWE in the reach above Fort Peck and the Fort Peck to Garrison reach were slightly above normal (112% and 111%, respectively). The March 1 annual inflow forecast was 29.8 MAF (120% of normal). All of the stored floodwaters from 2010 had been evacuated from the System by January 28 when System storage reached 56.8 MAF, the base of the annual flood control and multiple use zone. Some subsequent plains snowmelt resulted in some early System inflows, resulting in System storage on March 1 of 57.6 MAF, which occupied 0.8 MAF of the 16.3-MAF flood control storage space.

b. Conditions on April 1

The plains snowpack peaked about February 25, 2011. The plains snowpack was generally classified as “heavy”, which was very similar to 2010 with SWE amounts being varying between 4-6 inches. In some areas of the basin, particularly in the Milk River basin and upper James and Big Sioux River basins, the plains snowpack was classified as “very heavy” with SWE amounts exceeding 6 inches. The mountain SWE continued to be slightly above normal. The April 1 annual inflow forecast was 33.8 MAF (136% of normal). Per the Master Manual and based on the April 1 System storage, available storage in the upstream Section 7 U.S. Bureau of Reclamation (USBR) projects and the forecasted runoff into the System, the service level was increased by 10,000 cubic feet per second (cfs) from 35,000 cfs to 45,000 cfs. During April the mountain snowpack continued to climb. At mid-month, another storage and runoff forecast check resulted in the increase of the service level by an additional 5,000 cfs to 50,000 cfs. System storage on April 1 was 61.7 MAF, and 4.9 MAF of the 16.3-MAF flood control storage space was occupied.

c. Conditions on May 1

The NOAA CPC 1-month climate outlook indicated an increased probability of above-normal precipitation in the Northern Plains and Rockies, equal chances of above-normal and below-normal precipitation in the middle of the basin and an increased probability of below-normal precipitation in the lower basin. The mountain SWE accumulation was continued to increase in both reaches. Mountain snowpack normally peaks on or about April 15. On May 1, the mountain SWE was 141% of the normal April 15 peak above Fort Peck and 136% of the normal April 15 peak in the Fort Peck to Garrison reach. The May 1 annual inflow forecast was 44.0 MAF (178% of normal). This would have been the second highest runoff in the last 114 years, exceeded only in 1997 (49.0 MAF). On May 1 System storage was 65.5 MAF, occupying 8.7 MAF of the 16.3-MAF flood control storage space. While the mountain snowpack was very substantial, runoff from mountain snowpack normally extends over a 3-month period (May-July). System regulation studies indicated an average May System release of 57,500 cfs would be needed.

d. Conditions in mid- and late May

From May 20 to 22, generally between 5 and 8 inches of rain fell across the regions of eastern Montana, western South Dakota and northern Wyoming, covering an area of 50 million acres, which is the approximate size of the State of Iowa. In some isolated areas, 10-15 inches of rain fell over the 3-day period. Because this runoff came in the form of rainfall runoff rather than snowmelt runoff, the volume of runoff over this very large area quickly made its way to the Fort Peck and Garrison reservoirs and dictated a need to increase releases from all six reservoirs. Initial analyses called for releases from the lower five System projects to be increased to 85,000 cfs. On May 25 an additional 1.5 to 2 inches of rain fell in eastern Montana further exacerbating the flooding situation. On May 26, releases for the lower five System dams were forecast to be increased to range from 110,000 cfs to 120,000 cfs, with Fort Peck Dam releases increasing to 50,000 cfs. On May 27, the NWS precipitation forecasts indicated that an additional 2 to 3 inches over the eastern half of Montana would fall May 30-31. The decision was then made to increase releases on the lower five System projects to 150,000 cfs.

e. Conditions in June and July

In response to the historic rainfall and runoff in the upper basin, System releases were scaled up from 80,000 cfs on the beginning of June to 150,000 cfs by June 15. This release rate was held until June 21 after which they were increased to 160,000 cfs over the next 2 days. System releases were maintained at 160,000 cfs until the end of July. System storage peaked at 72.8 MAF on July 1, occupying 98% of the allocated flood control storage space (16.0 MAF of 16.3 MAF).

f. Conditions in August through December

Long-term precipitation and temperature outlooks indicated that the fall and winter of 2011 would be wetter than normal. Careful consideration was given to the idea of evacuating additional storage beyond the authorized 16.3 MAF of flood control storage. After ascertaining the immediate need of making necessary dam and levee repairs during the fall to prepare for the 2012 runoff season and the need for basin stakeholders to return to their homes and businesses before the winter, the Corps' Northwestern Division (NWD) leadership decided not to evacuate storage beyond the 16.3 MAF of flood control storage space. However, if fall and winter conditions allowed, the MRBWM office would evacuate additional storage and also be more aggressive with early season releases if 2012 runoff conditions were similar to the 2011 conditions. The System releases were stepped down from 160,000 cfs to 150,000 cfs over a 4-day period starting on July 30 and then gradually reduced to 90,000 cfs from August 19 to 31. From September 18 to October 3, the releases were again gradually reduced to 40,000 cfs. From December 7 to 15 the releases were reduced from 40,000 cfs to 22,000 cfs and held at that rate for the remainder of the CY.

The Fort Peck Reservoir was in or above the exclusive flood control zone for 71 days, from May 26 through August 4, and was in "surcharge" for 35 days, from June 3 through July 7. Garrison Reservoir was in or above the exclusive flood control zone for 79 days, from May 22 through August 8, and was in "surcharge" for 23 days, from June 20 through July 12. Oahe

Reservoir was in exclusive flood control zone for 78 days, from May 21 through August 6. Fort Randall Reservoir was in the exclusive flood control zone for 60 days, from June 19 through August 17.

2. Fort Peck Regulation – January to December 2011

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 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 4 lists the average monthly inflows and releases and the end-of-month (EOM) pool elevation for Fort Peck for 2010 and 2011 as well as the averages since the System first filled in 1967.

Table 4
Fort Peck – Inflows, Releases and Elevations

Month	Ave Monthly Inflow (cfs)			Ave Monthly Release (cfs)			EOM Elevation (ft msl)		
	2011	2010	1967-2011	2011	2010	1967-2011	2011	2010	1967-2011
January	9,100	7,000	7,200	8,900	4,700*	10,600	2235.3	2221.8	2227.3
February	12,000	6,600	8,700	9,800	4,300*	10,900	2235.8	2222.4	2226.6
March	17,900	9,900	11,900	7,400	4,400	7,900	2238.7	2224.2	2227.7
April	15,400	7,100	10,300	7,100	4,700	7,300	2240.9	2224.9	2228.5
May	46,100**	14,200	15,800	14,700	6,000	9,100	2248.9**	2227.4	2230.3
June	61,200**	25,600	19,800	52,600**	4,900*	10,600	2250.7**	2233.3	2232.7
July	26,700	15,200	12,500	41,500**	5,700	10,600	2246.6	2235.8	2232.9
August	10,800	7,600	7,900	26,600**	6,400	10,200	2241.9	2235.7	2231.7
September	10,100	8,500	7,800	23,000**	6,100	9,100	2237.9	2235.9	2230.9
October	10,200	7,800	7,400	9,200	6,100	8,000	2237.7	2235.8	2230.3
November	9,400	6,900	7,200	10,100	6,200	8,300	2237.2	2235.5	2229.7
December	8,800	8,200	6,600	11,100	7,800	9,500	2236.2	2235.4	2228.5

* monthly minimum of record ** monthly maximum of record

b. Winter Season 2011

The Fort Peck Reservoir level began 2011 at elevation 2235.4 feet mean sea level (ft msl), 1.4 feet above the base of annual flood control zone and 14.3 feet higher than the previous year having refilled following the 2000-2007 drought. The annual minimum reservoir level occurred on February 12 at 2235.2 ft msl, 14.1 feet higher than the 2010 annual minimum, which was 2221.1 ft msl on January 1, 2010.

c. Winter River and Ice Conditions Below Fort Peck

No special release reductions were required to prevent ice-jam flooding downstream of Fort Peck Dam. The average monthly discharge for December 2010 was below normal at 7,800 cfs, and January and February releases were above the normal monthly averages, with 8,900 cfs and 9,800 cfs, respectively. Ice-cover formation on the Missouri River began on December 11-12, 2010, when the Missouri River stage rose over 4.0 feet in the Wolf Point, MT area. The stage at Wolf Point peaked near 8.5 feet on December 16, 2010, which is well below the flood stage of 13.0 feet. The Missouri River at Culbertson, MT peaked on February 14 at a stage of 9.7 feet, which is also well below the flood stage of 19.0 feet. No reports of ice-affected flooding on the Missouri River below Fort Peck Dam were recorded during the 2011 winter season. The Fort Peck Reservoir (Fort Peck Lake) froze over on January 1, 2011 and was free of ice on April 27.

d. Spring Open Water Season 2011

This report includes a brief summary of operations for Fort Peck during the 2011 flood of record. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report. Inflows into Fort Peck started the year above average and continued through April before dramatically increasing in May to record levels. Fort Peck inflows for February, March and April were approximately 1.5 times their historic monthly average while releases from Fort Peck were just under their historic monthly average for that same period. Starting in May, average monthly inflows to the reservoir hit a record-setting 46,100 cfs in May and 61,200 cfs in June. Both of these average monthly inflows were about 3 times more than normal and shattered the previous average monthly record inflows of 36,800 cfs and 43,600 cfs, which were set in May and June 1975, respectively. In addition, the June inflow was the highest average monthly inflow since the System was fully functional (1967-2011). Fort Peck releases averaged 14,700 cfs in May and 52,600 cfs in June. The June release was more than double the previous record release of 26,200 cfs set in 1975. With the high inflows to Fort Peck, the reservoir rose nearly 17 feet from its January 1 elevation of 2235.4 ft msl to its peak elevation of 2252.3 ft msl on June 15, before ending the month at 2250.7 ft msl. The peak pool on June 15 was 0.7 feet higher than the previous peak pool of 2251.6 ft msl, which was set in July 1975.

e. Summer Open Water Season 2011

Peak daily flows into Fort Peck set records in June 2011. The peak daily inflow of 101,000 cfs occurred on June 6. This inflow exceeded the previous June maximum daily inflow into Fort Peck from the upstream mainstem and tributaries of 80,000 cfs for a total of 10 days.

The new record maximum daily release from Fort Peck was established on June 15, 2011 at 65,900 cfs. The previous record maximum was 35,400 cfs (July 1975), which was exceeded for 46 days in 2011.

As part of the continued evacuation of record runoff into the System in 2011, average monthly releases rates from Fort Peck were much above normal during the summer with 41,500, 26,600 and 23,000 cfs in July, August and September, respectively. Records for average monthly releases were set for all 3 months. Inflows during that same 3-month period of 26,700, 10,800 and 10,100 cfs, respectively, were almost twice normal for July and about 1.3 times normal for August and September. The reservoir level continued to steadily drop from 2250.7 ft msl at the beginning of July to 2237.9 ft msl at the end of September.

f. Fall Open Water Season 2011

Releases were held at 25,000 cfs through late September and were then reduced to 20,000 cfs. Fort Peck releases were eventually reduced to 9,000 cfs at the beginning of October. Releases were maintained near this level through early November, at which time they were increased to 11,000 cfs in early December to continue evacuation of the remaining water in the annual flood control and multiple use zone. The average release for December was 11,100 cfs. Inflows for October, November and December were about 1.3 times normal. The pool elevation declined 1.7 feet during these 3 months from 2237.9 ft msl at the beginning of October to 2236.2 ft msl by the end of December.

g. Summary

The highest record Fort Peck Reservoir level of 2252.3 ft msl occurred on June 15, 2011, eclipsing the previous reservoir level of 2251.6 ft msl set in July 1975. The lowest reservoir level during 2011 occurred on January 21 at 2235.2 ft msl. The average daily inflow of 19,800 cfs during 2011 was 194% of average (1967-2011) and was the highest average annual inflow since the System first filled in 1967. The average daily release of 18,500 cfs during 2011 was 199% of average (1967-2011) and was the highest average annual release since the System first filled in 1967. In 2011, Fort Peck rose 2.3 feet into the surcharge zone, which is above the top of the exclusive flood control zone, elevation of 2250.0 ft msl. This was the first time since 1975 that the Fort Peck pool had been in the surcharge zone.

3. Garrison Regulation – January to December 2011

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 5 lists the average monthly inflows and releases in cfs and the EOM pool elevation in ft msl for Garrison for 2010 and 2011 as well as the averages for these hydrologic factors since the System first filled in 1967.

Table 5
Garrison – Inflows, Releases and Elevations

Month	Ave Monthly Inflow (cfs)			Ave Monthly Release (cfs)			EOM Elevation(ft msl)		
	2011	2010	1967-2011	2011	2010	1967-2011	2011	2010	1967-2011
January	14,800	11,000	15,200	23,600	17,700	22,600	1840.0	1838.6	1831.8
February	18,000	10,600	18,400	25,800	16,400	23,700	1838.5	1837.5	1830.8
March	32,500	17,400	26,800	21,800	12,600	19,100	1840.5	1838.3	1832.2
April	53,700	14,000	23,000	14,900	10,100	18,500	1847.6**	1839.1	1833.0
May	88,200**	25,800	29,600	50,700**	14,500	21,400	1853.3**	1841.0	1834.5
June	144,600**	54,000	47,900	136,600**	14,800	25,100	1854.5**	1847.7	1838.7
July	111,700**	34,100	34,000	127,700**	14,600	26,200	1851.6	1850.8	1839.8
August	51,900**	15,500	18,700	91,100**	16,300	25,200	1844.5	1850.2	1838.1
September	37,300**	17,800	17,000	43,400	26,900	21,000	1842.8	1848.2**	1836.9
October	22,700	16,100	17,300	25,800	29,500	19,100	1841.9	1845.4	1836.2
November	20,300	12,900	16,000	28,400	27,400	19,900	1840.0	1842.4	1835.0
December	18,800	15,100	13,800	20,400	17,800	20,100	1839.5	1841.7	1833.5

* monthly minimum of record ** monthly maximum of record

b. Winter Season 2011

Releases from Garrison Reservoir were below normal for December; however, January and February releases were above their normal values. Garrison began December 2010 at 1842.3 ft msl, 0.9 feet higher than the previous year's elevation of 1841.4 ft msl. The 1842.3 ft msl elevation was 4.8 feet above the base of the annual flood control and multiple use zone. The reservoir level declined throughout the winter season and ended February at 1838.5 ft msl, 1.0 foot above the base of the annual flood control and multiple use zone, before dropping to its annual minimum elevation of 1837.7 ft msl on March 15. The Garrison Reservoir (Lake Sakakawea) froze over on January 3 and was free of ice on May 9.

c. Winter River and Ice Conditions Below Garrison

The Missouri River in the Bismarck, ND area rose over 4 feet on December 12-13, 2010 during river ice-cover formation. This type of rise in stage during the river ice formation is normal. The river ice-cover conditions were generally continuous from December 12, 2010 through March 18, 2011, at which time the river ice broke up due to warmer temperatures. The winter ice-affected Missouri River peak stage at Bismarck was 12.0 feet on February 7. This was 4 feet below the Bismarck flood stage of 16 feet and 1 foot below the Corps' winter freeze-in maximum stage target of 13 feet.

d. Spring Open Water Season 2011

This report includes a brief summary of operations for Garrison during the 2011 flood of record. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report. Runoff into Garrison Reservoir started the year with near-normal inflows in January and February. Slightly-above-normal runoff occurred in March and much-above-normal runoff occurred in April. As noted in ***Table 5***, record inflow occurred in 5 consecutive months, May through September. Releases from Garrison were near normal through March but then were reduced in April to reduce the potential for flooding in the Bismarck, ND area as the heavy plains snowpack melted. In May, releases were significantly increased as inflows started to increase rapidly. These factors resulted in Garrison Reservoir pool levels increasing nearly 17 feet, from 1838.5 ft msl at the end of February to 1853.3 ft msl by the end of May. The significant pool rise in April and May was due to a combination of above-normal inflows from a significant plains snowpack and above-normal precipitation in March and April, coupled with several record-setting rainfall events in the upper Great Plains in May and the start of the melt period of the mountain snowpack.

e. Summer Open Water Season 2011

Peak daily flows into Garrison also set records in June 2011. The peak daily inflow of 190,000 cfs occurred on June 13. The daily average inflows exceeded the previous June maximum daily inflow into Garrison of 125,000 cfs for a total of 39 days. Included in this inflow were the releases from Fort Peck. Subtraction of the Fort Peck release resulted in the maximum contribution of inflows from just the tributaries into Garrison of 158,000 cfs, which occurred on May 26 and exceeded the previous combined maximum daily inflow from the tributaries and Fort Peck by 33,000 cfs.

The record maximum daily Garrison release of 150,600 cfs was established on June 25, 2011. The previous record maximum was 65,200 cfs (July 1975), which was exceeded for 100 days in 2011.

During June and July, the delayed melting of the above-normal mountain snowpack runoff combined with the continued runoff from the record rainfall events in May resulted in record inflows into Garrison Reservoir: 144,600 cfs in June (302% of average), 111,700 cfs in July (329% of average), 51,900 cfs in August (278% of average) and 37,300 cfs in September (219% of average). Average inflows into Garrison over the 5-month March-July period were 86,140 cfs, which is the equivalent of 30.2 MAF. The magnitude of record releases were just as significant with 136,600 cfs in June, (544% of average) 127,700 cfs in July (487% of average), and 91,100 cfs in August (362% of average). While not a record, the September release of 43,400 cfs (207% of average) was still significant. The Garrison pool entered the surcharge zone (above 1854.0 ft msl) on June 20 for the first time since 1997 and peaked at 1854.6 ft msl on July 1, the second highest pool on record (1854.8 ft msl, July 1997). Following the peak pool in early July, the Garrison pool started to decline and fell below the surcharge zone on July 15 and the exclusive flood control zone (1850.0 ft msl) on August 8. The reservoir continued to steadily fall through mid-September before starting to level off, ending the month at 1842.8 ft msl, 11.8 feet below the peak pool.

f. Fall Open Water Season 2011

Fall releases were held steady at about 26,000 cfs in October through early November, and then increased to about 29,000 cfs to continue the evacuation of water from the annual flood control and multiple use zone. Releases were reduced to around 16,500 cfs starting in early December in anticipation of the December freeze-in downstream of Garrison Dam between Washburn and Bismarck, ND. After several days at 16,500 cfs, the stage at Bismarck for that release was observed to be about 2.5 to 3.0 feet lower than that same release in 2010. Therefore, releases were slowly increased to 23,000 cfs, with releases held for several days at 18,000 cfs and 20,000 cfs to observe the corresponding stage at Bismarck. Due to warmer-than-normal weather, the Bismarck-Washburn reach did not freeze in by the end of the year. Garrison ended December at an elevation of 1839.5 ft msl, 2.0 feet above the base of the flood control and multiple use zone.

g. Lake Audubon / Snake Creek Embankment

During the 2000-2007 drought, a 43-foot maximum water level difference between Lake Audubon and Lake Sakakawea was put in place. 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 that time relief wells have been installed and under seepage issues should not be a factor in future operations of the Lake Audubon. In the event the pool difference approaches the 43-foot maximum that was in place in 2007, the Omaha District's Geotechnical Branch will be consulted as to whether or not the 43-foot maximum is still a consideration. Since the Garrison Reservoir has returned to more normal elevations following the 8-year drought, this water level difference restriction has not been in effect.

In 2011, due to the record runoff into Garrison Reservoir, Lake Audubon's available storage was utilized. Water was pumped in from the Garrison pool starting in late May though early June. Lake Audubon peaked at 1849.5 ft msl on June 4, 2.5 feet above the normal summer operating level, and again on June 22. The pool was held nearly steady through early August when it was drawn down to the normal winter level of about 1845.0 ft msl.

h. Summary

The Garrison Reservoir pool elevation peaked at 1854.6 feet msl on July 1, 0.6 feet above the top of exclusive flood control pool and was the second highest recorded pool elevation on record. The record high pool elevation was 1854.8 feet msl set in July 1975. The reservoir was 3.3 feet higher than the 2010 peak. The lowest Garrison Reservoir level during 2011 occurred on March 15 at 1837.7 ft msl. Record average daily inflows were set for the months of May through September in 2011 with June's 144,600 cfs average daily inflow setting the all-time record for any month since the System first filled in 1967. The average annual inflow of 51,200 cfs was 223% of average (1967-2011) and was the highest average annual inflow since the System first filled. Record average daily releases were set for May through August with June's average daily release of 136,600 cfs setting the all time record (1967-2011). The average annual release of 50,900 cfs was 235% of average (1967-2011) and was the highest average annual release since the System first filled. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report.

4. Oahe and Big Bend Regulation – January to December 2011

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 6 lists the average monthly inflows and releases and the EOM pool elevations for Oahe for 2010 and 2011 as well as the averages since the System first filled in 1967.

A settlement agreement was approved in an order of dismissal by the United States District Court, District of South Dakota on August 8, 2003, in the case of Lower Brule Sioux Tribe et al. v. Rumsfeld, et al. (Civil No. 02-3014 (D.S.D.)). The agreement provides that the Corps will consult with the Lower Brule Tribe and the Crow Creek Sioux Tribe during any review and revision of the Missouri River Master Water Control Manual. This agreement also provides that the Corps will coordinate the regulation of Big Bend and the water level of Lake Sharpe with the two Tribes to include the following: the Corps will normally strive to maintain a reservoir level at Lake Sharpe between elevation 1419 ft msl and 1421.5 ft msl and, when the level of Lake Sharpe drops below elevation 1419 ft msl or exceeds elevation 1421.5 ft msl, 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 ft msl or rise above 1422 ft msl or, in the event the water level falls below 1418 ft msl or rises above 1422 ft msl, 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 2011 the Big Bend Reservoir level varied in the narrow range between elevations 1419.0 to 1421.5 ft msl. As per the settlement agreement, no additional coordination was necessary.

Table 6
Oahe – Inflows, Releases and Elevations

Month	Ave Monthly Inflow (cfs)			Ave Monthly Release (cfs)			EOM Elevation (ft msl)		
	2011	2010	1967-2011	2011	2010	1967-2011	2011	2010	1967-2011
January	24,800	18,700	23,000	22,500	17,800	20,800	1605.4	1607.6	1598.7
February	30,500	16,900	27,100	17,700	14,000	18,200	1607.7	1608.0	1600.4
March	50,400	39,000	31,500	13,900	6,800*	18,000	1614.4	1613.9	1603.0
April	41,400	23,300	27,200	26,000	10,200	20,800	1617.5	1616.1	1604.1
May	65,100**	26,000	28,000	52,600**	19,100	22,200	1618.8**	1617.2	1605.0
June	147,500**	23,100	30,800	142,500**	19,700	27,300	1619.6**	1617.6	1605.2
July	133,600**	17,000	28,800	144,200**	25,000	31,600	1617.5	1616.2	1604.3
August	95,300**	17,900	26,600	117,100**	32,100	34,100	1613.3	1613.0	1602.3
September	46,800	29,800	22,600	67,300**	39,200	29,700	1609.0	1610.7	1600.5
October	28,700	29,500	20,500	27,800	38,100	24,000	1609.0	1608.7	1599.3
November	29,500	29,000	21,300	36,300	37,800	22,600	1607.4	1606.5	1598.8
December	22,300	18,900	20,400	23,800	24,800	21,100	1606.8	1605.3	1598.4

* monthly minimum of record ** monthly maximum of record

Table 7 lists the average monthly inflows and releases in cfs and the EOM pool elevations in ft msl for Big Bend for 2010 and 2011 as well as the averages since the System first filled in 1967.

b. Winter Season 2011

During the winter, flooding in the Pierre-Fort Pierre area, especially at street intersections in the Stoeser Addition, has been a recurring problem since 1979. High Oahe releases, coupled with the formation of river ice cover in the LaFrambois Island area, have historically caused water to back up into a storm sewer outlet, flooding street intersections. The city of Pierre installed a valve on the Stoeser Addition storm sewer in the fall of 1998 to prevent winter flooding; however, Oahe releases will continue to be constrained at times to prevent flooding at other locations. A study, referred to as the Pierre/Fort Pierre Flood Mitigation Project, was initiated by the Omaha District in the late 1990's and finalized approximately 5 to 7 years later. This project involved the purchase or flood-proofing of homes along the Missouri River that may be impacted by ice-affected Missouri River flows. Approximately 100 homes were purchased and removed and about 20 were flood-proofed. Some home owners chose not to participate in the voluntary project.

Table 7
Big Bend – Inflows, Releases and Elevations

Month	Ave Monthly Inflow (cfs)			Ave Monthly Release (cfs)			EOM Elevation (ft msl)		
	2011	2010	1967-2011	2011	2010	1967-2011	2011	2010	1967-2011
January	20,600	17,700	20,500	19,700	16,800	20,400	1421.2	1421.1	1420.5
February	17,400	14,300	18,300	17,600	14,500	18,300	1420.7	1420.8	1420.4
March	17,100	13,200	18,800	17,200	13,100	18,800	1420.5	1420.7	1420.4
April	25,200	10,400	21,100	24,900	10,300	20,800	1420.7	1420.6	1420.5
May	49,200**	18,200	22,400	50,400**	17,900	22,300	1419.0	1420.5	1420.4
June	143,000**	19,400	27,600	142,100**	19,400	27,300	1419.8	1420.3	1420.3
July	141,600**	23,600	30,900	141,600**	23,100	30,500	1419.5*	1420.2	1420.3
August	113,500**	30,100	33,400	113,100**	29,600	32,900	1419.3	1420.0	1420.2
September	63,600**	36,600	29,200	62,800**	36,300	28,800	1419.6	1419.8	1420.3
October	25,800	35,500	23,800	24,700	34,700	23,300	1420.4	1420.6	1420.5
November	34,600	35,500	24,000	34,200	35,700	22,300	1420.6	1420.1	1420.4
December	22,500	22,500	20,900	22,700	22,400	20,600	1420.4	1420.1	1420.5

* monthly minimum of record ** monthly maximum of record

No flooding problems were experienced in this area during the winter of 2011. Due to the cold temperatures and ice formation on the Missouri River, a one unit minimum was implemented for Oahe several times over the winter. The one unit minimum, which is approximately 7,000 cfs, ensures that water is always flowing in the river downstream of Oahe Dam in order to lessen river ice-forming. The ice pack on the Missouri River approached as far upstream as river mile 1066.5, which is near the Missouri River at Pierre, SD stream gaging station and just downstream of the Hwy 14/83 bridge. The Oahe Reservoir (Lake Oahe) froze over on January 12 and was free of ice on April 2.

Big Bend was regulated in the winter season to follow power-peaking requirements with hourly releases varying widely. The daily average flow in winter season varied between 0 and 56,700 cfs. The Big Bend Reservoir (Lake Sharpe) froze over on December 14, 2010 and was free of ice on April 7.

c. Spring Open Water Season 2011

January and February runoff into Oahe Reservoir was slightly above normal. Starting in late February, the melting of the above-normal plains snowpack resulted in an average monthly inflow to Oahe of 50,400 cfs in March (160% of average) and 41,400 cfs in April (152% of average). During this same time period, releases were only 13,900 cfs (77% of average) and 26,000 cfs (125% of average), respectively. Oahe releases were kept lower than average in March due to high tributary inflows to Fort Randall, to Gavins Point and on the Missouri River downstream of Gavins Point. The combination of above-normal inflows and more normal releases over the first 4 months of the year caused the reservoir to rise 12.1 feet to 1617.5 ft msl at the end of April; 0.5 foot into the 3-foot exclusive flood control zone (1617.0 to 1620.0 ft msl). Inflows to Oahe accelerated in May following the significant rainfall events that occurred in the upper Great Plains and the melting of the above-normal mountain snowpack, setting monthly runoff records through September. The average monthly inflow for May was 65,100 cfs (233% of average) setting a new record for the highest average monthly inflow. The average monthly release for May was 52,600 cfs (237% of average) also setting a new record for the highest average monthly release. Through the month of May, the Oahe pool continued to rise and ended the month of May at 1618.8 ft msl, 1.8 feet into the 3-foot exclusive flood control zone.

d. Summer Open Water Season 2011

Peak daily flows into Oahe also set records in 2011. The peak daily inflow of 210,000 cfs occurred on June 21. The daily average inflows exceeded the previous June maximum daily inflow into Oahe of 103,000 cfs for a total of 73 days. Included in this inflow were the releases from Garrison. Subtraction of the Garrison release resulted in the maximum contribution of inflows from just the tributaries into Oahe of 108,000 cfs, which occurred on March 20 due to plains snowmelt. The total inflow (includes Garrison release) into Oahe that day was 128,000 cfs, which was well below the record maximum daily inflow (also occurred during a plains snowmelt period plus rainfall on frozen ground) of 204,000 cfs, which occurred in March 1987.

The new record maximum daily release from Oahe occurred on June 20, 2011 at 160,300 cfs. Previously, the record was 59,300 cfs, which was established in July 1997. The old record release was exceeded for 122 days in 2011.

Peak daily flows into Big Bend also set records in 2011. The peak daily inflow was 195,000 cfs, which occurred on June 21. The previous record inflow of 79,000 cfs occurred in June 1997. This previous inflow record was exceeded for 92 days in 2011. Big Bend tributary inflows were also relatively high in 2011, with a maximum daily inflow of 41,000 cfs on June 21.

The new record maximum Big Bend release was established at 166,300 cfs on June 26, 2011. The previous record of 74,300 cfs was set in July 1997. In 2011 the previous record was exceeded for 98 days.

During June and July, runoff from the delayed melting of the above-normal mountain snowpack combined with the continued runoff from the significant rainfall events in May and June resulted in record monthly average inflows to Oahe of 147,500 cfs in June (479% of average), 133,600 cfs in July (464% of average), 95,300 cfs in August (358% of average), and 46,800 cfs in September (207% of average). These inflows exceeded previous records and were by far the highest monthly inflows since the System was first filled in 1967. The releases from Oahe during that same period were also record-setting with a June release of 142,500 cfs (522% of average), July at 144,200 cfs (456% of average), August at 117,100 cfs (343% of average) and September at 67,300 cfs (227% of average). Despite the record releases, the Oahe pool continued to climb, peaking at a record elevation of 1619.7 ft msl on June 26. This elevation was 2.7 feet into the 3-foot exclusive flood control zone, or 0.3 foot from entering the surcharge zone. Once the System storage peaked on July 2, the Oahe pool level, as with Fort Peck, Garrison and Fort Randall, steadily declined through July, August and September, as stored flood waters in the exclusive flood control and the annual flood control and multiple use zones were evacuated. The reservoir elevation fell at a fairly steady rate through September ending the month at 1609.0 ft msl or 10.7 feet lower than at its peak.

e. Fall Open Water Season 2011

Fall releases from Oahe Reservoir continued to be above normal as the evacuation of water from the annual flood control and multiple use zone continued. Average releases for October (27,800 cfs, 116% of average), November (36,300 cfs, 161% of average) and December (23,800 cfs 113% of average) were much closer to normal than what usually occurs in a high-runoff year. when the snowmelt and rainfall runoff are captured in the spring and summer and then released in the fall at much-higher-than-average flow rates. During November, in response to lower-than-normal energy demand and transmission restrictions, the outlet tunnels were used to supplement power releases from Oahe. A constant 6,000 cfs release from the outlet works was started in early November and continued through the end of November. Releases were reduced in December in conjunction with the reduction in System releases at the end of the 10-day extended navigation season. Oahe ended 2011 with the pool elevation at 1606.8 ft msl, 0.7 feet below the base of the annual flood control and multiple use zone.

f. Summary

The highest Oahe Reservoir level during 2011 occurred on June 26 at 1619.7 ft msl. The peak reservoir elevation was 1.8 feet higher than the 2010 peak and set a record for the highest peak pool since the System first became fully operational in 1967. The prior record was 1618.7 ft msl, which was set in 1995 and repeated in 1996. The 2011 CY minimum pool elevation of 1604.9 ft msl occurred on January 6. The average annual inflow to Oahe of 59,700 cfs was 233% of average (1967-2011) and was the highest average annual inflow on record since the System first filled in 1967. The average annual release from Oahe of 57,600 cfs was 237% of average (1967-2011) and was the highest average annual release since the System first filled in 1967. In 2011, Oahe rose 2.7 feet into the 3-foot exclusive flood control zone, which extends from 1617.0 to 1620.0 ft msl. Big Bend ended the year at 1420.4 ft msl, within the normal regulating range. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report.

5. Fort Randall Regulation – January to December 2011

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 the 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 provide a location to store the water necessary to provide increased winter hydropower energy by allowing an annual fall drawdown of the reservoir to occur 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 8 lists the Fort Randall average monthly inflows and releases in cfs and the EOM pool elevation in ft msl for 2010 and 2011 as well as the averages since the System was first filled in 1967.

Table 8
Fort Randall – Inflows, Releases and Elevations

Month	Ave Monthly Inflow (cfs)			Ave Monthly Release (cfs)			EOM Elevation (ft msl)		
	2011	2010	1967-2011	2011	2010	1967-2011	2011	2010	1967-2011
January	23,000	20,300	21,900	17,300	14,100	15,100	1345.8	1345.5	1347.2
February	22,300	16,300	20,100	15,800	11,600	13,300	1350.6	1349.0	1352.0
March	25,100	23,500	21,600	15,100	6,800	15,500	1357.8	1361.1	1356.3
April	29,700	14,000	23,500	27,700	12,500	21,200	1359.8	1362.0	1357.8
May	58,500**	21,300	25,100	57,000**	22,800	25,400	1359.9	1360.8	1357.4
June	157,000**	28,400	30,400	134,600**	18,800	29,100	1373.9**	1366.5	1357.9
July	149,600**	26,700	32,000	156,000**	31,700	33,300	1369.3**	1363.1	1356.7
August	121,100**	32,400	34,400	133,000**	40,900	35,600	1361.2	1356.7	1355.4
September	68,900**	39,400	29,800	80,000**	44,800	34,800	1352.9	1352.3	1351.1
October	27,000	37,900	23,400	39,300	47,100	32,300	1341.9	1344.1	1343.1
November	36,200	38,100	22,300	38,800	43,900	28,700	1339.2	1338.3	1336.7
December	25,600	25,000	21,800	26,400	22,800	17,400	1338.3	1340.5	1341.1

* monthly minimum of record ** monthly maximum of record

b. Winter Season 2011

The Fort Randall daily winter releases ranged from 5,700 to 39,500 cfs. The Fort Randall Reservoir (Lake Francis Case) froze over on December 13, 2010 and was ice free on April 4.

c. Spring Open Water Season 2011

This report includes a brief summary of regulation of Fort Randall during the 2011 flood of record. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report. The Fort Randall pool rose from a March 1 pool of 1350.6 ft msl to 1359.8 ft msl on April 1, an increase of 9.2 feet, primarily due to above-normal runoff from the melting of the plains snowpack and above-normal rainfall. 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 15,100 cfs was 97% of normal, and the average April release of 27,700 cfs was 131% of normal. These releases corresponded with above-average inflows of 25,100 cfs in March (116% of average) and 29,700 cfs in April (126% of average). In May, the flow into Fort Randall Reservoir dramatically increased as the high runoff in the upper plains started working its way through the System in the form of releases from the upper projects. Inflows for

May were 58,500 cfs (233% of average) and set a new record for average monthly runoff into the reservoir. Releases for May were 57,000 cfs (224% of average), which also set a record for average monthly outflow.

d. Summer Open Water Season 2011

Maximum daily flows into Fort Randall also set a new record in 2011. The maximum day total of 218,000 cfs occurred on June 21 and more than doubled the previous June maximum day record of 95,000 cfs. The 95,000 cfs prior record was exceeded for 88 days in 2011. Tributary inflows (without the upstream Big Bend release) maxed out on June 21 at 55,000 cfs.

The new record maximum Fort Randall daily release of 160,000 cfs was established on July 27, 2011. The previous record of 67,500 cfs was set in November 1997 and was exceeded on 119 days in 2011.

In June and July, as the record runoff upstream continued to work its way through the System, this movement of water through the System combined with significant rainfall during June in the incremental reach between Big Bend and Fort Randall to create record inflows to the reservoir for June through September. The record inflows were 157,000 cfs in June (516% of average), 149,600 cfs in July (468% of average), 121,100 cfs in August (352% of average), and 68,900 cfs in September (231% of average). The releases from Fort Randall were just as significant and also set new records for that same period. Releases were 134,600 cfs in June (463% of normal), 156,000 cfs in July (468% of average), 133,000 cfs in August (374% of average), and 80,000 cfs in September (230% of average). The Fort Randall pool entered into the exclusive flood control zone for the second year in a row. The Fort Randall pool reached its peak elevation of 1374.0 ft msl on July 7, 1.0 foot from the top of the 10-foot exclusive flood control zone, which extends from 1365.0 to 1375.0 ft msl. This was highest pool on record (1967-2011), eclipsing the previous record set in 1997 by 1.8 feet.

Normally, a daily peaking pattern is established at Fort Randall during the nesting season to provide flexibility to regulate over a range of releases while minimizing impacts to birds nesting below the project. However, due to the record flooding and high releases, no peaking restrictions were enforced during 2012.

e. Fall Open Water Season 2011

Normal regulation of Fort Randall includes the lowering of the pool level at the end of the navigation season to 1337.5 ft msl, 17.5 feet below the normal summer level, to make room for capture of the winter powerplant releases from the upper reservoirs. During a full navigation season, the pool is maintained above 1353 ft msl through the Labor Day weekend before starting the lowering of the pool. In 2011 fall releases from Fort Randall Reservoir continued to be above normal as the evacuation of water from the annual flood control and multiple use zone continued. On September 1, the pool level was at 1361.2 ft msl. The lowering of Fort Randall was started after Labor Day and was extended into December due to the 10-day extension of the navigation season. Fort Randall reached its lowest level of 1337.7 ft msl on December 27.

f. Summary

The highest Fort Randall Reservoir level during 2011 occurred on July 7 at 1374.0 ft msl. The lowest reservoir level during 2011 occurred on December 27 at 1337.7 ft msl. The average annual inflow to Fort Randall of 62,000 cfs was 242% of average (1967-2011), and the average annual release of 61,800 cfs was 245% of average (1967-2010). Both set new records since the System first filled in 1967. In 2011 Fort Randall rose 9.0 feet into its 10-foot exclusive flood control zone, which extends from 1365.0 to 1375.0 ft msl. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report.

6. Gavins Point Regulation – January to December 2011

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 450,000 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 ft msl. Due to the limited storage, releases from Gavins Point must be backed up with releases out of 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. In 2011 powerplant capacity at Gavins Point had to be reduced to approximately 31,000 cfs due to the accumulation of debris in the trash racks, resulting in the need to pass slightly more water through the spillway.

Table 9 lists the Gavins Point average monthly inflows and releases in cfs and the EOM pool elevation in ft msl for 2010 and 2011 as well as the averages since the System was first filled in 1967.

b. Winter Season 2011

The Gavins Point average daily release was above the normal winter release rate for the entire winter season. Winter releases varied from 17,000 cfs to 19,000 cfs in January and from 19,000 cfs to 21,100 cfs in February. The Gavins Point Reservoir (Lewis and Clark Lake) froze over on December 21, 2010 and was free of ice on March 24, 2011. Gavins Point Reservoir reached the year’s lowest elevation of 1204.7 ft ms on May 4.

Table 9
Gavins Point – Inflows, Releases and Elevations

Month	Ave Monthly Inflow (cfs)			Ave Monthly Release (cfs)			EOM Elevation (ft msl)		
	2011	2010	1967-2011	2011	2010	1967-2011	2011	2010	1967-2011
January	18,400	17,000	17,300	18,500	15,900	17,100	1207.2	1207.4	1207.5
February	20,000	14,300	16,400	20,700	15,000	17,300	1205.5	1205.9	1205.7
March	21,500	15,100	19,600	21,000	15,000	19,600	1206.5	1206.1	1205.6
April	30,000	15,400	25,100	30,300	15,300	25,000	1205.7	1206.2	1205.8
May	57,000	25,600	29,000	56,300	25,200	28,800	1206.5	1206.8	1206.0
June	139,200**	27,400	32,500	139,000**	27,700	32,200	1206.3	1205.6	1206.2
July	159,800**	35,400	35,500	159,700**	35,100	35,100	1205.8	1206.0	1206.7
August	136,900**	42,300	37,400	136,200**	41,900	36,900	1206.6	1206.3	1207.3
September	82,500**	48,200	36,900	81,900**	47,200	36,500	1207.3	1208.1	1207.7
October	40,500	48,700	34,600	40,100	48,700	34,400	1207.3	1207.6	1207.8
November	40,200	46,100	31,100	40,100	46,100	31,100	1207.0	1207.2	1207.6
December	28,000	25,700	19,500	27,700	25,200	19,500	1207.8	1207.8	1207.4

* monthly minimum of record ** monthly maximum of record

c. Winter River and Ice Conditions Below Gavins Point

No major ice-affected discharge or stage reductions were experienced during the winter season.

The first signs of floating ice on the Missouri River during the 2011 winter season were noted on December 1, 2010 in the reach from the Ponca (NE) State Park downstream to Sioux City, IA, with 20% floating ice and 3- to 6-foot ice pads. No floating ice was reported on the Missouri River in the reaches downstream from Sioux City until December 7, 2010, when ice reports showed floating ice from Ponca State Park downstream to Nebraska City, NE. The floating ice reports noted 10 to 30% floating ice and ice pads ranging from 5 to 15 feet in size. The season's first round of extreme cold weather on December 13 and 14 produced the greatest volumes of floating ice on the Missouri River for the month. These volumes were as high as 95% floating ice with ice pads sizes varying from 5 to 15 feet in the river reach from Ponca State Park downstream to the Cooper Nuclear Powerplant, which is located just south of Nebraska City, NE. During this same period the lower Missouri River had reports of floating ice ranging from 50% at the Kansas City water treatment plant to 5% near the Corps' Napoleon, MO office.

From January though early February the ice reports showed floating ice ranging from 5 to 90% with ice pads sizes from 3 to 20 feet. Gavins Point releases were stepped up in early January from 17,000 to 19,000 cfs. The increased flow provides a slightly larger surface area and slightly faster flows, both of which assist in decreasing the chance of ice jams downstream Missouri River reach. In early February, the Gavins Point releases were increased up to 21,000 cfs and remained at that level through the remainder of the winter season.

Another round of below-zero temperatures during this time period resulted in the winter season's greatest extent of ice on the Missouri River. From February 2 to 4, ice reports were made from Ponca State Park downstream to the Chamois (MO) Powerplant. This reach of the Missouri River is approximately 635 river miles. On February 2 the Missouri River ice observers reported the largest volumes of floating ice for the month with 50 to 90% floating ice and ice pads from 10 to 30 feet in size. ***Figure 10*** shows a picture of the Missouri River, looking downstream, with 90% floating ice with the ice pads ranging from 20 to 30 feet near the Mormon Bridge (Interstate I-680) at Omaha, NE. The Missouri River stage at Omaha was 13.9 feet and the flow was about 25,700 cfs at the time the picture was taken. Gavins Point releases were 19,000 cfs. The last report of floating ice was made on March 1, 2011. At that time the Missouri River was essentially free of floating ice except for two locations: 2% floating ice at the Belle of Sioux City, IA and 1% floating ice at Nebraska City, NE, both with ice pads less than a foot in size.

d. Spring Open Water Season 2011

This report includes a brief summary of operations for Gavins Point during the 2011 flood of record. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report. The March spring pulse from Gavins Point was not conducted in 2011 because of the high tributary and Missouri River flows. The combination of melt of the plains snowpack in eastern South Dakota, eastern Nebraska and western Iowa and heavy localized rain over eastern South Dakota raised the Missouri River levels well above the downstream flow limits. The magnitude of the March pulse is 5,000 cfs minus the flow on the James River just above its confluence with the Missouri River upstream from Sioux City, IA. A month-long “natural” pulse was provided by the James River. In mid-March, flows at the James River at Scotland, SD, the most downstream gaging station on the James River, increased from about 1,000 cfs to a peak of about 25,000 cfs in late March and then dropped to about 12,000 cfs in mid-April. The Missouri River flows at Omaha were above the flow limit of 41,000 cfs starting on March 19 through December 11; at Nebraska City, above the flow limit of 47,000 cfs from March 18 through December 13; and at Kansas City, above the flow limit of 71,000 from March 27 through October 10. The downstream Missouri River flow limits are the safeguards to reduce or eliminate the pulse to ensure that the 2-day pulse does not exacerbate downstream flooding of agricultural land along the Missouri River.

Flow support for the 2011 navigation season began on March 23 at Sioux City, IA; March 25 at Omaha, NE; March 26 at Nebraska City, NE; March 28 at Kansas City, MO; and April 1 at the mouth of the Missouri River near St. Louis, MO.

During high water years, the rate at which floodwater is evacuated is calculated monthly, or more frequently if needed, to facilitate a smooth transition of releases. Because the ability to evacuate water is severely restricted during the winter months, most floodwater evacuation is accomplished during the navigation season (April 1 to December 1). Thus floodwater evacuation rates are defined as an increment of release above navigation flows, which are 31,000 cfs at Omaha, 37,000 cfs at Nebraska City and 41,000 cfs at Kansas City. The floodwater evacuation rate is based on a computation of water supply that considers the volume of water already stored in the System and tributary reservoirs and the forecast runoff for the remainder of

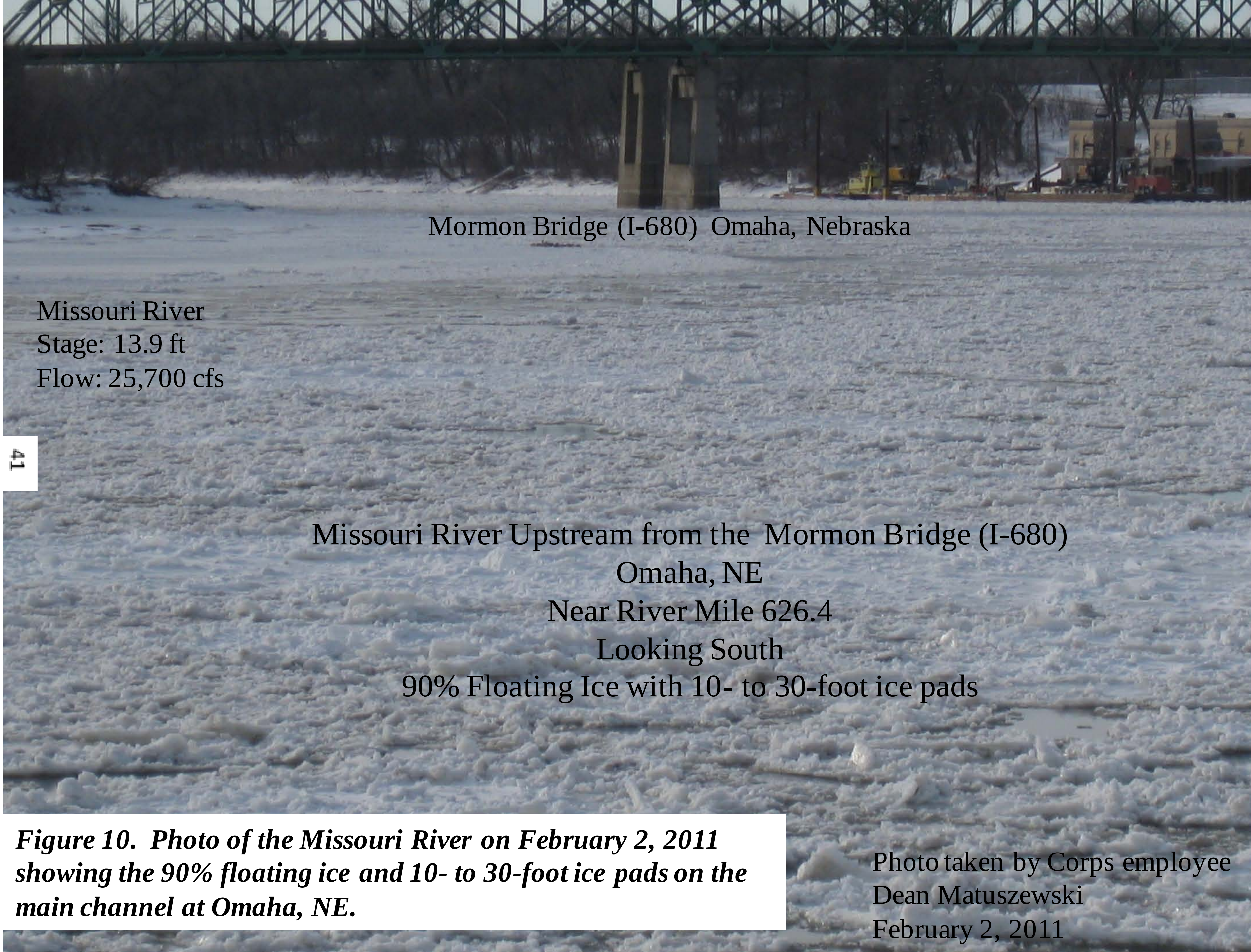


Figure 10. Photo of the Missouri River on February 2, 2011 showing the 90% floating ice and 10- to 30-foot ice pads on the main channel at Omaha, NE.

the year. The goal is to evacuate floodwater at the lowest rate possible over a long period of time to provide flood damage reduction for downstream communities.

In early April, the service level was increased 10,000 cfs from 35,000 cfs to 45,000 cfs.   The raising of the service level by 10,000 cfs eliminated the ability for the May pulse to be run. The 10,000-cfs flow limit "windows" at Omaha (31,000 to 41,000 cfs) and Nebraska City (37,000 to 47,000 cfs) were closed. In mid-April, another computation of water supply and forecast runoff resulted in the service level being increased another 5,000 cfs from 45,000 cfs to 50,000 cfs.

In late April, the MRBWM office was contacted by Corps' Mississippi Valley Division (MVD) and Lakes and River Division (LRD) to see if release changes could be made from the Corps' tributary and/or System reservoirs in the Missouri River basin to reduce flood risk on the Mississippi River. Releases were cut from the Corps' Kansas City District (NWK) Harry S Truman project in Missouri. MRBWM did not make reductions from the System reservoirs to help out the Mississippi River. During the period from late April through early May, releases from Gavins Point were increased from 33,500 cfs to 45,000 cfs, and they were held at that rate from April 29 through May 6. Earlier flood evacuation plans had indicated releases could go higher than 45,000 cfs; however, they were held at that rate due to the Missouri River being above flood stage from Nebraska City, NE to just north of Kansas City, MO. Holding releases at 45,000 cfs benefited that reach of the Missouri River and may have provided incidental benefits to the Mississippi River. In early May, another computation of water supply and forecast runoff resulted in the service level being increased another 10,000 cfs from 50,000 cfs to 60,000 cfs, and the Gavins Point release was, therefore, increased from 45,000 cfs in early May to 56,500 cfs in mid-May.

No cycling of Gavins Point releases was initiated in early May 2011. Cycling of releases has been conducted in previous years in early 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. However, during 2011 the flood water evacuation process rendered the cycling of releases moot, since the vast majority of habitat would already be inundated from the flood water evacuation releases. On April 25 the Corps notified the U.S. Fish and Wildlife Service (USFWS) that flood water evacuation would preclude any reservoir operations for terns and plovers during the 2011 nesting season.

The May spring pulse was not conducted in 2011**.** System storage was the only one of the three requirements met to run the May spring pulse. On May 1, the System storage of 65.5 MAF well exceeded the minimum 40 MAF required storage. The second requirement is the downstream Missouri River flow limits. The flow limits of 41,000, 47,000 and 71,000 cfs were exceeded the entire month of May at Omaha, Nebraska City and Kansas City, respectively, due to increases to the service level for the purpose of flood evacuation. The third requirement is the Missouri River water temperature at Yankton, SD of 16^{o}C or warmer. The Missouri River water temperature at Yankton did not exceed 16 degrees Centigrade (^{o}C) until June 1. All three requirements must be met between the dates of May 1 and May 19 in order for the Corps to run the May spring pulse.

e. Summer Open Water Season 2011

As described in greater detail in the ***Summary Report on Regulation – 2011 Flood*** report and well as in Section II.C.1 of this report, record-breaking rainfall fell in the upper basin during May. In response to the historic rainfall and runoff in the upper basin, System releases were scaled up from 80,000 cfs in the beginning of June and eventually reached 160,000 cfs on June 23. System releases were maintained at 160,000 cfs until the end of July.

During June and July, the delayed melting of the above-normal mountain snowpack runoff combined with the continued runoff from the record rainfall events in May resulted in record inflows into the System. Due to the relatively small incremental drainage area upstream of Gavins Point, inflows into Gavins Point are almost all directly a result of releases from upstream System reservoirs. As shown on ***Table 9*** and as with the rest of the System, record inflows were observed at Gavins Point during a 4-month period from June through September – 139,200 cfs, 159,800 cfs, 136,900 cfs and 82,500 cfs, respectively. The magnitude of the record releases were just as significant during that same 4-month period - 139,000 cfs, 159,700 cfs, 136,200 cfs and 81,900 cfs, respectively. Gavins Point has a total storage of 450,000 AF. Thus, with an average daily release of 160,000 cfs, which is a daily volume of 317,000 AF, the volume of water in Gavins Point could be replaced in less than 2 days. Total flood control storage in Gavins Point is about 100,000 AF. Since Gavins Point is a small storage project in comparison to the other System projects and has very little flood control storage, releases were set to correspond with inflows in order to maintain a steady pool of about 1206.0 ft msl.

The maximum daily inflow of 168,000 cfs occurred on June 27. This inflow exceeded the prior maximum June record daily inflow in 1997 of 61,000 cfs for 127 days. The prior annual maximum record was 74,000 cfs, which also occurred in 1997. This higher level was exceeded in 116 days in 2011. Tributary inflows to Gavins Point were relatively high following heavy June rains. The maximum tributary inflow was 19,000 cfs on June 21. This maximum inflow combined with all of the other inflows into the System reservoirs on that day to result in the highest daily tributary daily inflow of 693,000 cfs. The significance of setting the annual maximum inflow near the end of June is that it occurred well after record releases during the flood were forecasted in late May 2011. Not only did record tributary inflows occur in 2011, but they also occurred over a long duration, making the total volume of water to be moved through the System a new record of 61.0 MAF that shattered the previous record set in 1997 of 49.0 MAF.

The new record maximum daily Gavins Point release was established at 160,700 cfs on June 27. The prior record was established in October and November 1997 at 70,100 cfs, which was exceeded for 119 days, or almost 4 months, in 2011.

Based on the July 1 System storage check, a 10-day extension of the navigation season to December 10 was provided. As described in greater detail in the ***Summary Report on Regulation – 2011 Flood*** report and in Section II.C.1 of this report, the drawdown strategy involved System releases being stepped down from 160,000 cfs to 150,000 cfs over a 4-day period starting on July 30 and then gradually reduced to 90,000 cfs from August 19 to 31.

f. Fall Open Water Season 2011

As part of the drawdown strategy, from September 18 to October 3, the Gavins Point releases were again gradually reduced to 40,000 cfs. During the December 7-15 period, the releases were reduced from 40,000 to 22,000 cfs and held at that rate for the remainder of the year. The 2011 navigation season was the second consecutive year for a full season length plus a 10-day extension.

g. Summary

The highest Gavins Point Reservoir level in 2011 was 1208.6 ft msl, reached on February 11. The lowest reservoir level during 2011 occurred on May 4, at 1204.7 ft msl. The 2011 average annual inflow to Gavins Point of 64,500 cfs was 230% of average (1967-2010). The 2011 average annual release from Gavins Point of 64,300 cfs was 231% of average (1967-2010). Both average annual inflow and releases are records and exceed previous records set in 1997 of 52,400 cfs and 52,300 cfs, respectively.

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. Events that occurred in connection with regulation activities during 2011 that may be considered unusual, or recently have come to the attention of MRBWM, are discussed in the following paragraphs.

1. Lawsuits

There were no lawsuits related to regulation of the System in 2011.

2. Intrasystem Unbalancing and Fort Peck Mini-Test

As described in the 2010-2011 AOP, the unbalancing of the three large upper reservoirs and Fort Peck "mini-test" have not been implemented in recent years. By late 2009, the System storage had recovered sufficiently from the drought that the Corps planned on transitioning to unbalancing in 2010 to benefit reservoir fisheries. However, the 2009 and 2010 runoff events provided more variability of reservoir levels than was required by the current Missouri River Natural Resources Committee (MRNRC) guidelines (see ***Plate 3***, 2010-2011 AOP). Additionally, experience in recent years has shown that storing water in the annual flood control and multiple use zone, particularly at Oahe, as the current criteria requires in order to implement unbalancing, is undesirable due to the flood control impacts. In the 2010-2011 AOP, the Corps stated that it planned to work with each of the appropriate state agencies in 2011 to determine a modified version of unbalancing that could be implemented in the future that did not adversely impact flood control. However, that effort was precluded by the 2011 flood event. The Corps will continue this effort in 2012 as discussed in the 2011-2012 AOP.

The endangered species modified flow "mini-test," which was designed to monitor the effects of higher spring releases and warmer water released from the Fort Peck spillway, requires a reservoir elevation of approximately 2229 ft msl to avoid unstable flows over the spillway. In previous years, the "mini-test" was not possible because reservoir elevations during May and June were below the spillway crest elevation of 2225 ft msl. Fort Peck Reservoir reached elevation 2229 feet msl in June 2010. However, in 2009, a priority for pallid sturgeon recovery was placed on the Lower Yellowstone Project at Intake, MT. The Fort Peck mini-test and full test flows will be deferred until the efficacy of the Lower Yellowstone Project has been assessed as discussed in the 2011-2012 AOP. The groundbreaking for this project took place in August 2010.

3. Summary of Project Flood Operations

As previously discussed, runoff in 2011 was a record 61.0 MAF. There were many non-routine regulation items related to the flood. A majority of these items will be discussed in the ***Summary Report on Regulation – 2011 Flood*** report. For this summary, non-routine items pertaining to regulation of the six System dams will be discussed.

At Fort Peck, releases were made from the spillway from May 6 to 23 and from June 2 to September 30. Maximum spillway releases of approximately 52,000 cfs were made during mid-June. At Garrison, releases were made from both the outlet tunnels and the spillway. Outlet tunnel releases were as high as approximately 79,000 cfs, with the tunnels being used at various release rates from May 6 to October 11. Spillway releases reached nearly 63,000 cfs, and the spillway was used from June 1 to August 17 except for a few days for spillway slab repairs. This was the first time that the Garrison spillway was used for regulation purposes. Outlet tunnel releases were made at Oahe from May 6 to October 7 and from November 9 to 29. The Oahe spillway was not used. At Big Bend, releases were made using the spillway from June 3 to August 28. Spillway releases were also made on August 31 and September 8. This was the first time that the Big Bend spillway was used for regulation purposes. At Fort Randall, supplemental releases were made from both the outlet tunnels and the spillway. Spillway releases were made from approximately late April to early October. Maximum spillway releases were approximately 142,000 cfs on July 7 and 13. Outlet tunnel releases were made from approximately late May to late June, and for a few days in July. Tunnel releases resumed in mid-September and continued until December 8. Maximum tunnel releases were approximately 117,000 cfs on July 7. At Gavins Point, spillway releases were made from April 25 through the end of the year. Winter spillway releases were required during maintenance of the hydropower units and to allow for higher-than-normal winter releases.

To accommodate variations in power demands during the record releases, powerplant releases at some of the projects were varied in a day to night pattern, with higher powerplant releases occurring during the day. This required adjusting releases from the outlet tunnels or spillway twice per day to maintain the required total project release. In addition, power system load control required hourly variations in powerplant releases at either Oahe or Fort Randall, which required additional adjustment to supplemental releases. These adjustments lessened later in the summer as power demands increased and total project releases were reduced.

During the flood event, the Big Bend elevation was held at a level slightly below that which it would normally be regulated. The reservoir was generally held between 1419 and 1420 rather than 1420 to 1421 feet msl. Because of the relatively short reach between Oahe and Big Bend, the lower reservoir level helped reduce stages slightly in the Pierre and Fort Pierre area.

Further detail on individual regulation for these reservoirs is found in Section II.C of this report.

E. Reservoir Elevations and Storage

Reservoir elevations and storage contents of the System reservoirs at the end of July 2011 are presented in ***Table 10*** and the same information for the end of December 2011 is presented as ***Table 11***. The 12-month-change columns for the end of July indicate significant increases in the elevations and respective storages in the Fort Peck, Garrison, Oahe and Fort Randall reservoirs, with all four reservoirs rising into their exclusive flood control zones (greater than 2246, 1850, 1617 and 1365 ft msl, respectively). By the end of December, all four were well below their bases of exclusive flood control.

Table 10
Reservoir Levels and Storages – July 31, 2011

Project	Reservoir Elevation		Reservoir Storage in 1,000 AF		
	Elevation (ft msl)	12-Month Change (ft)	Total	Above Min. Level*	12-Month Change
Fort Peck	2246.6	+10.8	17,634	13,546	+2,462
Garrison	1851.6	+0.8	22,920	17,940	+291
Oahe	1617.5	+1.3	22,237	16,864	+564
Big Bend	1419.5	-0.7	1,591	-30	-50
Fort Randall	1369.3	+6.2	4,850	3,333	+602
Gavins Point	1205.8	-0.2	339	32	-5

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

Table 11
Reservoir Levels and Storages – December 31, 2011

Project	Reservoir Elevation		Reservoir Storage in 1,000 AF		
	Elevation (ft msl)	12-Month Change (ft)	Total	Above Min. Level*	12-Month Change
Fort Peck	2236.2	+0.8	15,255	11,167	+181
Garrison	1839.5	-2.2	18,638	13,658	-771
Oahe	1606.8	+1.5	18,515	13,142	+456
Big Bend	1420.4	+0.3	1,636	15	+5
Fort Randall	1338.3	-2.2	2,323	806	-145
Gavins Point	1207.8	0.0	383	76	-5

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

Figure 11 shows the end-of-July pool elevations for Fort Peck, Garrison and Oahe plus total System end-of-July storage for 2008 through 2011. Individual tables with the historic maximum, average and minimum pool elevations for each reservoir are also shown on ***Figure 11*.** During 2011, the upper three reservoirs all had higher July 31 pool levels than 2010. During the 2000-2007 drought, all three reservoirs experienced their historical minimum record pool levels: Garrison in 2005, Oahe in 2006, and Fort Peck in 2007.

Record reservoir pool elevations were set in 2011 for two of the three reservoirs for which data are presented in ***Figure 11***. The record pool for Fort Peck Reservoir was set on June 15, 2011 at 2252.3 ft msl. Oahe Reservoir's record pool level of 1619.7 ft msl was set on June 27, 2011. A record was not set for the Garrison Reservoir pool level in 2011; however, the highest level last year was the second highest on record at 1854.6 ft msl, 0.2 foot below the record set in July 1975. Although not shown on ***Figure 11***, a record pool level was also set for Fort Randall Reservoir at 1374.0 ft msl on July 7, 2011. This record was 1.8 feet above the previous record. The 2011 maximum System storage was also a record at 72.8 MAF on July 1, 0.7 MAF above the previous record.

F. Summary of Results

1. Flood Control

This report includes a brief summary of the flood control operations for the System during the 2011 flood of record. For more details, refer to the ***Summary Report on Regulation – 2011 Flood*** report.

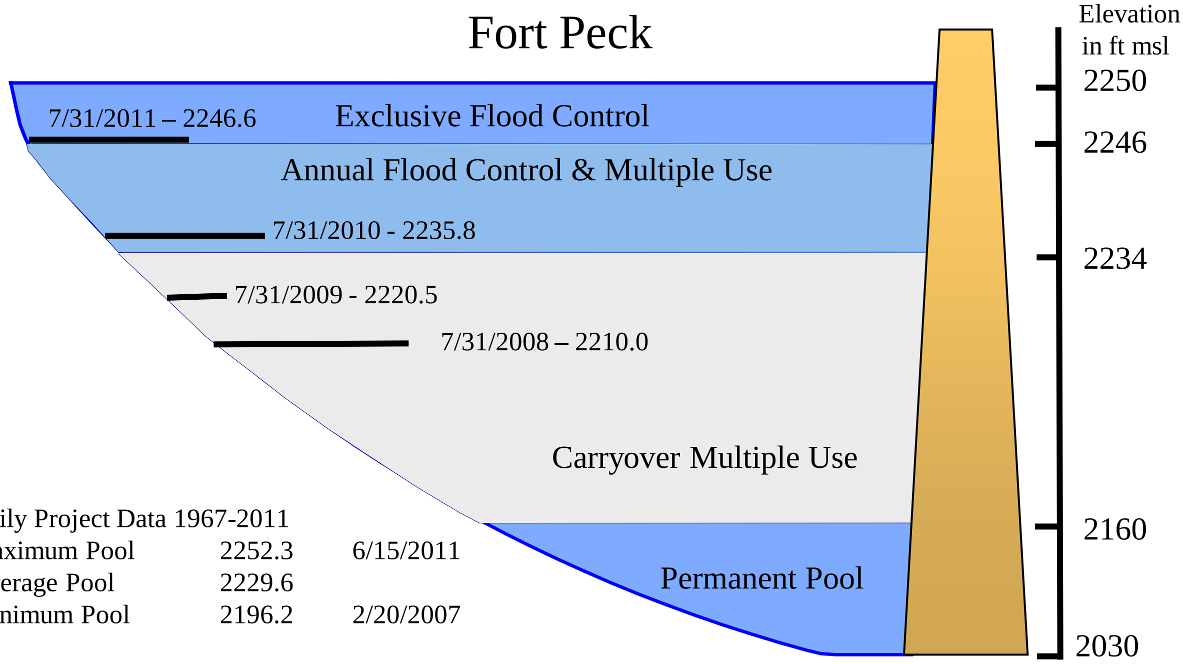
Record releases during 2011 were a result of record runoff into the upper basin from above-normal plains snowpack, much-above-normal and late-arriving mountain snowpack and record rainfall during May. The storage of flood waters resulted in the use of the "surcharge" pool at both Fort Peck and Garrison. The System storage peaked at 72.8 MAF on July 1, occupying 98% of the allocated flood control storage space (16.0 MAF of 16.3 MAF).

The estimated total flood damages prevented by all Corps projects in the basin during 2011 were estimated to exceed $8.2 billion ($4.6 billion Omaha District; $3.6 billion Kansas City District). As shown in ***Figure 12A***, the estimated total flood damages prevented by the System alone during 2011 were $5.5 billion ($2.3 billion Omaha District; $3.2 billion Kansas City District). The un-indexed flood damages prevented by the System since its construction now total $32.7 billion, the bulk of which were prevented during the 6-year period from 1993 to 1999 and the 2-year period of 2010 and 2011 (see ***Figure 12B***). ***Figure 12B*** indicates the flood damages prevented indexed to 2011. For comparison purposes, the ***Figures 12A*** and ***12B*** include the construction cost of the dams.

Figure 13 shows the regulated (actual experienced) and unregulated (with no System reservoirs and tributary reservoirs upstream from them) Missouri River flows at Wolf Point, MT; Bismarck, ND; Sioux City, IA; Omaha, NE; Nebraska City, NE and St. Joseph, MO. Flood stage and days above flood stage for both conditions are also shown on ***Figure 13***.

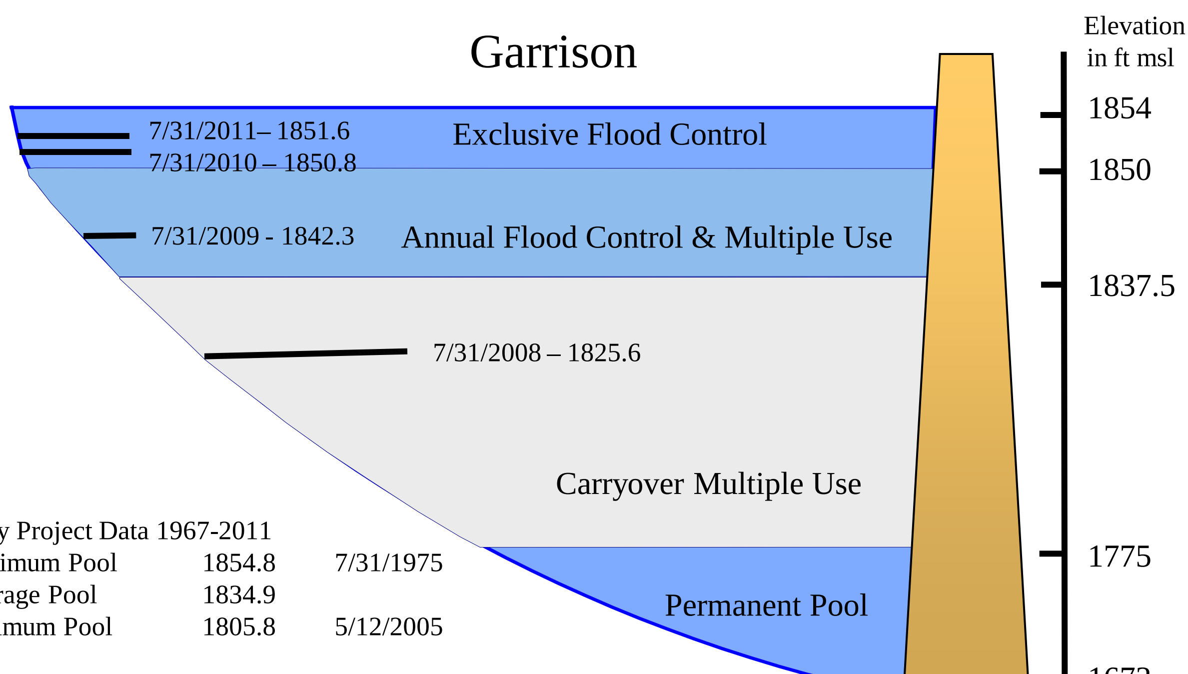
Missouri River System Reservoirs
End of July Pool Elevations and Total System Storage

Fort Peck



Daily Project Data 1967-2011		
Maximum Pool	2252.3	6/15/2011
Average Pool	2229.6	
Minimum Pool	2196.2	2/20/2007
Maximum for 2011	2252.3	6/15/2011
Minimum for 2011	2235.2	2/12/2011

Garrison

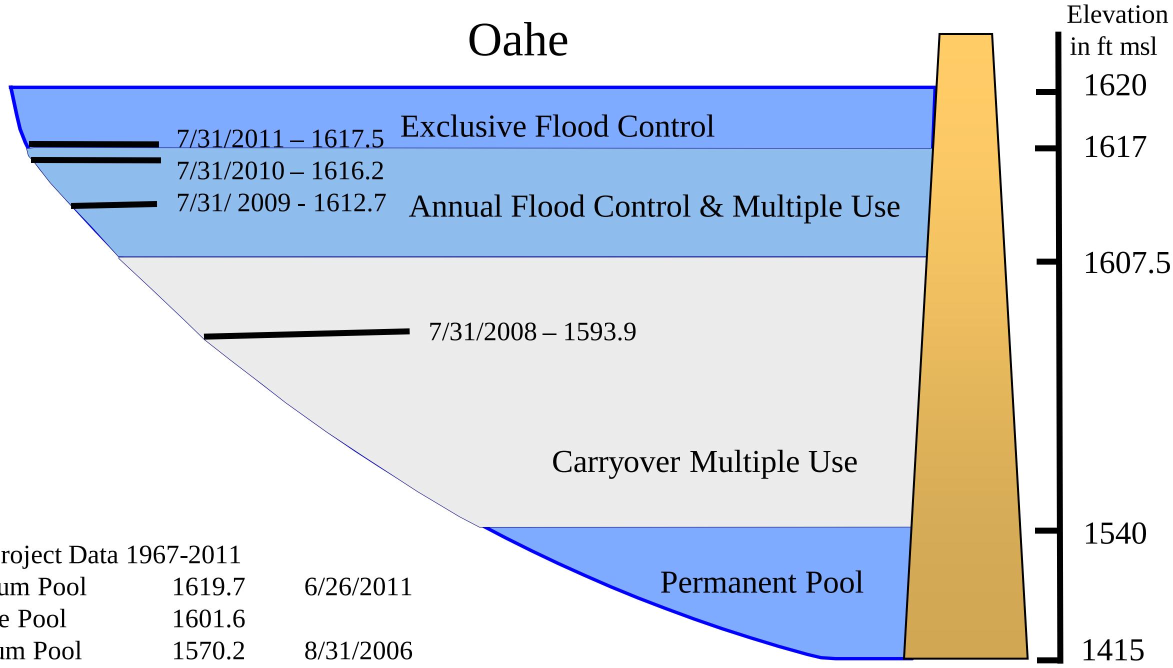


Daily Project Data 1967-2011		
Maximum Pool	1854.8	7/31/1975
Average Pool	1834.9	
Minimum Pool	1805.8	5/12/2005
Maximum for 2011	1854.6	7/01/2011
Minimum for 2011	1837.7	3/15/2011

Figure 11A. End of July pool elevations for Fort Peck and Garrison.

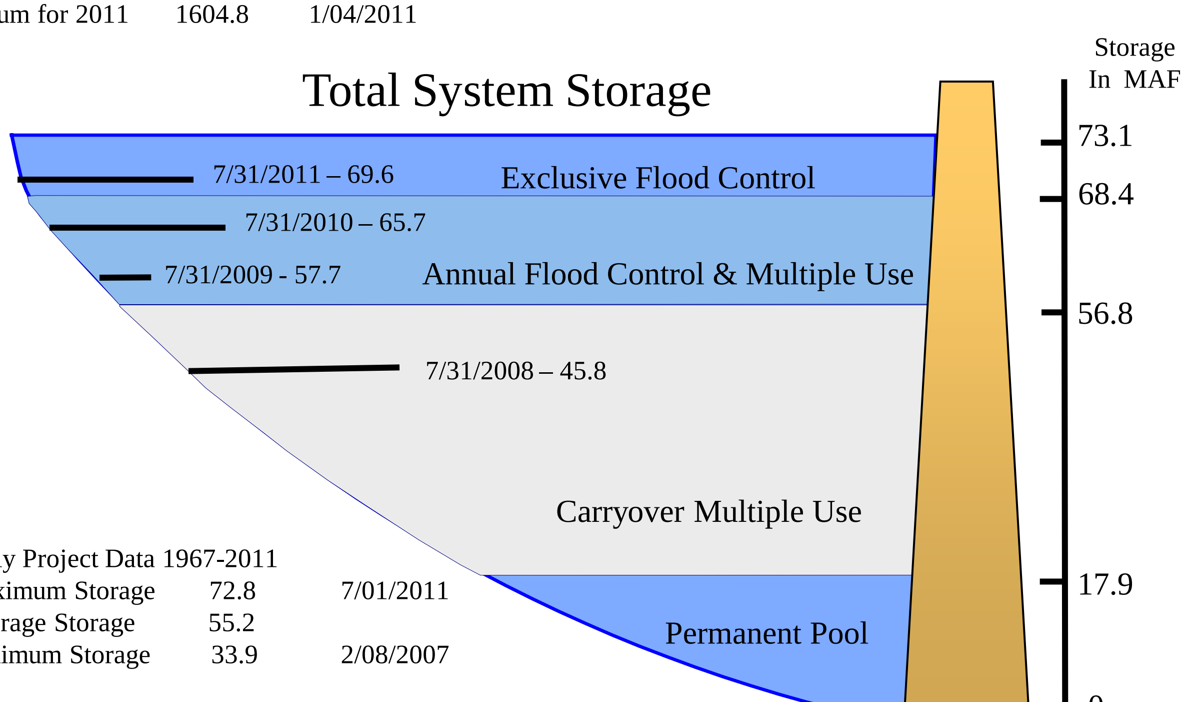
Missouri River System Reservoirs
End of July Pool Elevations and Total System Storage

Oahe



Daily Project Data 1967-2011		
Maximum Pool	1619.7	6/26/2011
Average Pool	1601.6	
Minimum Pool	1570.2	8/31/2006
Maximum for 2011	1619.7	6/26/2011
Minimum for 2011	1604.8	1/04/2011

Total System Storage



Daily Project Data 1967-2011		
Maximum Storage	72.8	7/01/2011
Average Storage	55.2	
Minimum Storage	33.9	2/08/2007
Maximum for 2011	72.8	7/01/2011
Minimum for 2011	56.7	12/30/2011

Figure 11B. End of July pool elevation for Oahe and Total System Storage.

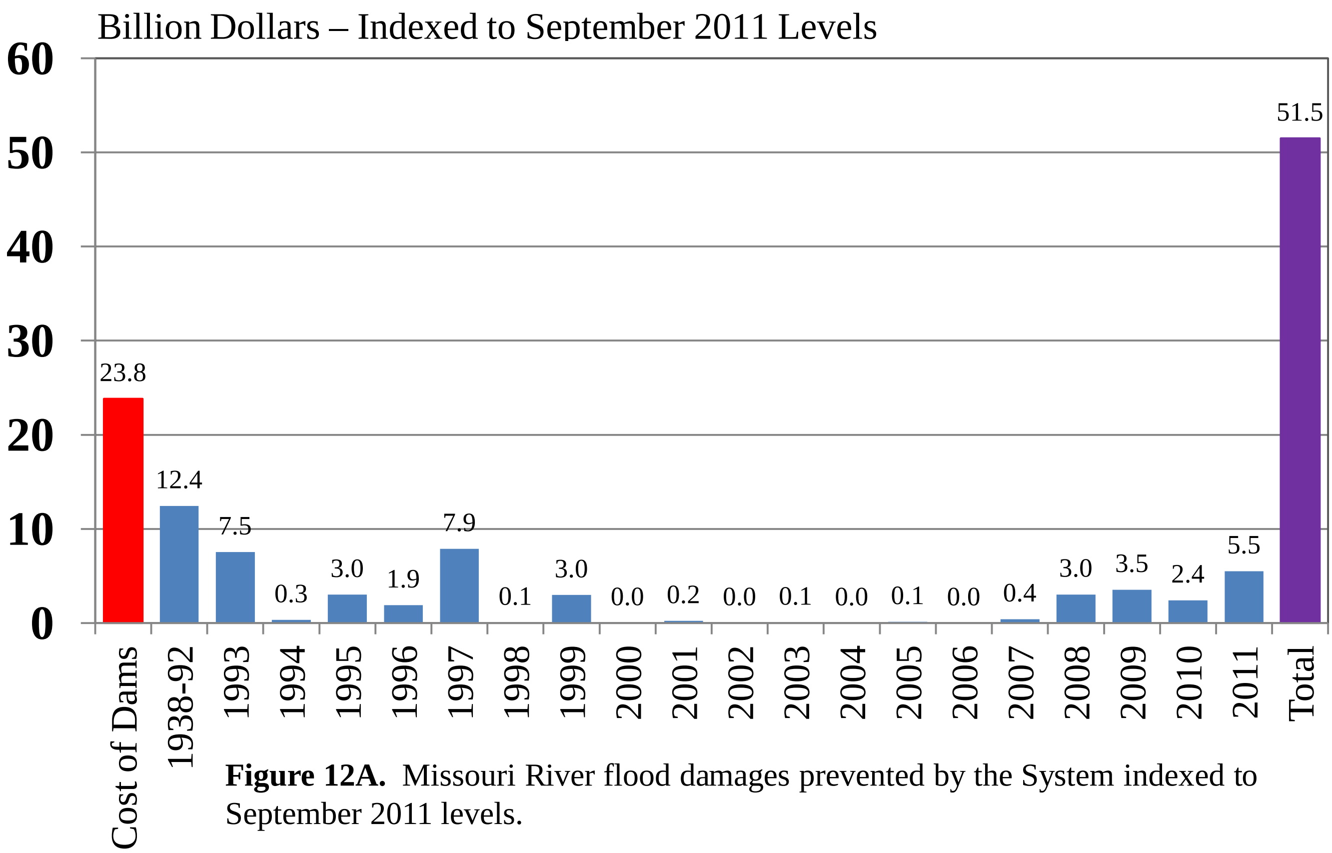


Figure 12A. Missouri River flood damages prevented by the System indexed to September 2011 levels.

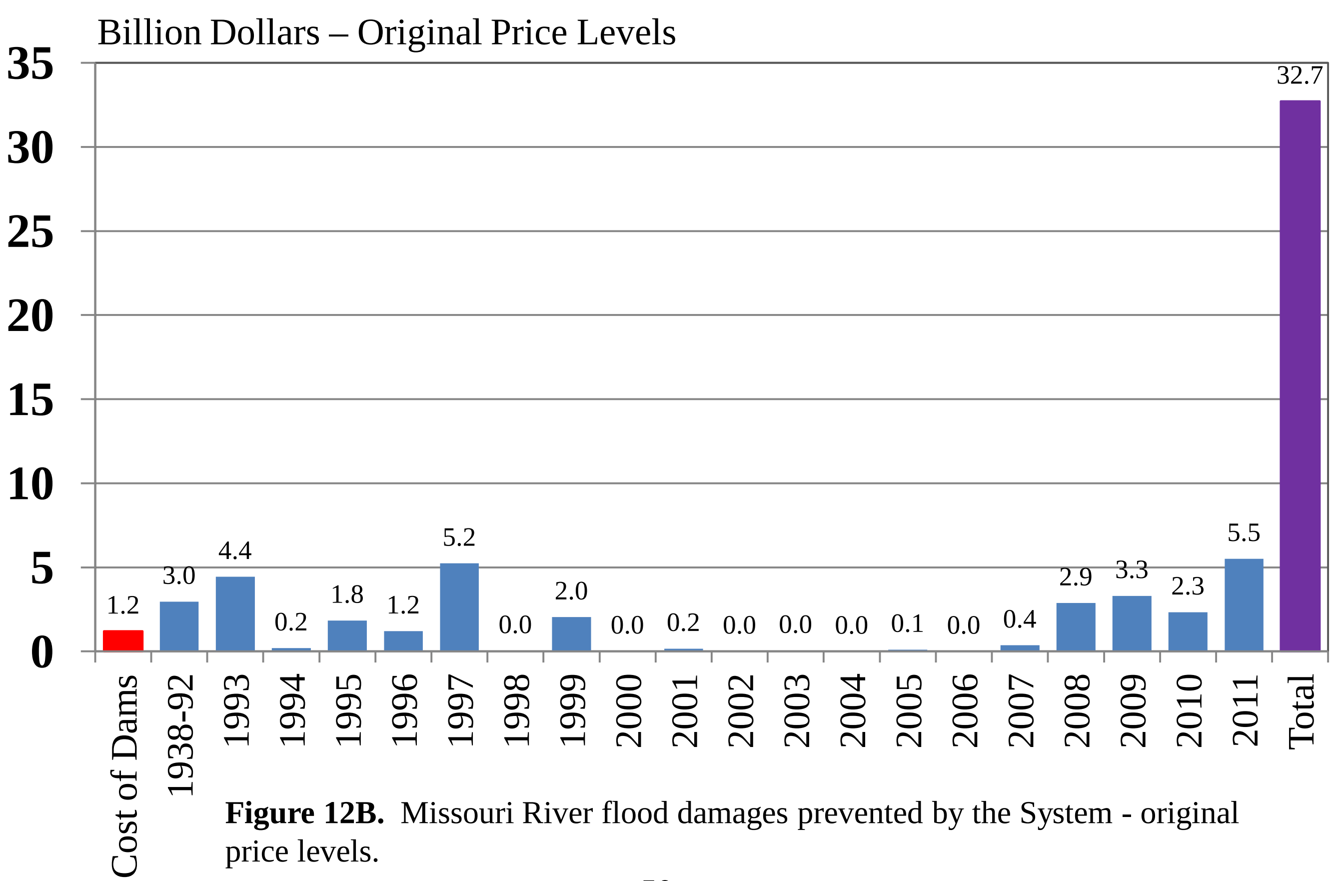
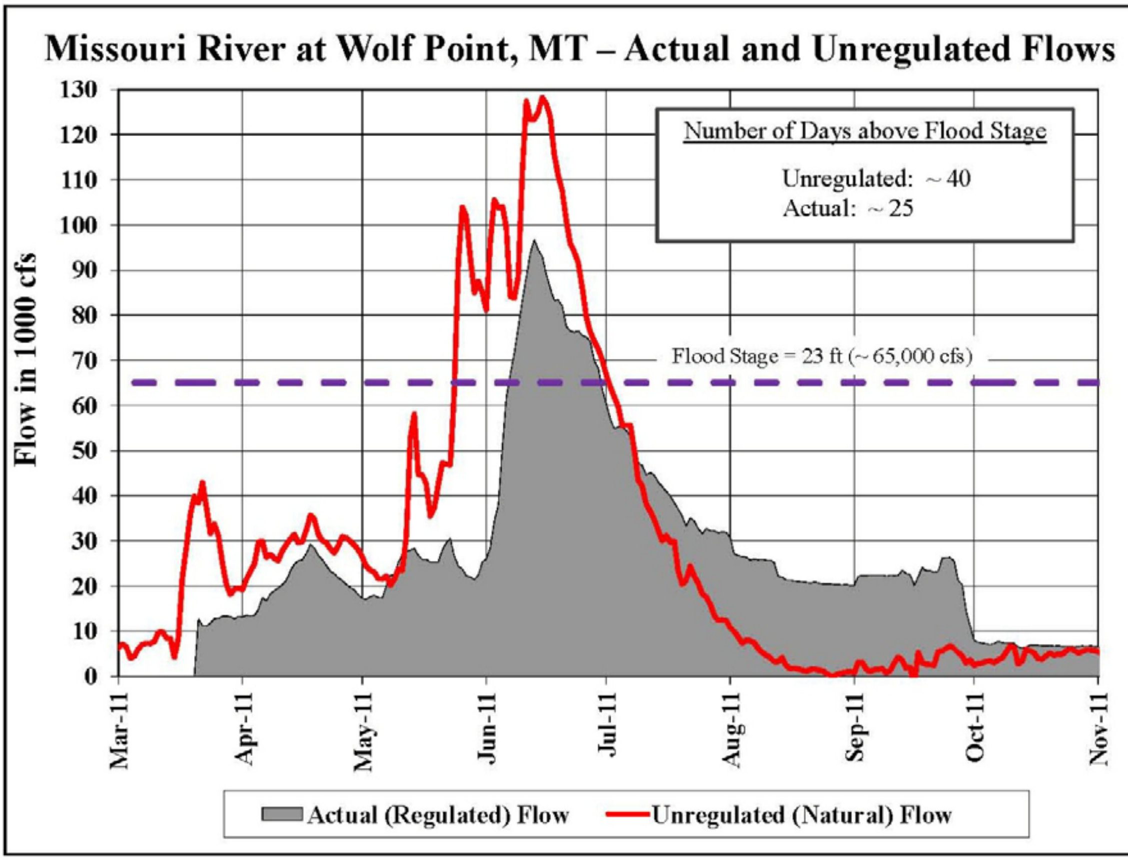


Figure 12B. Missouri River flood damages prevented by the System - original price levels.



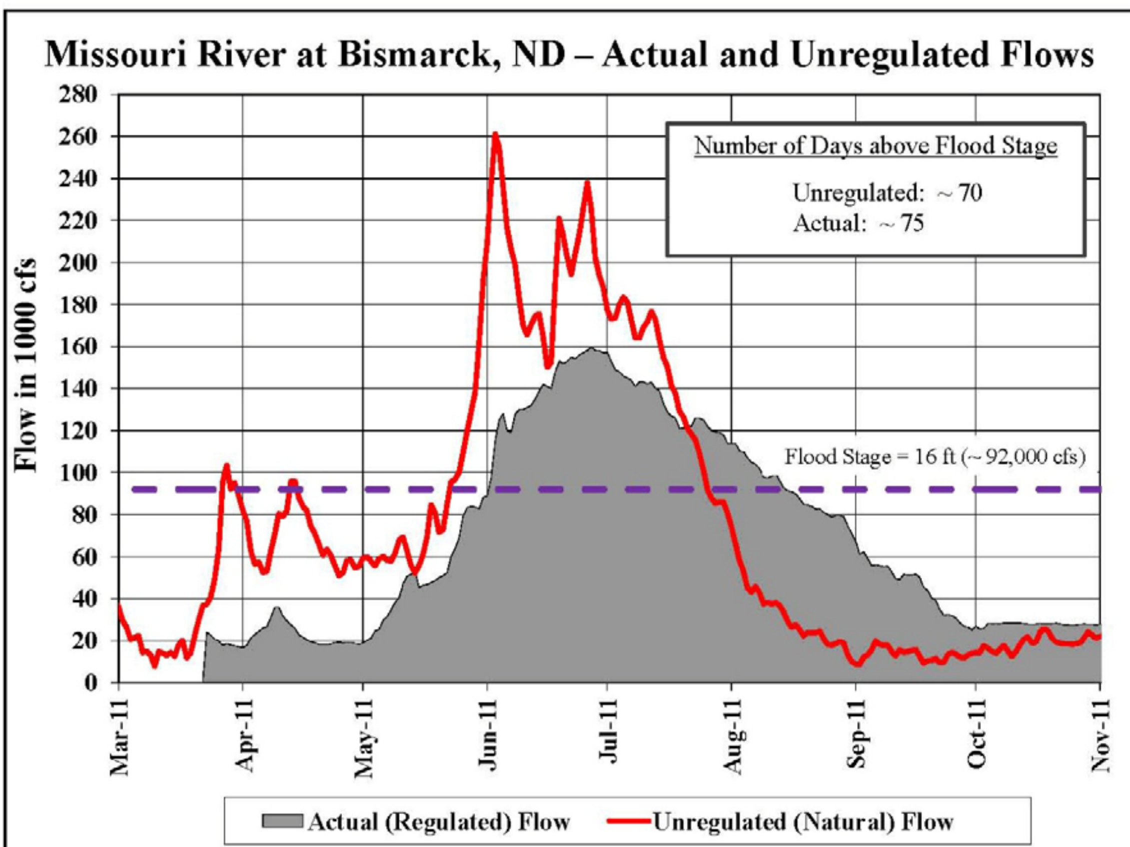


Figure 13A. Actual and unregulated flows – Wolf Point, MT and Bismarck, ND.

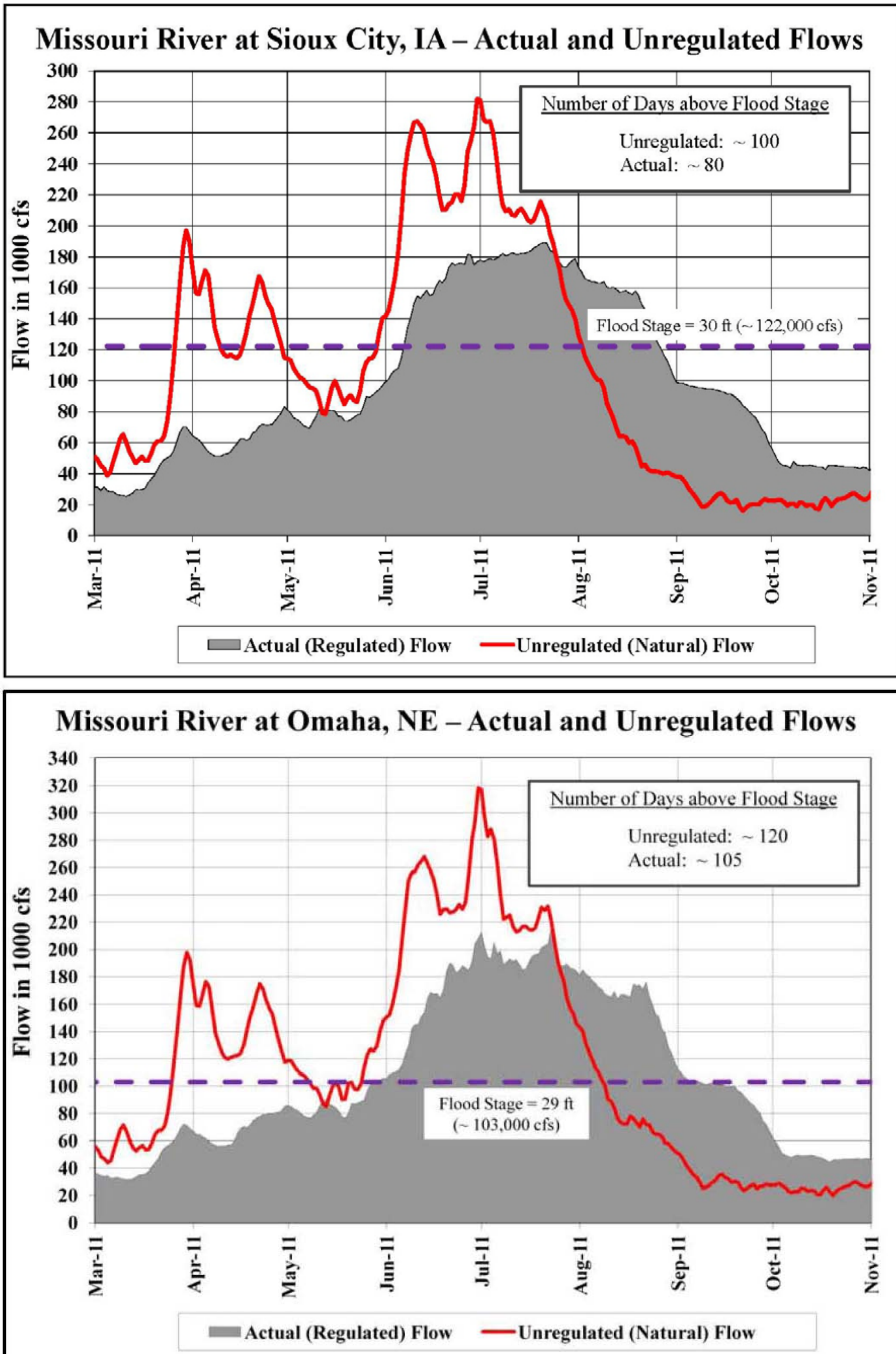


Figure 13B. Actual and unregulated flows – Sioux City, IA and Omaha, NE.

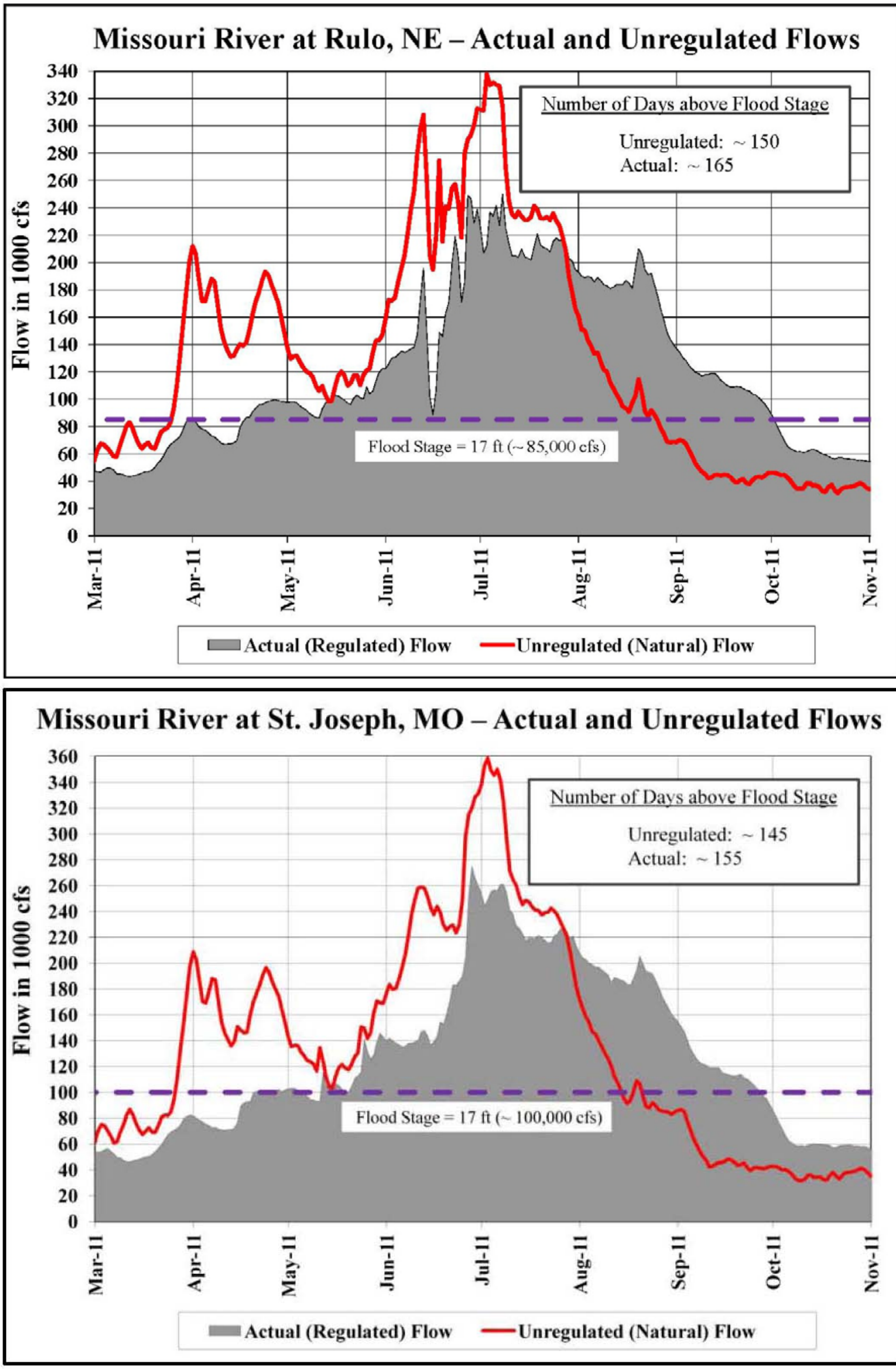


Figure 13C. Actual and unregulated flows – Rulo, NE and St Joseph, MO.

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.

Due to record inflows and releases during the summer of 2011, damages to irrigation intakes were assessed as part of the more comprehensive post-flood basin assessment jointly completed by the Corps' Omaha District (NWO) and Kansas City District (NWK).

3. Water Supply and Water Quality Control

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. This was not the case in 2011 due to record inflows and releases from all six System projects.

Due to the historic releases, stretches of the Missouri River, specifically reaches directly downstream of the projects, experienced significant channel degradation. The short-term and yet-to-be-determined long-term, resultant channel and river stage conditions may mimic low water conditions, even with normal or higher-than-normal project releases. 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.

During 2011 NWO conducted long-term, fixed-station ambient water quality monitoring at the System reservoirs and on the lower Missouri River. Water quality conditions of the water discharged through each of the System dams was continuously monitored. The intensive survey of the lower Missouri River was conducted jointly with the NWK and extended from Gavins Point Dam to the river's mouth at St. Louis.

The NWO has identified eight priority water quality issues that have relevance to the System projects. These identified priority issues are:

1) Determine how regulation of the System affects water quality in the impounded reservoir and downstream river reaches. Utilize the CE-QUAL-W2 hydrodynamic and water quality model to facilitate this effort.

2) Evaluate how eutrophication is progressing in the System reservoirs, especially regarding the expansion of anoxic conditions in the hypolimnion during summer stratification.

3) Determine how flow regime, especially the release of water from System projects, affects water quality in the Missouri River.

4) Determine how current water quality conditions in the Missouri River (e.g., water temperature, turbidity) may be affecting pallid sturgeon populations in the Missouri River.

5) Provide water quality information to support Corps reservoir regulation elements for effective surface water quality and aquatic habitat management.

6) Provide water quality information and technical support to the 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.

7) Identify existing and potential surface water quality problems at NWO projects and develop and implement appropriate solutions.

8) Evaluate surface water quality conditions and trends at NWO projects.

Table 12 provides a summary of water quality issues and concerns at each of the System projects based on NWO monitoring and a review of current State integrated water quality reports.

The State of North Dakota's water quality standards protects the Garrison Reservoir (Lake Sakakawea) for a coldwater fishery. Water temperature and dissolved oxygen levels are primary water quality factors that determine the suitability of water for coldwater aquatic life. The State of North Dakota has defined coldwater fish habitat in Lake Sakakawea as being ≤15 °C and having dissolved oxygen levels ≥ 5 milligrams per liter (mg/l). The State recently promulgated the following water quality standards to protect coldwater habitat in Lake Sakakawea:

- A hypolimnetic maximum temperature criterion of 15°C for Class 1 lakes and reservoirs, including Lake Sakakawea, that are thermally stratified.

- Lake Sakakawea must maintain a minimum volume of water of 500,000 AF that has a temperature of 15°C or less and a dissolved oxygen concentration of not less than 5 mg/l.

Maintaining coldwater habitat in Lake Sakakawea has proven to be a challenge during the recent droughts. Coldwater habitat in Lake Sakakawea is supported by thermal stratification that allows a quiescent, coldwater zone (i.e., hypolimnion) to exist in the lower depths of the reservoir during the summer. Lake Sakakawea is a bottom-withdrawal reservoir, and the invert elevation of the intake portals to the powerplant is 2 feet above the reservoir bottom. Thus, during the summer thermal stratification period, water is drawn from the coldwater habitat volume of the reservoir and discharged through the powerplant. Lower pool levels resulting from drought conditions (i.e., 2003 through 2008) also reduced the hypolimnetic volume of Lake Sakakawea. During the recent drought years, the lower pool elevations reached a point where the reduced hypolimnetic volume of cold water, in concert with the degradation of

Table 12
Water Quality Issues and Concerns in the Omaha District

Project	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 Recreation	Lead Mercury Aquatic Plants - Native	No NA**	Yes	Mercury	---
• Missouri River, Fort Peck Dam to the Milk River	Yes (MT)	Aquatic Life Cold Water Fishery	Water Temperature Degraded riparian vegetation Other flow regime alterations	No NA**	No	---	---
• Missouri River, Milk River to the Poplar River	Yes (MT)	Aquatic Life Warm Water Fishery	Water Temperature Degraded riparian vegetation Other flow regime alterations	No NA**	No	---	---
• Missouri River, Poplar River to North Dakota	Yes (MT)	Aquatic Life Warm Water Fishery	Water Temperature Other flow regime alterations	No NA**	No	---	---
Garrison • Lake Sakakawea	Yes (ND)***	Fish Consumption	Methyl-Mercury	No	Yes	Mercury	Coldwater fishery during drought conditions Hypolimnetic 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	No	---	---	---	No	---	---
Big Bend • Lake Sharpe	Yes	Coldwater Permanent Fish Life	Temperature	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	No	---	---	---	No	---	---
Gavins Point • Lewis and Clark Lake	Yes	Aquatic Life	Nutrients (Total Phosphorus and Total Nitrogen)	No	No	---	Sedimentation Emergent aquatic vegetation
• Missouri River, Gavins Point Dam to the Big Sioux River	No	---	---	---	No	---	Reduced suspended sediment and turbidity impacts to pallid sturgeon. Assimilative capacity and flow reduction
• Missouri River, Big Sioux River to Platte River	Yes (NE)	Aquatic Life	Cancer Risk and Hazard Index Compounds (Primarily PCBs and Dieldrin)	No	Yes	Dieldrin PCBs	Reduced suspended sediment and turbidity impacts to pallid sturgeon. Assimilative capacity and flow reduction
• Missouri River, Boyer River to Council Bluffs water supply intake	Yes (IA)	Drinking Water	Arsenic	No	No	---	---
• Missouri River, Platte River (NE) to Kansas	Yes (NE)	Recreation Aquatic Life	*E. coli* Cancer Risk and Hazard Index Compounds (Primarily PCBs and Dieldrin)	Yes (*E. coli*)	Yes	Dieldrin PCBs	Reduced suspended sediment and turbidity impacts to pallid sturgeon. Assimilative capacity and flow reduction

* Information taken from published state Total Maximum Daily Load (TMDL) 303(d) reports and listings as of January 1, 2011.
** Impairment identified in Montana's integrated report, but not on 303(d) list for development of a TMDL.
*** Was delisted in 2010 for impairment to Fish and other Aquatic Biota (water temperature and low dissolved oxygen) when Lake Sakakawea pool elevations recovered from drought conditions.

dissolved oxygen in the deeper water of the reservoir, limited the maintenance of coldwater habitat through the end of the summer thermal stratification period. During this period, North Dakota listed Lake Sakakawea as impaired for Fish and Other Biota on the State's 303(d) list due to warm water temperatures and low dissolved oxygen levels. The 2010 North Dakota Integrated Water Quality Report delisted Lake Sakakawea. The delisting was based on the 500,000-AF requirement for coldwater habitat being met with a return to "normal" pool levels.

Water temperature and dissolved oxygen depth profiles that were measured during water quality monitoring conducted at Lake Sakakawea over the 9-year period (2003 through 2011) were used to estimate the volume of water in the reservoir that meets the coldwater habitat conditions defined by the State of North Dakota. ***Plate 3*** shows estimated reservoir and coldwater habitat volumes by year for 2003 through 2011. Coldwater habitat estimated in the Lake Sakakawea during 2009 and 2010 was significantly greater compared to the other years, and were the only years during the 9-year period that the 500,000-AF minimum water quality standards criterion for coldwater habitat was seemingly met. Coldwater habitat estimated in Lake Sakakawea during 2011 was less than that estimated for 2009 and 2010 and fell below the 500,000-AF minimum in late September. This occurred in 2011 even though Lake Sakakawea experienced extreme high pool levels into early August due to extreme runoff and flooding. Two possible explanations for the 2011 situation are:

1) Record high discharges occurred at Garrison Dam in 2011 to manage extreme flooding. Daily outflow from Garrison Dam averaged 89,900 cfs (178,000 AF/day) over the 5-month period from May through September. These outflows resulted in a flushing time of 134 days. The flushing time is computed by determining the amount of time (days) to replace the July 1 volume of 23.8 MAF, based on the average daily outflow over the May-September 5-month period (89,900 cfs, or 178,000 AF). This compares to flushing times of 385, 380, 429, 326, 440, 521, 655 and 654 days for 2003, 2004, 2005, 2006, 2007, 2008, 2009 and 2010, respectively. The flushing time in 2011 was almost five times less than the 2009 and 2010 times. The lower flushing time in 2011 may have resulted in greater dissolved oxygen degradation in the hypolimnion because hypoxic water was drawn from the upstream reaches of the reservoir to the dam at much faster rates due to record releases. This may have resulted in the occurrence of low dissolved oxygen conditions in the downstream reaches of the reservoir that "pinched off" coldwater habitat from below. This did not occur in 2009 and 2010 under the high flushing times.

2) September 2011 water quality monitoring at Lake Sakakawea happened to occur just prior to the complete fall turnover of the reservoir. At that time water temperatures were approaching isothermal conditions above 15°C and the 15°C maximum temperature criterion was exceeded. Past water quality monitoring at Lake Sakakawea has indicated that the 15°C maximum temperature criterion for coldwater habitat is regularly exceeded by up to 3°C for a short time period at fall turnover. The criterion is exceeded until water temperatures cool below 15°C.

Thermal stratification of the Fort Randall Reservoir (Lake Francis Case) during the summer results in the development of hypoxic conditions in the reservoir's hypolimnion. Lake Francis Case is a bottom-release reservoir, and hypoxic water is passed through Fort Randall Dam during power production during July and August. Under these conditions, dissolved oxygen levels in areas of the Fort Randall Dam tailwaters fall below South Dakota's water quality standards' minimum dissolved oxygen criterion of 5 mg/l. Conditions monitored in 2010 indicated that the low dissolved oxygen levels in the tailwaters are not seemingly impairing the designated Warmwater Permanent Fish Life Propagation beneficial use as regions of refugia exist in the impacted area. In addition, there is no evidence of current or past summer fish kills in the Fort Randall Dam tailwaters attributable to hypoxic conditions. If warranted, dissolved oxygen conditions in the Fort Randall Dam tailwaters, during periods of hypoxic dam releases, could be mitigated by drawing water from the reservoir's surface and spilling it down the spillway. This was not an issue in 2011, as flood conditions required spillway releases the entire summer.

At this time, Nebraska does not have approved nutrient criteria in the State's water quality standards. In the interim, the Nebraska Department of Environmental Quality (NDEQ) and the U.S. Environmental Protection Agency (EPA) have agreed to nutrient and chlorophyll targets for beneficial use support assessments. The interim targets for chlorophyll *a*, total phosphorus and total nitrogen are 10 micrograms per liter (µg/l), 50 µg/l and 1,000 µg/l, respectively, and apply to a lake growing season of May through September. If the growing season's mean concentrations exceed any of these three targets, an impaired status to the Aquatic Life use will be noted and the cause of this impairment will be listed as "nutrients". The Aquatic Life use of the Gavins Point Reservoir (Lewis and Clark Lake) has been identified as impaired due to nutrients based on these criteria.

4. Navigation

The first towboat using the Missouri River in 2011 was the *Motor Vessel* (*MV) Jamie Leigh*, which is owned by Jefferson City River Terminal, entering the Missouri River on March 20 with four barges loaded with cement and headed to the Jefferson City, MO terminal at river mile (RM) 143. The *MV Mary Lynn*, operated by River Marine Enterprises, was the first towboat to arrive at the AgriServices Terminal, Brunswick, MO (RM256) with six barges loaded with fertilizer on March 27. The *MV Mary Lynn* made a second trip passing Kansas City, MO (RM367) and arriving at Nebraska City, NE (RM462) on April 14 with four fertilizer-loaded barges. On making its third trip, the *MV Mary Lynn* was the first tow to arrive at Blair, NE (RM648) on May 22. The eight barges were loaded with plant construction equipment for Novozymes, a new enzyme production plant to support the ethanol industry. The *MV Mary Lynn* left Blair a few days later, just at the beginning of the flood of 2011.

On June 7, due to record releases being made from Gavins Point Dam, the Coast Guard, in coordination with the Corps and basin responders, closed the Missouri River to all traffic from RM 811 to RM550. By July 11 the Coast Guard closed the Missouri River in reach phases that finally closed the river to all traffic from RM811 to RM226.3 (see ***Table 13)*.** The Coast Guard opened the river to traffic in reach phases, eventually opening the entire river to traffic on September 27. With the reopening of the river and the Corps' announcement that the flood releases supporting navigation support flows would be extended to December 10, the Jefferson River Terminal and Magnolia Marine Transportation accelerated their towing services by bringing in extra towboats to supply the basin with cement and asphalt rebuilding materials of high demand to repair infrastructure flood damages. The River Marine Enterprises also increased its towing service by providing general agricultural and equipment deliveries. The *MV Mary Lynn* made two more trips to Blair, delivering twelve barges of Novozymes plant equipment delayed by the river closings.

Table 13

Coast Guard - Missouri River Closure and Re-Opening Events

	Missouri River – River Mile Reach		
Date	**Closed**	**Re-Opened**	**Open**
Jun 7[1]	811 - 550		550 - mouth
Jun 17	811 - 450		450 - mouth
Jun 24	811 - 397		397 - mouth
Jun 27	811 - 386		386 - mouth
Jul 11	811 - 226.3		226.3 - mouth
Aug 18	811 - 256	256 - 226.3	256 - mouth
Aug 25	811 - 380	380 - 256	380 - mouth
Sep 3	753 - 380	811 - 753	811 - 753 & 380 - mouth
Sep 9	753 - 498	498 - 380	811 - 753 & 498 - mouth
Sep 27[2]		753 - 498	811 - mouth

[1] Also closed Big Sioux River from Military Road Bridge to confluence with Missouri River

[2] Also opened Big Sioux River from Military Road Bridge to confluence with Missouri River

There were ten river reaches that had mild to significant flood damages that challenged navigation during October and November with groundings, delays and stoppages because of excessive shoaling, narrow channels and swift currents. The two most challenging river mile locations were at RM133 and RM213. At RM133 shoaling and a narrow channel stopped several tows for a few days. The Corps' Missouri River Area Office maintenance fleet staff repaired some of the nearby damaged structures to return more river flow back into the navigation channel. In addition to the stoppage, some of the tows had to break the barges apart and make separate trips with single barges to get through problem areas. In one incident, an Ellis Construction boat assisted by pulling on the head end of the *MV Mary Lynn* tow that was stuck to the river bank due to the narrow channel and swift current at RM213.

There were two towboats that tied for the last-to-use the Missouri River for the 2011 season. On December 14 the *MV Jamie Leigh* delivered two cement loads to Jefferson City, MO and the *MV Kathryn Ann*, owned by Hermann Sand and Gravel, delivered two loads of fire clay to St. Louis, MO. There were no tows with a Sioux City, IA (RM735) destination during 2011.

Table 14 shows the Missouri River tonnage data for 2007 – 2010 compiled by the Waterborne Commerce Statistics Center (WCSC). The 2010 total of 4.831 million tons includes 4.346 million tons for sand and gravel, 0.105 million tons for waterways materials, and 0.380 million tons for long-haul commercial tonnage. The reduction of total tonnage of 0.205 million tons compared to 2009 was due to permit restrictions on the sand and gravel river mining companies that began in 2008 and also the downturn of building construction that began at the end of 2007. In 2010, the 0.380 million tons of long-haul commercial tonnage increased by

0.110 million tons from 2009. The largest total tonnage year was 2001 at 9.73 million tons. The largest long-haul commercial tonnage, excluding sand, gravel and waterway material, occurred in 1977 at 3.34 million tons. ***Figure 14A*** shows total navigation tonnage on the Missouri River and ***Figure 14B*** shows the long-haul commercial navigation tonnage. The Missouri River long-haul commercial tonnage in 2011 is currently estimated to total about 0.355 million tons, based on carrier interviews, towboat activity and barge counts from the Corps' daily boat reports. ***Figure 15A*** shows the navigation tonnage value of the commodities since 1960, using 2012 present-worth computations. ***Figure 15B*** shows the navigation tonnage value of long-haul commercial commodities since 1960. The ***Figures 14A***, ***14B***, ***15A*** and ***15B*** tonnages and tonnage values for 2011 are estimates and will change once final WCSC tabulations are available.

Table 14
Missouri River Tonnage by Commodity (1000 Tons)

Commodity Classification Group	2007	2008	2009	2010
Farm Products	0	0	18	35
Corn	0	0	4	13
Wheat	0	0	0	0
Soybeans	0	0	14	23
Misc Farm Product	0	0	0	0
Nonmetallic Minerals	6283	5415	4666	4388
Sand/Gravel	6281	5415	4649	4346
Misc Nonmetallic	2	0	17	42
Food and Kindred	28	16	32	36
Pulp and Paper	0	0	0	0
Chemicals	7	5	26	72
Fertilizer	5	4	24	70
Other Chemicals	2	1	2	1
Petroleum (including coke)	132	87	120	118
Stone/Clay/Glass	130	55	57	76
Primary Metals	0	0	0	0
Waterway Materials	101	81	117	105
Other	3	12	0	0
Total Commercial	6684	5671	5036	4831
Total Long-Haul Commercial	303	175	270	380

Navigation season target flows for past years are given in ***Table 15***. ***Table 16*** shows the scheduled lengths of past System-supported navigation seasons, with total tonnage and ton-miles for each year.

Figure 16 presents discharge data at Sioux City, IA; Nebraska City, NE and Kansas City, MO, three of the four navigation flow-target locations for 2011. The three graphs demonstrate that actual flows at these locations were greatly influenced by record System releases.

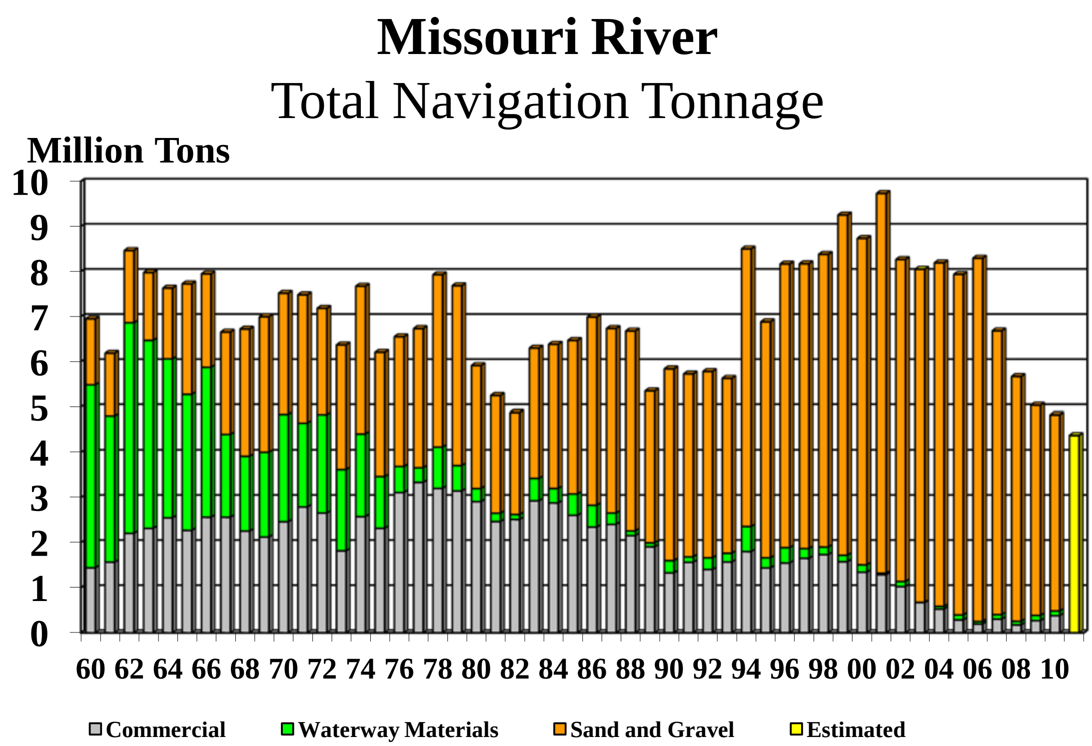


Figure 14A. Missouri River total navigation tonnage from 1960 to 2011 (estimated).

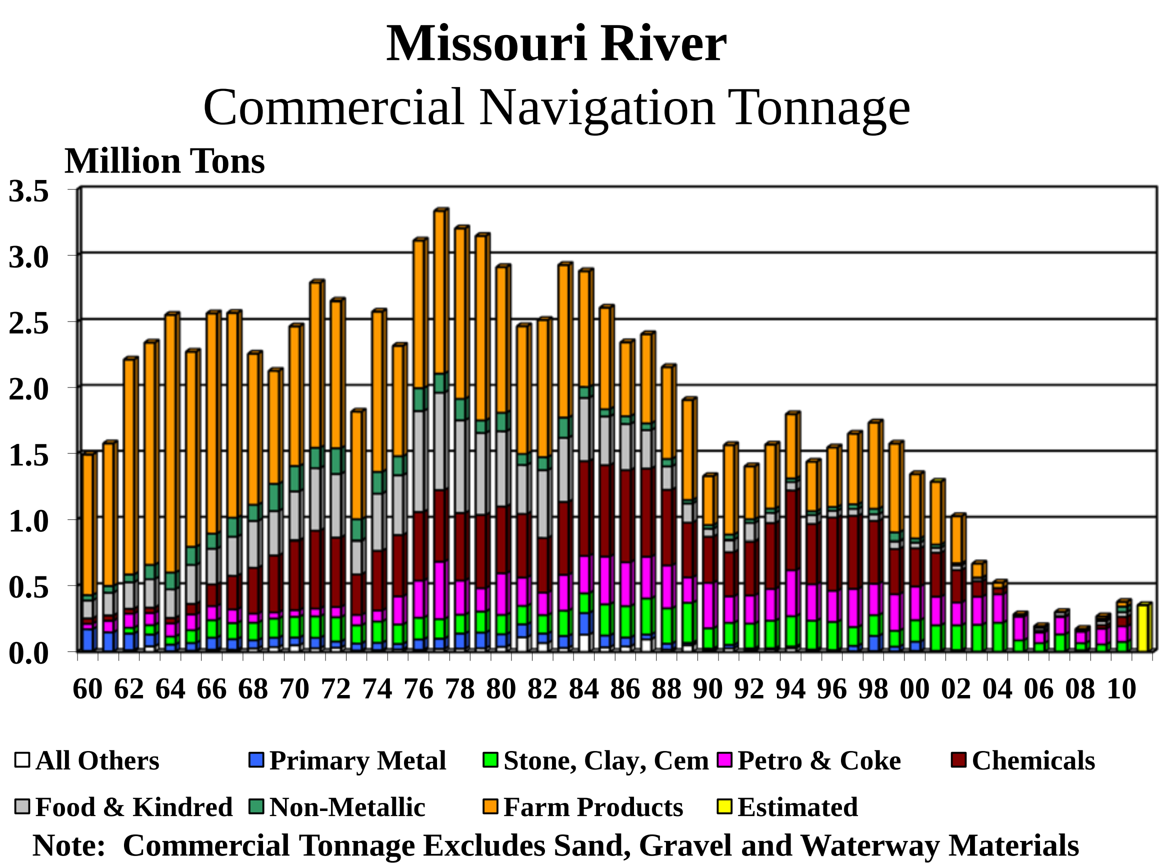


Figure 14B. Missouri River commercial navigation tonnage from 1960 to 2011 (estimated).

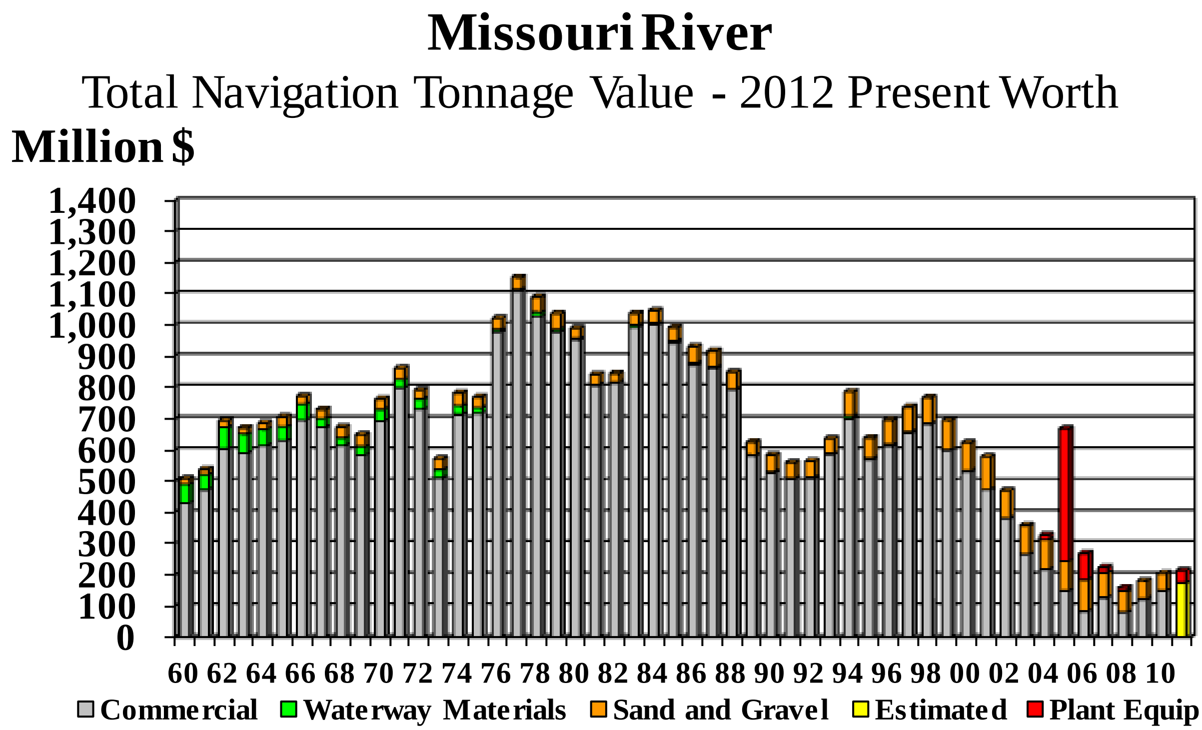


Figure 15A. Total navigation tonnage value using 2012 present worth computations.

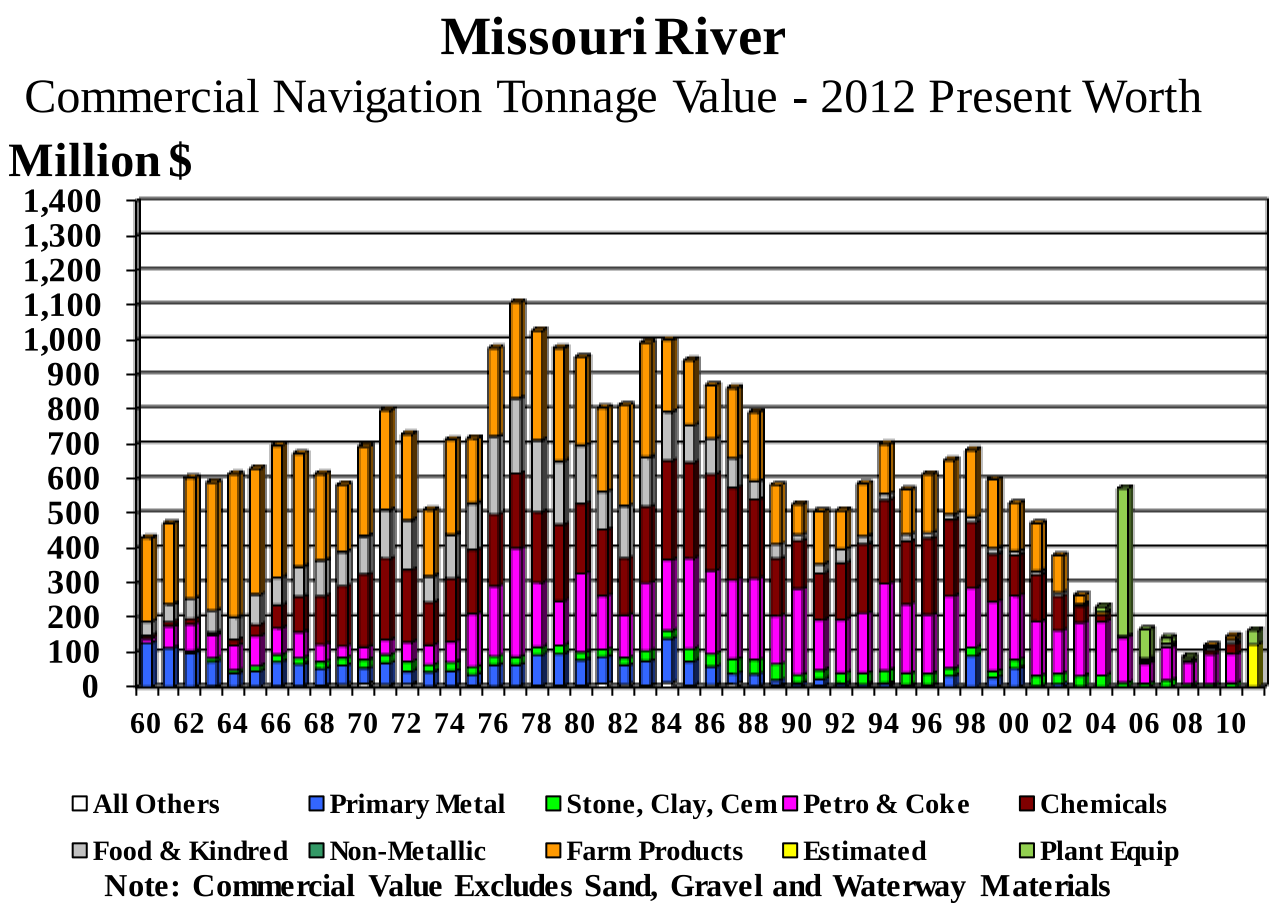


Figure 15B. Commercial navigation tonnage value using 2012 present worth computations.

Table 15
Navigation Season Target Flows
(1000 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)	*	*	*	*

(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 16
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(12)	4,829,714(12)	132,747(12)
2011	8(4)	355,000(13)	4,000,000(13)	120,000(13)

(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) Preliminary
(13) Estimated using boat report barge counts.

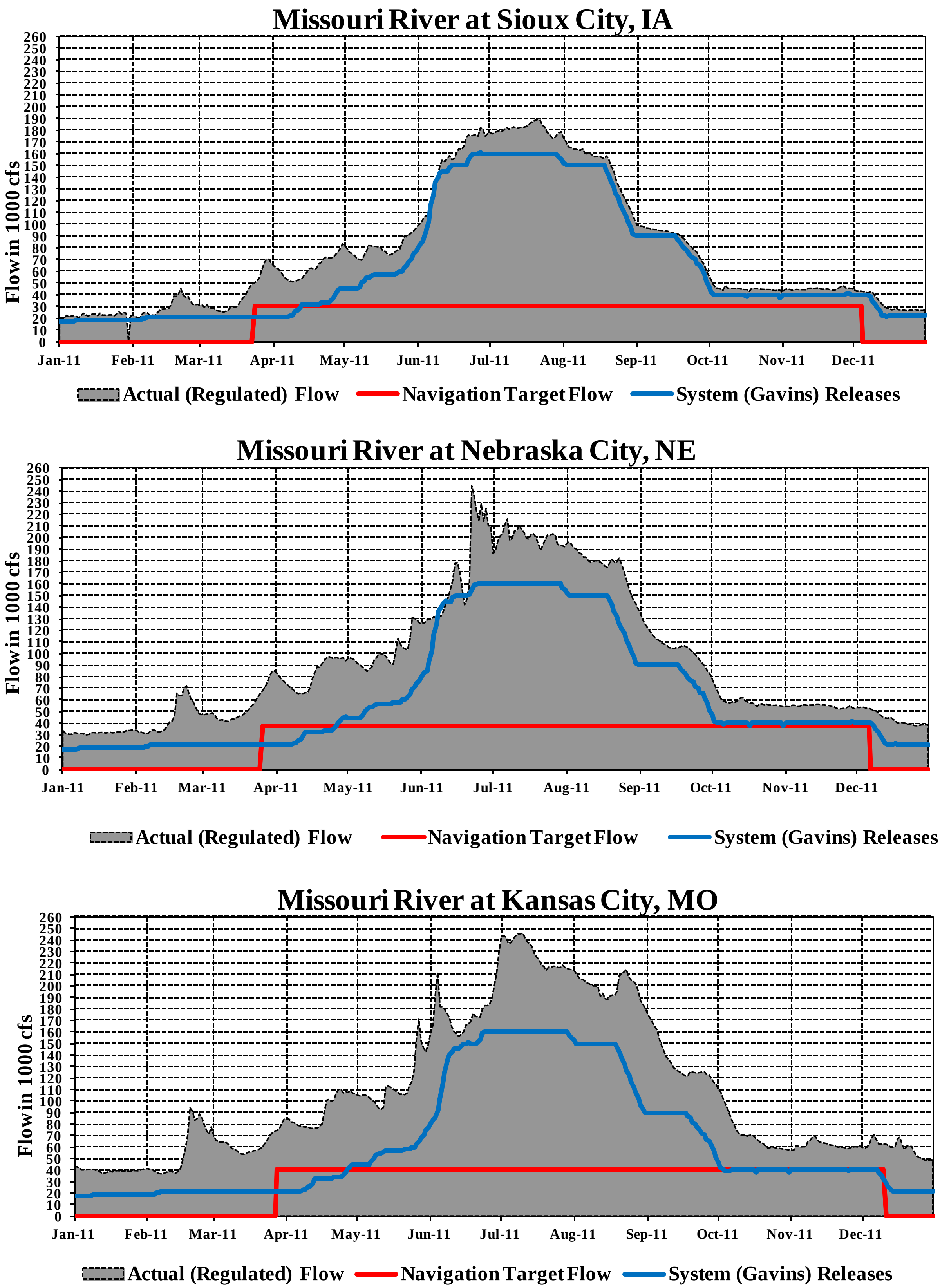


Figure 16. Actual flow, System releases and navigation target flows – Sioux City, IA; Nebraska City, NE and Kansas City, MO.

Supplemental Missouri River navigation support from the Kansas River reservoir projects was not required during the 2011 navigation season.

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

The energy generated in 2011 was transmitted over a Federal transmission system that traverses 7,920 circuit miles. This past year, service was provided to over 360 wholesale customers. Customers in a 6-state area receiving direct service include 200 municipalities, 2 Federal agencies, 29 state agencies, 26 USBR projects, 5 irrigation districts, 37 rural electric cooperatives, 6 public utility districts, 11 private utilities, 26 Native American Services and 24 power marketers. Additional benefits were provided by the interconnections to the Southwestern and Bonneville Power Administrations and other areas of the Western Area Power Administration (Western).

Statistics from the Omaha Public Power District (OPPD) show that the average customer uses approximately 11,750 kilowatt hours (kWh) of energy annually. Based upon the total System generation of 11.1 billion kWh, the energy generated in CY 2011 by this portion of the Federal power system could have supplied all of the yearly needs of about 945,000 residential OPPD customers. In addition to the clean, renewable energy transmitted to the Midwest area, System hydropower provides an added measure of stability to the regional power system with the ability to meet full load in 5 seconds or less. Large coal-fired and nuclear units are reinforced by idle hydropower units, typically in 30 seconds. Outside utilities benefit through reserve sharing by calling on the hydropower capability within several minutes of a known problem. In addition, hydropower generation can be integrated with wind generation to provide balance to the regional power system. This balance is achieved by using hydropower to rapidly respond to the increased power system variation and forecast errors caused by wind. Currently, there is approximately 825 MW of wind generation capability in Western's balancing area.

The excellent reliability of System hydropower is indicated by having to maintain a 10% reserve, while thermal power must maintain a 15% reserve. Although the Federal hydropower that serves the Missouri River region accounts for only 9% of the region's energy, it is large enough to fill gaps and provide a positive benefit to the integrated system.

Hydropower generation in 2011 was 11.1 billion kWh, which was 119% of average since the System first filled in 1967 and the highest since 1999 when 11.2 billion kWh were generated. The 2011 generation was 2.4 billion kWh more than the 2010 generation of 8.7 billion kWh and 7.2 billion kWh more than the record low of 4.9 billion kWh, set in 2008. Generation was much higher in 2011 due to the increased releases from the System projects. Western purchased about 2.1 billion kWh between January 1, 2011 and December 31, 2011, at a cost of $87.5 million to supplement System hydropower production.

Despite record runoff and releases in 2011, the ability to maximize hydropower generation for the System was adversely affected by a variety of factors. The water evacuation strategy required continued high releases in the late summer and early fall, but much lower releases for the remainder of the fall, generally increasing the overall water spilled. Hydropower generation was also limited by transmission loading relief (TLR). A TLR occurs when generation is curtailed to prevent transmission equipment from exceeding established operating limits in congested areas. Low demand during parts of the year also limited the ability to generate hydropower and required additional spilled water. Lastly, hydropower unit maintenance and other scheduled work required spills during parts of the fall despite the lower release levels. In contrast, the 1997 energy market allowed for much-higher–than-normal generation throughout the summer and fall, and much of the fall hydropower unit maintenance was re-scheduled to the spring or was cancelled and performed in subsequent years.

System generation with individual project distribution for each calendar year in million megawatt hours (MWh) (billion kWh) since 1954 is shown on ***Figure 17***. The total generation from the Federal system (peak capacity and energy sales) for 2011 is shown in ***Table 17***. The tabulations in ***Table 18*** and ***Table 19*** summarize the total gross generation and power regulation 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 17
Gross Federal Power System Generation – January 2011 through December 2011

	Energy Generation 1000 kWh	**Peak Hour kW**	**Generation Date**
Corps Powerplants – Mainstem			
Fort Peck	1,261,676	210,000	June 9
Garrison	2,598,123	407,000	May 17
Oahe	3,335,737	717,000	June 10
Big Bend	1,607,136	418,000	June 9
Fort Randall	1,684,721	364,000	April 29
Gavins Point	644,665	119,000	April 21
Corps Subtotal	**11,132,058**	**2,051,000**	June 5
USBR Powerplants			
Canyon Ferry	421,461	57,000	June
Yellowtail*	556,996	129,000	July
USBR Subtotal	**978,457**	**186,000**	
Federal System Total	**12,110,515**	**2,237,000**	

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

System Power Generation 1954 - 2011

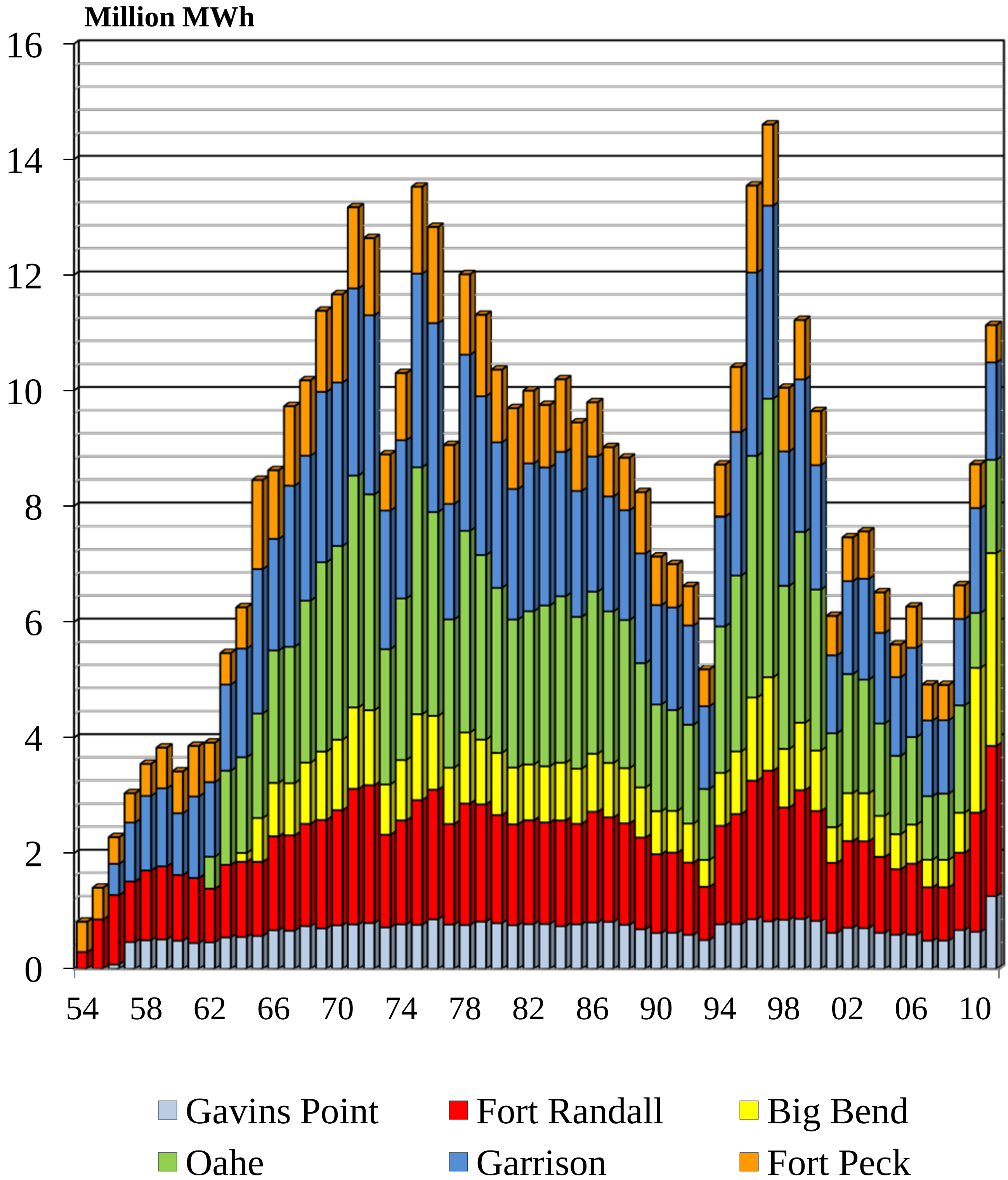


Figure 17. System power generation by project from 1954 to 2011.

Table 18
Historical Generation and Load Data - Peaks
Eastern Division, Pick-Sloan Missouri Basin Program*
Data at Plant (1000 kW)
January 1, 2011 through December 31, 2011

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	1402		70		1,472		470		1,942	Jan 19	8:00
February	1305		69		1,374		550		1,924	Feb 18	8:00
March	1525		54		1,579		254		1,833	Mar 2	8:00
April	1129		74		1,203		75		1,278	Apr 5	8:00
May	1662		153		1,815		225		2,040	May 10	18:00
June	1839		171		2,010		320		2,330	Jun 29	17:00
July	1841		177		2,018		463		2,481	Jul 19	18:00
August	1875		176		2,051		525		2,576	Aug 1	15:00
September	1814		125		1,939		214		2,153	Sep 1	16:00
October	1614		77		1,691		154		1,845	Oct 27	8:00
November	1803		60		1,863		387		2,250	Nov 21	8:00
December	1466		63		1,529		229		1,758	Dec 6	8:00

* This tabulation summarizes the total gross generation and power operations for the Eastern Division marketing area system shown on Table 17.
** During hour of peak total system load

Table 19
Historical Generation and Load Data - Total
Eastern Division, Pick-Sloan Missouri Basin Program*
Data at Plant - (1000 kWh)
January 1, 2011 through December 31, 2011

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	745,167		61,530		806,697		222,910		1,029,607
February	655,090		54,952		710,042		132,091		842,133
March	630,536		56,315		686,851		108,080		794,931
April	778,984		89,458		868,442		37,217		905,659
May	1,114,298		110,232		1,224,530		36,348		1,260,878
June	1,134,582		117,543		1,252,125		61,158		1,313,283
July	1,173,766		129,228		1,302,994		95,923		1,398,917
August	1,186,722		122,261		1,308,983		59,896		1,368,879
September	1,027,800		72,878		1,100,678		45,473		1,146,151
October	882,469		72,368		954,837		47,886		1,002,723
November	997,580		64,036		1,061,616		43,305		1,104,921
December	805,023		63,850		868,873		88,536		957,409

*Powerplants from Table 17

6. 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 1-foot deep and are subject to desiccation through wave action and slight drops in water level. In the Fort Peck Reservoir, a forage fish spawn normally occurs between April 15 and May 30.

North Dakota Game and Fish Department reported that the high releases in 2011 caused the thermocline in Lake Sakakawea to develop exceptionally deep, and entrainment of virtually all species was documented with these releases. Of major concern is the cumulative impact of entrainment on the rainbow smelt population. Entrainment rates were highest after the standard survey was conducted and the impacts of 2011 releases will not be known until 2012 surveys are completed. Paddlefish entrainment was also exceptionally high with high mortalities noted. Recovery of tagged fish below Garrison indicated some did survive entrainment. Tagged walleye returns further showed high walleye entrainment. Salmon fishing on Garrison was generally slow due the high entrainment of salmon.

With the rising water levels in 2011, South Dakota Game, Fish and Parks survey estimates indicate Lake Oahe experienced above average fish production for the third consecutive year. Both sport- and bait-fish have benefited from the high water levels and have resulted in increased angler catch rates of many species. Currently, walleye relative abundance is the third highest ever recorded, and angler catch rates of walleye, northern pike, yellow perch and channel catfish are high. Chinook salmon were adversely affected by the high discharges, and many of these fish passed through Oahe Dam resulting in very low angler catch rates in 2011. Rainbow smelt appeared to have the most successful spawn since the ‘90s; however, due to high entrainment through Oahe Dam, the majority of these fish were lost from the system. Despite the good spawn, it appears the rainbow smelt population has declined appreciably from previous years and a successful spawn is needed in 2012 to maintain such high predator abundance.

7. Threatened and Endangered Species

This was the 26th year of reservoir regulation since the piping plover (plover) and least tern (tern) were Federally listed as T&E species, respectively. This was the sixth year of operating for the endangered pallid sturgeon per the revised Master Manual. No March pulse from Gavins Point was released in 2011 due to forecasted flows in excess of the downstream flow limits and the James River flows were in excess of 5,000 cfs. There was no May pulse because actual and forecasted downstream flows were in excess of the downstream flow limits.

The least 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 on 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 Fort Peck, Garrison, Fort Randall, and Gavins Point dams for different combinations of daily and hourly power peaking; however, the cross-sectional data need to be updated following the 2011 Flood.

Beginning in 1999, NWO 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. During 2011, no release decisions were made based on the needs of these two bird species.

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.

During 2011 the majority of terns and plovers were found on Lewis and Clark Lake on mechanically created habitat. The record runoff into the System during 2011 resulted in record releases and very high reservoir pools throughout the nesting season, thus limiting available nesting habitat. The record high reservoir releases and pool level rises resulted in the loss of 58 tern eggs and one tern adult and 72 piping plover eggs. A detailed description of the factors affecting tern and plover nesting, fledge ratios and habitat conditions and creation activities can be found in the Missouri River Recovery Program 2011 Annual Report (*www.moriverrecovery.org*).

The population distribution and productivity for terns and plovers for 1986 through 2011 are shown in ***Tables 20*** and ***21***. Productivity estimates for these birds on the Missouri River do not include least terns and piping plovers raised in captivity from 1995 to 2002. Adult bird totals listed in ***Tables 20*** and ***21*** 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.

8. Recreation and Resource Management

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 drought

Table 20
Missouri River System
Interior Least Tern Survey Data

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fort Peck Lake																										
Adults	-	4	3	4	6	10	0	7	9	2	0	0	4	0	0	0	0	2	0	0	2	2	0	0	0	0
Fledglings/Pair	-	-	0	3.00	-	0.40	{}	0	0.44	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Fort Peck to Lake Sakakawea																										
Adults	-	-	18	48	92	66	110	31	58	95	128	162	25	40	13	39	34	38	48	34	36	77	22	46	26	0
Fledglings/Pair	-	-	0.33	0	0.17+	0.55+	0.25+	0.45+	1.41+	0.99+	0.33	0.53	.1.52	1.70	0.15	0.97	0.59	0.63	0.50	2.18	1.17	1.38	1.45	0.87	1.00	0.00
Lake Sakakawea																										
Adults	-	-	7	15	6*	8	29+	17	35	7	27	2	23	9	10	34	21	25	16	26	48	53	14	15	11	3
Fledglings/Pair	-	-	0	0	-	-	0.83+	0.12+	0	0	0.15	0	1.04	0.67	0.20	0.76	0.86	0.56	0.88	0.31	0.71	0.72	2.57	1.07	0.00	0.00
Garrison to Lake Oahe																										
Adults	171	175	142	121	174	195	198	145	217	284	105	41	141	105	105	125	126	144	142	157	139	123	73	108	134	0
Fledglings/Pair	-	-	0.93	0.43	0.44+	0.58	0.48	0.28	0.54	0.91	0.08	0.39	1.52	1.50	1.03	1.26	1.83	1.28	1.13	0.73	0.81	1.06	1.34	0.48	1.36	0.00
Lake Oahe /Sharp																										
Adults	16*	21*	82	97	100	143	124	125	160	84	74	101	110	57	85	94	106	70	73	131	128	186	111	71	48	39
Fledglings/Pair	0.75	1.62	0	0	-	-	0.42	0	0.06	0	0.24	0.16	1.29	0.88	1.01	1.34	1.32	1.20	1.26	0.87	1.14	0.48	0.58	0.96	0.17	1.33
Ft. Randall to Niobrara																										
Adults	25	60	0	4	26	32	13	38	43	10	2	0	64	124	72	71	84	50	71	76	55	74	58	23	10	0
Fledglings/Pair	0.48	0.43	0	0	0.31+	0.63	0.46	0	0	0	0	0	0.94	1.03	1.26	0.14	0.71	0.92	0.37	0.47	0.69	0.30	1.14	0.43	0.00	0.00
Lake Lewis and Clark																										
Adults	0	0	45	29	63	55	29	76	44	16	28	60	120	76	44	58	46	46	13	4	0	85	225	214	272	231
Fledglings/Pair	-	-	0.13	0.62	0.35+	0	1.59	0.97	0	0	0	1.57	2.33	0.21	0.38	1.17	1.04	0.39	0.00	0.00	0.00	1.58	0.67	0.76	1.01	0.15
Gavins Point to Ponca																										
Adults	181	232	252	210	167	193	187	272	211	93	82	115	148	161	149	232	314	366	359	476	383	410	278	211	159	0
Fledglings/Pair	0.26	0.46	0.49	0.55	0.46+	0.26	0.21	0.83	0.48	0.49	0.27	0.90	2.27	2.41	1.72	1.09	1.32	0.75	1.04	1.34	0.63	0.59	1.14	1.00	1.17	0
Total Adults	393	492	549	528	634	702	690	711	777	591	446	481	635	572	551	653	731	741	722	904	802**	1,010	781	696	650	273
Fledglings/Pair	0.26	0.46	0.59	0.54	0.38	0.41	0.42	0.50	0.41	0.67	0.21	0.66	1.73	1.42	1.22	1.04	1.27	0.87	0.95	1.09	0.80**	0.75	0.98	0.80	1.02	0.32

5-Year Running Average Interior Least Tern Fledge Ratio Goal = 0.94

- Data not collected
* Partial Survey Results
{} No Birds Found
+ Subsampling of Selected Nesting Areas
** Includes adults and fledglings from Lake Francis Case

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.

Table 21
Missouri River System
Piping Plover Survey Data

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fort Peck Lake																										
Adults	16	10	20	12	22	25	26	30	4	5	0	0	4	2	0	4	2	17	9	26	20	16	9	12	3	2
Fledglings/Pair	-	-	1.70	1.50	3.18	1.20	1.00	0.60	1.50	1.20	0	0	0	2.00	0	1	2	0.35	2.22	1.08	1.2	0.5	0.22	0.33	0	0
Fort Peck to Lake Sakakawea																										
Adults	-	-	5	11	17	13	0	4	9	20	24	23	4	5	4	3	2	6	0	2	5	0	0	0	0	0
Fledglings/Pair	-	-	0	0.18	0	0	{}	0+	0	3.50	1.00	0.87	1.00	0	0	1.33	0	2.67	0	4	0.4	0	0	0	0	0
Lake Sakakawea																										
Adults	-	-	143	57	132	150	108	8	45	24	70	3	119	83	277	424	469	528	738	746	430	399	363	85	38	24
Fledglings/Pair	-	-	0	0	-	-	1.50	8.5+	1.24	0	0.57	0.67	1.24	1.25	1.61	1.25	1.65	1.06	1.5	0.89	0.61	0.7	0.68	0.21	0.89	1.67
Garrison to Lake Oahe																										
Adults	139	160	113	84	71	124	77	127	119	261	45	6	74	139	99	149	119	149	164	220	175	222	218	275	287	0
Fledglings/Pair	-	-	0.97	0.26	1.04+	1.13+	1.06+	0.54+	0.87	0.87	0.09	0	1.84	0.88	1.41	1.53	2.03	1.66	1.16	0.8	0.77	0.97	1.37	0.94	0.84	0
Lake Oahe /sharp																										
Adults	4*	4*	55	140	88	87	143	66+	85	30	21	31	98	46	141	184	203	301	372	364	331	273	281	158	44	20
Fledglings/Pair	-	2.50*	0	0	-	-	0.97+	0.33	0.09	0.93	0.29	1.29	1.06	0.30	1.45	1.41	2.16	1.84	1.41	1.21	0.99	0.62	0.9	0.47	0.1	0.4
Ft. Randall to Niobrara																										
Adults	11	16	0	0	12	25	8	12	17	0	3	0	33	51	62	38	35	37	42	42	37	21	26	16	6	0
Fledglings/Pair	0.18	0.13	0	0	0.67*	0.48	0.75	0	0	0	0	0	1.27	1.02	0.87	0.74	1.03	1.46	0.71	0.81	0.38	0	1	1	0	0
Lake Lewis and Clark																										
Adults	0	0	31	18	30	33	6	32	12	4	6	32	84	67	28	34	44	14	0	24	4	20	57	122	152	134
Fledglings/Pair	-	-	0.06	0.56	0.67+	0	0	0.06	0.33	0	0	1.25	2.45	0.30	0.5	0.71	1.68	1.57	0	0.17	0.5	1.8	1.37	1.8	1.25	0.22
Gavins Point to Ponca																										
Adults	172	177	212	122	148	166	112	109	62	63	22	22	49	141	186	218	260	286	262	340	309	300	320	238	74	2
Fledglings/Pair	0.05	1.13	0.62	0.21	0.39+	0.35	0.34	1.06	0.61	0.16	0	0	2.20	1.60	2.17	1.85	2.29	1.9	1.87	1.97	0.78	0.39	1.39	1.09	1.86	0
Total Adults	342	367	579	444	521	623	480	388	353	407	191	117	465	534	797	1054	1134	1338	1587	1764	1311	1251	1274	906	604	182
Fledglings/Pair	0.06	1.08	0.73	0.32	0.76	0.62	0.94	0.76	0.61	0.84	0.39	0.87	1.61	1.01	1.58	1.41	1.91	1.5	1.49	1.15	0.78	0.66	1.06	0.94	1.01	0.43

10-Year Running Average Piping Plover Fledge Ratio Goal = 1.22

- Data not collected
* Partial Survey Results
{} No Birds Found
\+ Subsampling of Selected Nesting Areas

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.

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. In 2011, the main impacts to recreation areas at all of the projects were related to the record runoff, as noted in later paragraphs.

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.

During 2011, public use at the System reservoirs totaled 41,984,600 visitor hours, an 8% decrease from 2010. Visitor attendance figures at the System reservoirs from 2008 through 2011 are shown in ***Table 22***. ***Figure 17*** displays recreation-related visitor hours at each of the six System projects for the years 1954 through 2011. Although the drought had an impact on visitation during the years from 2000-2007, much of the reduction shown in ***Figure 17*** is attributed to the data collection changes 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 2011 visitation in South Dakota presented in ***Table 22*** and ***Figure 17*** reflects 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.

Table 22
Visitation at System Reservoirs (Visitor Hours)

Mainstem Project	2008	2009	2010	2011	Percent Change 2010-2011
Fort Peck	5,443,000	5,820,400	6,173,900	6,455,300	+5 %
Garrison	13,121,800	13,773,900	15,698,700	14,190,300	-10 %
Oahe	9,641,300	9,322,300	9,503,100	6,964,900	-27 %
Big Bend	3,794,000	3,210,200	3,346,500	2,528,100	-26 %
Fort Randall	1,139,800	1,030,900	1,067,000	1,108,500	+4 %
Gavins Point	9,612,300	8,880,300	9,410,000	10,737,500	+14 %
System Total	**42,752,300**	**42,038,100**	**45,199,200**	**41,984,600**	**-8 %**

The reporting method was changed from recreation days to visitor hours in 1987, and the reporting period was changed from calendar year to fiscal year in 1989 for all Corps projects. All Corps projects, including the System projects, are now reporting visitation using the Visitation Estimation Reporting System (VERS).

System Visitation
1954 - 2011

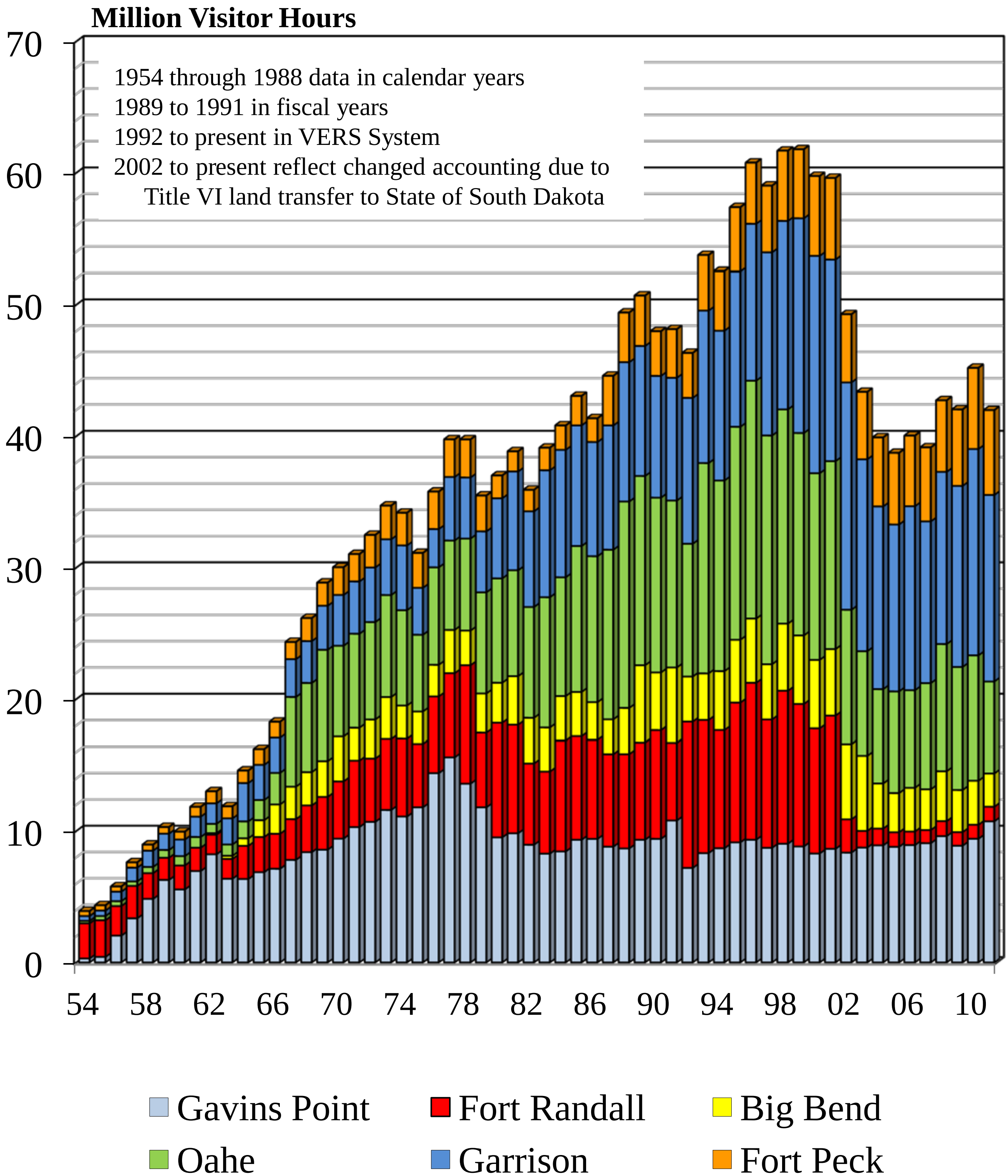


Figure 18. System visitation by project from 1954 to 2011.

The 8% decrease in visitor hours for 2011 is attributed to the impacts of high reservoir levels and the record project releases. In some cases, the number of visitors increased but overall visitor hours declined due to the closure of areas such as campgrounds that tend to be used for longer periods.

At Fort Peck, some of the recreation areas were impacted by high water during June and July, with some of the areas being closed, partially closed or with limited access. However, other recreation areas saw normal to increased visitation. The Fort Peck Interpretive Center had a 72 percent increase in visitors, and a large increase in visitors to the project spillway also occurred. Several recreation areas at Garrison were closed from June through August, and one recreation area experienced low visitation due to the access highway being unusable for the majority of the season. Visitation at the spillway was much above that experienced in previous years. Oahe visitation was impacted by numerous site closures including many of the recreation areas that were closed due to high water. In addition, numerous roads were closed near the reservoir and river, reducing or eliminating access to outdoor recreation areas. These resulted in a significant decrease in visitor-hours. The stilling basin area showed a large increase in visitors, with a 32 percent higher number of visits compared to 2010. At Big Bend several recreation areas downstream of the project were closed for a 3-month period due to the high releases. Visitation increased in some areas near the spillway. Fort Randall had a 70 percent increase in visitors to the visitor center and a 41 percent increase in visitors to the tailrace area. Although the number of visitors showed a large increase, the visitor hours showed only a slight increase due to the closing of the downstream boat ramp and the closing of recreation areas on much of the reservoir. At Gavins Point, there was a large increase in traffic immediately below the dam, as visitors came to view the spillway and the record project releases.

9. Cultural Resources

As acknowledged in the 2004 Programmatic Agreement (PA) for the Operation and Management of the Missouri River Mainstem System, wave action and the fluctuation of reservoirs levels results in erosion along the banks of the reservoirs. During drought conditions, cultural resource sites are exposed as the pool levels decline. With higher-than-normal reservoir levels in 2011, a number of sites were still affected. The Corps will continue to work with the Tribes utilizing 36 CFR Part 800 and the PA to address the exposure of sites. The objective of a programmatic agreement is to deal "…with the potential adverse effects of complex projects or multiple undertakings…" The objective of the PA was to collaboratively develop a preservation program that would avoid, minimize and/or mitigate the adverse effects of the System regulation. All Tribes, whether signatory to the PA or not, may request government-to-government consultation on the regulation of the System and the resulting effect on historic and cultural properties and other resources.

The planned preservation program is outlined by multiple stipulations in the PA. One of the stipulations, or program components, is the 5-year plan. This plan outlines how the Corps will accomplish its responsibilities under the PA and National Historic Preservation Act. The "Draft Five Year Plan, dated July 2011" (see website *https://www.nwo.usace.army.mil/CR*) is currently being implemented.

The plan includes inventory, testing and evaluation, mitigation and other specific activities that will allow the Corps to avoid, minimize and/or mitigate the adverse effects to cultural sites on the Corps' lands within the System.

Under the terms of Stipulation 18 of the PA the Corps has agreed to consult/meet with the affected Tribes and Tribal Historic Preservation Officers (THPO's), State Historic Preservation Officers (SHPO's), the Advisory Council on Historic Preservation (ACHP) and other parties on the draft AOP. The purpose of this consultation/meeting is to determine whether operational changes are likely to cause changes to the nature, location or severity of adverse effects to historic properties or to the types of historic properties affected and whether amendments to the Corps' Cultural Resources Management Plans and Draft Five Year Plan are warranted in order to better address such effects to historic properties. A letter, dated September 22, 2011, was sent to the Missouri River basin Tribes offering consultation on the 2011-2012 AOP. To date, no requests for consultation have been received; however, three Tribes participated in the fall AOP public meetings in October and November 2011. No Tribe provided written input on the draft AOP.

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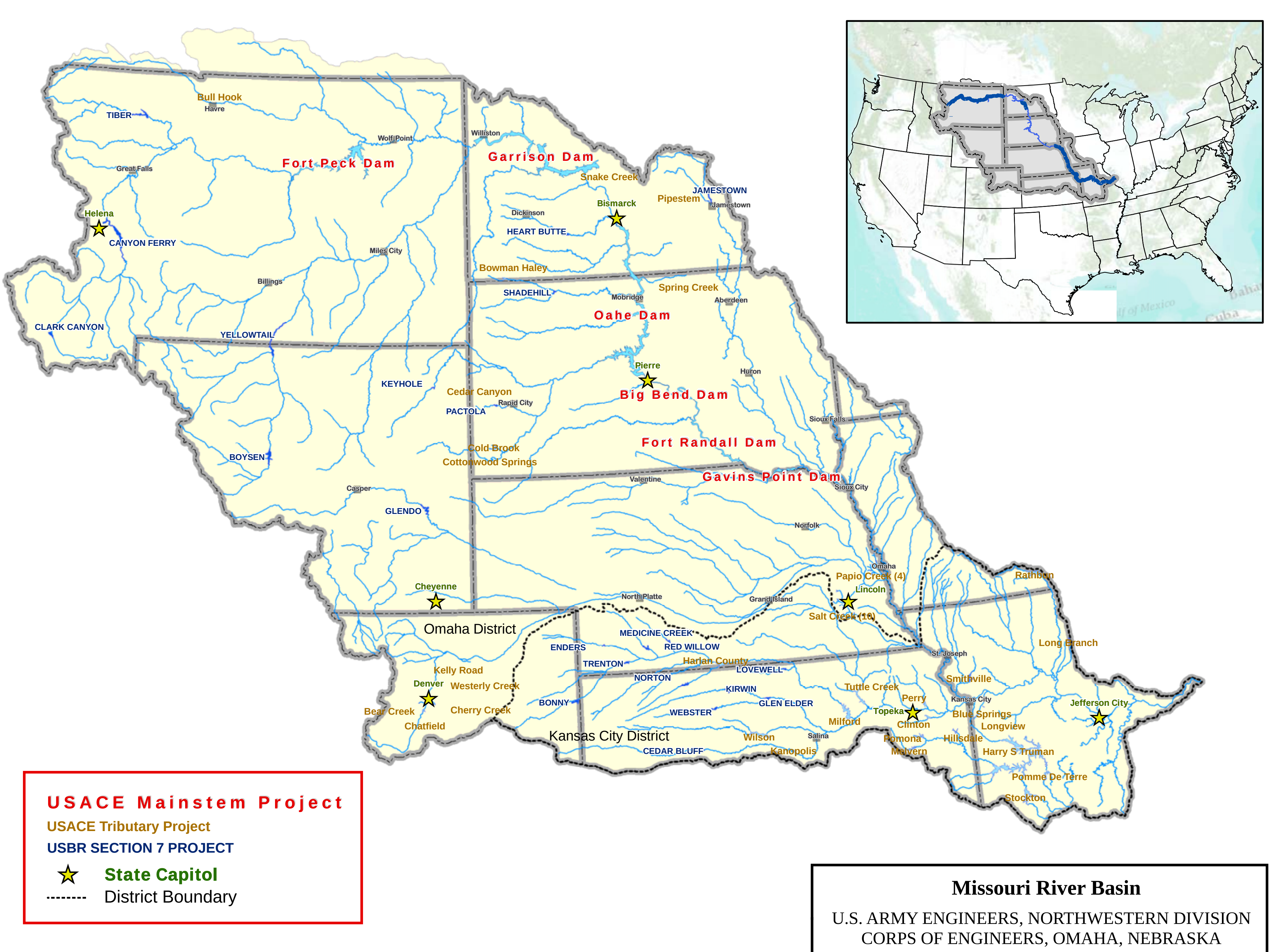

PLATE 1. Missouri River Basin Map.

Item No.	Subject	Fort Peck Dam - Fort Peck Lake	Garrison Dam - Lake Sakakawea	Oahe Dam - Lake Oahe
	Summary of Engineering Data -- Missouri River Mainstem System			
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 241,000 acres	1854 msl 380,000 acres	1620 msl 374,000 acres
27	Max. normal op. pool elev. & area	2246 msl 234,000 acres	1850 msl 364,000 acres	1617 msl 360,000 acres
28	Base flood control elev & area	2234 msl 210,000 acres	1837.5 msl 307,000 acres	1607.5 msl 312,000 acres
29	Min. operating pool elev. & area	2160 msl 89,000 acres	1775 msl 128,000 acres	1540 msl 117,000 acres
	Storage allocation & capacity			
30	Exclusive flood control	2250-2246 971,000 a.f.	1854-1850 1,489,000 a.f.	1620-1617 1,102,000 a.f.
31	Flood control & multiple use	2246-2234 2,704,000 a.f.	1850-1837.5 4,222,000 a.f.	1617-1607.5 3,201,000 a.f.
32	Carryover multiple use	2234-2160 10,700,000 a.f.	1837.5-1775 13,130,000 a.f.	1607.5-1540 13,461,000 a.f.
33	Permanent	2160-2030 4,088,000 a.f.	1775-1673 4,980,000 a.f.	1540-1415 5,373,000 a.f.
34	Gross	2250-2030 18,463,000 a.f.	1854-1673 23,821,000 a.f.	1620-1415 23,137,000 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	17,700 a.f. 1030 yrs.	25,900 a.f. 920 yrs.	19,800 a.f. 1170 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	1670-1680 15,000- 60,000 cfs	1423-1428 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)	1,043	2,245	2,618
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

Plate 2. Summary table contains the engineering data for the Missouri River Mainstem System.

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	633,000 at elev 1379.8	584,000 at elev 1221.4		24
270,000	508,000	345,000		25
1423 msl 61,000 acres	1375 msl 102,000 acres	1210 msl 30,000 acres	1,188,000 acres	26
1422 msl 60,000 acres	1365 msl 95,000 acres	1208 msl 27,000 acres	1,140,000 acres	27
1420 msl 57,000 acres	1350 msl 77,000 acres	1204.5 msl 23,000 acres	986,000 acres	28
1415 msl 51,000 acres	1320 msl 38,000 acres	1204.5 msl 23,000 acres	446,000 acres	29
1423-1422 60,000 a.f.	1375-1365 985,000 a.f.	1210-1208 57,000 a.f.	4,664,000 a.f.	30
1422-1420 117,000 a.f.	1365-1350 1,309,000 a.f.	1208-1204.5 86,000 a.f.	11,639,000 a.f.	31
	1350-1320 1,607,000 a.f.		38,898,000 a.f.	32
1420-1345 1,621,000 a.f.	1320-1240 1,517,000 a.f.	1204.5-1160 307,000 a.f.	17,886,000 a.f.	33
1423-1345 1,798,000 a.f.	1375-1240 5,418,000 a.f.	1210-1160 450,000 a.f.	73,087,000 a.f.	34
November 1963	January 1953	August 1955		35
25 March 1964	24 November 1953	22 December 1955		36
5,300 a.f. 430 yrs.	18,400 a.f. 250 yrs.	2,600 a.f. 180 yrs.	89,700 a.f.	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 1228-1239 5,000-60,000 cfs	1155-1163 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
969	1,729	727	9,331 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) 1967-2010 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
August 2011

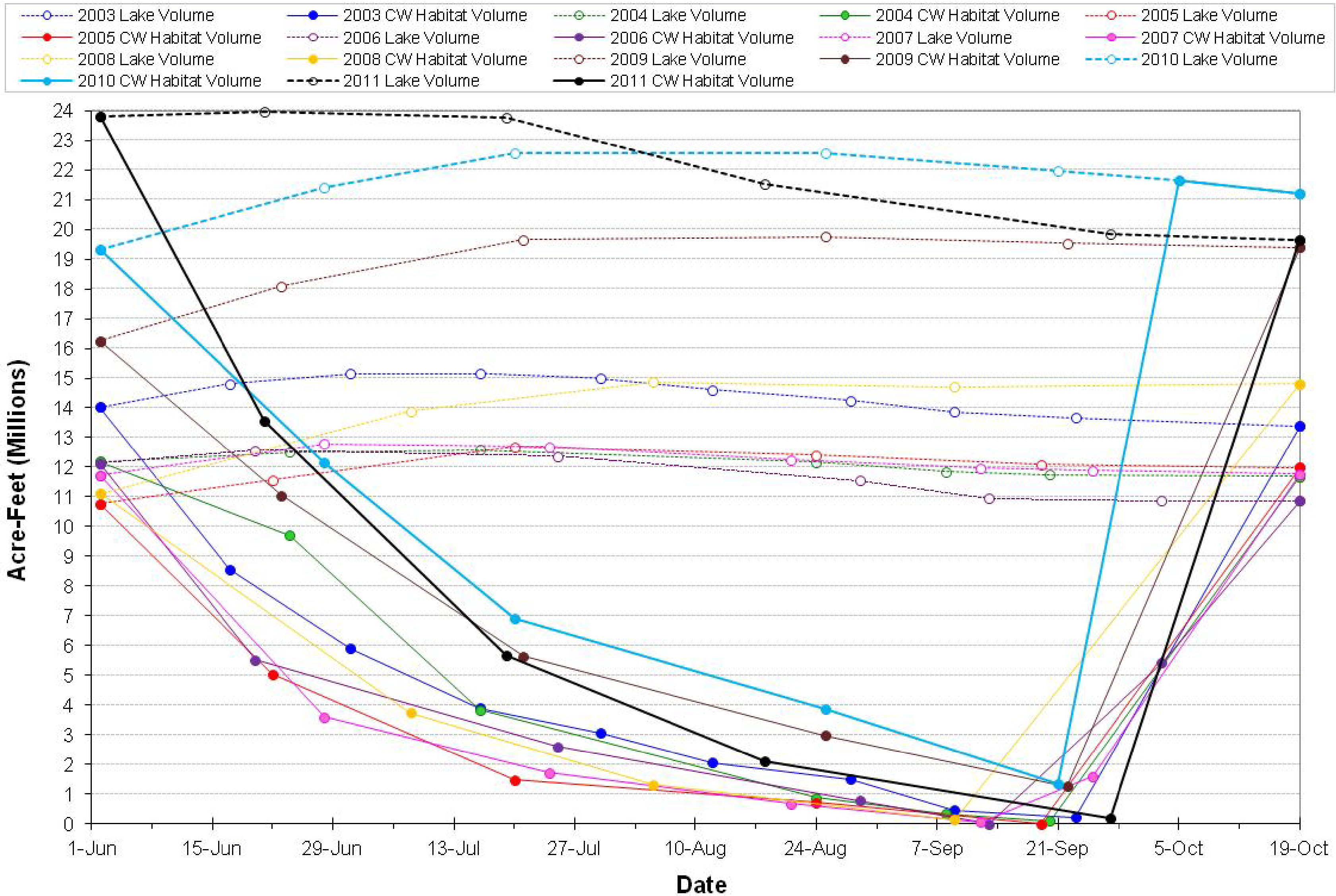

Plate 3. Garrison Dam / Lake Sakakawea Estimated Coldwater Habitat 2003 through 2011.