Missouri River Mainstem Reservoir System

2011 Flood Regulation and a Glimpse at 2012

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Missouri River Mainstem Reservoir System

Congressionally Authorized

Project Purposes
Flood Control
Navigation
Hydropower
Irrigation
Recreation
Water Supply
Water Quality
Fish and Wildlife
(Including endangered species)

Bank Stabilization and Navigation Project
Sioux City, IA – St. Louis, MO
Missouri River Mainstem Reservoir System

Zones & Allocations of the Total Storage Capacity

Exclusive Flood Control 6%
Annual Flood Control & Multiple Use 16%
Carryover Multiple Use 53%
Permanent Pool 25%
16.3 MAF
Flood Storage

Congressionally Authorized Purposes
- Flood Control
- Water Quality Control
- Irrigation
- Navigation
- Hydropower
- Water Supply
- Recreation
- Fish and Wildlife

MAF is Million Acre Feet
Mainstem Reservoir Storage Capacity

Million Acre-Feet

Fort Peck
- Permanent
- Carryover
- Annual Flood
- Exclusive Flood

Garrison
- Permanent
- Carryover
- Annual Flood
- Exclusive Flood

Oahe
- Permanent
- Carryover
- Annual Flood
- Exclusive Flood

Big Bend
- Permanent
- Carryover
- Annual Flood
- Exclusive Flood

Fort Randall
- Permanent
- Carryover
- Annual Flood
- Exclusive Flood

Gavins Point
- Permanent
- Carryover
- Annual Flood
- Exclusive Flood
Runoff Components

- Plains Snowpack: March and April
- Mountain Snowpack: May, June and July
- Rainfall: March through October

2011 Runoff = 61.0 MAF

Highest runoff since 1898

Previous Record was 49.0 MAF in 1997
Plains Snowpack
25 February 2011
March 2011 Precipitation (% normal)
April 2011 Precipitation (% normal)
2010 – 2011 Mountain Snowpack

Above Fort Peck

Feb 1: 112% of normal

Fort Peck to Garrison

Feb 1: 111% of normal
2010 – 2011 Mountain Snowpack

Above Fort Peck

Mar 1: 110% of normal

Fort Peck to Garrison

Mar 1: 107% of normal

Snow Water Equivalent, in inches
2010 – 2011 Mountain Snowpack

Above Fort Peck

Apr 1: 116% of normal

Service Level increased 10 kcfs from 35 to 45 kcfs

Fort Peck to Garrison

Apr 1: 112% of normal
2010 – 2011 Mountain Snowpack

Above Fort Peck

May 1: 141% of normal
Apr 15 peak

Fort Peck to Garrison

May 1: 136% of normal
Apr 15 peak

Service Level increased 10 kcfs from 50 to 60 kcfs
2010 – 2011 Mountain Snowpack

Above Fort Peck

Peak (May 2):
141% of normal
Apr 15 peak

Fort Peck to Garrison

Peak (May 2):
136% of normal
Apr 15 peak

Snow Water Equivalent, in inches
May 2011 Precipitation (inches)
June 2011 Precipitation (inches)

NWS Central Region: June, 2011 Monthly Observed Precipitation
Valid at 7/1/2011 1200 UTC - Created 7/2/11 17:40 UTC
July 2011 Precipitation (inches)
Top of exclusive

Base of exclusive flood zone

Base of the annual flood control zone

Mar 2011 Aug 2011

Stor (ac-ft)
What Actually Happened

- Runoff in 2011 was 61.0 million acre-feet (MAF), 246 percent of normal and the highest runoff in 114 years
  - June was the single wettest month on record with 14.8 MAF of runoff, surpassing the old record of 13.2 MAF set in April 1952.
  - July was the fourth wettest single month on record with 10.2 MAF

- Combined May through July runoff of 34.3 MAF is higher than the total annual runoff in 102 of 113 years in the period of record

- 1881 Design Event Was Exceeded
Missouri River Mainstem System
Annual Runoff above Sioux City, IA

Historic Drought Periods

U.D. 34.3 MAF
L.D. 16.2
L.Q. 19.3
U.Q. 24.4
Med. 30.3

2011
Missouri River Runoff above Sioux City
2011 Actual/Forecasted versus Normal

Million Acre-Feet

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

Normal: [Bars]
2011 Actual/Forecasted: [Bars]

Jan: 130 %
Feb: 223 %
Mar: 266 %
Apr: 283 %
May: 279 %
Jun: 320 %
Jul: 320 %
Aug: 260 %
Sep: 130 %
Fort Peck

Construction Started: 1935
In Operation: 1940

Length of Dam = 21,030 ft; ~ 4 miles

Spillway capacity*
~ 230 kcf/s

5 Francis turbine power units; ~ 15 kcf/s
2 regulating tunnels ~ 45 kcf/s

2011 Peaks
release – 65,000 cfs
elevation – 2252.3 (2.3’ surcharge)
storage – 19.0 MAF

Previous Peaks
release – 35,000 cfs (1975)
elevation – 2251.6 (1.6’ surcharge, 1975)

*Capacity at max operating pool
**Garrison**

- **Length of Dam**: 11,300 ft
- **3 regulating tunnels**: ~ 98 kcfs
- **5 Francis turbine power units**: ~ 41 kcfs
- **Spillway capacity**
  - ~ 660 kcfs
  - Never used prior to 2011
- **Construction Started**: 1946
- **In Operation**: 1955

**2011 Peaks**
- **Release**: ~ 150,000 cfs
- **Elevation**: 1854.4 (0.4' surcharge)
- **Storage**: 24.0 MAF

**Previous Peaks**
- **Release**: 65,000 cfs (1975)
- **Elevation**: 1854.8 (0.8' surcharge, 1975)

*Capacity at max operating pool*
Spillway (highly erodible, has never been used)

Length of Dam = 9,300 ft

6 regulating tunnels: ~ 110 kcfs

2011 Peaks
release – 160,000 cfs
elevation – 1619.6 (top of spillway gates – 1620')
storage – 23.0 MAF

Previous Peaks
release – 59,000 cfs (1997)
elevation – 1618.7 (1995, 1996)

Construction Started: 1948
In Operation: 1962
Big Bend

2011 Peaks
release – 166,000 cfs

Previous Peaks
release – 74,000 cfs (1997)

8 Fixed Blade turbine power units; ~ 103 kcfs

Length of Dam = 10,570 ft

Construction Started: 1959
In Operation: 1964

Spillway capacity*
270 kcfs
Never used prior to 2011

*Capacity at max operating pool
Fort Randall

2011 Peaks
release – 160,000 cfs
elevation – 1374.0 (top of spillway gates – 1375’)

Previous Peaks
release – 67,000 cfs (1997)
elevation – 1372.2 (1997)

8 Francis turbine power units; ~ 44 kcfs

Length of Dam = 10,700 ft

Construction Started: 1946
In Operation: 1953

Spillway capacity*
~ 508 kcfs

4 regulating tunnels; ~ 128 kcfs

*Capacity at max operating pool
Gavins Point

2011 Peaks
release – 160,000 cfs

Previous Peaks
release – 70,000 cfs (1997)

Construction Started: 1952
In Operation: 1955

Length of Dam = 8,700

Spillway capacity*
~ 345 kcfs

3 Kaplan turbine power units; ~ 34 kcfs

*Capacity at max operating pool
Pierre, South Dakota
Dakota Dunes, South Dakota
Fort Calhoun, Nebraska
Omaha, Nebraska
Missouri River Stage Reduction Due to Reservoir Operations

- Culbertson, MT: 1.8 feet
- Bismarck, ND: 5.2 feet
- Yankton, SD: 4.9 feet
- Sioux City, IA: 3.2 feet
- Decatur, NE: 5.3 feet
- Omaha, NE: 3.8 feet
- Nebraska City, NE: 0.7 feet
- Rulo, NE: 1.2 feet
- Kansas City, MO: 6.9 feet
- Boonville, MO: 3.3 feet
- St. Joseph, MO: 3.6 feet
- Hermann, MO: 4.0 feet
- Waverly, MO: 1.0 feet
Missouri River at Sioux City, IA – Actual and Unregulated Flows

Flood Stage = 30 ft (~ 122,000 cfs)

Number of Days above Flood Stage

- Unregulated: ~ 100
- Actual: ~ 80

Flow in 1000 cfs

- Actual (Regulated) Flow
- Unregulated (Natural) Flow
Damages Prevented

- Corps Mainstem Projects: $5.5 billion
- Corps Tributary Projects: $0.2 billion
- USBR Projects: $0.2 billion
- Mainstem Urban Levees: $1.5 billion
- Mainstem Nonurban Levees: $0.1 billion
- Corps Local Protection: $0.2 billion
  - Channels and Levees: $0.2 billion
- Emergency Measures: $0.5 billion

Total: $8.2 billion
Annual Runoff Volume Frequency

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Annual Runoff Volume (KAF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>10000.0</td>
</tr>
<tr>
<td>1.1</td>
<td>100000.0</td>
</tr>
<tr>
<td>2</td>
<td>61,000 KAF</td>
</tr>
<tr>
<td>5</td>
<td>49,040 KAF</td>
</tr>
<tr>
<td>10</td>
<td>50,740 KAF</td>
</tr>
<tr>
<td>50</td>
<td>49,040 KAF</td>
</tr>
<tr>
<td>100</td>
<td>1881 50,740 KAF</td>
</tr>
<tr>
<td>500</td>
<td>2011 Computed Probability = 0.002 (500-yr)</td>
</tr>
</tbody>
</table>

Computed Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Weibull plotting positions)
Historic Data
System Tested as Never Before...

- System storage peaked at a record 72.8 MAF on 1 July
  - 16 MAF stored flood waters in mainstem reservoirs
  - Corps and Bureau of Reclamation tributary reservoirs also utilized
- Four mainstem reservoirs utilized exclusive flood control zone
  - Fort Peck, Garrison, Oahe and Fort Randall
- Three mainstem reservoirs set record pool levels
  - Fort Peck, Oahe and Fort Randall
- Two mainstem reservoirs utilized surcharge storage
  - Fort Peck and Garrison
- Spillways at two mainstem dams were operated for the first time
  - Garrison and Big Bend
- Record releases from all mainstem reservoirs
Independent External Review Panel

Panel Recommendations

1. Support a program of infrastructure enhancement.
2. Update hydrologic studies to include 2011.
4. Improved cooperation/collaboration with NWS, USGS and NRCS.
5. Studies to enhance data collection and forecasting (especially plains snow).
6. Implement modern interactive, graphics decision support system.
Analysis of Missouri River Mainstem Flood Control Storage

- Two Step Process
  - Determine the potential effect of additional flood control storage on 2011 releases.
  - Evaluate potential economic impacts of alternative flood control scenarios.

- Report available at:
Analysis of Missouri River Mainstem Flood Control Storage

Conclusions

► Additional flood control storage would enhance flood risk reduction in a repeat of the 2011 flood, but would not have prevented record releases in 2011.

► Additional flood control storage would have a negative impact on other authorized purposes.

► Additional flood control storage would have little impact on lower basin rainfall driven flood events such as 2010.

► Flood control storage is one piece of the solution; increasing channel capacity and reducing encroachment in the flood plain would further enhance flood risk reduction.
Current Conditions and Expected Results for Authorized Purposes in 2012
Missouri River Mainstem System

Storage Zones and Allocations

Exclusive Flood Control 6%

Annual Flood Control & Multiple Use 16%

Carryover Multiple Use 53%

Permanent Pool 25%

Historic max - 2011

June 8, 2011

61.8

January 26, 2012

56.1

Historic min - 2007

June 8, 2012

61.8

56.9

68.4

July 8, 2011

56.8

61.8

68.4

72.8

73.1

June 8, 2011

33.9

17.9

0
1.2 feet into FC zone.

0.6 foot below FC zone.

1.4 feet below FC zone.

0.1 MAF below FC zone.
Plains Snowpack

1 March 2011

1 March 2012
The Missouri River basin mountain snowpack normally peaks near April 15. Normally, 100 percent of the peak accumulation has occurred by April 15. On April 15 the mountain snowpack in the “Total above Fort Peck” reach is currently 92 percent of normal and the “Total Fort Peck to Garrison” reach is currently 80 percent of normal.

*Generally considered the high and low year of the last 20-year period.

Provisional data. Subject to revision.
The Missouri River basin mountain snowpack normally peaks near April 15. By June 15, normally 25% of the peak remains. On June 7 the mountain snowpack SWE in the “Total above Fort Peck” reach is currently 3.7”, 70% of normal and 21% of the normal April 15 peak. The mountain snowpack SWE in the “Total Fort Peck to Garrison” reach is 3.2”, currently 58% of normal and 21% of the normal April 15 peak. The snowpack peaked in the “Total above Fort Peck” reach on April 9 at 97% of the normal April 15 peak. The snowpack peaked in the “Total Fort Peck to Garrison” reach on March 22 at 88% of the normal April 15 peak.

*Generally considered the high and low year of the last 20-year period.

Provisional data. Subject to revision.
The U.S. Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

**July 5, 2011**
Valid 8 a.m. EDT

**October 4, 2011**
Valid 8 a.m. EDT

**January 3, 2012**
Valid 7 a.m. EDT

**April 3, 2012**
Valid 7 a.m. EDT

Author: Richard Heim/Liz Love-Brack, NOAA/NESDIS/NCDC

Author: Brian Fuchs, National Drought Mitigation Center
Historical Drought Periods

Annual Runoff above Sioux City, IA

Historical Drought Periods:
- U.D.: 34.3 MAF
- U.Q.: 30.3
- Med.: 24.4
- L.Q.: 19.3
- L.D.: 16.2

Percentage:
- 10%
- 25%
- 50%
- 75%
- 90%

Years:
- 1895 to 2011

Values:
- 2012: 22.1 MAF
System Storage
April 1 Forecast

Million Acre-Feet

Top of Exclusive Flood Control – 73.1 maf
Base of Exclusive Flood Control – 68.4 maf

Base of Annual Flood Control – 56.8 maf

System Storage Check

2011 2012 2013
Flood Control

- All flood storage space available at start of runoff season (plus 0.7 MAF)
- Risk of snowmelt driven flooding is low, however rainfall driven flooding can still occur
Hydropower

Billion kWh

Gavins Point, Ft. Randall, Big Bend, Oahe, Garrison, Fort Peck, Forecast
Navigation

- March 15 storage check
  - Full service flow support
  - Target locations
    - Sioux City (31,000 cfs)
    - Omaha (31,000 cfs)
    - Nebraska City (37,000 cfs)
    - Kansas City (41,000 cfs)

- July 1 storage check
  - Full service support for Basic and Upper Basic
  - 1,600 cfs below Full Service for Lower Basic
  - Full length season Basic and Lower Basic
  - 10-Day extension for Upper Basic
Water Supply – Water Quality

Irrigation – Recreation

- Near normal elevations and releases
- Some issues expected due to 2011 flood
  - Recreation areas, irrigation, water supply intakes, marinas
Fish and Wildlife

- Steady to rising levels at upper three reservoirs during forage fish spawn
  - Favor Fort Peck and Oahe if runoff not sufficient
- Minimize zero releases at Fort Randall
Each Federal Agency shall... ensure that any action authorized, funded, or carried out by such agency... is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat…
Threatened and Endangered Species
Piping Plover and Least Tern

- Gavins Point
  - Steady release – flow to target
  - Cycle Gavins Point releases
- Intra-day peaking patterns – Garrison & Fort Randall
- Measures to minimize take
Threatened and Endangered Species

Bi-Modal Spring Pulse – Pallid Sturgeon

- 2003 Amended Biological Opinion – Reasonable and Prudent Alternative
- March and May pulses – not implemented in 2012
- Working with US Fish and Wildlife Service on path forward
Summary

- Slightly below normal runoff
- Meet all authorized purposes
- Addressing panel recommendations
- Flood repair work on-going
Thank you.