The Great Flood of 2011: Defining the Cause

A Missouri Corn Growers Association Report Fall 2011

Examining the Conditions, Decisions and Consequences of the 2011 Missouri River Flood

History

The Missouri River System is the longest river system in the United States, stretching from Montana to its confluence with the Mississippi River directly above the city of St. Louis, Mo. Often referred to as the Big Muddy for its dark, silt- filled waters, the Missouri River has a history of escaping its banks.

According to the Risk Management Society, the first detailed account of Missouri River flooding happened in 1881 due to an ice jam break. Northeastern Nebraska was flooded, reportedly killing thousands of livestock and three people. An entire town, Niobrara, Neb., relocated to higher ground after the event (Holbrook, 2011).

In April of 1943, a rapid snowmelt resulted in flooding in Nebraska and Iowa. At its crest, the river spanned 15 miles wide between the towns of Decatur, Neb., and Onawa, Iowa causing $1.4 million in damage. In response to this flood, Congress passed the Flood Control Act of 1944, creating the Pick-Sloan Missouri Basin Program. The plan called for a system of reservoirs and dams to be constructed in the Missouri River Basin that could regulate the flow of water down the river and reduce the risk of flooding (Holbrook, 2011).

Executive Summary

The Missouri River Mainstem Reservoir System was authorized by President Harry S. Truman in the Pick-Sloan Missouri Basin Program of 1944 to minimize flooding. Since then, operation of the system has shifted from flood control to include often competing purposes such as recreation and habitat restoration. As a result, the river has experienced consecutive years of flooding.

This year water released from Gavins Point Dam reached 160,000 cubic feet per second (cfs), more than double previous record releases. Though operating under the highest runoff scenario in the Missouri River Master Manual, the U.S. Army Corps of Engineers (Corps) should have noticed a "substantial departure from normal runoff" and operated in emergency mode.

As of January 2011, snowpack was 141 percent of normal and forecasts from the National Oceanic and Atmospheric Administration (NOAA) projected runoff for spring 2011 would be extreme. As rains continued, the Corps had to begin releasing large amounts of water all at once in May. The high water lasted for months, breaching levees, flooding homes, towns and over 400,000 acres of farmland.

Current Congressional appropriations are markedly lopsided, with over $78 million dedicated to environmental restoration and only $6.2 million allocated to Operations and Management. The 2011 flood must serve as a clarion call to ensure future operation of the system focuses on flood control. The Corps should use 2011 as the new data point, look at reservoir levels and improve forecasting methods. In addition, appropriations must correctly reflect that flood control is the number one priority in managing the Missouri River Reservoir System.

The series of dams had not yet been completed when another disaster occurred in 1952. Similar to the 1943 flood, heavy snowpack and early melt caused severe flooding along the Missouri River. This prompted President Truman to increase support for flood prevention programs already in place and finish the system.

The next major flood event occurred in 1993. Though the system was in place, it was not enough to control the simultaneous inundation of both the Missouri and Mississippi Rivers. Significant rains downstream of the reservoirs also contributed to the record flood. From April to October 1993 over 100,000 homes were overcome and 32 people lost their lives, while 15 million acres of farmland were covered with flood water (Holbrook, 2011).

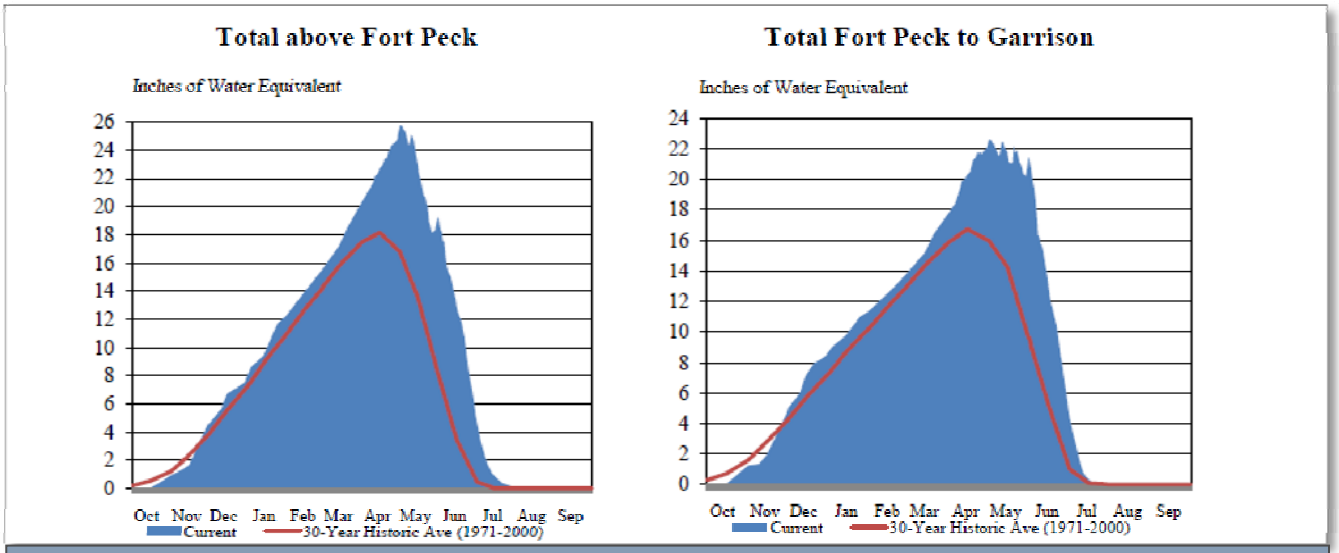
In 2011, the Missouri River flooded for the third time in four years, once again raising questions about the effectiveness of the system. This year's flood occurred as downstream states such as Missouri and Kansas received well below average rainfall.

Yet the river still rose dramatically above flood stage, breaching and overtopping many levees and flooding towns as well as thousands of acres of farmland. What could be the cause of such a devastating flood in a summer that was so dry?

Conditions

As early as December 2010, signs of spring flooding appeared in the Upper Missouri River Basin. When factoring in snowpack, precipitation and runoff, the conditions occurring in the spring of 2011 were like none seen in recent history. Although the series of reservoirs along the river system was designed to reduce flood risk, the system didn't fulfill this task, causing significant flooding across eight Midwestern states. What went wrong?

Due to high levels of snow accumulation in the mountains, the Upper Basin began seeing record levels of snowpack runoff. As of January 2011, runoff was 141 percent above normal in the mountains above Fort Peck, Mont. Runoff levels reached 222 percent above normal by April. Snowpack at these



A graph from the Corps shows snowpack in relation to the 30 year average. In March of 2011 when snowpack accumulation usually begins to slow, it actually was increasing at a more rapid pace than usual. In April snowpack was increasing at a substantial rate, when on average the snowpack has peaked or begun to decline.

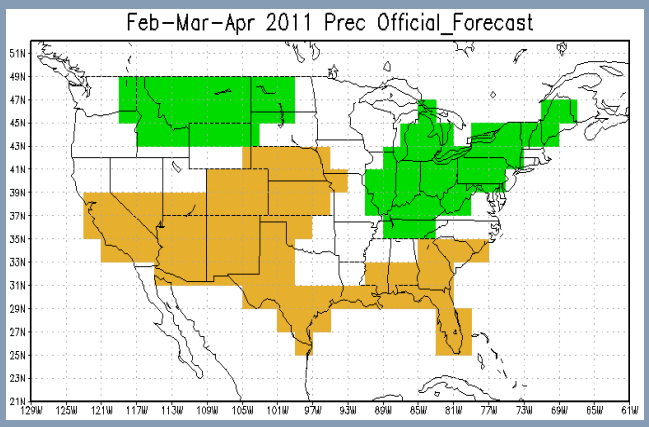
times were at 114 percent and 116 percent respectively above Fort Peck. These were key indicators flooding was not only possible, but probable, in the pursuing spring. Yet the Corps still did not take any preventative action to adequately manage the water that was sure to come through the system (U.S. Army Corps of Engineers, 2011c).

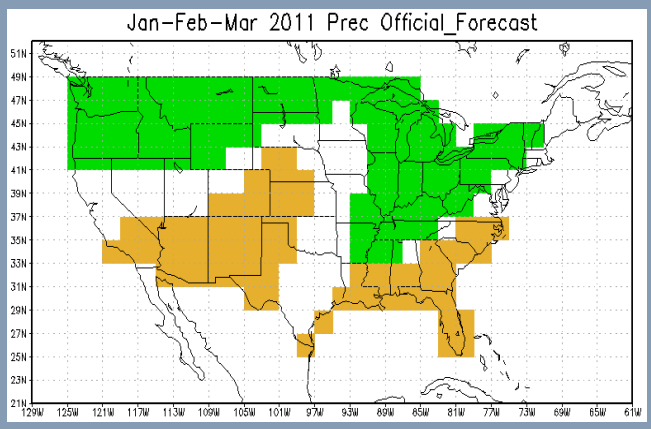
The snowpack, which generally peaks around mid-April, continued to accumulate through early May. Though some argue the numbers were only slightly above normal in January and February, it is indisputable that by March snowpack levels were heading off the charts. These numbers were showing up well before actual flooding began. The Corps indicated they planned adequately for the amount of snowpack, but were caught off guard by the historic rainfalls in the Upper Basin.

While rainfall reached historic levels in the Upper Basin, the increase should have been predictable. The first factor to consider is the La Niña period. During a La Niña period, the Upper Midwest is usually wetter than normal while the southern half of the United States is drier than average. This alone should have been a reason for planning for increased rainfall.

The Corps utilizes the National Oceanic and Atmospheric Administration's (NOAA) weather forecasts to make decisions related to the Missouri River System. Although the Corps stated they could not have planned for the increase in rainfall, when looking at early precipitation forecasts from NOAA it is obvious the Upper Basin was going to receive above average precipitation.

The following graphics from the NOAA website show the forecasts throughout the spring. Green indicates above average while tan indicates below average.

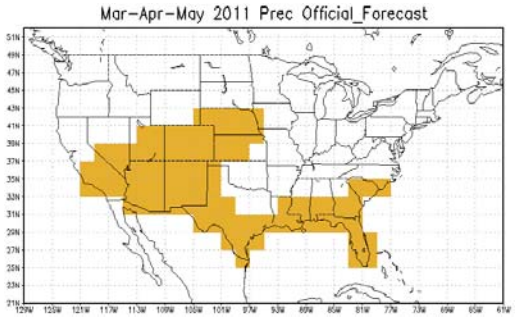


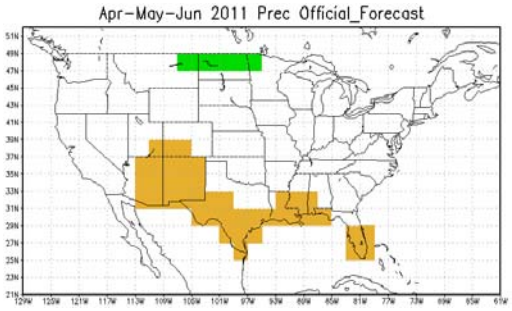


The graphics indicate the pattern predictable during a La Niña season.

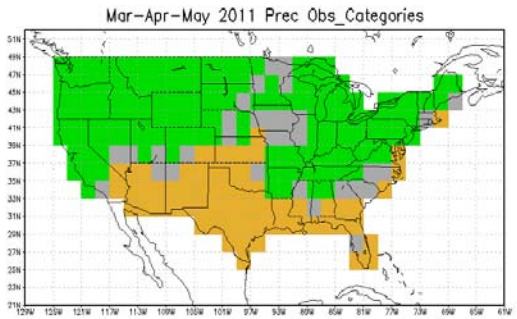
These projections are an example the Corps had information at their disposal to predict higher than average rainfall for the first part of the year.

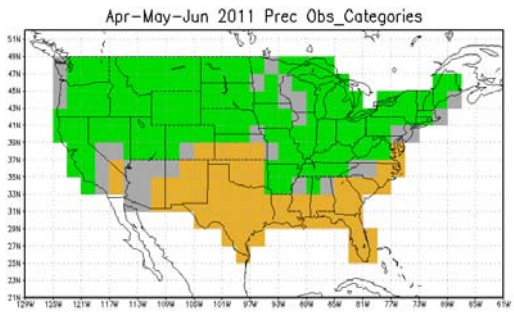
Forecasted Precipitation
March through June





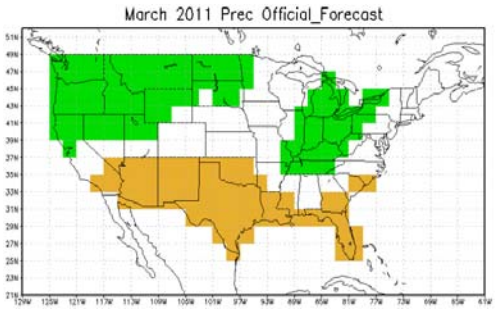
Observed Precipitation
March through June

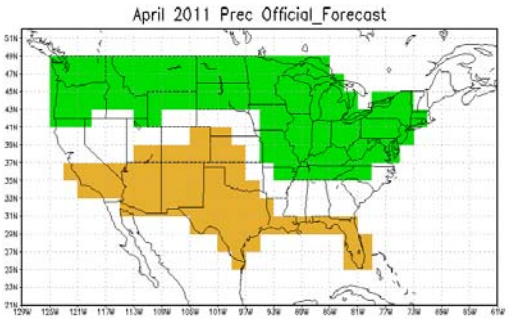


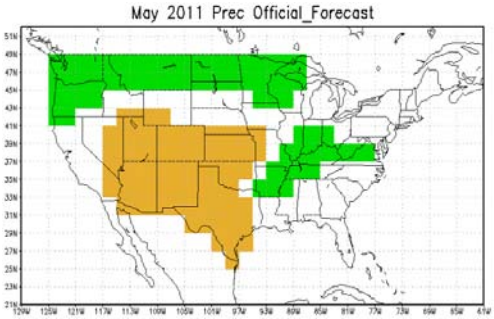


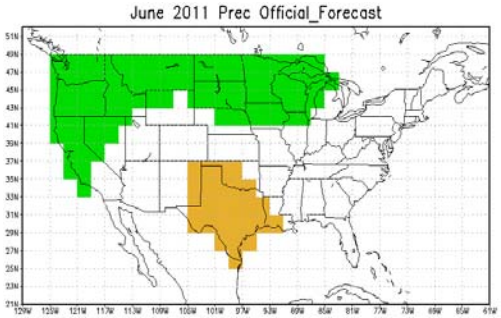
Green indicates above average precipitation while tan indicates below average.

The difference in projected versus observed precipitation supports the Corps' claims they did not have information to believe above average precipitation would occur. Though the three-month forecast was drastically inaccurate, they were not the only forecasts the Corps had available. NOAA forecasts are provided for each individual month. These short-range forecasts provide a more accurate prediction of precipitation for the system.









When viewing each month separately, a very different story is told about rainfall for the upcoming spring. How could the Corps not have anticipated this increased precipitation?

System Storage & Reservoir Releases

The management of the Missouri River System is based upon the guidance provided in the Master Manual. The Annual Operating Plan (AOP) outlines release schedules for each of the reservoirs to ensure the system accommodates each of the following eight uses according to the Master Manual:

- flood control
- navigation
- irrigation
- water supply
- recreation
- hydropower
- water quality
- fish and wildlife

Citizens in flooded areas argue if the Corps would have increased releases earlier, it would have minimized flooding and reduced the time period water remained high in the Basin. The forward of the AOP states: "*This plan may require adjustments such as when substantial departures from expected runoff occur...*"

So did the Corps adjust for this event? There is no doubt there was a substantial departure from expected runoff. The following excerpt from the AOP better describes how releases are determined.

Simulations for the March 1, 2011 to February 29, 2012 time period use five statistically derived inflow scenarios based on an analysis of historic water supply. The report detailing the development of these inflow scenarios was updated in July 2008 to include 9 additional years of inflow data that now extends from 1898 to 2006. Using statistically derived inflow scenarios provides a good range of simulation for dry, average, and wet conditions, and eliminates the need to forecast future precipitation, which is very difficult.

The five statistically derived inflows are identified as the Upper Decile, Upper Quartile, Median, Lower Quartile and Lower Decile runoff conditions. Upper Decile runoff (34.3 MAF) has a 1 in 10 chance of being exceeded, Upper Quartile (30.3 MAF) has a 1 in 4 chance of being exceeded, and Median (24.4 MAF) has a 1 in 2 chance of being exceeded. Lower Quartile runoff (19.3 MAF) has a 1 in 4 chance of the occurrence of less runoff, and Lower Decile (16.2 MAF) has a 1 in 10 chance of the occurrence of less runoff. There is still a 20 percent chance that a runoff condition may occur that has not been simulated; i.e., a 10 percent chance runoff could be lower than Lower Decile and a 10 percent chance runoff could be greater than Upper Decile.

The highest expected runoff according to the AOP is 34.3 million acre feet (MAF). In the spring, total expected runoff for 2011 was anticipated to be at 57.6 MAF, with runoff from January to June at 42.3 MAF, well above the Upper Decile for annual runoff (U.S. Army Corps of Engineers, 2010).

Was the Corps operating at the Upper Decile? Did this governmental agency diverge from the Upper Decile due to "substantial departures from expected runoff?"

A look at actual releases compared to the release schedule of the Upper Decile should provide a clearer answer.

Scheduled versus Actual Releases

Reservoir	Jan. Schedule	Jan. Actual	Feb. Schedule	Feb. Actual	Mar. Schedule	Mar. Actual	April Schedule	April Actual	May Schedule	May Actual
Gavins Point	20,000	18,500	20,000	20,700	23,000	21,000	30,000	30,000	37,500	56,300
Fort Peck	8,000	8,900	12,000	9,800	6,000	7,400	9,000	7,100	11,000	13,000
Garrison	26,000	23,600	28,000	25,800	15,000	21,800	25,000	14,900	32,000	50,700
Oahe	23,000	22,500	23,000	17,700	24,000	13,900	26,000	26,000	32,000	52,600
Fort Randall	16,000	17,300	15,000	15,800	19,000	15,100	27,000	27,700	32,000	57,000
Big Bend	N/A		N/A		N/A		N/A		N/A	

Scheduled releases are approximates based on AOP bar graph.
Releases measured in cubic feet per second (CFS).

When looking at the comparison of planned versus actual releases, the numbers show the Corps was operating very closely to Upper Decile operations. In May, the Corps announced the decision to diverge from the release schedule to operate in emergency mode due to "substantial departure from expected runoff." By this time, the flexibility of the system had been lost.

In a video released by the Corps, Chief of Missouri River Basin Water Management Jody Farhart stated increased releases were due to heavy rainfall in Montana during May, causing substantial departures from anticipated runoff as earlier described.

This raises the question: should the Corps use this year as a new data point and adjust the models to accommodate a flood of this nature? Doing so will ensure the Corps has the correct flexibility to manage the system in the case of a similar event.

Instead it appears the Corps is discounting data from this event and not adjusting reservoir levels for 2012 runoff. They believe it has a small chance of happening again.

With the spring of 2012 already shaping up to be another La Niña cycle and flooding on the Missouri in three out of the last four years, is that an assumption we can afford to make?

To the families whose homes and farms were under water for 14 weeks as of October 1, the answer is black and white. To not use information from this event would be similar to building a sandcastle at low tide and continuing to forget about the high tide washing it away.

The next question: should the Corps have determined there was a departure from anticipated runoff sooner? Though the data above seems to provide a straightforward answer, those numbers should not be observed in isolation.

Let's pull back and look at the five-year average of daily inflows and outflows by month.

If the average conditions of the previous five years were drought conditions, it would make complete sense for the Corps to make up for the increased runoff. But considering inflows had doubled, snowpack was well above normal, and previous years flooding at those average levels, it should have been apparent in early spring that runoff was at the "substantial departure from normal."

Had that been the case, the Corps should have begun releasing high volumes earlier than they did.

In an article featured in the *Capital Journal* of Pierre, S.D., Ruth Brown reports on emails sent to a Washington, D.C.-based agency. *"In February, Fort Pierre Public Works Director Brad Lawrence essentially predicted a 'flood of biblical proportions' if the U.S. Army Corps of Engineers did not start releasing water from Oahe Dam."*

The emails also stated, *"The Corps will hold back water to help alleviate the downstream flooding, filling the reservoirs to capacity in the process. Once full, they will pass everything that comes in"* (Brown, 2011).

The Corps claim they couldn't have predicted this year's events until May, when rainfall in the Basin increased. Emails predicted these outcomes as early as February.

2011 Missouri River Flood		Jan	Feb	Mar	Apr	May
	Snow Pack (Above Fort Peck)	114%	112%	110%	116%	141%
	Snow Pack (Fort Peck to Garrison)	119%	111%	107%	112%	136%
	Runoff (Above Sioux City)	112%	114%	120%	136%	178%
Reservoir	*Flows measured in 1,000 cfs*					
FTPK	Avg Daily Inflow	9.1	12	17.9	15.4	46.1
	5 year avg	6.14	6.62	8.62	8.2	13.08
	Difference	**2.96**	**5.38**	**9.28**	**7.2**	**33.02**
	Avg Daily Outflow	8.9	9.8	7.4	7.1	14.7
	5 year avg	6.88	6.68	5.08	5.1	6.64
	Difference	**2.02**	**3.12**	**2.32**	**2**	**8.06**
GARR	Avg Daily Inflow	14.8	18	32.5	53.7	88.2
	5 year avg	12.42	12.22	17.9	17.46	26.44
	Difference	**2.38**	**5.78**	**14.6**	**36.24**	**61.76**
	Avg Daily Outflow	23.6	25.8	21.8	14.9	50.7
	5 year avg	16.42	15.82	15.84	11.78	13.86
	Difference	**7.18**	**9.98**	**5.96**	**3.12**	**36.84**
OAHE	Avg Daily Inflow	24.8	30.5	50.4	41.4	65.1
	5 year avg	16.72	17.88	27.32	25.42	18.64
	Difference	**8.08**	**12.62**	**23.08**	**15.98**	**46.46**
	Avg Daily Outflow	22.5	17.7	13.9	26	52.6
	5 year avg	14.9	14.5	11.2	11.76	12.4
	Difference	**7.6**	**3.2**	**2.7**	**14.24**	**40.2**
BEND	Avg Daily Inflow	20.6	17.4	17.1	25.2	49.2
	5 year avg	14.08	14.12	12.26	11.26	11.58
	Difference	**6.52**	**3.28**	**4.84**	**13.94**	**37.62**
	Avg Daily Outflow	19.7	17.6	17.2	24.9	50.4
	5 year avg	14.12	14.06	11.94	11.3	11.2
	Difference	**5.58**	**3.54**	**5.26**	**13.6**	**39.2**
FTRA	Avg Daily Inflow	23	22.3	25.1	29.7	58.5
	5 year avg	16.2	16.5	16	13.96	13.44
	Difference	**6.8**	**5.8**	**9.1**	**15.74**	**45.06**
	Avg Daily Outflow	17.3	15.8	15.1	27.7	57
	5 year avg	11.6	9.64	7.98	11.1	14.82
	Difference	**5.7**	**6.16**	**7.12**	**16.6**	**42.18**
GAVPT	Avg Daily Inflow	18.4	20	21.5	30	57
	5 year avg	13.44	12.58	12.54	14.6	17.4
	Difference	**4.96**	**7.42**	**8.96**	**15.4**	**39.6**
	Avg Daily Outflow	18.5	20.7	21	30.3	56.3
	5 year avg	13.32	12.74	12.66	14.32	17.34
	Difference	**5.18**	**7.96**	**8.34**	**15.98**	**38.96**

As early as January, average daily inflows were rising well above the five-year average at most reservoirs. By February, levels were approximately double the five-year average at most locations.

- By May 20, the Corps began increasing releases from the reservoirs by a significant amount, reaching 100,000 cfs from Gavins Point in eight days.
- In a conference call on June 9, the Corps informed the public that releases had reached 150,000 cfs and would remain at that level.
- A short time later, releases jumped to 160,000 cfs and stayed at that level well into August.
- Releases only dropped as low as 90,000 cfs into September. This is still higher than the previous record releases from Gavins Point (70,000 cfs) - a seemingly small number when compared to the highest releases of 2011.

The Impact

On June 5, Levee L-575 at River Mile 552.5 near Hamburg, Iowa breached. This levee protected Interstate 29 as well as the town of Hamburg. The highway is a main travel and shipping corridor connecting Kansas City, Mo., with Omaha, Neb. It is predicted to stay closed for an extended period of time due to erosion and damage to the roadway and overpasses. The economic impact this will have on the region is currently unknown, but sure to be substantial.

This was just one of many levees to break below Gavins Point. By mid-summer, all non-federal levees north of Kansas City had been breached or overtopped in addition to several levees below Kansas City.

Intense flooding occurred from the Dakotas through mid-Missouri. U.S. Department of Agriculture Secretary Tom Vilsack estimated 400,000 to 500,000 acres of farmland were inundated with flood water, much of it remaining under water for up to 15 weeks or more.

As a result of the high water pressuring levees for over four months, towns, families and farmland have and continue to suffer devastating losses in 2011. Even if a levee does not overtop, it is not designed for the constant pressure of high water levels. For that reason, many levees that did not overtop were breached. Contributing to the deteriorating situation was the fact that work was still in progress to repair damage from 2010 flooding.

According to Global Information System (GIS) data prepared by the Missouri Corn Growers Association, a high flow (150,000 cfs) scenario could inundate up to 119,747 acres of corn in Missouri causing as much as $92,202,810 in crop losses from corn acres alone. This data was based on Corps' inundations maps and compared with average yield and price estimates for inundated acres.

These numbers are especially distressing when one adds in the financial loss of homes, infrastructure and other intangibles. The flood of 2011 will have a long-term affect on all who experienced it.

Shifting Focus

The flood event of 2011 cannot be changed. However, it is possible to make changes to better prepare for another such event. There is one main focus that needs to be addressed. That focus has several different facets.

For the first time in many years, if ever, the vast majority of states along the system have agreed flood control is the number one reason for the system above all other uses. The system should be operated to protect life and property first and foremost.

Two things need to happen to reaffirm that flood control is the number one use of the Missouri River Reservoir System:

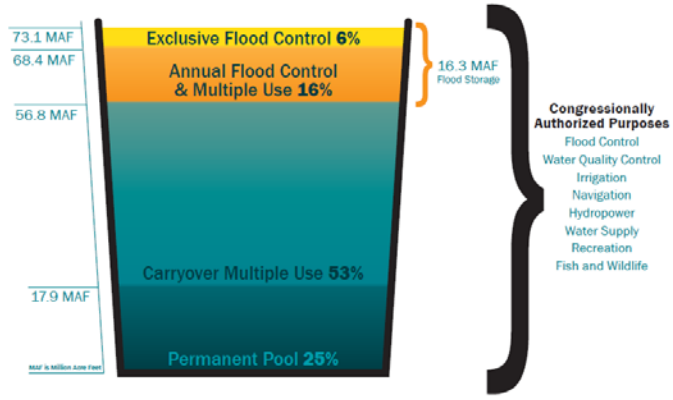
1. *Increase flexibility of the system to accommodate future events similar to the 2011 flood.*
2. *Redirect funding to make flood control the number one priority.*

One way to increase flexibility is to use this event as a new data point. The Upper Decile of releases was far from being able to handle the runoff that occurred this year. Treating 2011 as an outlier event is unwise, especially when considering flooding has occurred three out of the last four years on the Missouri River.

By using this as a new data point, the Corps will have the flexibility to release water more quickly, which may prevent record, long-term high releases experienced this year.

Additionally, a closer look at how the Corps can improve forecasting measures is needed. Currently the AOP indicates the Corps uses future forecasts minimally and relies more heavily on historical data. Being better able to utilize the forecasts for what lies ahead will allow the Corps to decide earlier if they are going to see a "substantial departure from normal runoff" and adjust releases accordingly. This will allow better flood control management during an emergency situation.

It is also important to look at pool allocation from the Corps. Currently, the Corps' objective is to ensure storage levels are at 56.8 MAF at the beginning of the flood season to accommodate runoff (U.S. Army Corps of Engineers, 2010).



Annual Runoff 1898 - 2011 Above Sioux City, Iowa

The Annual Flood Control & Multiple Use and Exclusive Flood Control comprise 22 percent of storage allocations. It is time to lower the 56.8 MAF level in order to provide increased flexibility in a flood situation.

In light of multiple flood years, the system should be managed for floods, not drought. Addressing pool allocations is one way to do that. If there had been increased storage for flood water and quicker releases in 2011, home owners, farmers, business leaders and community members would not have suffered the intensity and duration of the 2011 flooding.

Redirect Funding to Make Flood Control the Number One Priority

CORPS BUDGET Cost as of 2006	CENWK* (1,000)	CENWO** (1,000)	TOTAL (1,000)	% of Total Cost
Land Acquisition	$29,059	$19,509	$48,568	36
Planning, Engineering, Design	$13,695	5,781	19,476	15
Habitat Development	$29,428	24,978	54,406	41
Construction Management	$2,461	2,743	5,204	4
O&M During Construction	$1,727	1,012	2,739	2
Monitoring (1)	$1,379	1020	2,399	2
TOTAL	**$77,749**	**$55,043**	**$132,792**	**100**

**CENWK - Northwest Division Kansas City District* ***CENWO - Northwest Division Omaha District*

It is easy to argue the Corps' focus has shifted to endangered species and restoring habitat rather than controlling floods.

Land Acquisition and Habitat Development represent 77 percent of the budget . Land Acquisition is used for restoring habitat to the same condition it was when Lewis and Clark navigated the river. It is hard to argue flood control is the number one priority when the accounts assisting in flood control (O&M and Construction Management) only comprise 6 percent of the budget.

To truly shift the focus back to flood control, Congress needs to redirect a significant portion of Missouri River Recovery Program (MRRP) funding to Operations & Management (O&M) improvements. MRRP funding for Fiscal Year 2012 is over $78 million with the O&M budget being approximately $6.2 million (U.S. Army Corps of Engineers, 2011f).

Flood control cannot be the number one priority without proper reflection in appropriations. Additionally, funds would allow improvements to Bank Stabilization and Navigation Project structures to accomplish such improvements for the benefit of flood control and navigation.

The Corps should also terminate land acquisition efforts and discontinue distribution of "willing seller" letters.

Of the 166,750 acres authorized for purchase, currently 60,476 acres have been acquired by the Corps with 22,381 acres in Missouri (U.S. Army Corps of Engineers, 2011f). At a time when levees are in desperate need of rebuilding, this practice must stop. It is irresponsible to direct government dollars to government acquisition of private land in lieu of protecting citizens.

Moving Forward

While nothing can be done to change 2011, we can utilize lessons learned to prepare for future events. It is the Corps responsibility to fully evaluate the 2011 flood and identify measures to prevent future flooding.

While there is flexibility to meet all of the needs of the system, flood control should not be sacrificed. Farmers who take the risk of farming along the river realize they will experience floods, but not at the current level or frequency. The system was authorized to control floods and should be managed accordingly.

Conclusion

The management focus of the Missouri River Reservoir System has shifted from flood control to include often competing purposes such as recreation and habitat restoration. As a result, residents along the Missouri River are experiencing multiple years of flooding and record crest levels due to historic releases from the reservoir system.

Record releases from Gavins Point were previously 70,000 cubic feet per second (cfs). In 2011 releases reached 160,000 cfs, flooding towns, homes and thousands of acres of prime farmland. The following changes need to be made to ensure the system is managed for flood control:

1. ***Increase flexibility of the system to accommodate events such as the 2011 flood while prioritizing flood control as the number one use.***
    a. Adjust pool allocation for increased flood control
    b. Use 2011 as a new data point in modeling
    c. Improve forecasting methods and utilization
2. ***Redirect funding to make flood control the number one priority.***
    a. Shift funding from Missouri River Recovery Program (MRRP) to Operations & Management (O&M) budgets
    b. Refocus funding to flood control in lieu of restoration project.

A system designed to manage floods is not working properly. It is the Corps' responsibility to make the necessary changes to ensure the impact of flooding is minimized and residents along the river feel a sense of security living and working alongside this national treasure.

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The Missouri Corn Growers Association was formed in 1978 to protect the rights of its members, build new markets for corn and increase opportunities for Missouri corn farmers through sound public policy.

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