SECTION III

THE 2011 FLOOD

A. INTRODUCTION

The 2011 Mississippi River Flood broke numerous stage records and produced the highest flows ever recorded along the waterway from Cairo to the Morganza Floodway (below the Morganza Floodway all record flows date to before floodway construction). River stages and flow rates were comparable to the major floods of 1927 and 1937. Well above-average precipitation fell throughout the Mississippi, Missouri, and Ohio River Valleys from January through early May. Several areas across the Mississippi Valley reached flood stage beginning in late February. In April, two major storm systems deposited record levels of rainfall on the Mississippi River watershed. That rainfall combined with the springtime snowmelt resulted in the river and many of its tributaries swelling to record levels by the beginning of May.

The primary meteorological factors that led to the historic Mississippi River Flood of 2011 included above-normal snowfall over the Upper Mississippi Valley, elevated river levels from heavy rain events from February to April, and a very heavy rain event the end of April/beginning of May. Heavy snow in December 2010/early January 2011 and again at the end of February/beginning of March led to 150 to 300 percent of normal SWE (snow water equivalents) on the ground over Minnesota and Wisconsin. Cold temperatures delayed the melting process until the third week of March, which allowed for the crest from the snow to reach the confluence of the Mississippi and Ohio Rivers at the end of April.

Heavy rains that fell over the Ohio and Middle Mississippi Valleys between the end of February and the middle of March produced the 14th highest historical stage at Cairo on March 18. The river fell through the end of April, but rain occurred once again at the beginning of April producing river stages of 9 feet above flood stage at Cairo by the middle of April. At that time, very heavy rains began and lasted from the middle of April through the beginning of May over the watershed from Arkansas City to Chester and over the Lower Ohio Valley.

Two week totals from April 19 to May14 of 8 to16 inches of rain occurred over the Mississippi watershed from Arkansas City to Caruthersville and amounts of 12 to 22 inches occurred over the watershed from Caruthersville to Chester and over the Lower Ohio Valley. These amounts were 600 to 1000 percent of normal rainfall for that time period. With the addition of the water from 150 to 300 percent of normal snow water equivalents over Minnesota and Wisconsin which melted and reached the confluence of the Mississippi and Ohio Rivers in conjunction with the very heavy rains and already elevated river levels, river stages exceeded record levels at the confluence of the Mississippi and Ohio Rivers on April 29 and at downstream locations as the flood progressed.

B. METEOROLOGICAL AND PHYSICAL CONDITIONS

Heavy snow in December 2010 and January 2011 produced snow water equivalents over the watershed north of Rock Island of 2 to 6 inches by the end of January. One inch or less of snow water equivalents were on the ground over the watershed from St Louis to Rock Island. A heavy snow storm struck the entire Mississippi watershed during the first and second weeks of February, resulting in 3 to 6 inches of snow water equivalent totals to the north of Rock Island and 3 inches or less of snow water equivalents from Natchez to Rock Island. Above normal temperatures over the Mississippi watershed the weekend of February 12 to 13 resulted in all of the snow to the south of Rock Island, IL melting by February 16. River ice coverage of 70 to 100 percent along the mainstem

Mississippi River to the north of St Louis also began its initial break-up at this time causing some ice jam flooding. Due to the snow melt and ice break-up, minor flooding was experienced along the mainstem Mississippi River from Grafton to Hannibal during the third week of February and minor to moderate flooding was occurring over many tributaries in Iowa, Missouri, and Illinois. Also due to snow melt, the Ohio River at Cairo (the confluence of the Mississippi and Ohio Rivers) was predicted to crest at 38.0 feet (flood stage is 40.0 feet) on March 1. By the weekend of February 19 to 20, the only snow remaining over the Mississippi watershed was 2 to 6 inches of snow water equivalents to the north of Dubuque.

A strong low pressure area moved out of the Southern Plains on February 24 and across the Middle Mississippi and Ohio Valleys, bringing rainfall amounts of 1 to 4 inches to the watershed from Helena, AR to St Louis, MO and snowfall amounts to 7 inches (1/2 inch SWE) to the watershed north of St Louis. Ten tornadoes and 202 damaging winds incidents occurred as the system moved through the watershed. A second heavy rain event of 1 to 4 inches occurred over the watershed from Greenville to Rock Island on February 27 and 28. After these events, minor to moderate flooding was being experienced along the mainstem Mississippi from Osceola to Grafton and on numerous tributaries in Missouri and Illinois and the Ohio Valley. The Ohio River at Cairo had risen above flood stage to 44.3 feet on March 1 with a forecasted crest of 48.0 feet on March 7.

A third round of 1 to 4 inches of rain occurred March 4 and 5 across the watershed to the south of Dubuque with snow falling over the watershed north of Dubuque. Rain continued on March 8 and 9 as another low pressure area moved across the watershed, bringing snowfall amounts to 8 inches (3/4 inch SWE) over the watershed north of Dubuque and rainfall amounts of 1 to 4 inches over the watershed south of Dubuque. As a result of these rain events, minor to moderate flooding continued on the mainstem Mississippi from Osceola to Grafton; along the Illinois River downstream from Starved Rock; along the Ohio River downstream from McAlpine L&D; and over numerous tributaries over the Ohio and Tennessee Valleys and over Mississippi and Louisiana. Cairo had reached a stage of 50.7 feet on March 10 with the crest forecasted to reach 52.0 feet on March 12. The last rain event in this series occurred on March 14 to 15 where 2 inches or less of rain occurred over the watershed to the south of Keokuk.

The heaviest rains occurred locally over the Lower Ohio Valley near Cairo. This caused the River to rise to a crest of 53.41 feet on March 18, the 14th highest historical crest. At the time of the crest at Cairo, minor to major flooding was being experienced along the mainstem Mississippi River from Memphis to Cape Girardeau and along the entire Ohio River. Minor to moderate flooding was occurring along the Illinois River downstream from Peoria and over numerous tributaries to the south of St Louis. Snow began to melt over the watershed north of Dubuque on March15 with snow water equivalents of 1 to 5 inches remaining on the ground over the watershed to the north of Dubuque on March 22. These snow water equivalents were 150 to 300 percent of normal over Minnesota and Wisconsin and caused minor to major flooding along the mainstem Mississippi River beginning the last week of March. The Mississippi River at St Paul exceeded major flood stage and reached its 8th highest crest on March 29 at 19.01 feet.

The Ohio River at Cairo fell below flood stage on April 3, but rainfall amounts of 1 to 2 inches on April 8 and 9 and 1 to 4 inches on April 11 and 12 caused the river to rise again above flood stage on April 10 with a crest of 47.0 feet predicted for April 20. A second round of heavy rains began as a cold front moved through the Middle Mississippi/Ohio Valleys on April 14 to 15. Rainfall amounts of 1 to 4 inches accompanied by widespread severe thunderstorms (32 tornadoes, 396 damaging winds incidents, and 324 large hail reports on April 19) moved through the watershed from Greenville to Dubuque on April 18 to 20. With this rain, the Ohio River at Cairo was forecasted to reach a crest of 51.0 feet on

April 30. The frontal system basically became stalled over the Arkansas and Ohio Valleys from April 20 to May 2, setting up the rain event that caused the Ohio River at Cairo to exceed record levels. As the front stalled, daily rounds of heavy rains occurred over the watershed from Arkansas City to Chester with rainfall totals from April 22 to 27 of 5 to 14 inches falling. On April 28, the Mississippi River at St Louis was cresting around 34.1 feet and the Ohio River at Cairo was rising at 58.7 feet with an expected crest of 60.5 feet on May 1. The final round of rain occurred from April 30 to May 2 over the watershed from Greenville to Chester and over the Lower Ohio Valley where 2 to 8 inches fell. Cairo reached 61.0 feet during the morning of May 2 with a forecasted crest of 63.0 feet on May 5. The front finally exited the watershed and rains ended on May 3.

Two week totals from April 19 to May 4 of 8 to16 inches occurred over the Mississippi watershed from Arkansas City to Caruthersville and amounts of 12 to 22 inches occurred over the watershed from Caruthersville to Chester and over the Lower Ohio Valley (figure III-1). These amounts were 600 to 1000 percent of normal rainfall for that time period (figure III-2). The addition of 150 to 300 percent of normal snow water equivalents over Minnesota and Wisconsin (figure III-3), which melted and reached the confluence of the Mississippi and Ohio Rivers in synchronization with the heavy rains, and elevated river levels from early April rains were the key factors that led to the 2011 Flood.

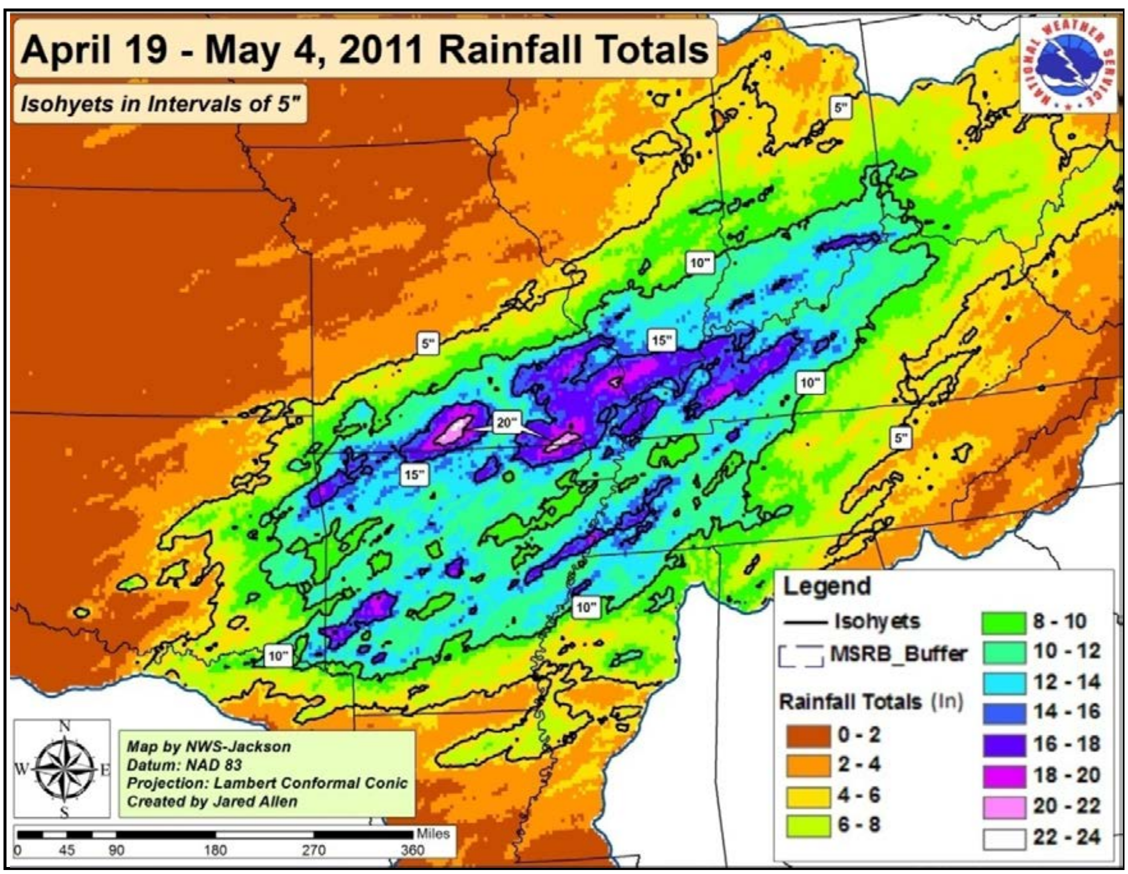

Figure III-1. Rainfall Totals Over Portions of the Lower Mississippi and Ohio Watersheds From April 19 to May 4, 2011

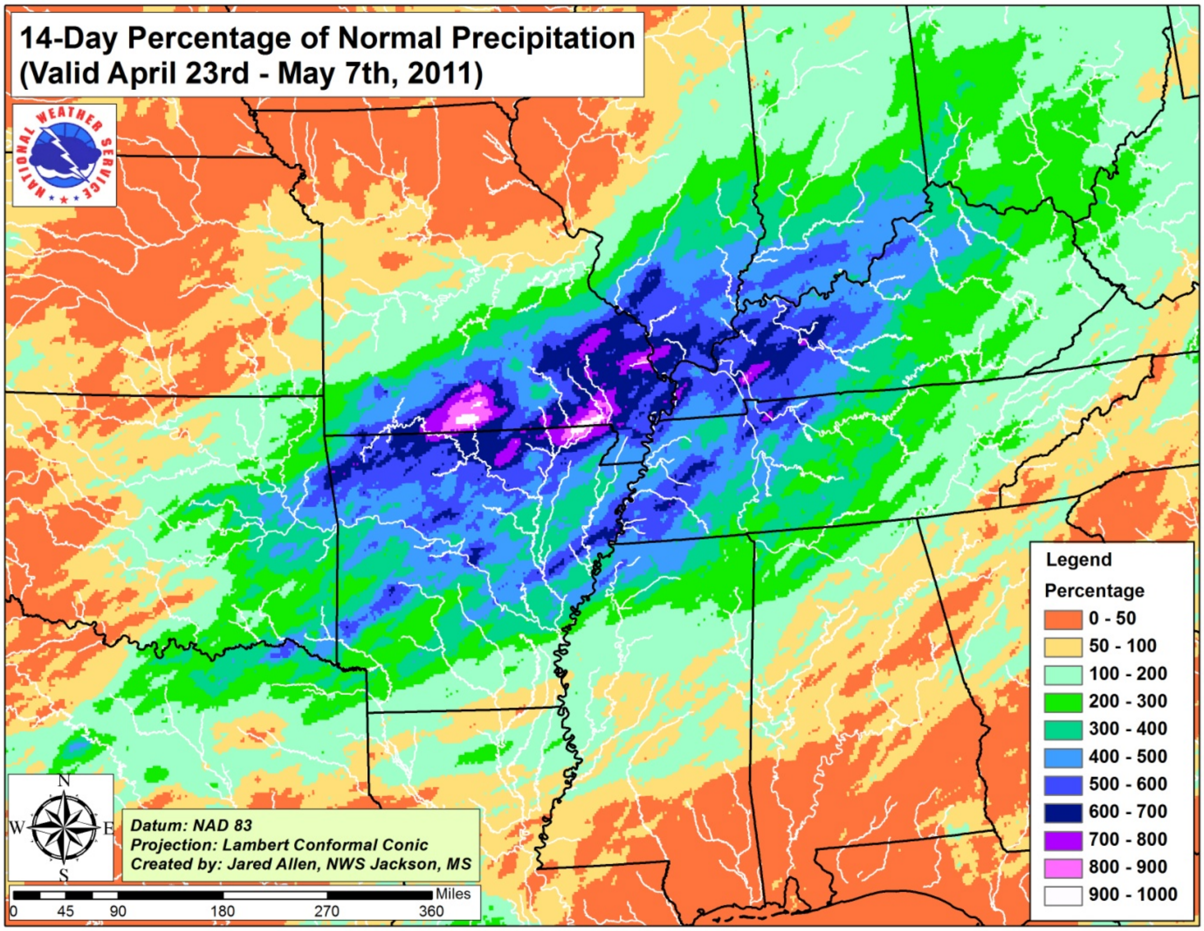

Figure III-2. Percent of Normal Precipitation Over Portions of the Lower Mississippi and Ohio Watersheds From April 23 to May 7, 2011

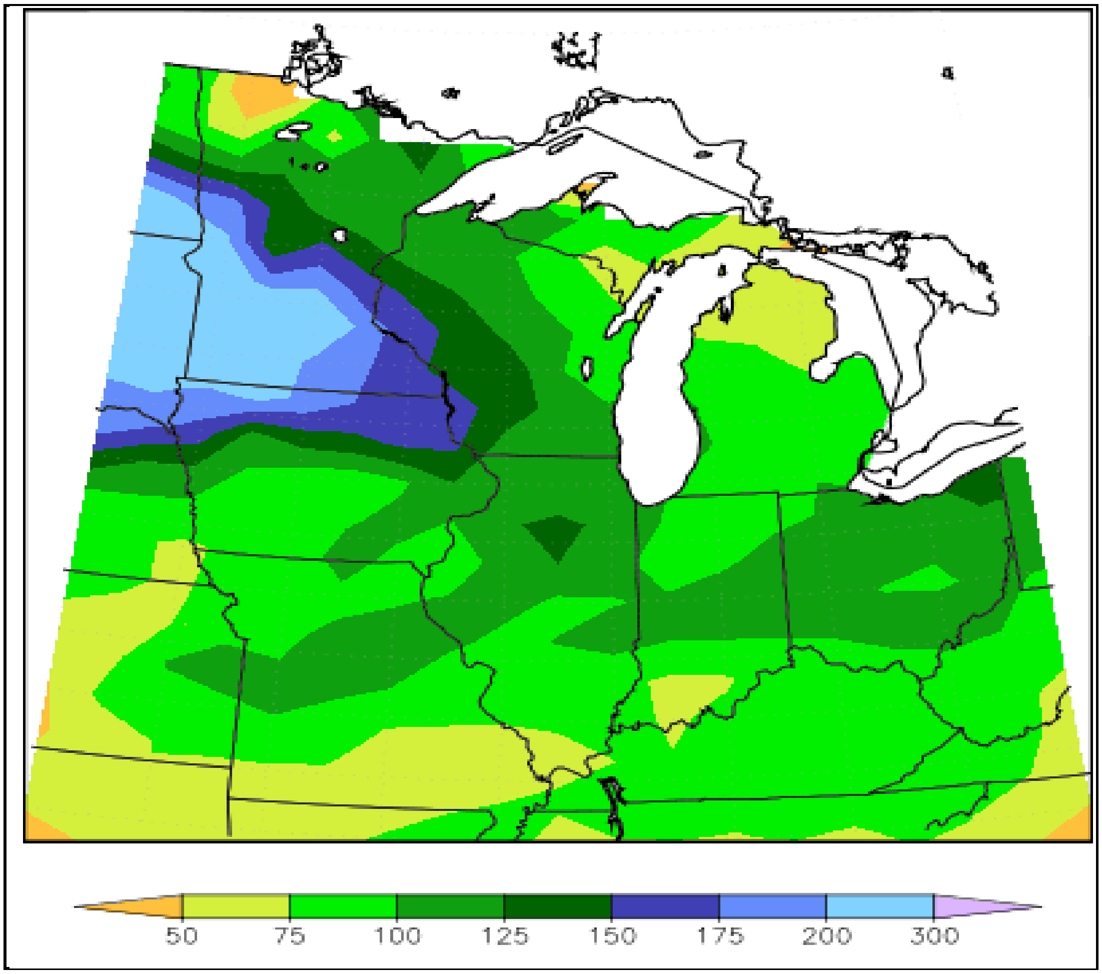

Figure III-3. 150 to 300% of Normal Snow Water Equivalents Over the Watershed North of Dubuque, IA From December 1, 2010 to February 28, 2011
(Source: Midwestern Regional Climate Center, Illinois State Water Survey, UI at Urbana-Champaign)

C. HISTORICAL FLOODS

There were major floods on the LMR in 2011, 2008, 1997, 1995, 1993, 1983,1973, 1950, 1937, 1929 and 1927. Past floods can provide some historical context for the 2011 Flood. Figures III-4 through III-14 are hydrographs for key locations on the Mississippi, Ohio, and Atchafalaya Rivers and illustrate how the 2011 Flood and other floods of note affected river stages at those locations, relative to flood stage and the PDF at each location.

Please note that physical gage locations may have varied slightly during the historical record. Because of this, hydrograph data may not be directly comparable between years at the same gage.

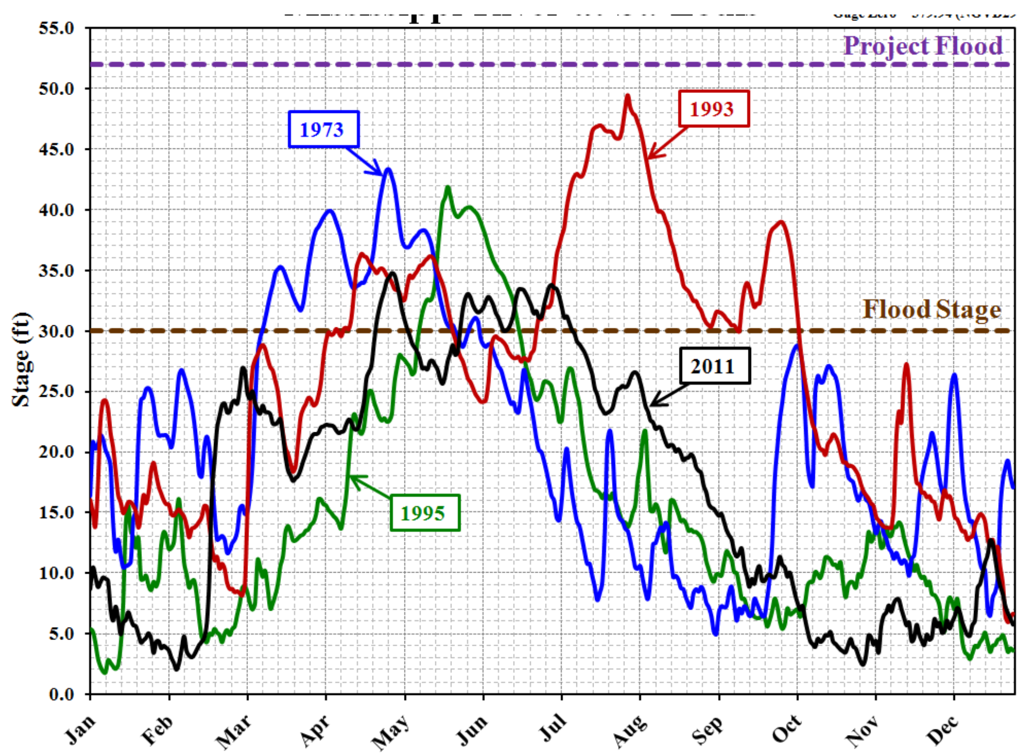

Figure III-4. Mississippi River Hydrograph, St. Louis, MO
[Gage Zero=379.94 (NGVD29), project flood refers to urban St. Louis protection (non-MR&T projects)]

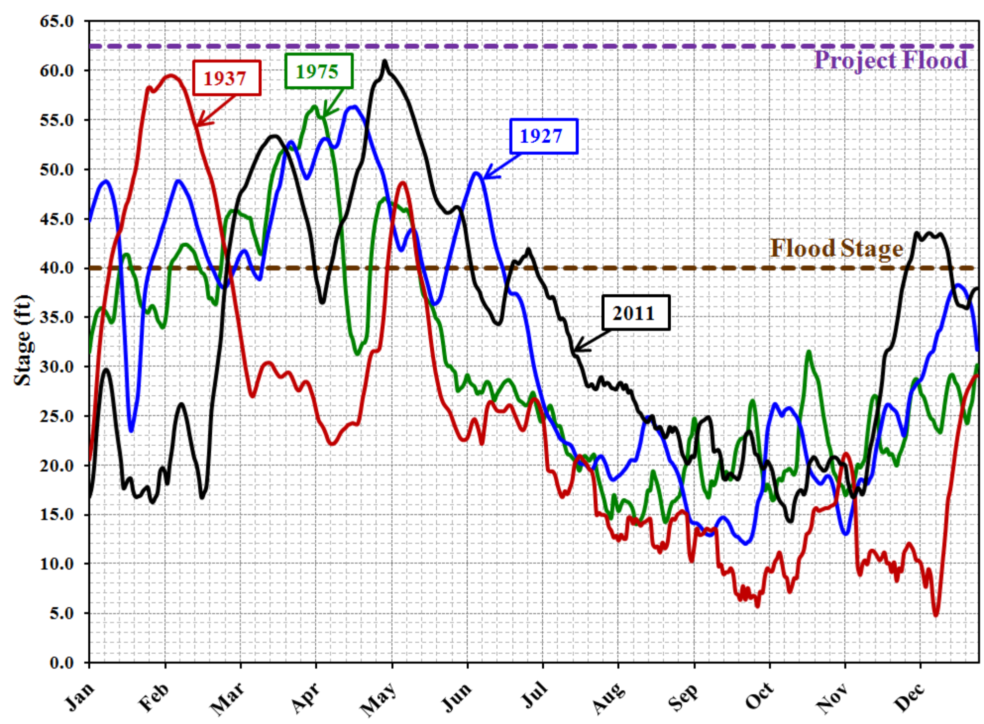

Figure III-5. Ohio River Hydrograph, Cairo, IL - Gage Zero=270.474 (NGVD29)

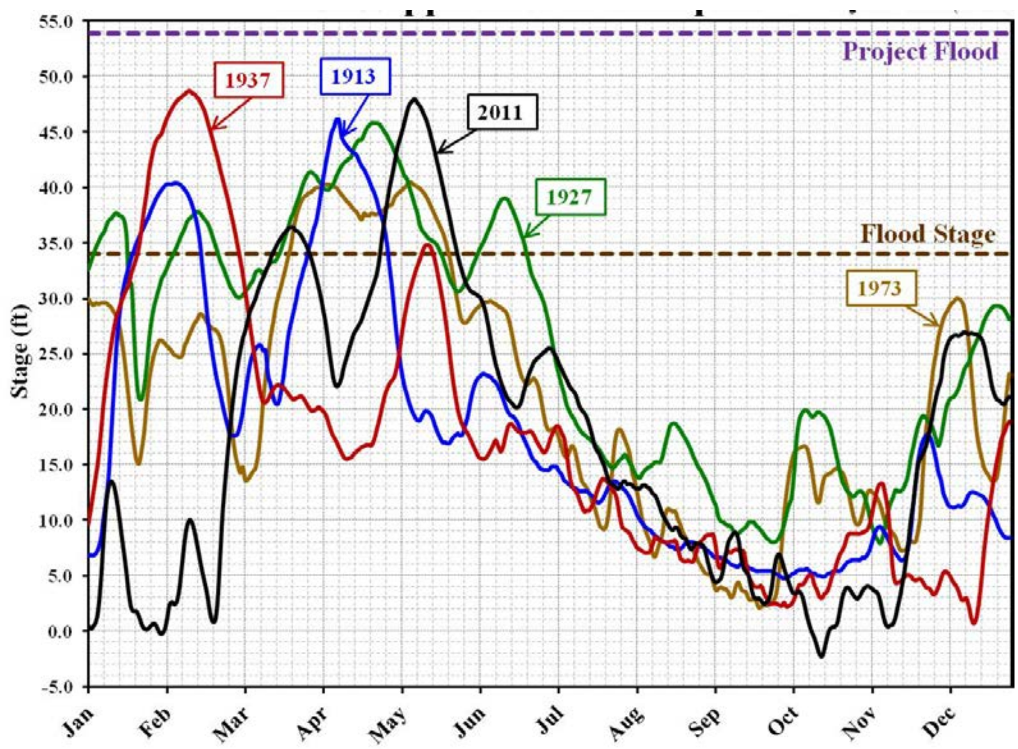

Figure III-6. Mississippi River Hydrograph, Memphis, MO - Gage Zero=183.91 (NGVD29)

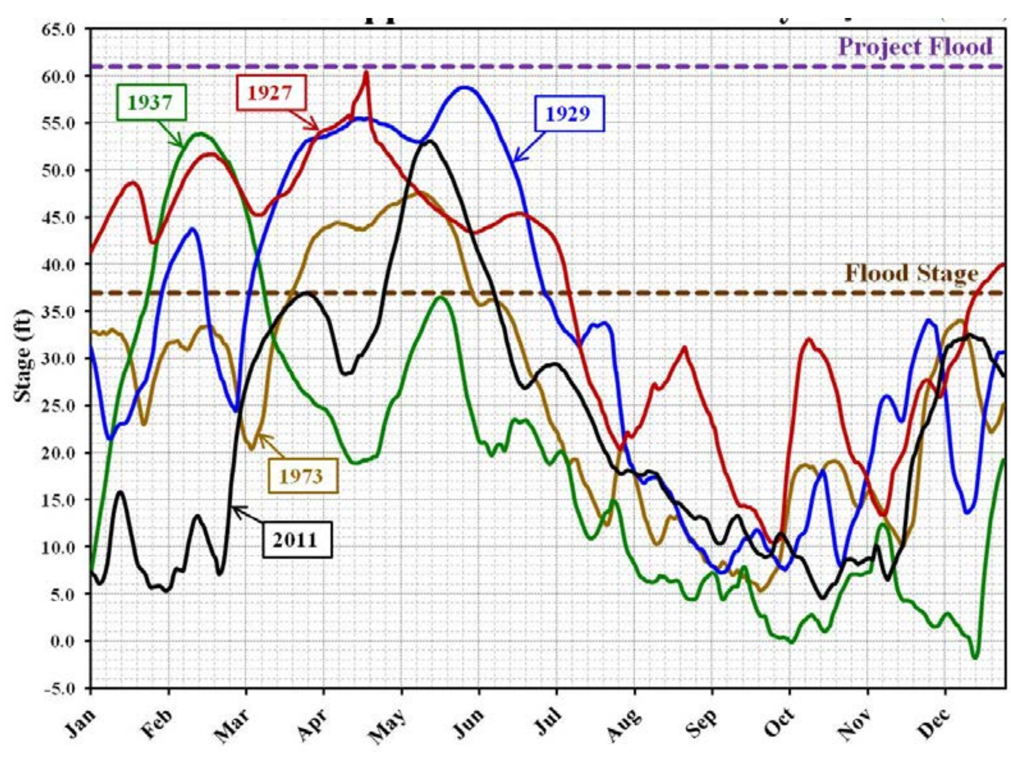

Figure III-7. Mississippi River Hydrograph, Arkansas City, AR - Gage Zero=96.66 (NGVD29)

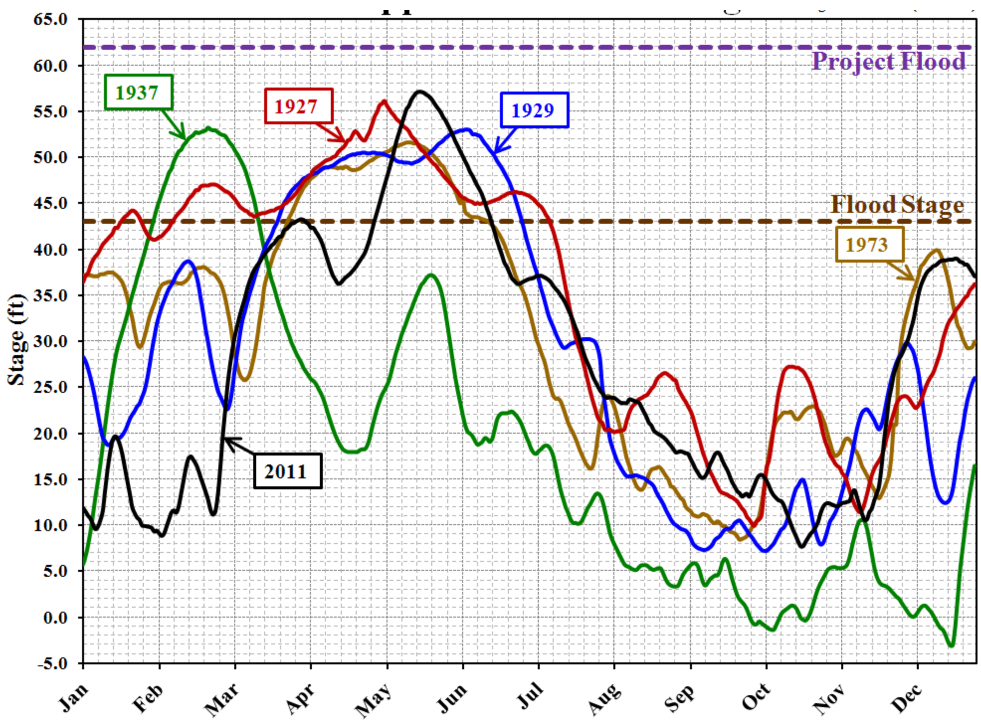

Figure III-8. Mississippi River Hydrograph, Vicksburg, MS - Gage Zero=46.23 (NGVD29)

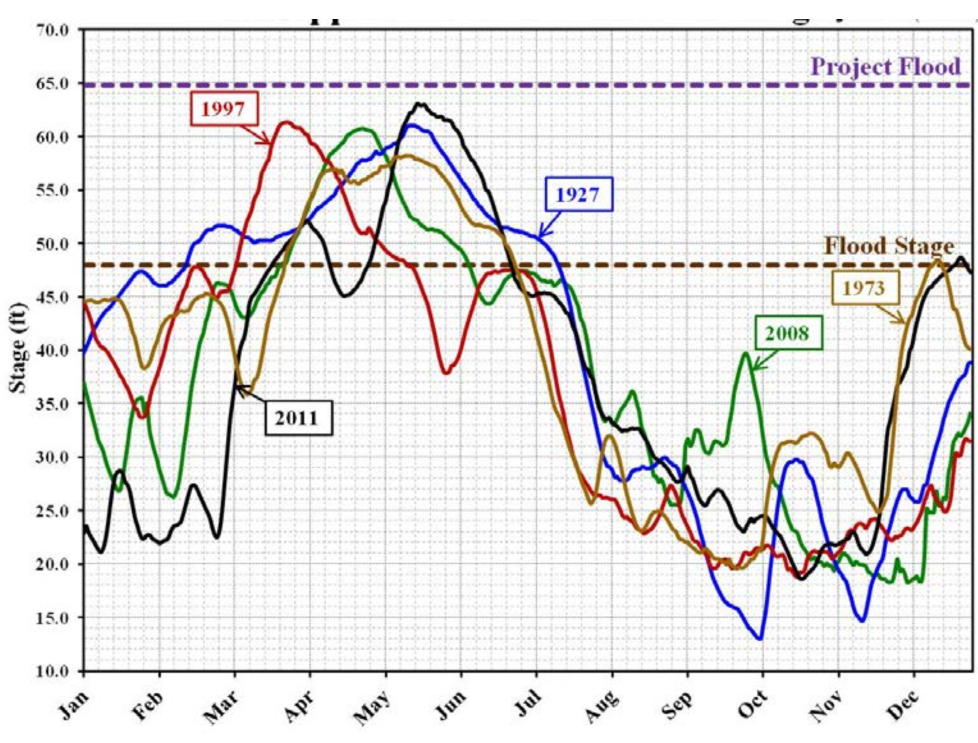

Figure III-9. Mississippi River Hydrograph, Red River Landing, LA - Gage Zero=0.0 (NGVD29)

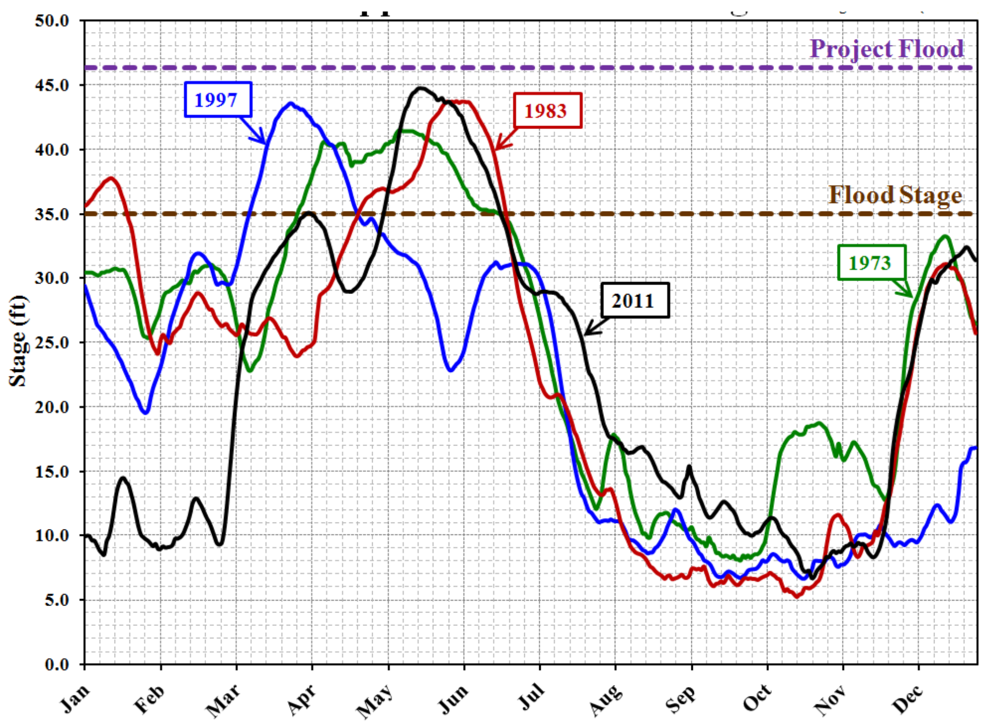

Figure III-10. Mississippi River Hydrograph, Baton Rouge, LA - Gage Zero=0.0 (NGVD29)

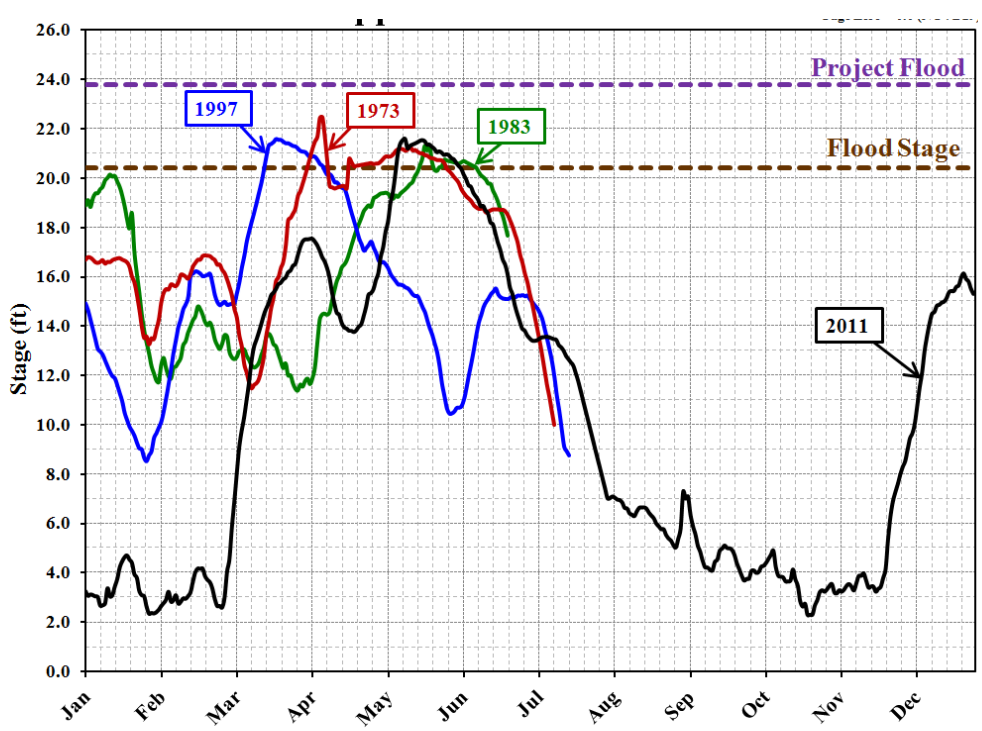

Figure III-11. Mississippi River Hydrograph, Bonnet Carré, LA - Gage Zero=0.0 (NGVD29)

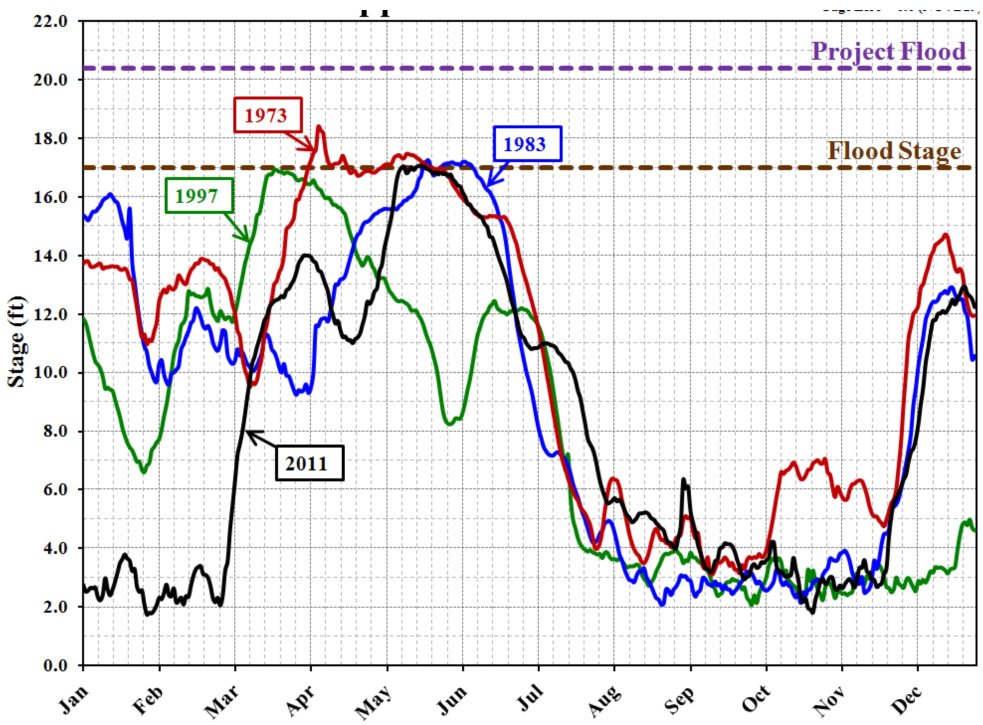

Figure III-12. Mississippi River Hydrograph, New Orleans, LA - Gage Zero=0.0 (NGVD29)

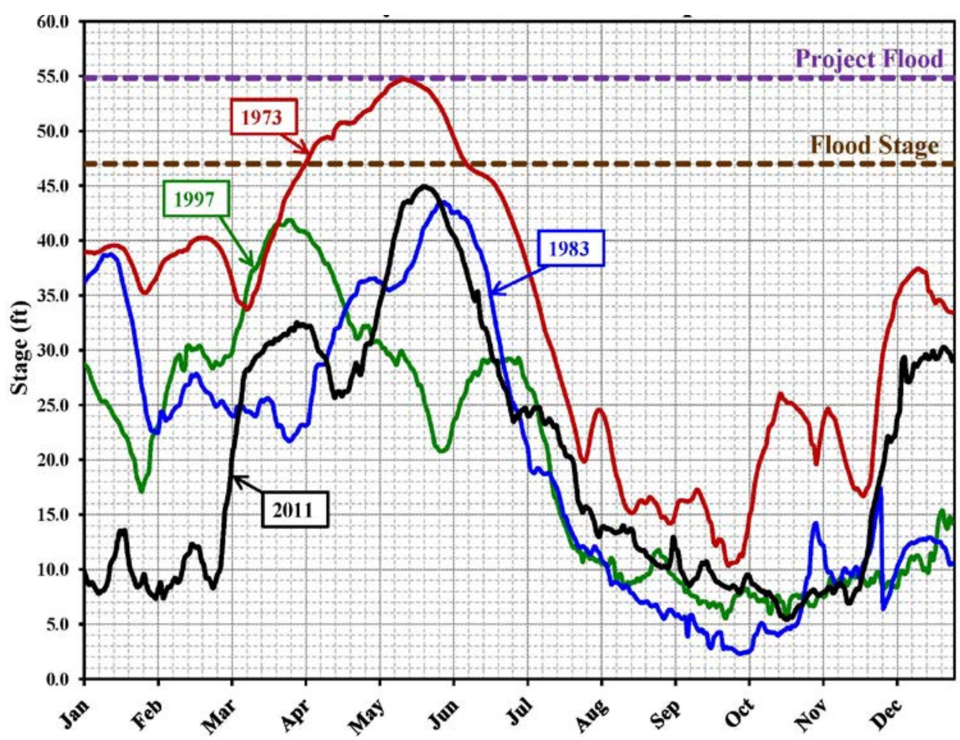

Figure III-13. Atchafalaya River Hydrograph, Simmesport, LA - Gage Zero=0.0 (NGVD29)

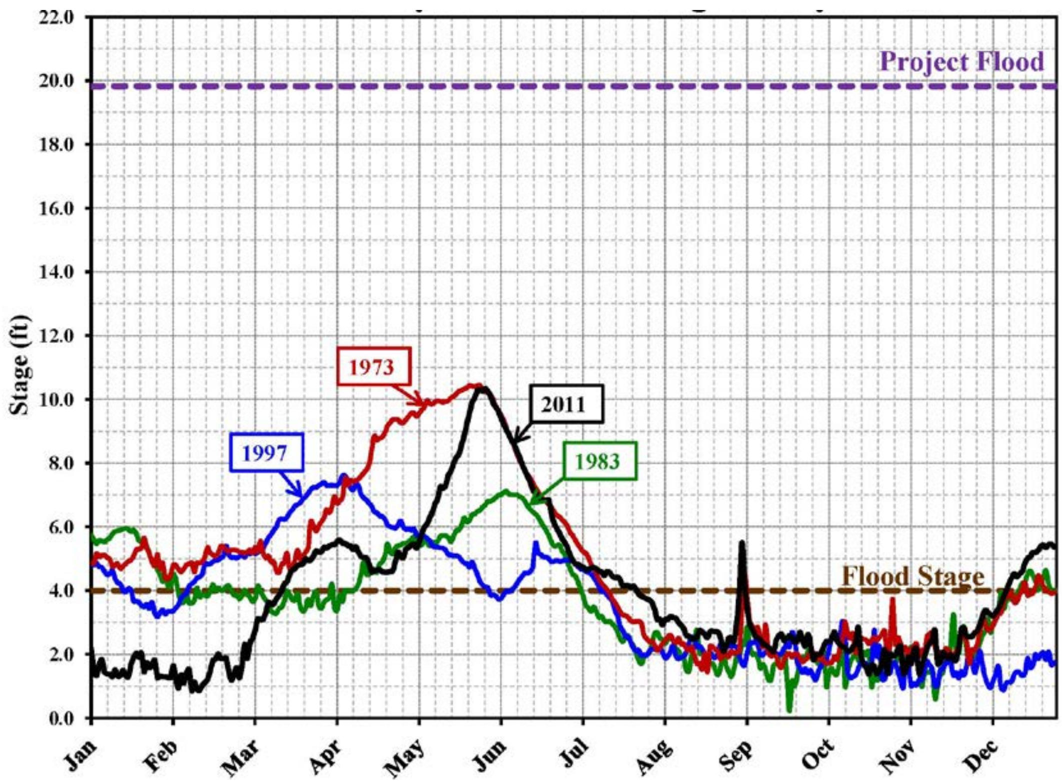

Figure III-14. Atchafalaya River Hydrograph, Morgan City, LA - Gage Zero=0.0 (NGVD29)