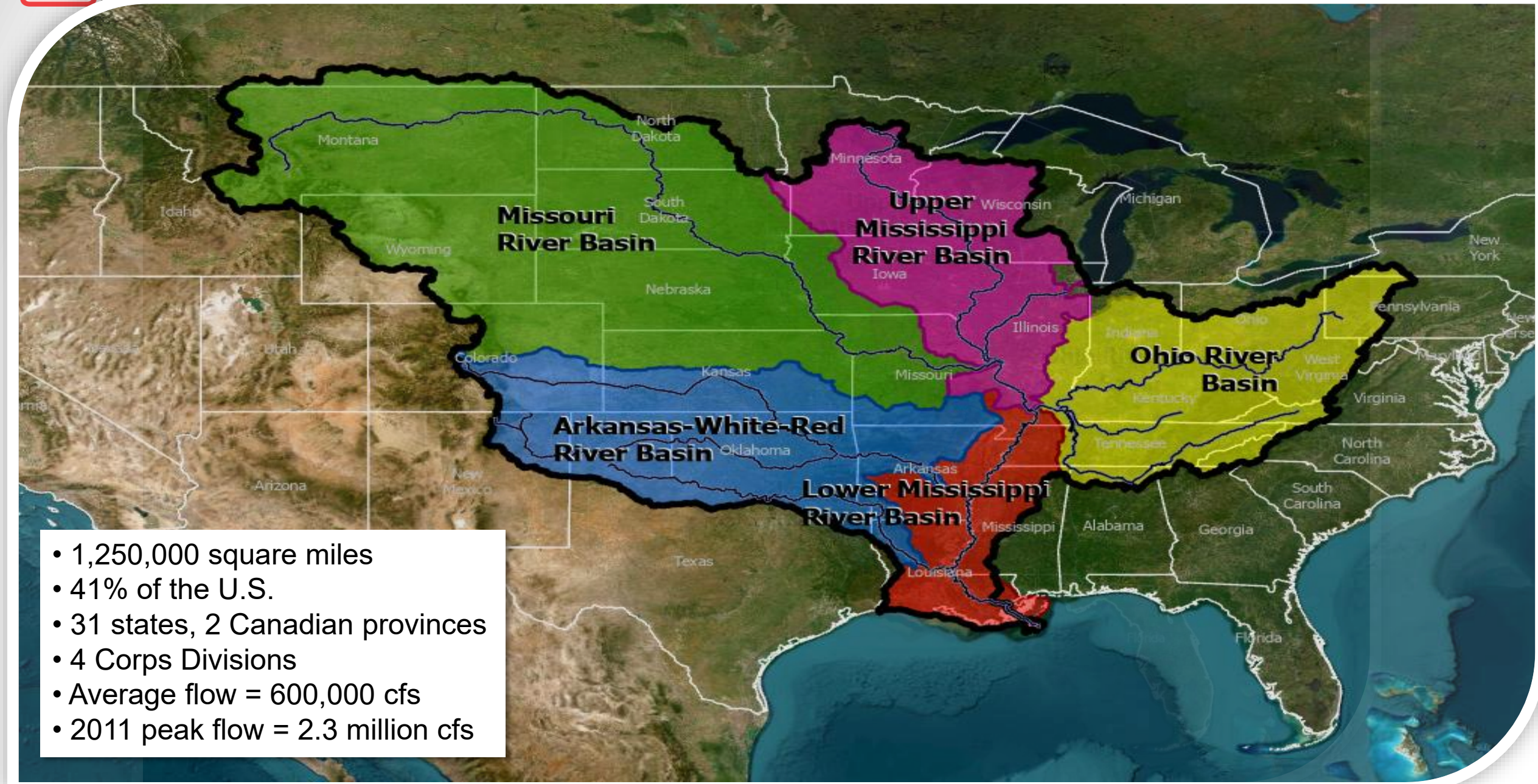
HOW WATER WORKS IN THE MISSISSIPPI RIVER BASIN

U.S. ARMY

US Army Corps of Engineers®

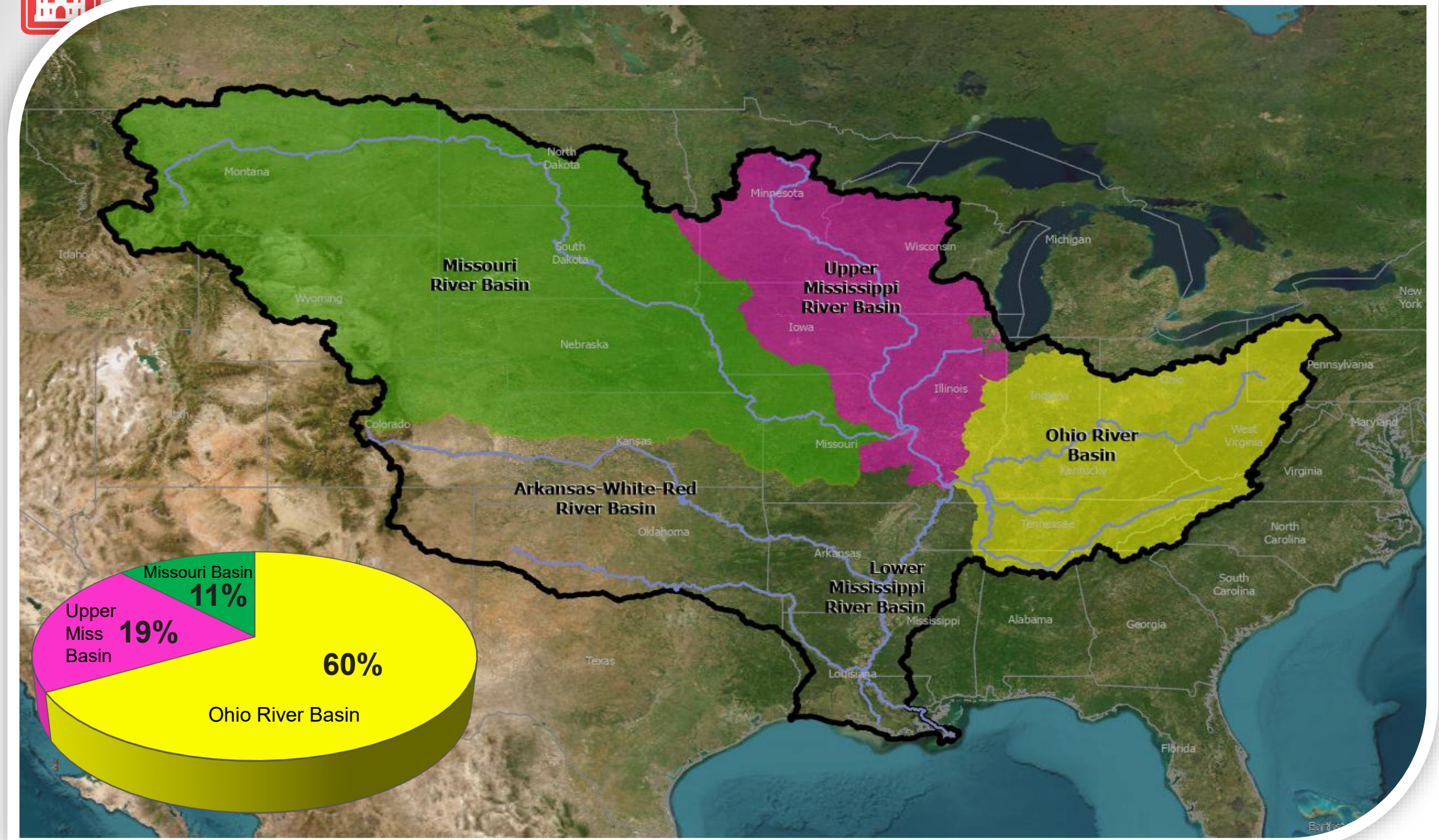
MISSISSIPPI VALLEY DIVISION
US ARMY CORPS OF ENGINEERS

Mississippi River Watershed

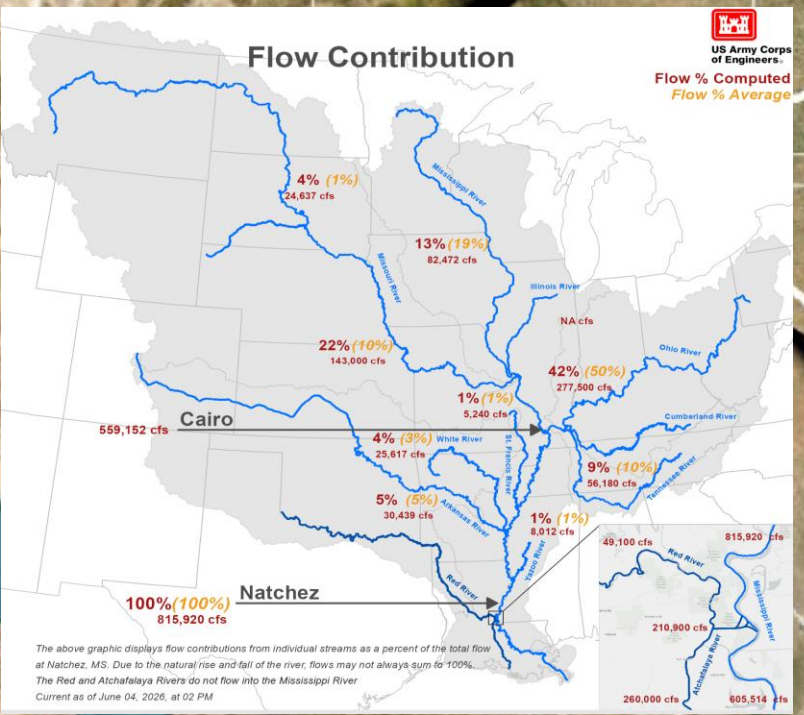


- 1,250,000 square miles
- 41% of the U.S.
- 31 states, 2 Canadian provinces
- 4 Corps Divisions
- Average flow = 600,000 cfs
- 2011 peak flow = 2.3 million cfs

Watersheds Above Cairo



Flow Percentages on Average



1%

Gavins Point

19%

10%

50%

5%

St. Francis River

90% @ Cairo

1%

3%

White River

10%

1%

Yazoo River

100% @ Natchez

Missouri River

Mississippi River

Illinois River

Ohio River

Tennessee River

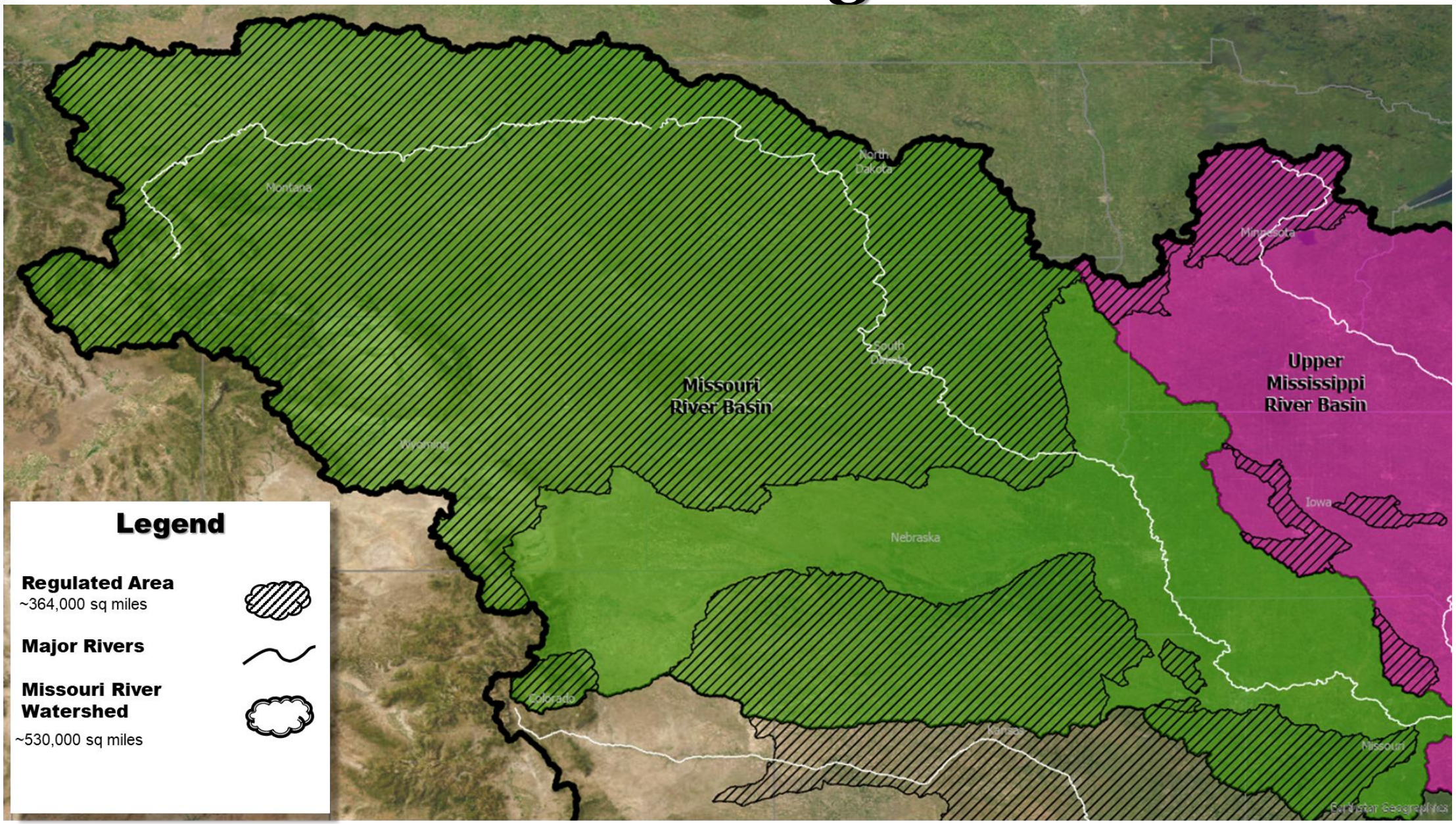
Arkansas River

Red River

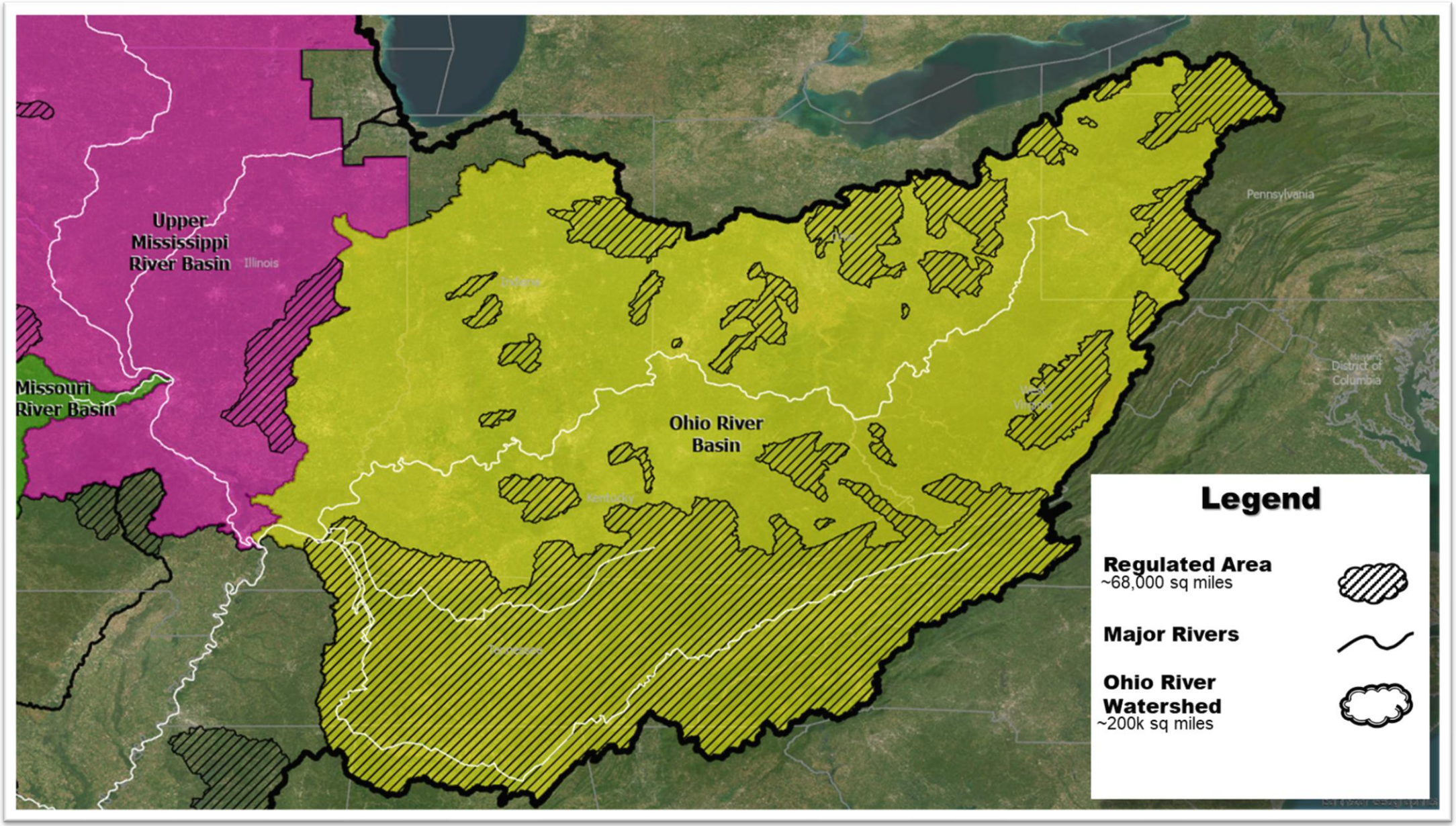
Atchafalaya River

Earthstar Geographics

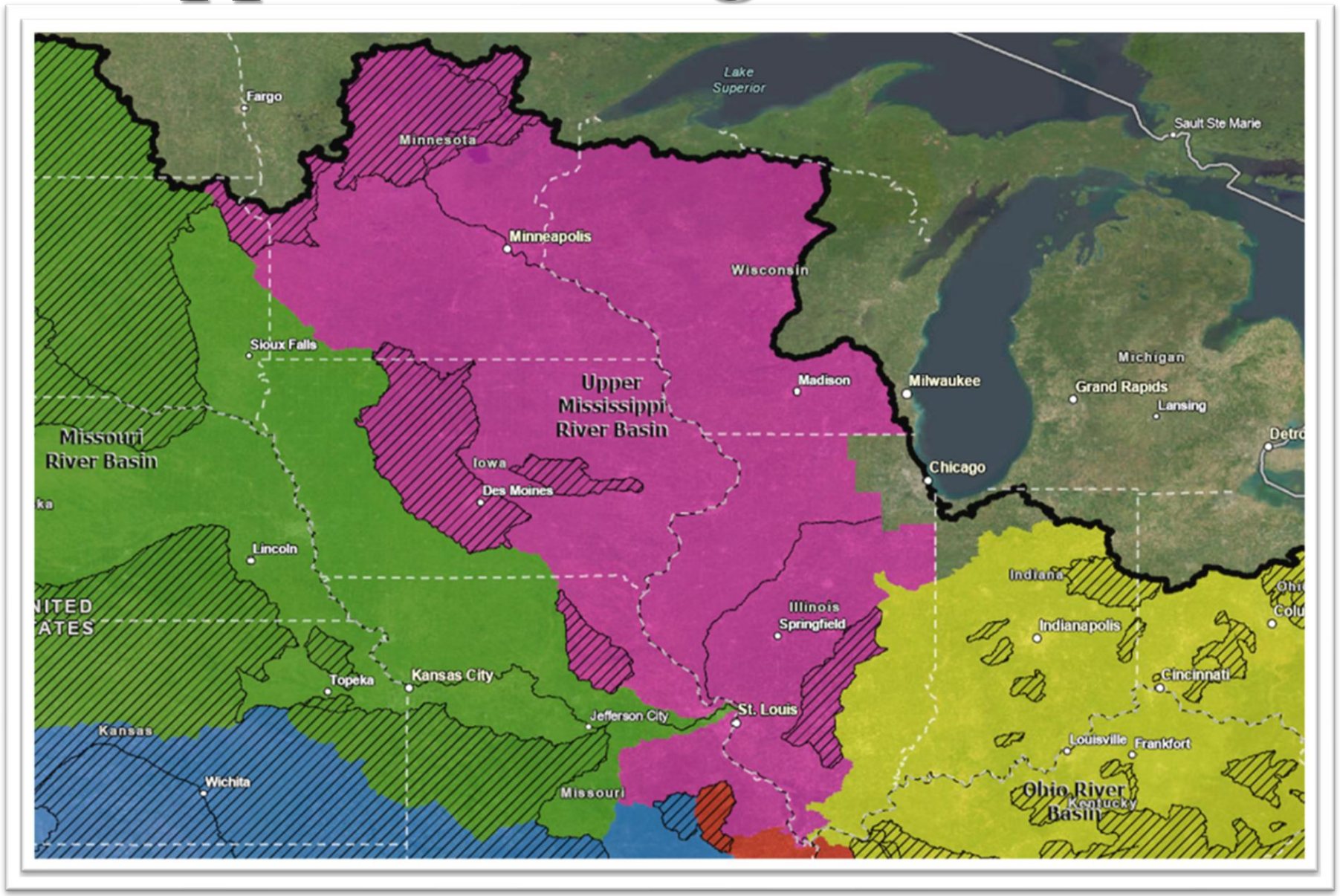
Missouri Basin Regulated Area



Ohio Basin Regulated Area



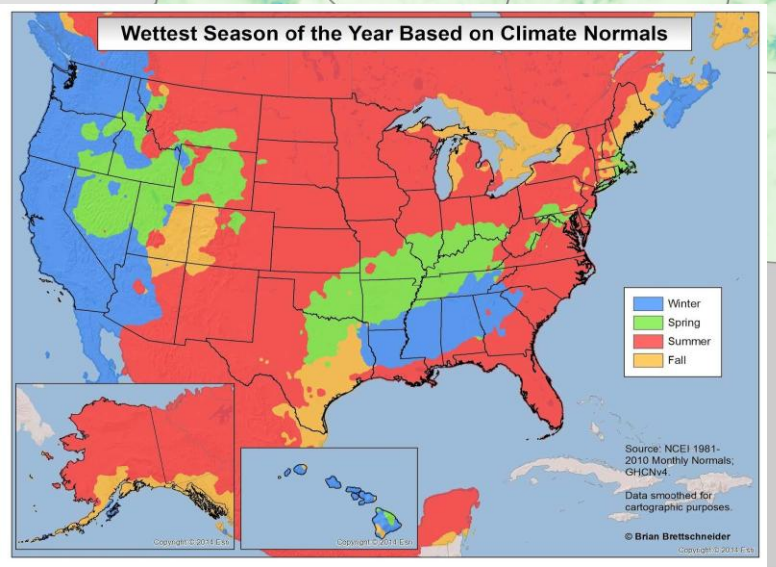
Upper Miss Regulated Area



8

WHERE THE RAIN OCCURS

U.S. annual average precipitation (1991–2020)



1991–2020 Normals

Total precipitation (inches)

0 10 20 30 40 50 60 70 80

NOAA Climate.gov
Data: NCEI

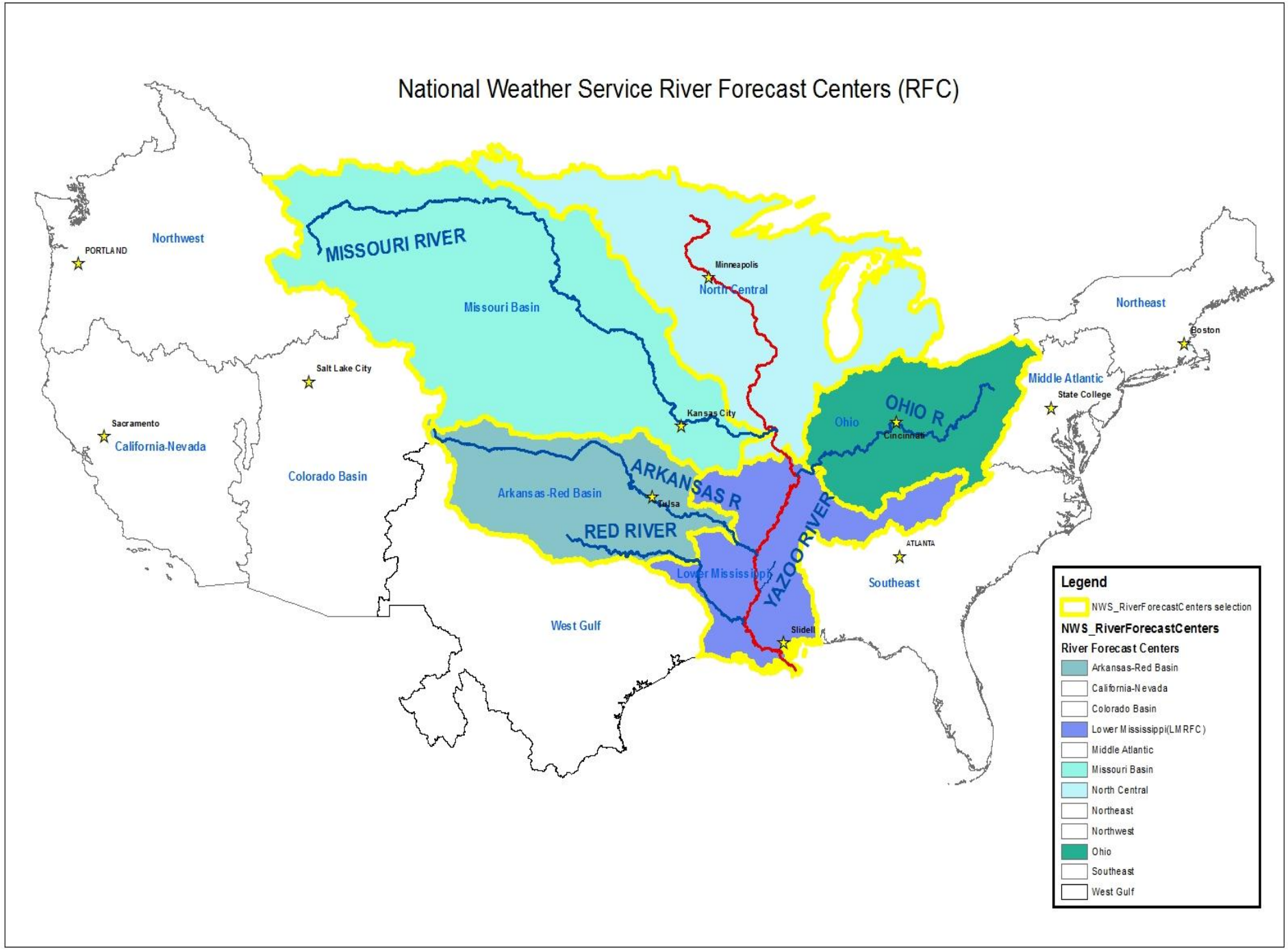
WHERE WE ARE - USACE WORLDWIDE

USACE DIVISIONS

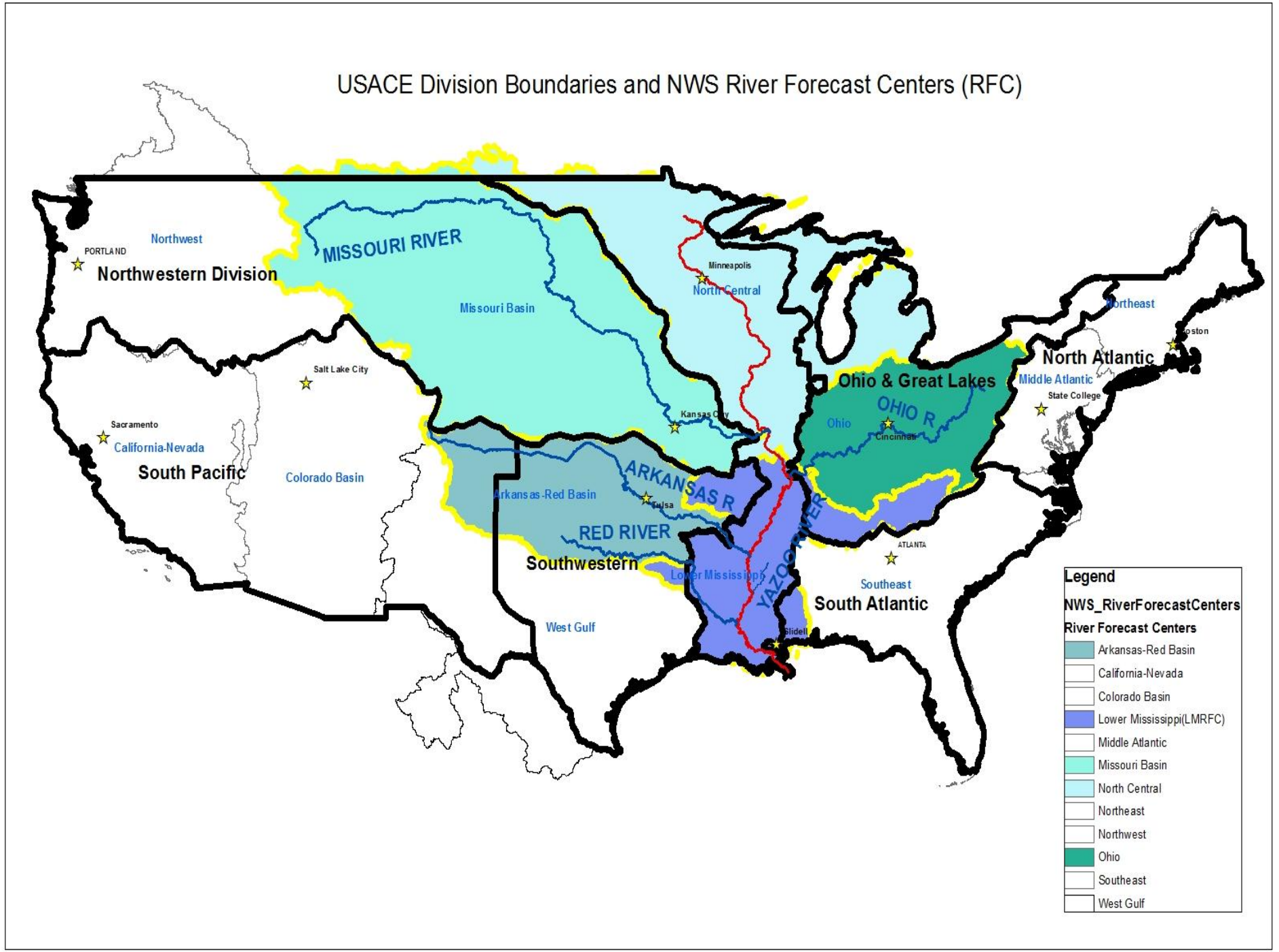
- Northwestern NWD
- South Pacific SPD
- Southwestern SWD
- Mississippi Valley MVD
- Great Lakes & Ohio River LRD
- South Atlantic SAD
- North Atlantic NAD
- Pacific Ocean POD
- Trans Atlantic TAD

Other USACE Organizations

249th Engineer Battalion (Fort Belvoir, VA)
Army Geospatial Center (Alexandria, VA)
Engineer Research & Development Center (Vicksburg, MS)
Engineering and Support Center (Huntsville, AL)
Finance Center (Millington, TN)
Humphreys Engineer Center Support Activity (Alexandria, VA)
Institute for Water Resources (Alexandria, VA)
Logistics Activity (Millington, TN)
Marine Design Center (Philadelphia, PA)


National Weather Service River Forecast Centers (RFC)
Northwest
PORTLAND
MISSOURI RIVER
Missouri Basin
Minneapolis
North Central
Northeast
Boston
Salt Lake City
Middle Atlantic
State College
Sacramento
California-Nevada
Kansas City
Ohio
OHIO R
Cincinnati
Colorado Basin
Arkansas-Red Basin
ARKANSAS R
Tulsa
RED RIVER
YAZOO RIVER
ATLANTA
Lower Mississippi
Southeast
West Gulf
Slidell
Legend
NWS_RiverForecastCenters selection
NWS_RiverForecastCenters
River Forecast Centers
Arkansas-Red Basin
California-Nevada
Colorado Basin
Lower Mississippi(LMRFC)
Middle Atlantic
Missouri Basin
North Central
Northeast
Northwest
Ohio
Southeast
West Gulf

10


USACE Division Boundaries and NWS River Forecast Centers (RFC)
Northwest
PORTLAND
Northwestern Division
MISSOURI RIVER
Missouri Basin
Minneapolis
North Central
Northeast
Boston
North Atlantic
Middle Atlantic
State College
Salt Lake City
Ohio & Great Lakes
OHIO R
Ohio
Cincinnati
Kansas City
Sacramento
California-Nevada
South Pacific
Colorado Basin
ARKANSAS R
Arkansas-Red Basin
Tulsa
RED RIVER
Southwestern
Lower Mississippi
YAZOO RIVER
ATLANTA
Southeast
South Atlantic
West Gulf
Gulfport
Legend
NWS_RiverForecastCenters
River Forecast Centers
Arkansas-Red Basin
California-Nevada
Colorado Basin
Lower Mississippi(LMRFC)
Middle Atlantic
Missouri Basin
North Central
Northeast
Northwest
Ohio
Southeast
West Gulf

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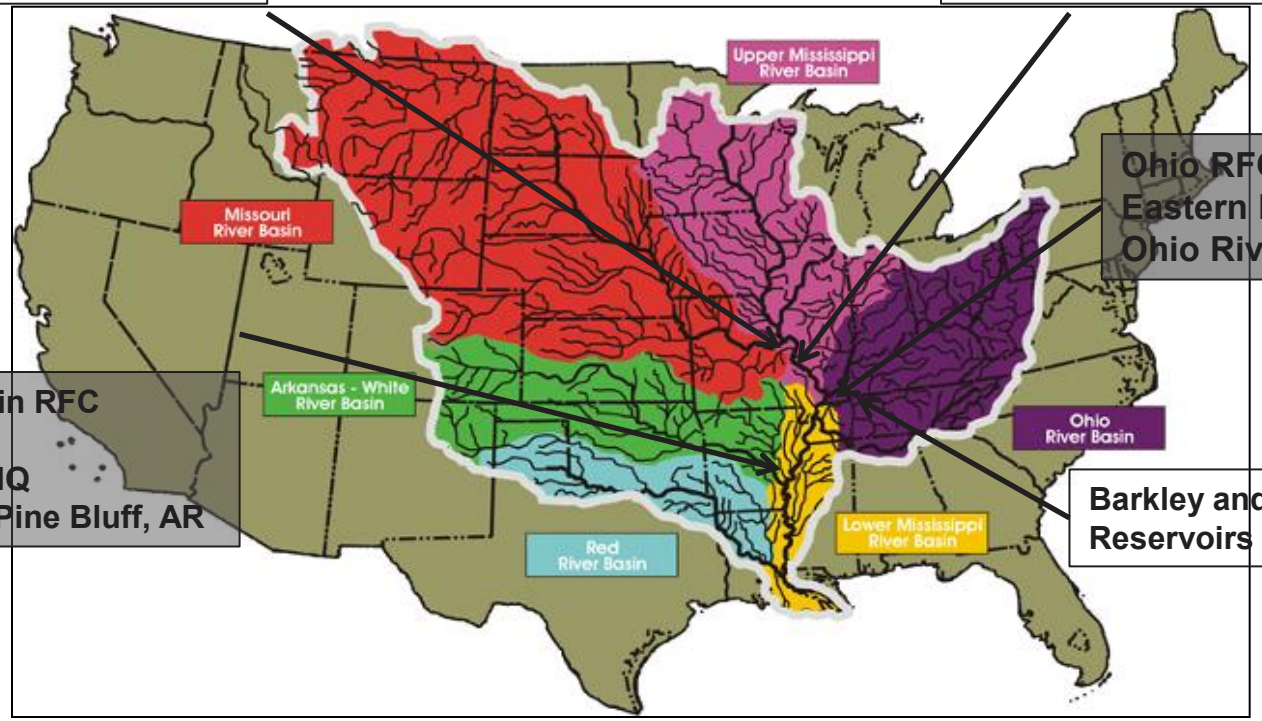
Missouri Basin RFC (MBRFC)
Central Region HQ
Missouri River at Hermann, MO

North Central RFC (NCRFC)
Central Region HQ
Mississippi River at Chester, IL



Ohio RFC (OHRFC)
Eastern Region HQ
Ohio River at Smithland, IL

Arkansas-Red Basin RFC (ABRFC)
Southern Region HQ
Arkansas River at Pine Bluff, AR

Barkley and Kentucky Reservoirs

6A Input 48hr Future Rainfall (QPF)

730A Barkley & Kentucky Flows From TVA. In Flood Ops Flows Come From LRD

815A Preliminary MVN Old River Control Structure Discharges

900A ABRFC Pine Bluff Flows and SWL Arkansas Dam 2 Flows

1030A LMRFC Checks For Consistency With Final NCRFC, OHRFC, & LRD Forecasts

1030A-Noon LMRFC Issues 28 day Forecast using 28 day forecasted rain

6A | **7A** | **8A** | **9A** | **10- 10:30A** | **11 A** | **12 P** | **1P-10P**

(Central)

730A Preliminary OHRFC Smithland Flows

755A MBRFC Forecast for Hermann

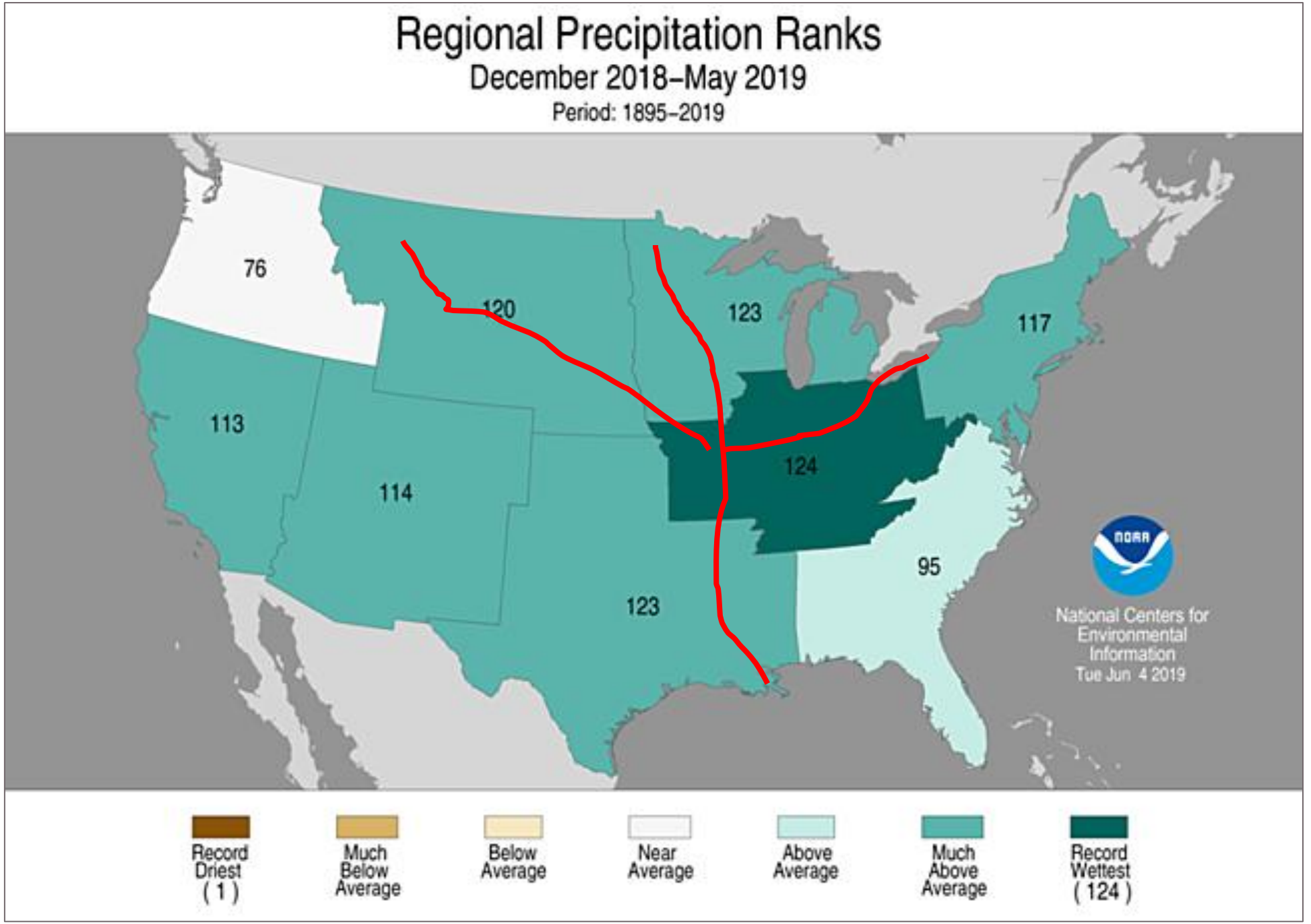
800A Preliminary NCRFC Chester & Murphysboro Flows

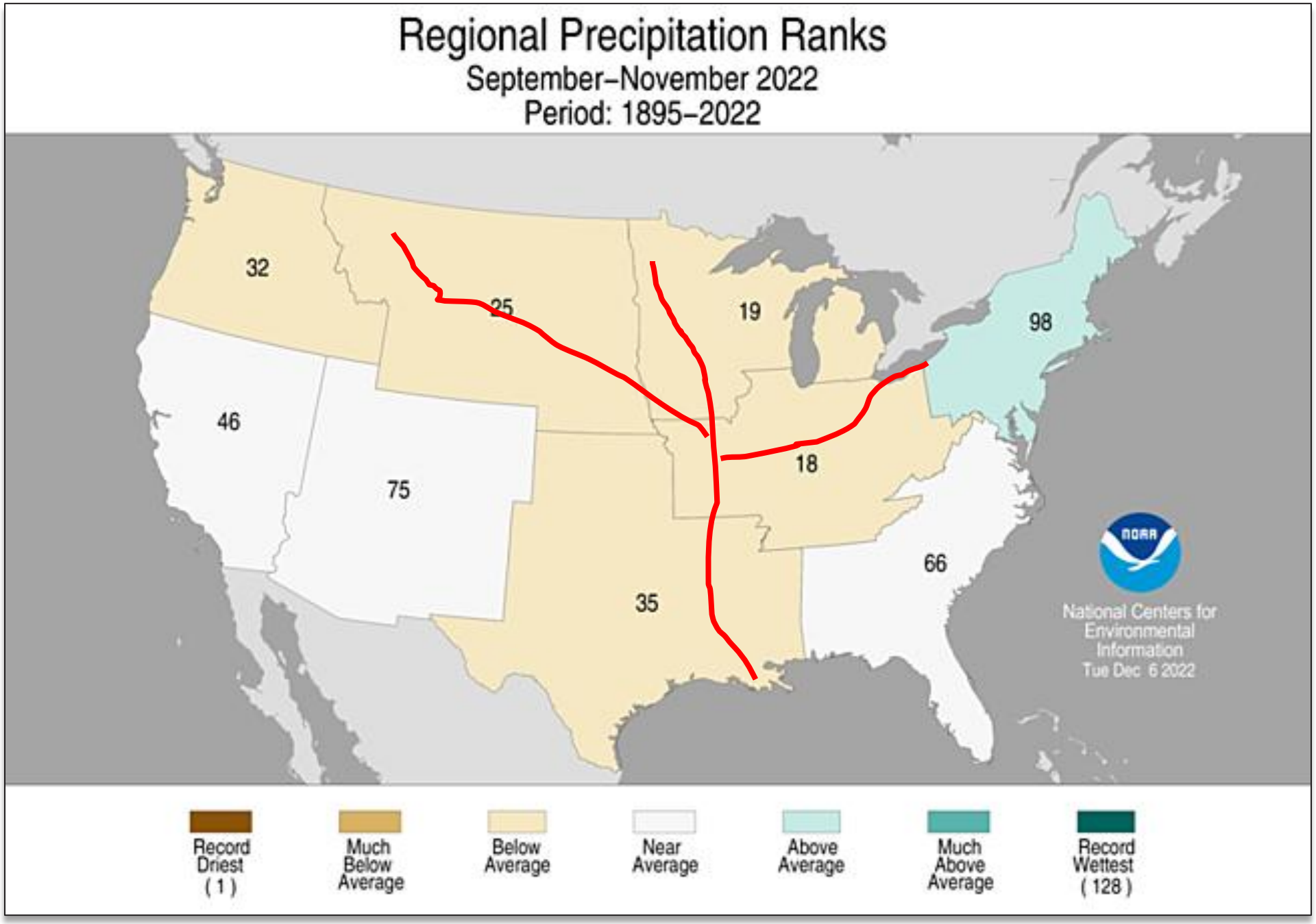
830A Preliminary LMRFC Cairo & Paducah Forecasts

10-1030A LMRFC Mainstem Public Forecasts Are Issued Using 48 hours of Rainfall

Noon-1P LMRFC issues a 14 day forecast using Zero QPF (No Future Rainfall)

Afternoon & Evening Updates

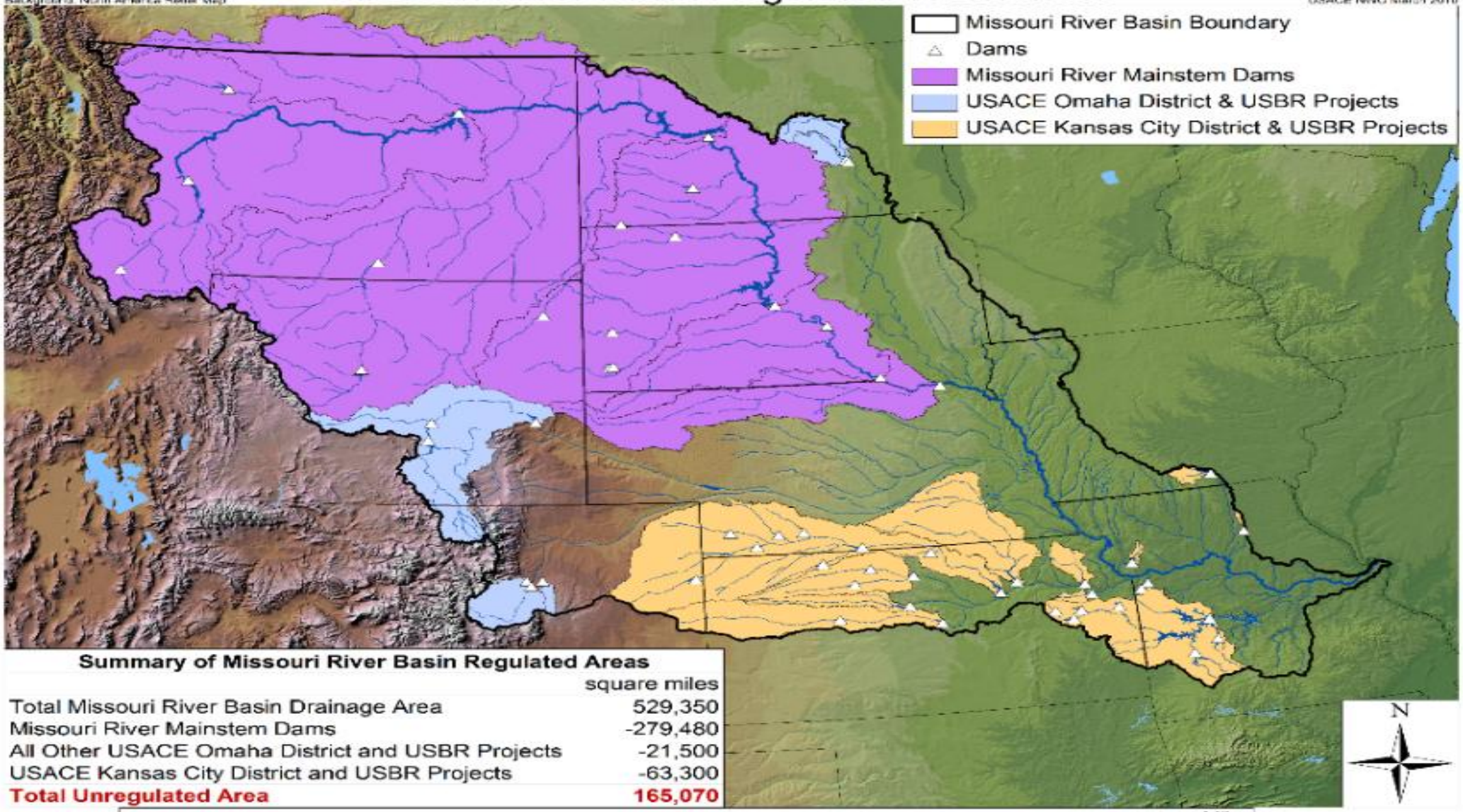

Regional Precipitation Ranks
December 2018–May 2019
Period: 1895–2019
76
120
123
117
113
114
124
95
123
National Centers for Environmental Information
Tue Jun 4 2019
Record Driest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Wettest (124)


Regional Precipitation Ranks
September–November 2022
Period: 1895–2022
32
25
19
98
46
75
18
66
35
National Centers for Environmental Information
Tue Dec 6 2022
Record Driest (1)
Much Below Average
Below Average
Near Average
Above Average
Much Above Average
Record Wettest (128)

Missouri River Basin Regulated Watersheds

Background: North America Relief Map

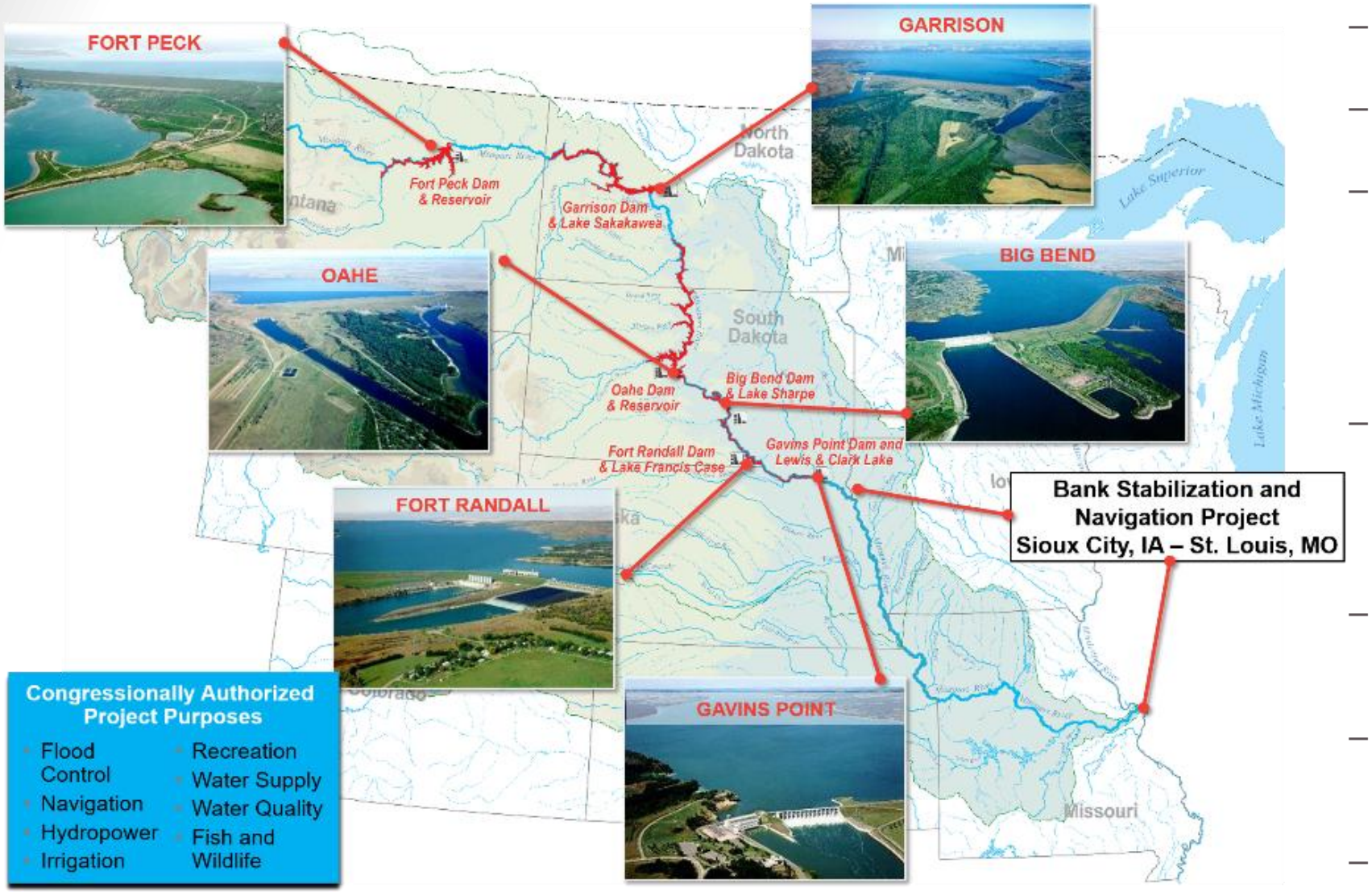
USACE NWO March 2018



Summary of Missouri River Basin Regulated Areas

	square miles
Total Missouri River Basin Drainage Area	529,350
Missouri River Mainstem Dams	-279,480
All Other USACE Omaha District and USBR Projects	-21,500
USACE Kansas City District and USBR Projects	-63,300
Total Unregulated Area	**165,070**

MISSOURI RIVER MAINSTEM SYSTEM



- 529,350 Square Miles
  - 1/6 of CONUS
- 2341 Miles Long
- 10 States, 2 Canadian Provinces
- Highly Diverse
  - Geographically/Geologically
  - Meteorologically/Hydrologically
    - ~ 16 Inches in Fort Peck
    - ~ 42 Inches in St. Louis
- River of Thirds
  - 1/3 Channelized
  - 1/3 Impounded
  - 1/3 Natural State
- 279,480 mi^2 Regulated by Mainstem Projects
- 83,800 mi^2 Regulated by Tributary Projects
- 165,070 mi^2 Unregulated

AUTHORIZATION/MISSION

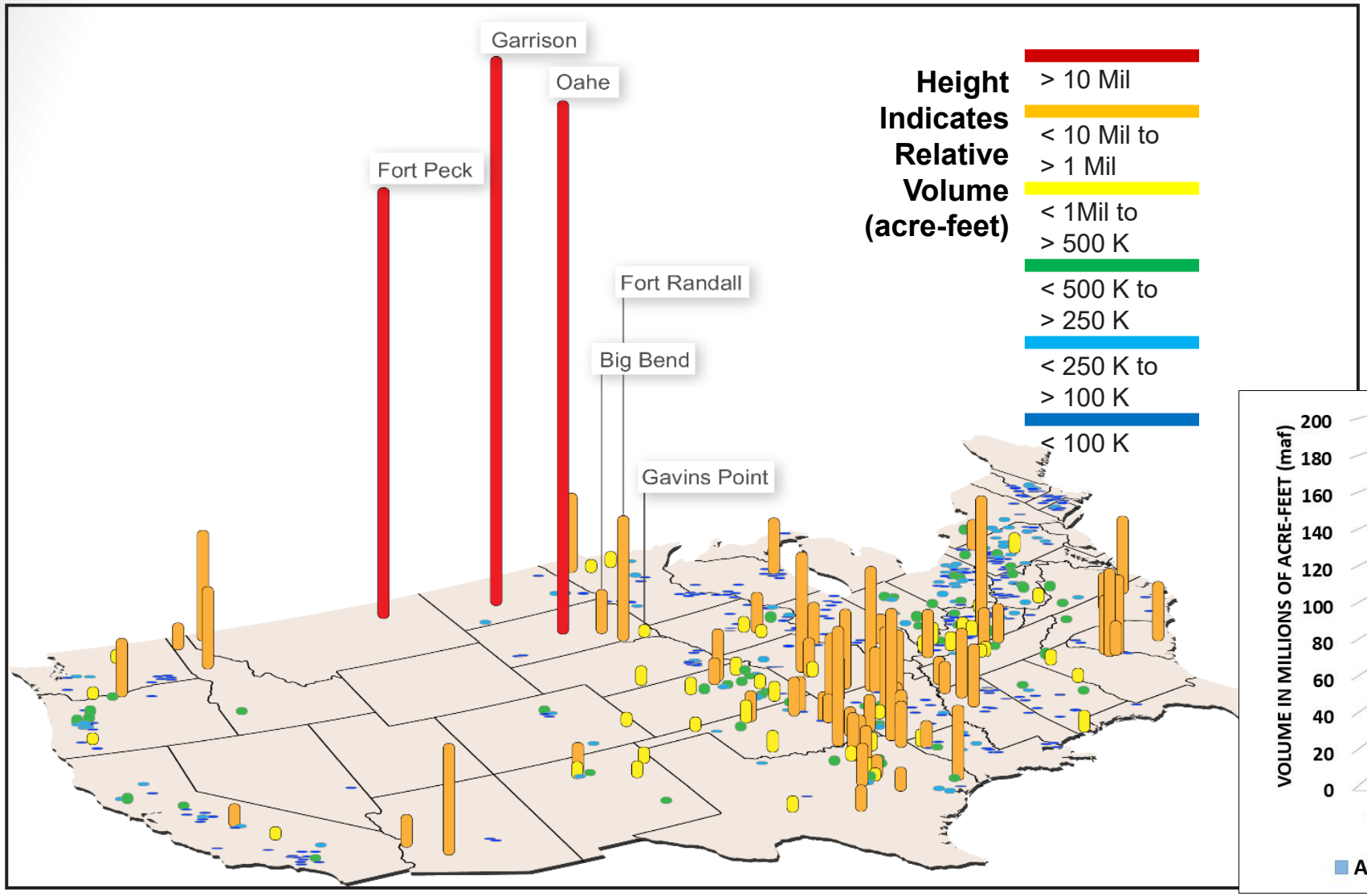
- Eight Authorized Purposes (1944 FCA)
  - Flood Control – Requires Empty Space
  - Navigation
  - Water Supply
  - Hydropower
  - Water Quality Control
  - Recreation
  - Irrigation
  - Fish and Wildlife

Requires Access to Water or Releases

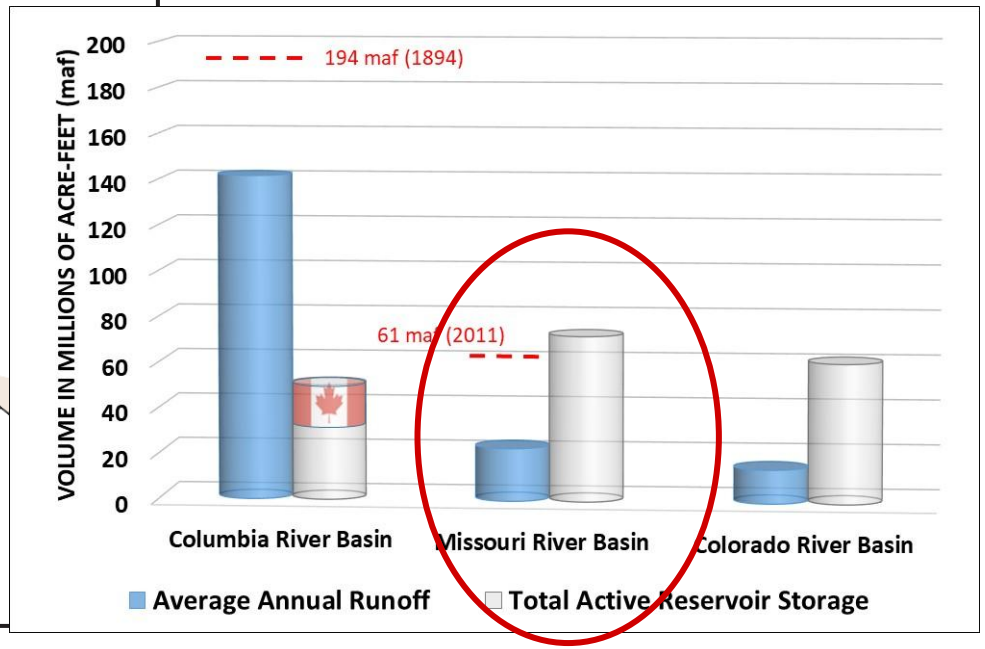
- Runoff Driven System – The runoff drives system releases and is managed on an annual basis. We do not carryover water in the flood control zones
- Basically operate for flood control or meeting downstream targets (navigation, Water Supply)
- Not authorized to operate for Mississippi River benefits

USACE RESERVOIR STORAGE COMPARISON

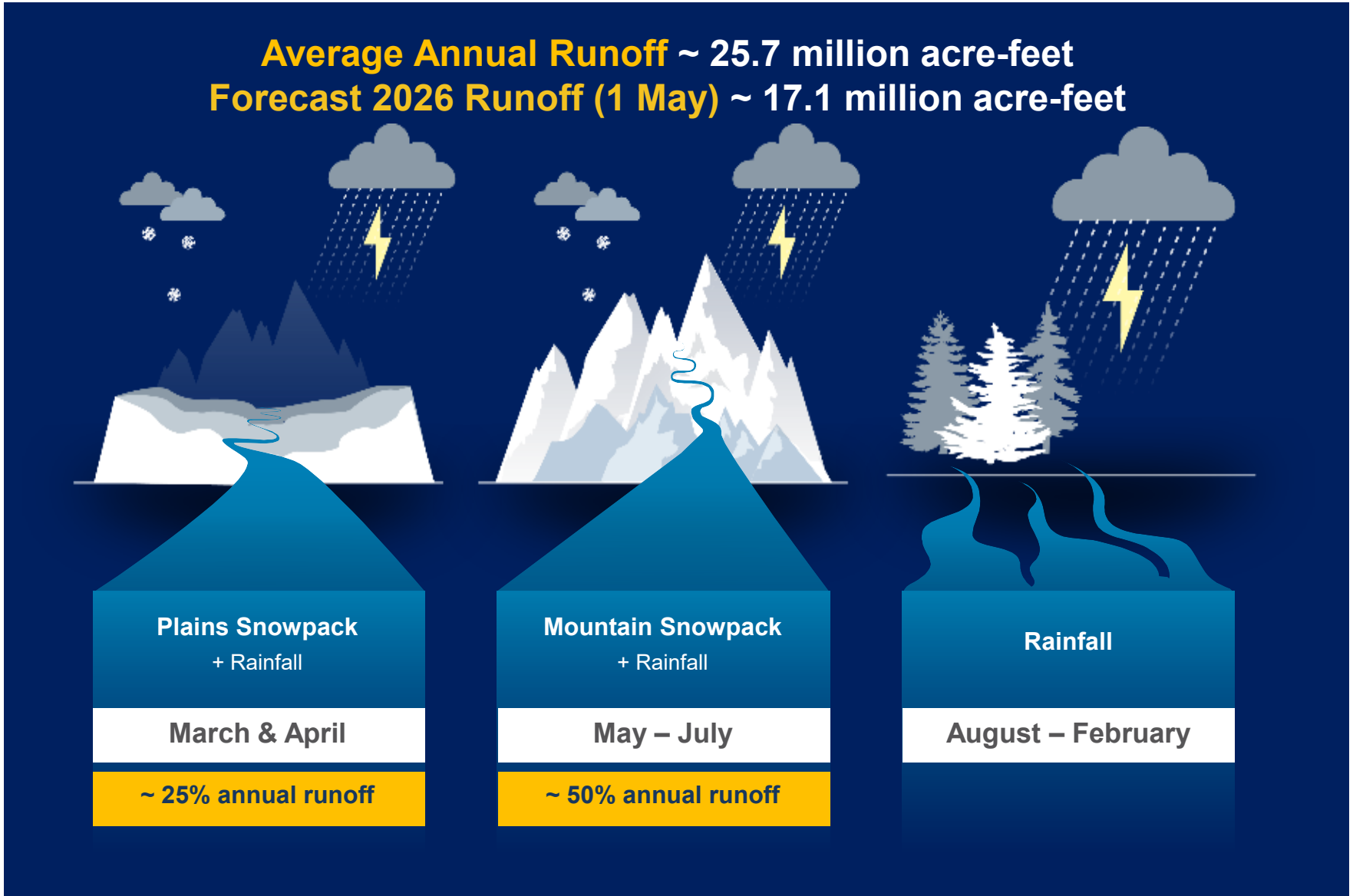
USACE Reservoir Storage Capacity



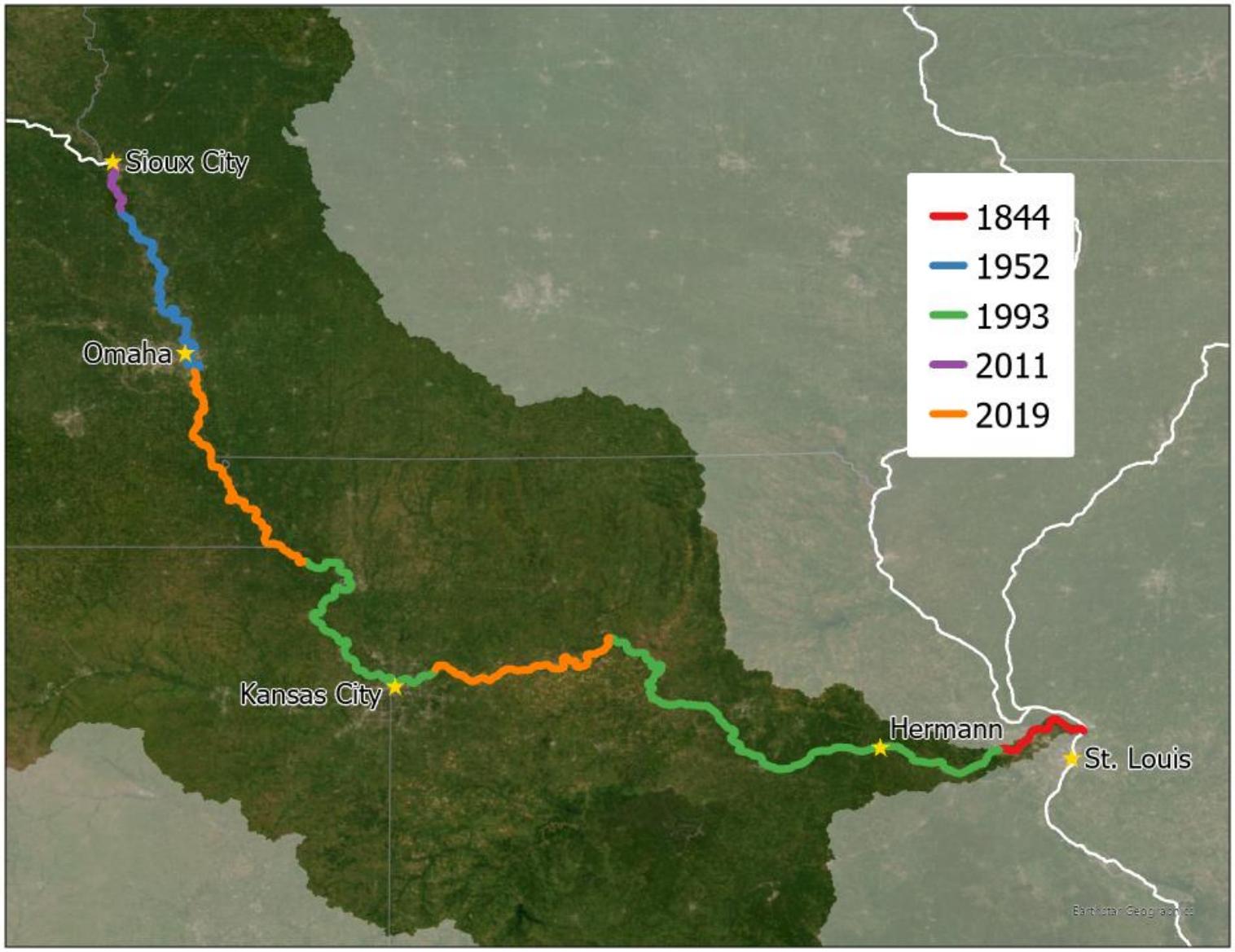
- Largest Reservoir Storage System in North America (72.4 MAF)
- Garrison, Oahe and Fort Peck are the 3rd, 4th, and 5th Large Storage Reservoirs in the Federal Inventory
- Total Storage ~ 3 x Ave Runoff (see below)



MISSOURI RIVER BASIN RUNOFF ABOVE SIOUX CITY, IOWA



MISSOURI RIVER RECORD FLOOD STAGES



Main Stem Reservoir Flood storage based on 1881 flood

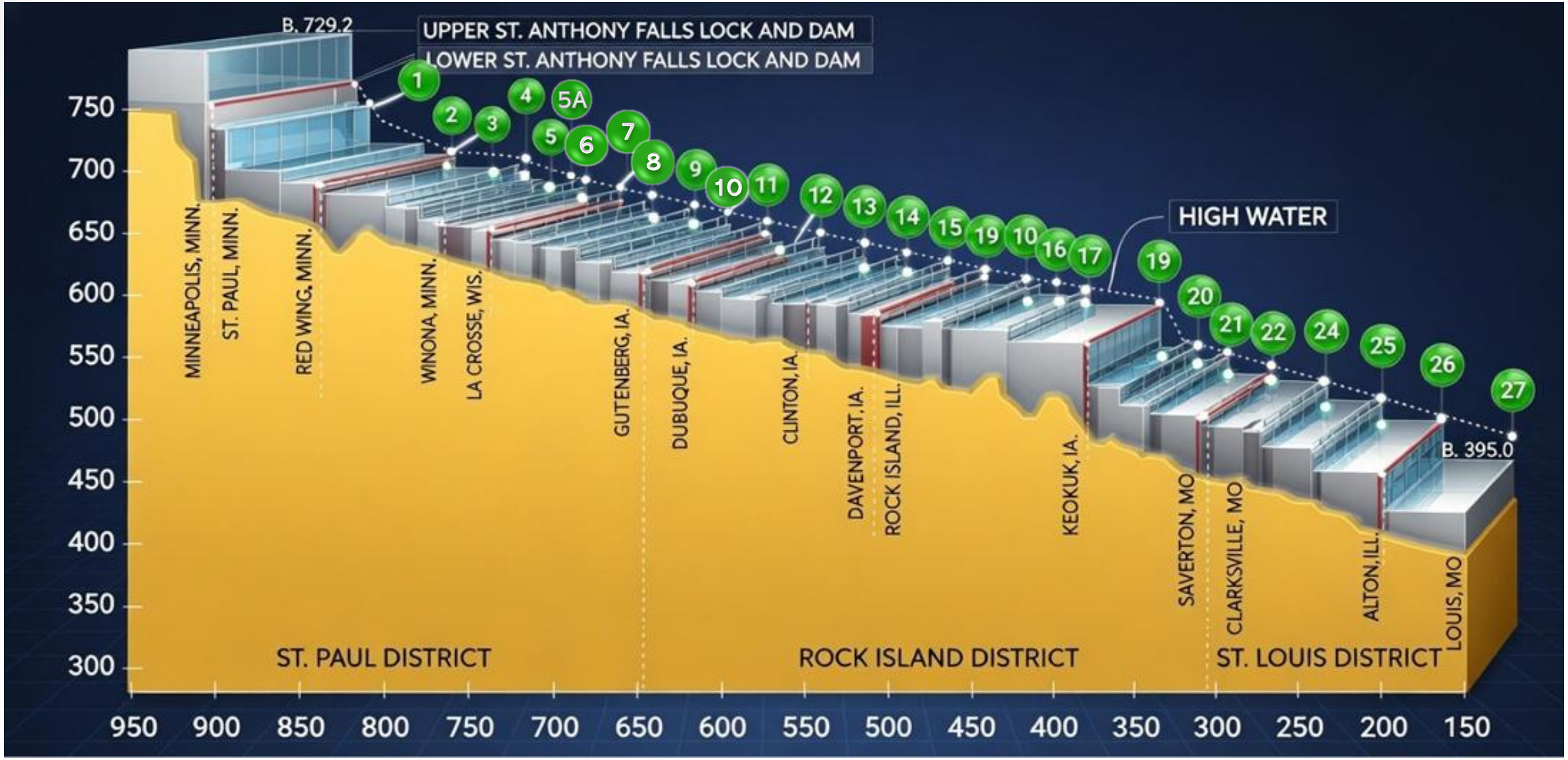
Reservoir flow reduction at Hermann

Flood	Without Reservoir	With Reservoir	Reduction
1881	390,000		
1952	368,000		
1993	955,000	750,000	21%
2011	357,000	279,000	22%
2019	652,000	420,000	36%

Post Reservoirs record upstream of Omaha is 2011

Break in 2019 records was result of two distinct crests

UPPER MISS L&D SYSTEM



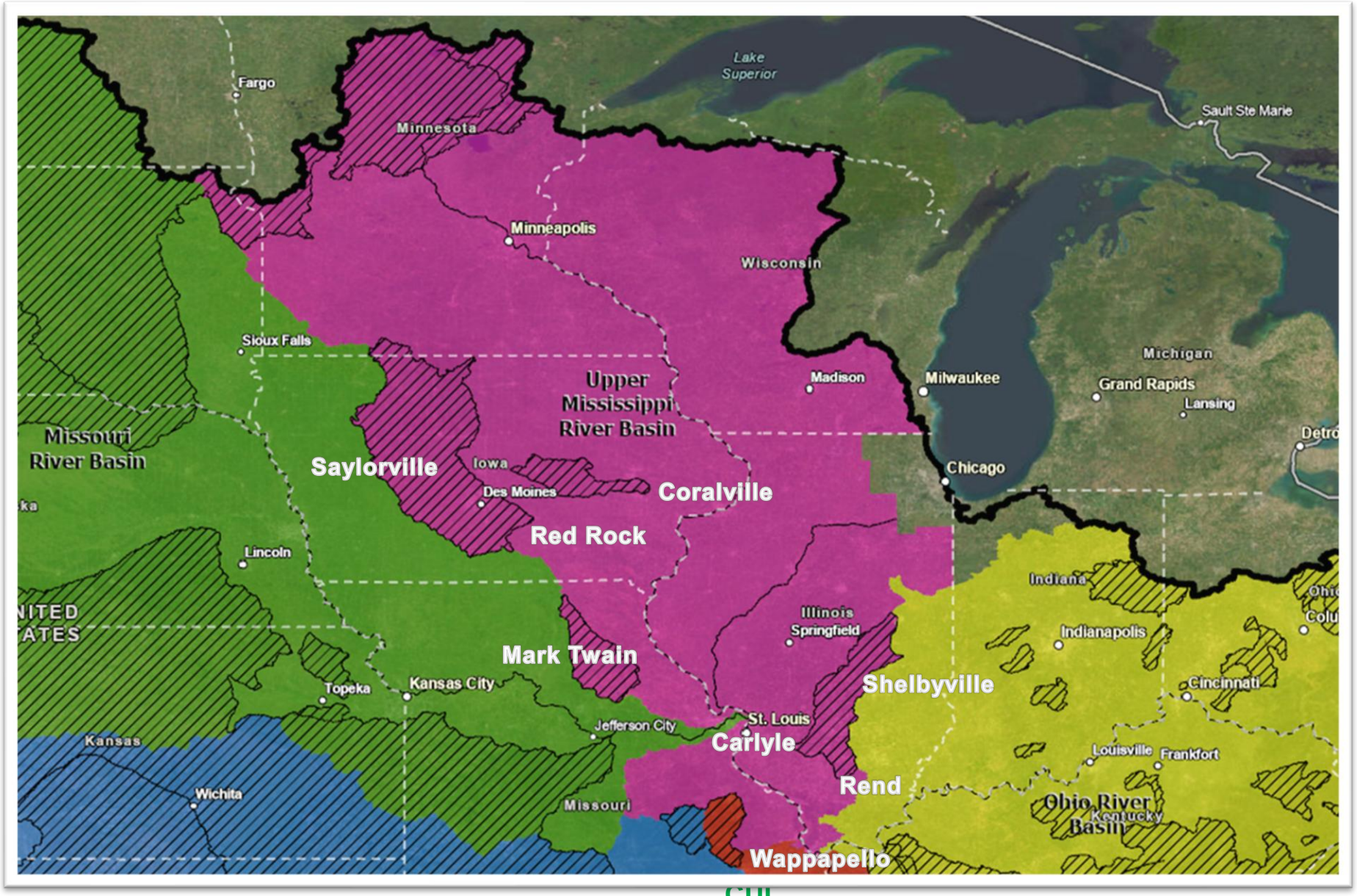
MAP OF L&D VS OPEN RIVER NAVIGATION

27 Locks and dams on the Upper Mississippi

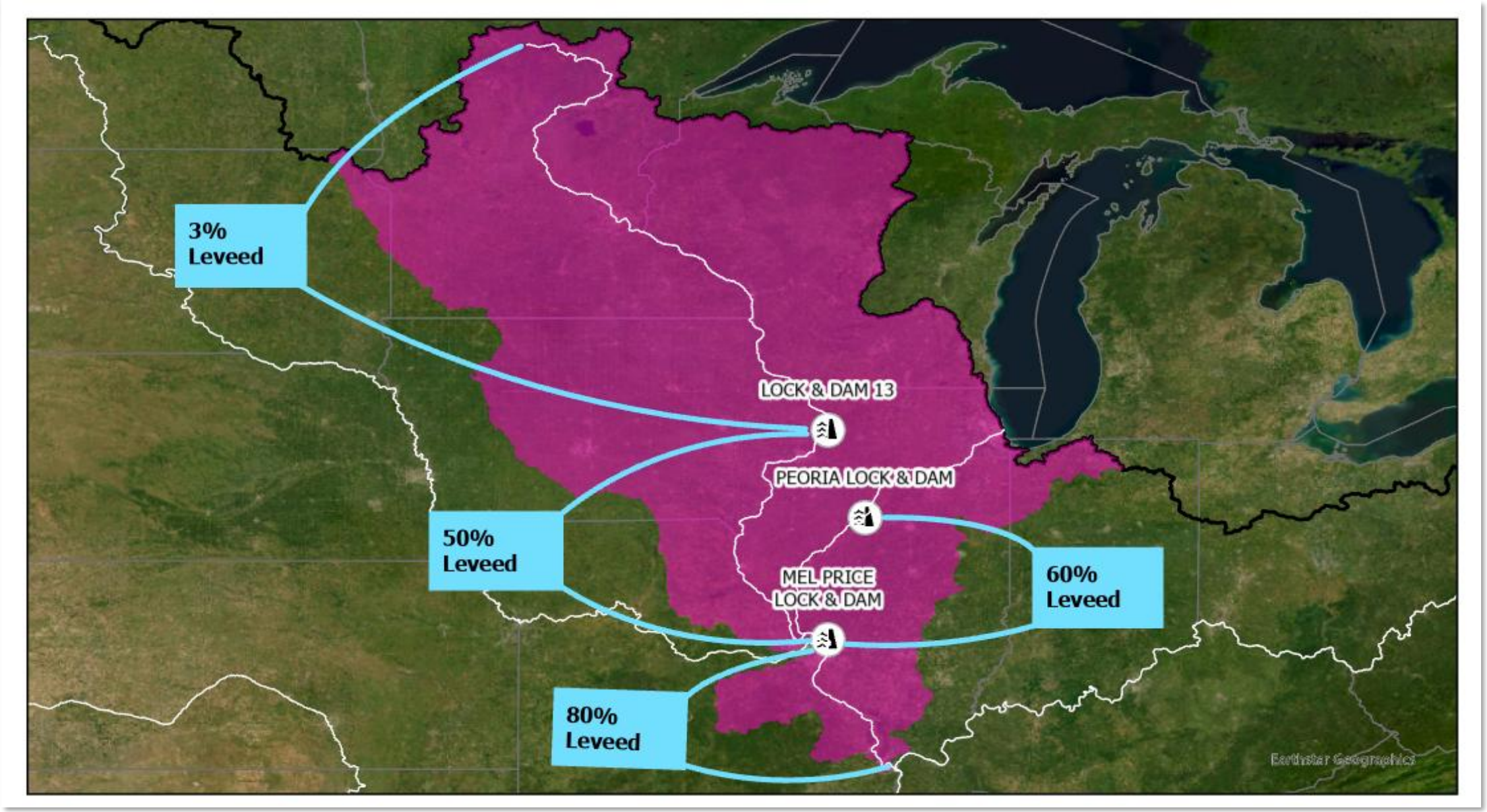
7 Locks and dams on the Illinois River

Open River navigation downstream of Mel Price Lock and Dam

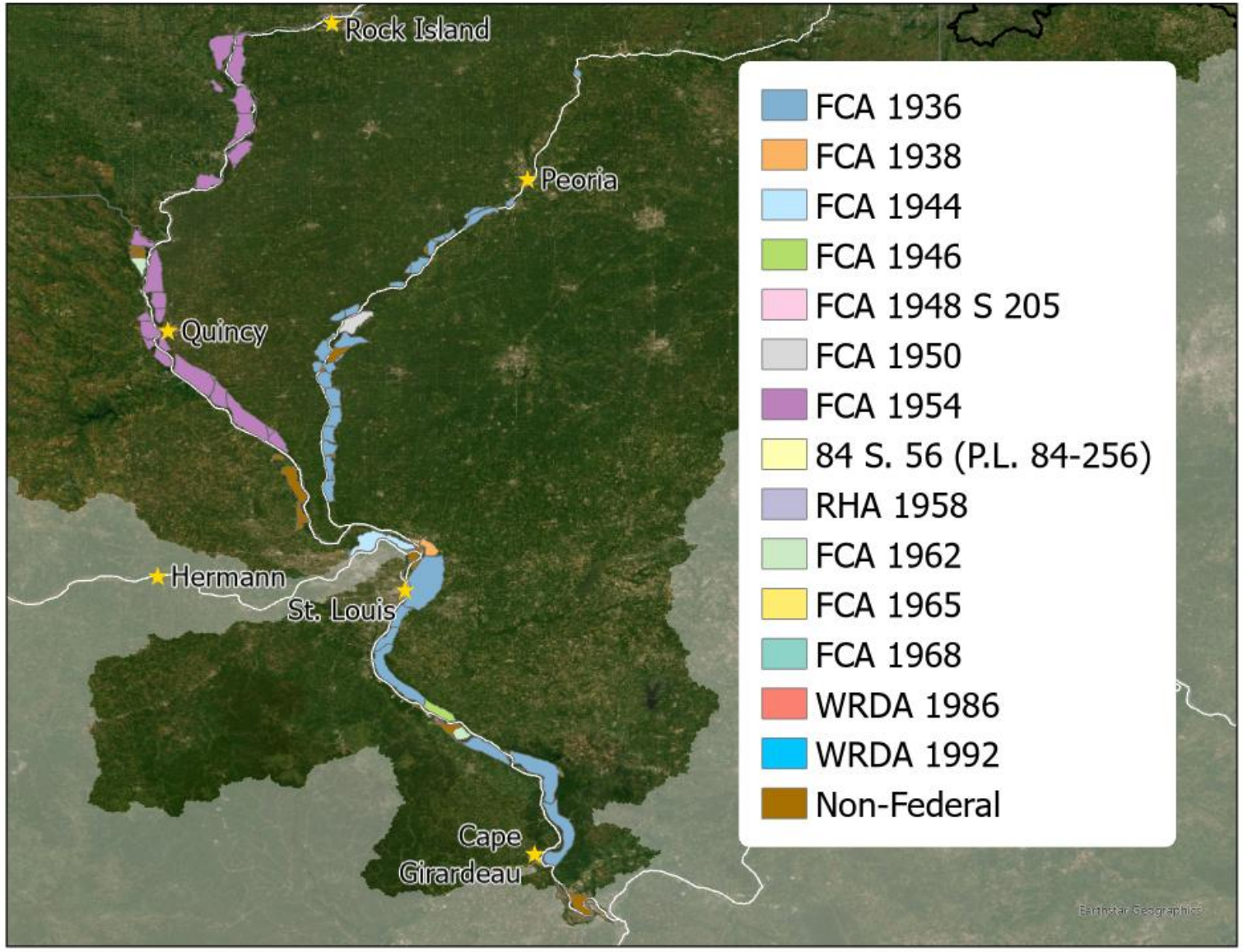
Upper Miss Regulated Area



Upper Miss Leveed Area



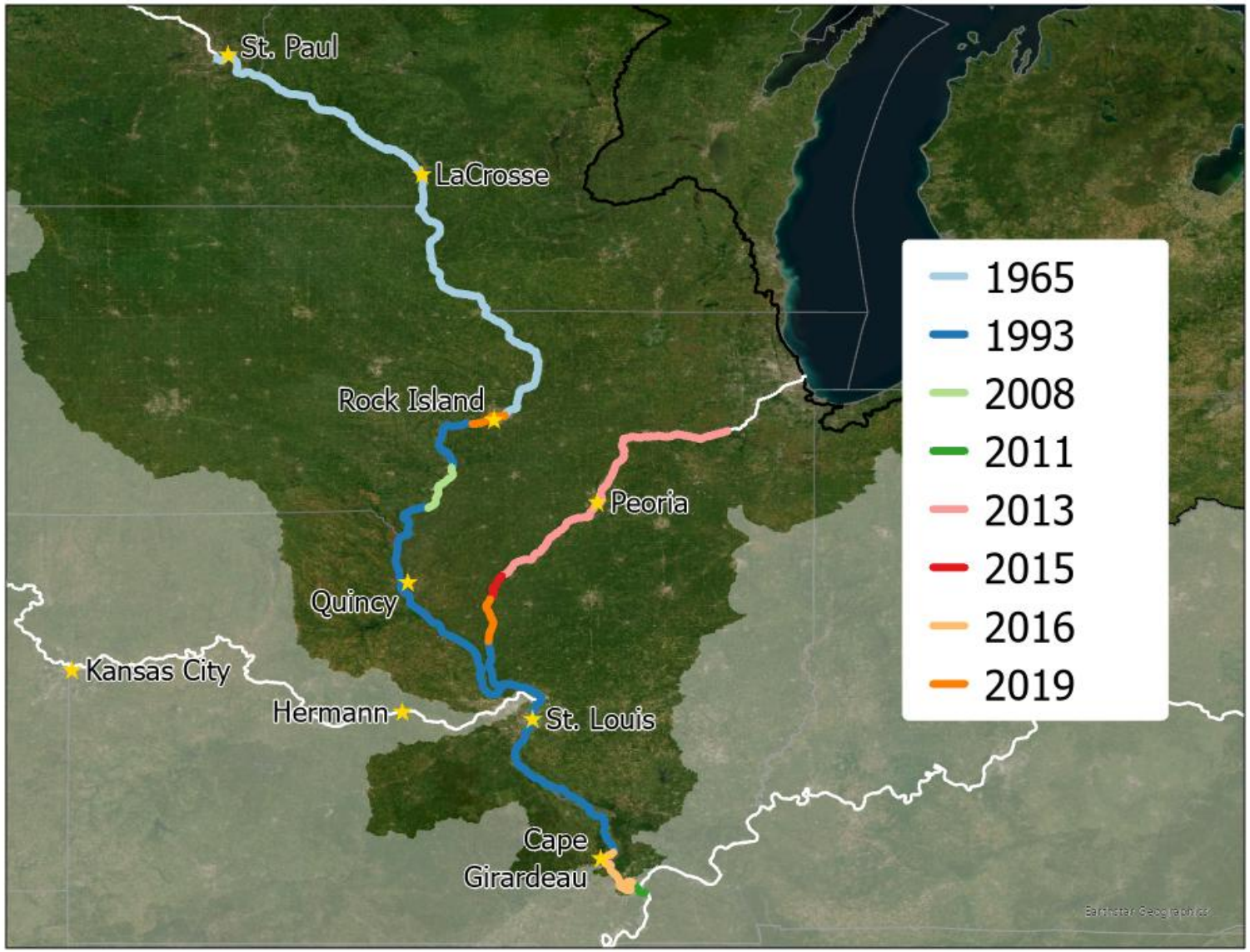
ORIGINAL LEVEE AUTHORITIES



- 14 Original Authorizations
- Additional authorizations for improvements to many systems
- 1936 FCA authorized most levees on Illinois River and Mississippi below Missouri River
- 1954 FCA authorized most levees between Rock Island and Missouri River

Note: 15 additional levees north of this graphic

UPPER MISS RECORD FLOOD STAGES



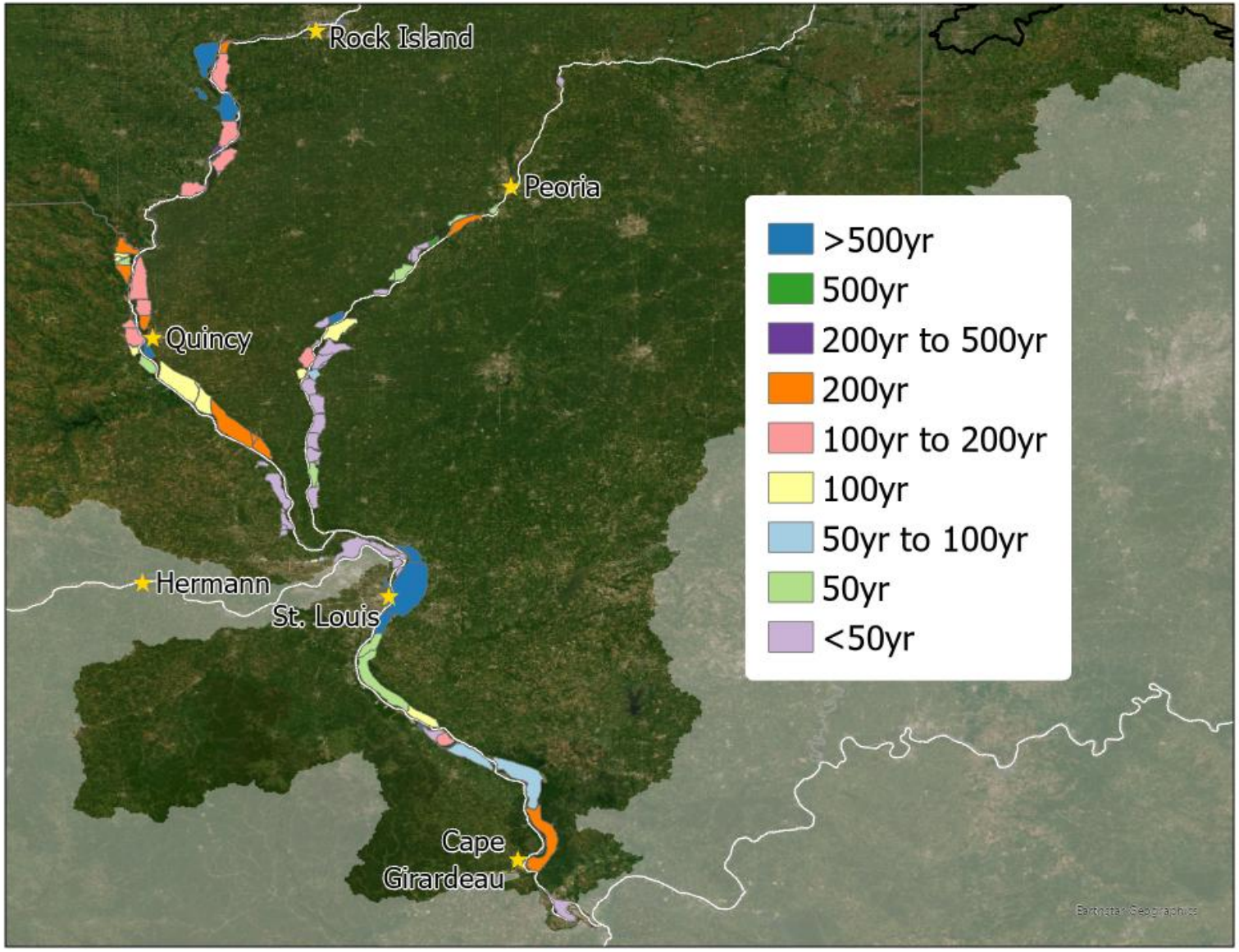
Upper Mississippi River

- Large floods are driven by rain on snow upstream of Lock and Dam 15 at Rock Island
- Downstream of Rock Island, widespread heavy rainfall is the driver of floods like 1993
- Localized heavy rains in 2008, 2015/2016, and 2019 accounted for smaller stretches of river.

Illinois River

- Heavy rainfall over large portions of the basin drive large floods like 2013
- Localized heavy rains may set records in smaller reaches like 2015/2016 and 2019
- Backwater from the Mississippi may set record stages like 1993

LEVEE PHYSICAL OVERTOPPING FREQUENCY

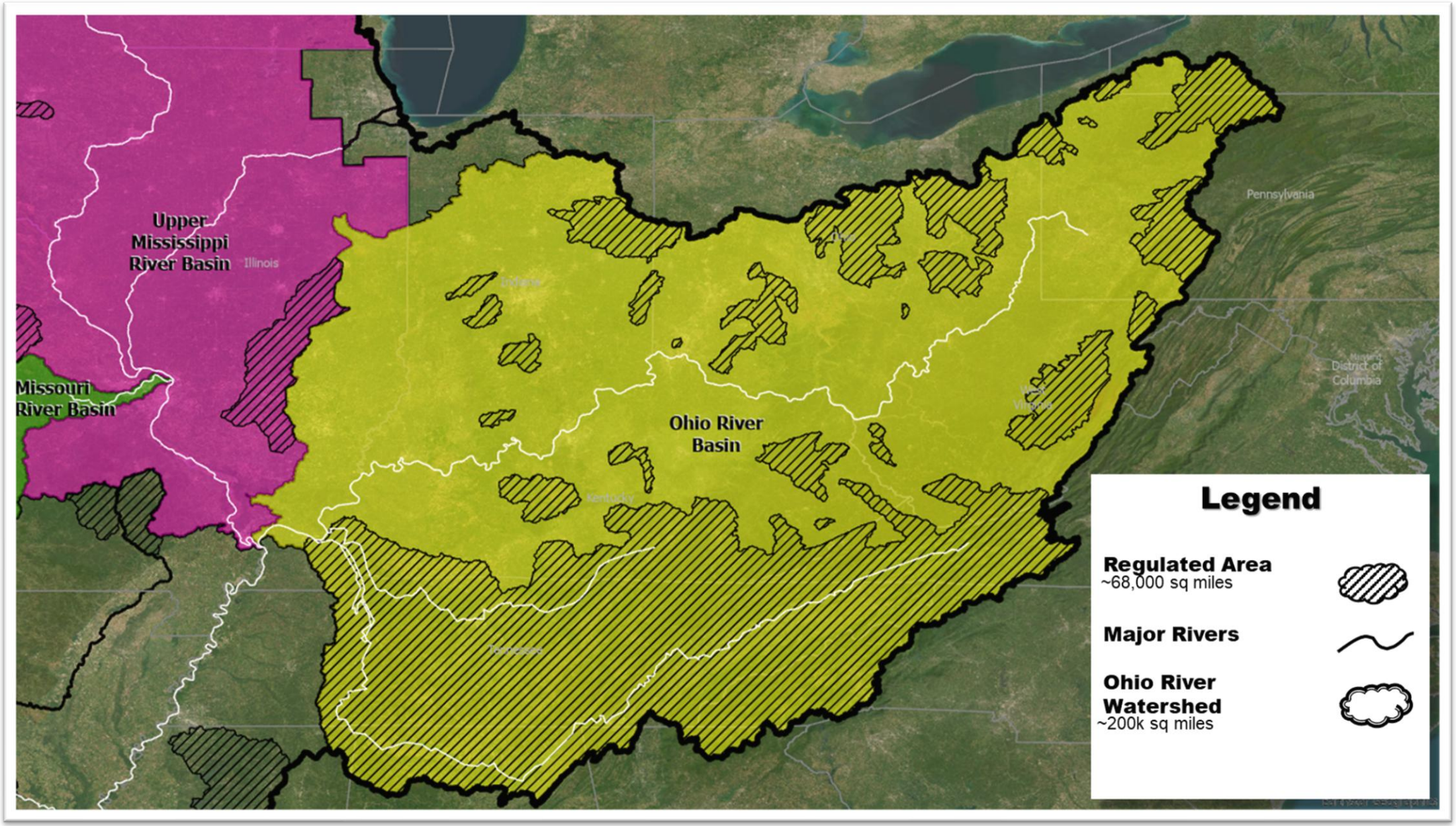


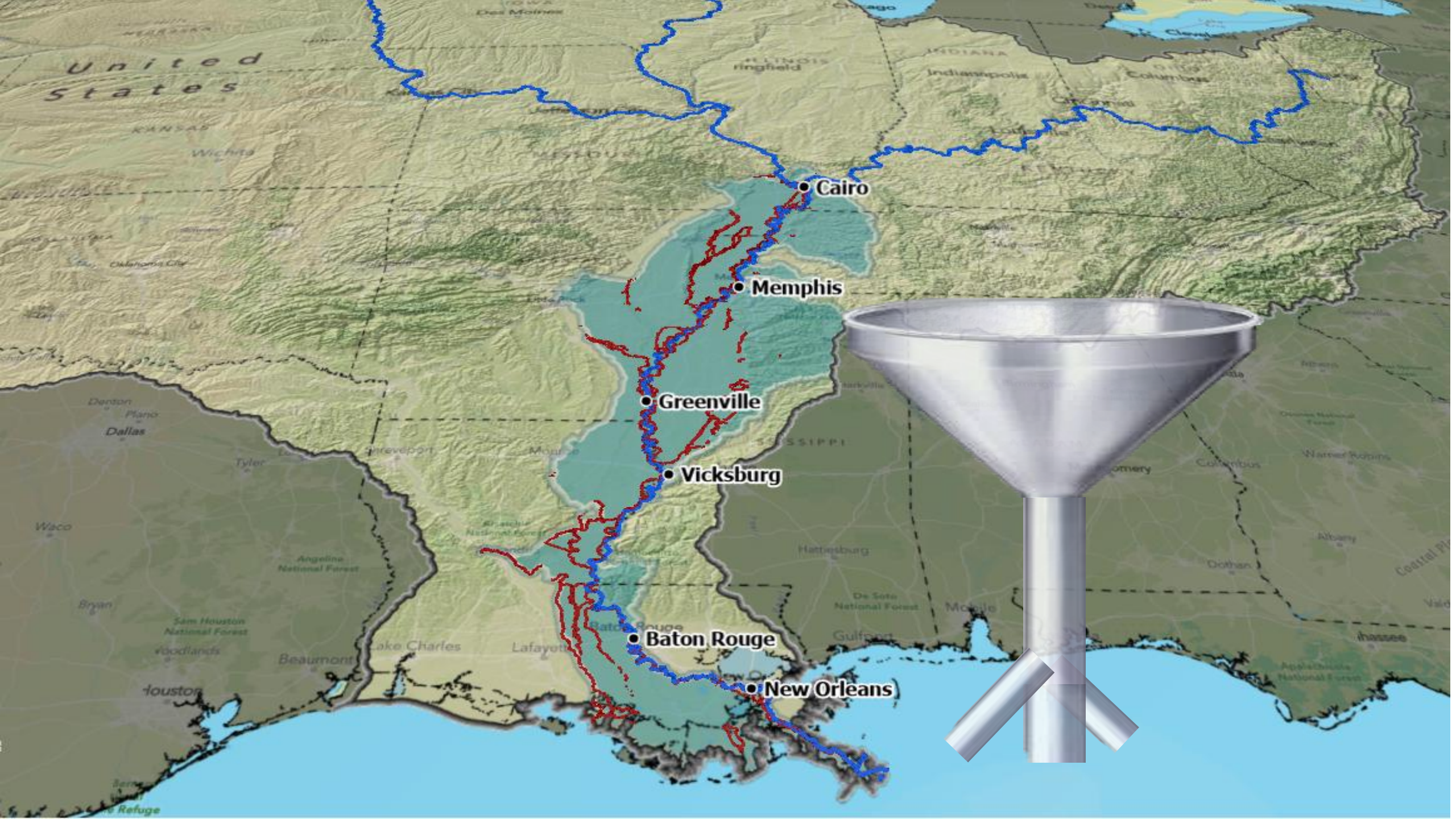
- Overtopping frequency varies widely throughout the basin.
- Urban levees were generally given superiority over agricultural levees in authorizations
- Levee failure due to geotechnical and structural deficiencies was not considered in these frequencies
- Values determined using 2004 Upper Mississippi Flow Frequency study profiles

Note: 15 additional levees north of this graphic

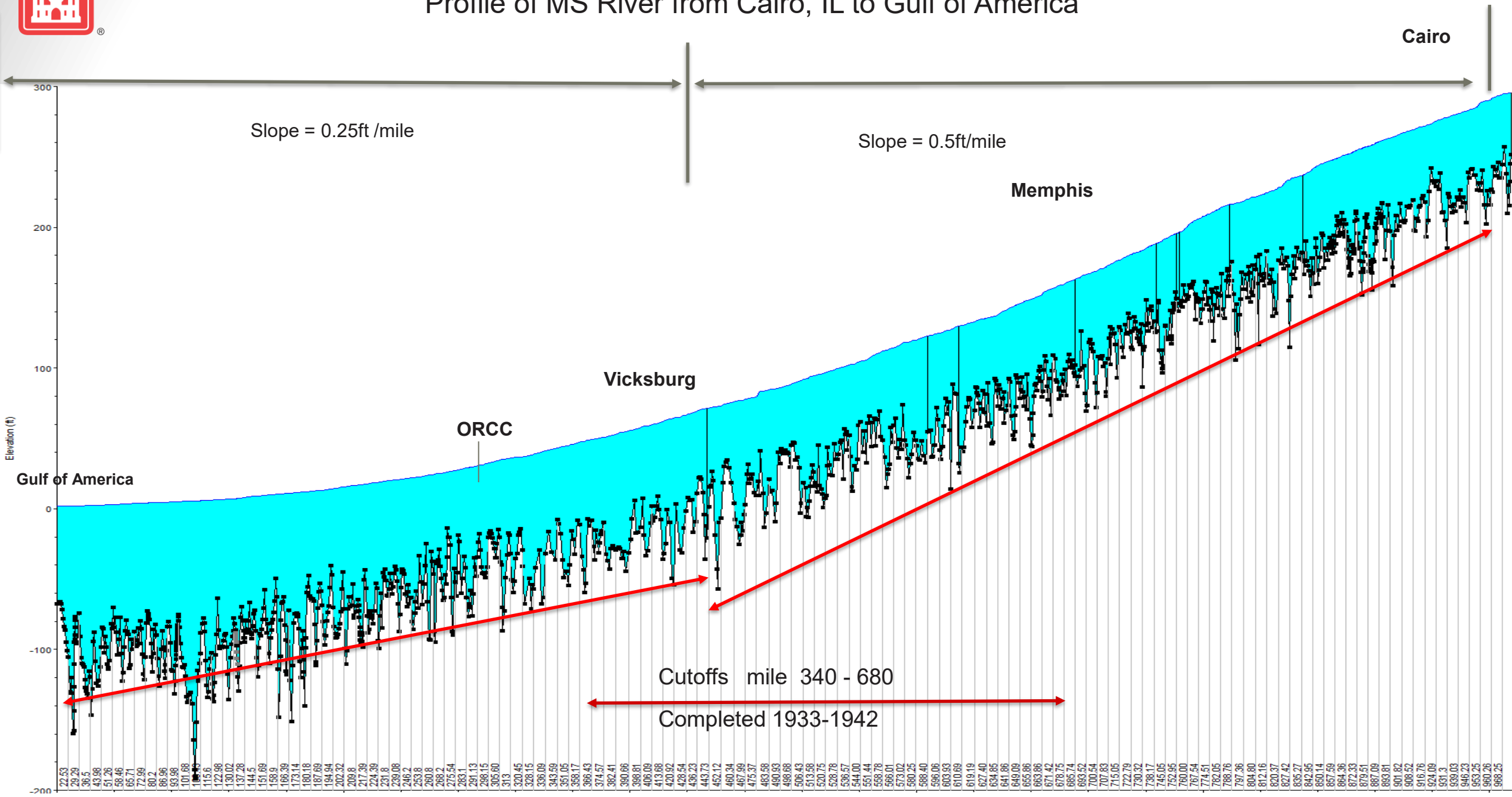
Source: 2008 Upper Mississippi River Comprehensive Study – Appendix B

Ohio Basin Regulated Area




Cairo
Memphis
Greenville
Vicksburg
Baton Rouge
New Orleans

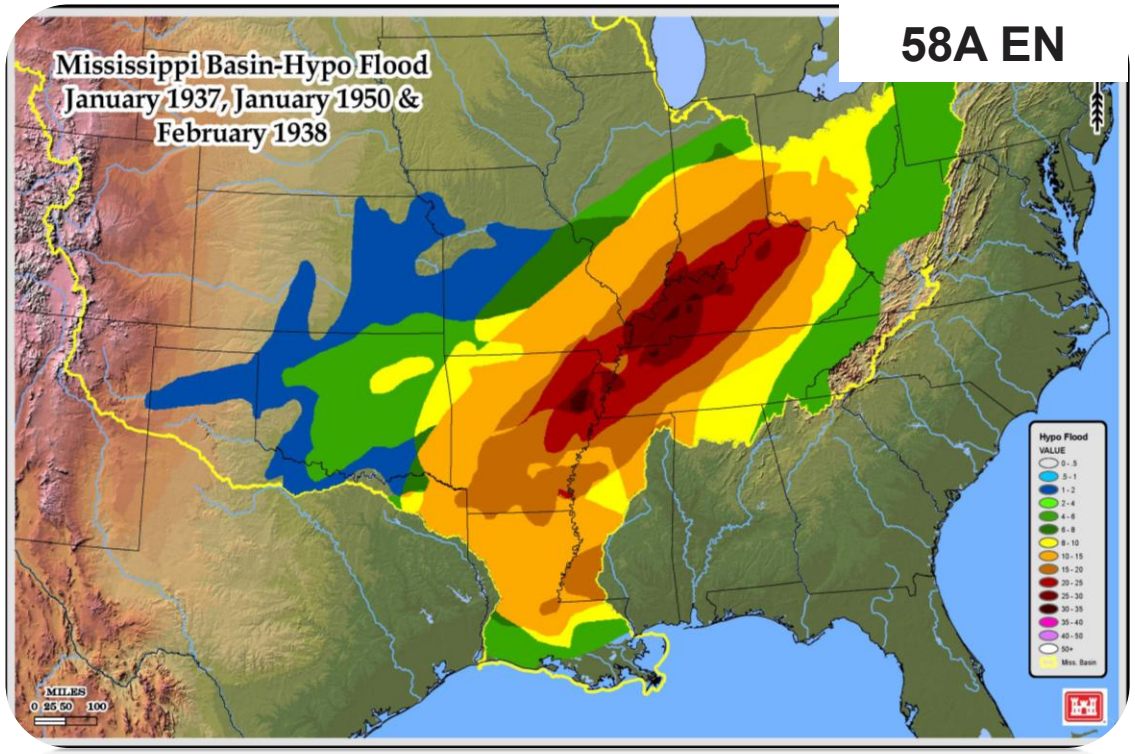
Profile of MS River from Cairo, IL to Gulf of America



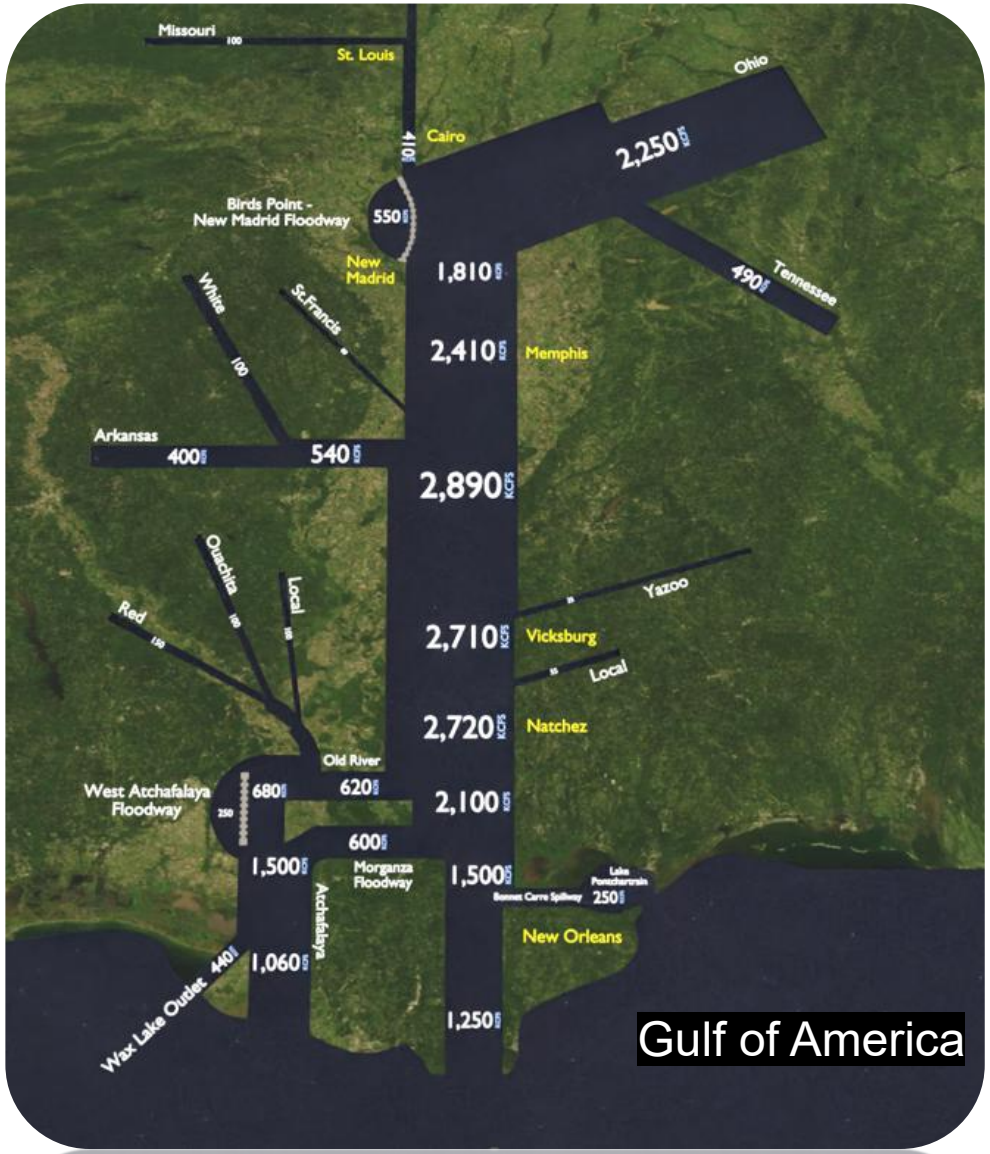
THE MISSISSIPPI RIVER AND TRIBUTARIES PROJECT WAS AUTHORIZED BY THE 1928 FLOOD CONTROL ACT

The MR&T project has four major features:
1. Levees / Floodwalls
2. Floodways / Backwater Areas
3. Channel improvement and stabilization
4. Tributary basin improvements

These features work together to provide risk reduction from floods, efficient navigation, and environmental protection and enhancement.



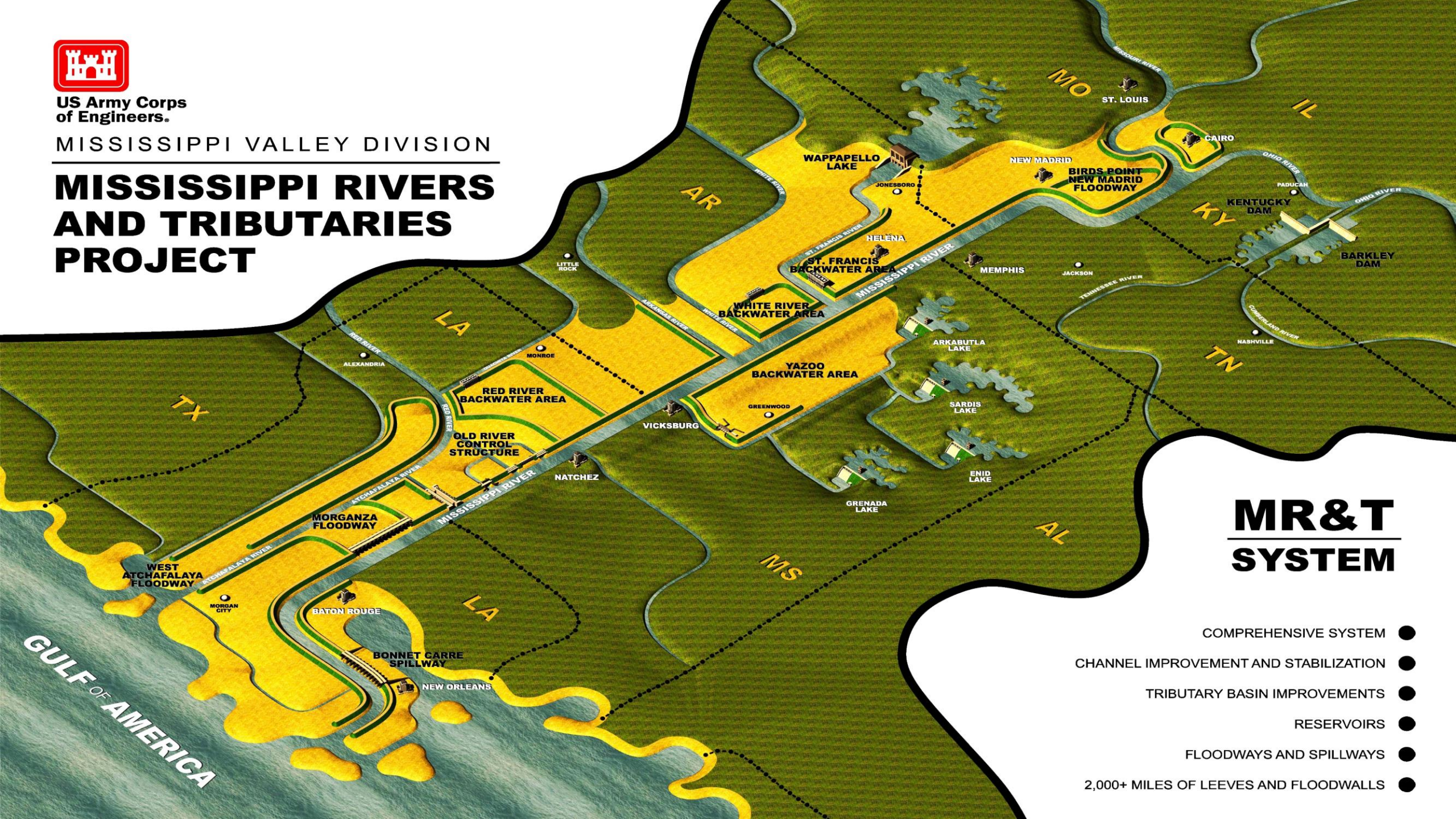
Project Design Flood



US Army Corps of Engineers.

MISSISSIPPI VALLEY DIVISION

MISSISSIPPI RIVERS AND TRIBUTARIES PROJECT



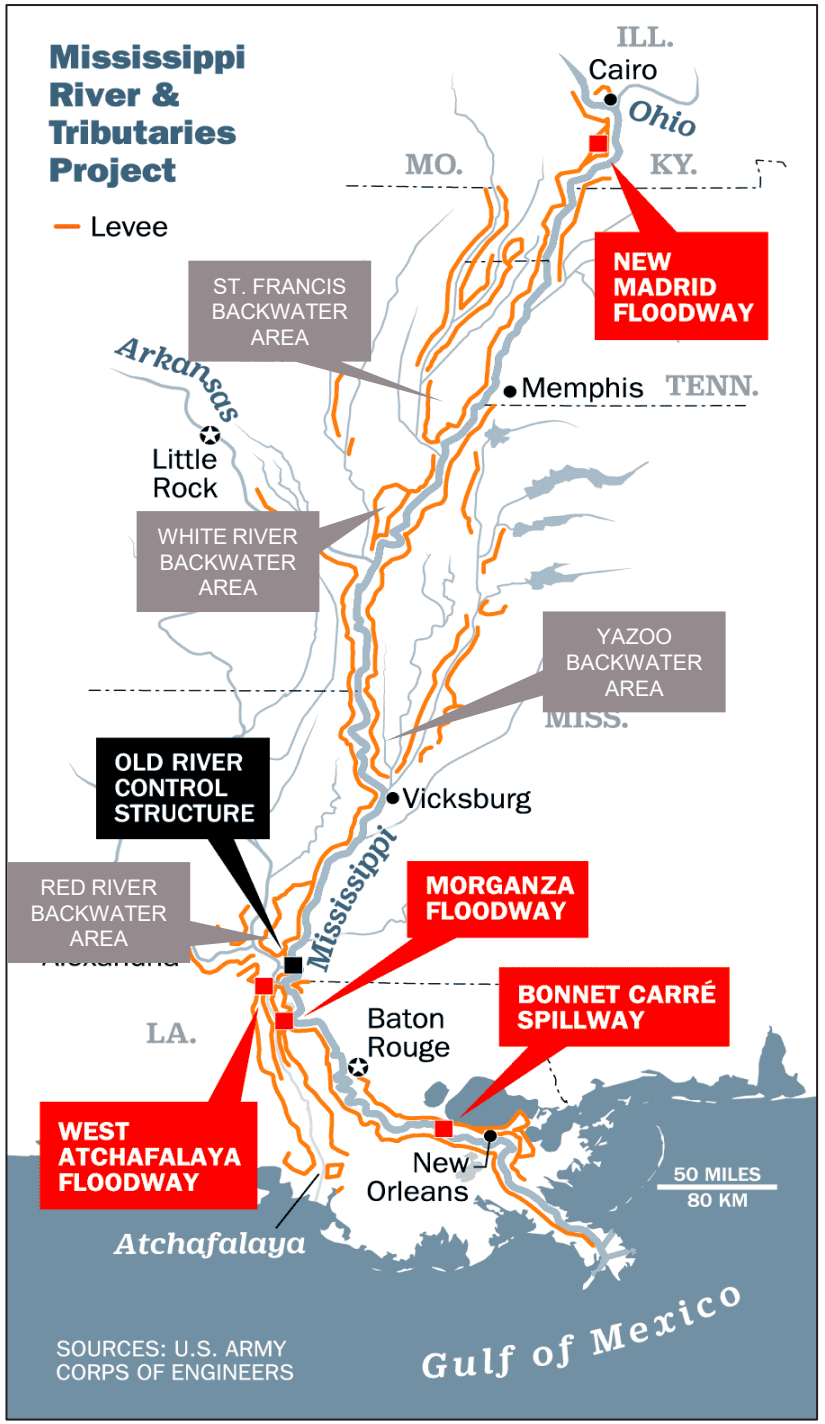
MR&T SYSTEM

- COMPREHENSIVE SYSTEM
- CHANNEL IMPROVEMENT AND STABILIZATION
- TRIBUTARY BASIN IMPROVEMENTS
- RESERVOIRS
- FLOODWAYS AND SPILLWAYS
- 2,000+ MILES OF LEEVES AND FLOODWALLS

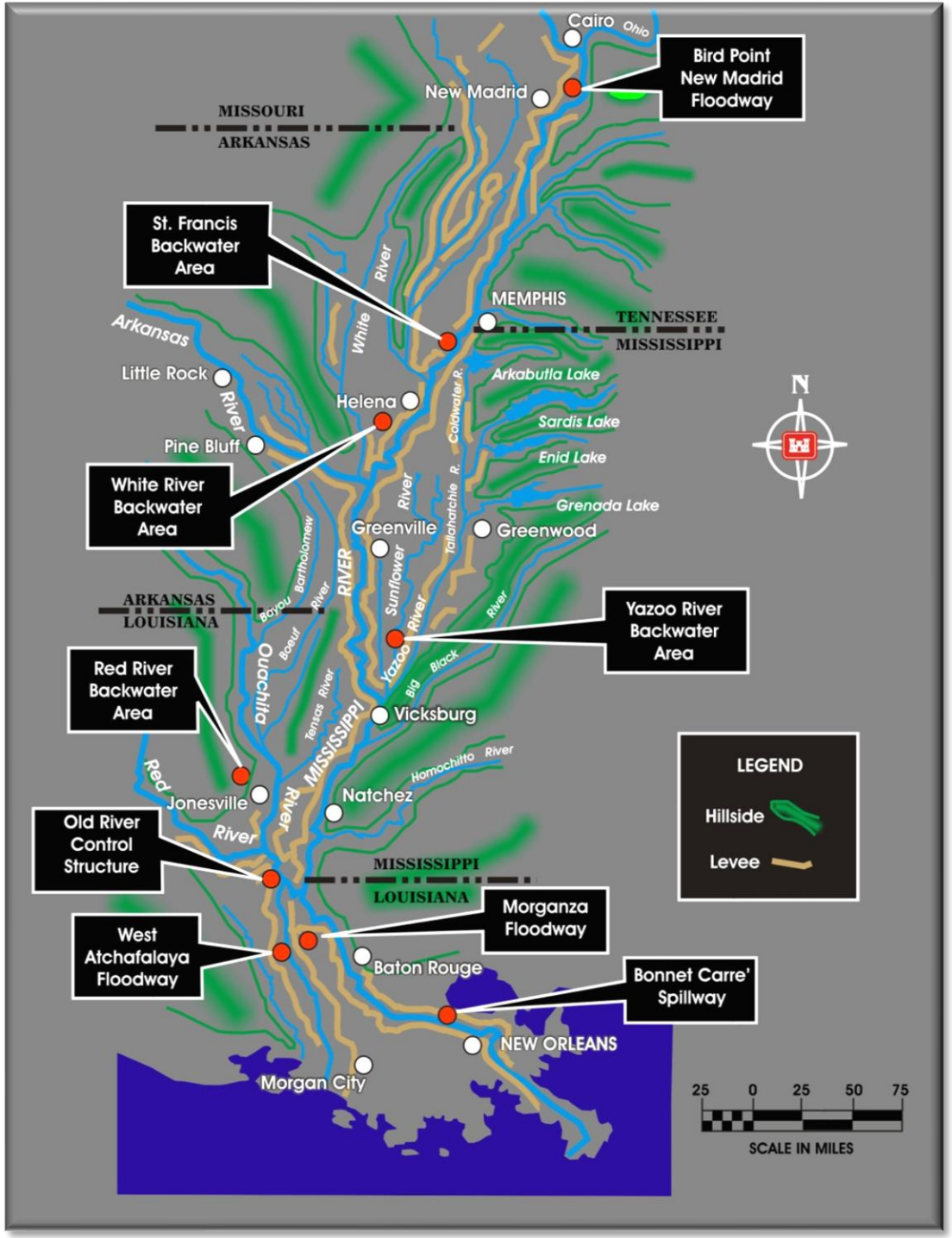
Project Features

- **Floodways & Spillways** --constructed to protect people, property and navigable waterways:
  - Reduce flood stages by diverting water
  - Are controlled by USACE, coordinated with civil authority
  - Operational decision with BG Peeples (CG, Mississippi Valley Division)

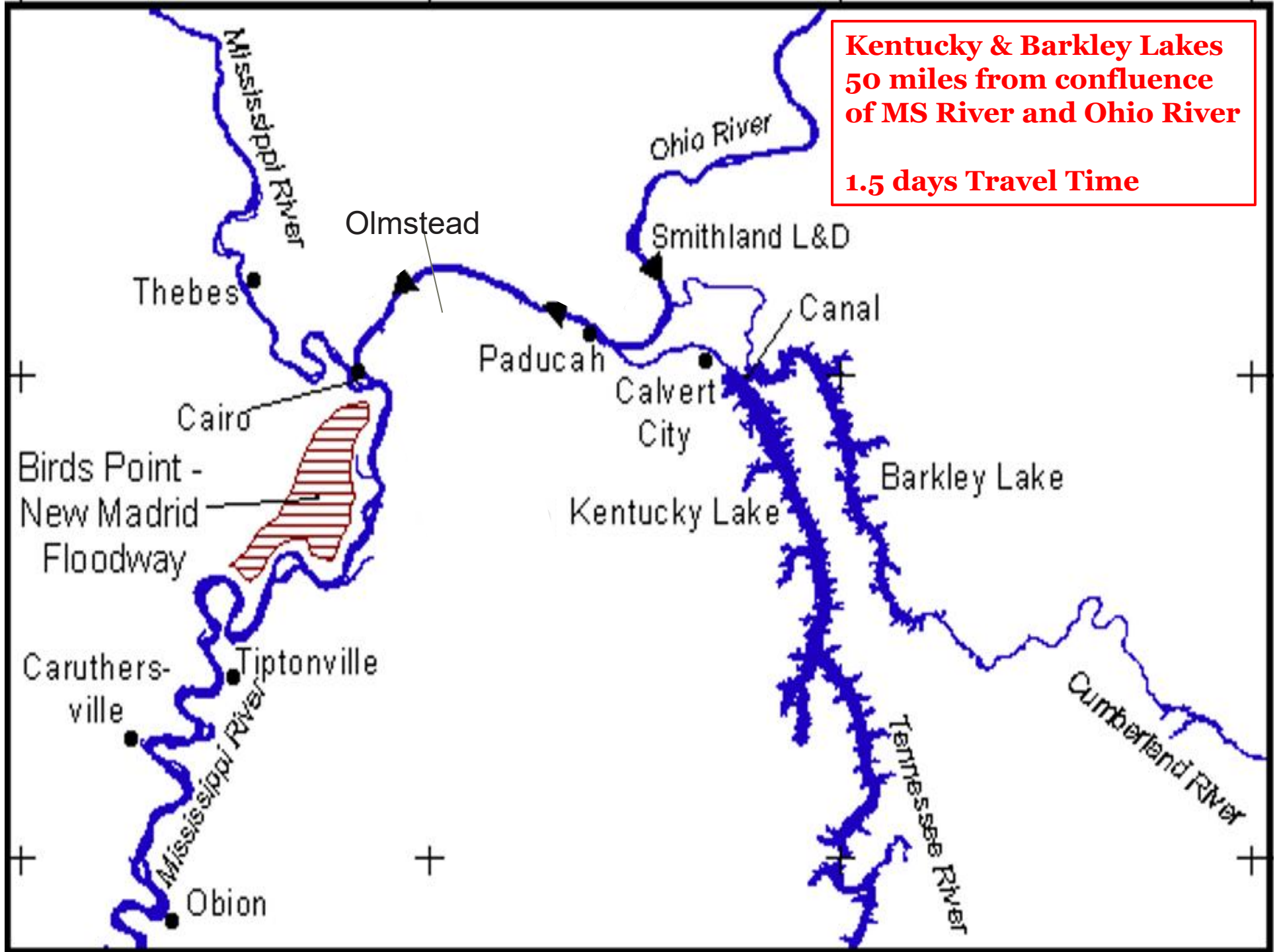
- **Decisions based on river levels and flow rates:**
  - Birds Point-New Madrid –Ohio River at Cairo, IL over 60 feet and rising
  - West Atchafalaya –Mississippi River at Simmesport over 58 feet
  - Morganza–Mississippi flow is over 1.5M cfs, or over 57 feet at floodway
  - Bonnet Carre–Mississippi River over 1.25M cfs at spillway or 17.0 feet at New Orleans or faster than



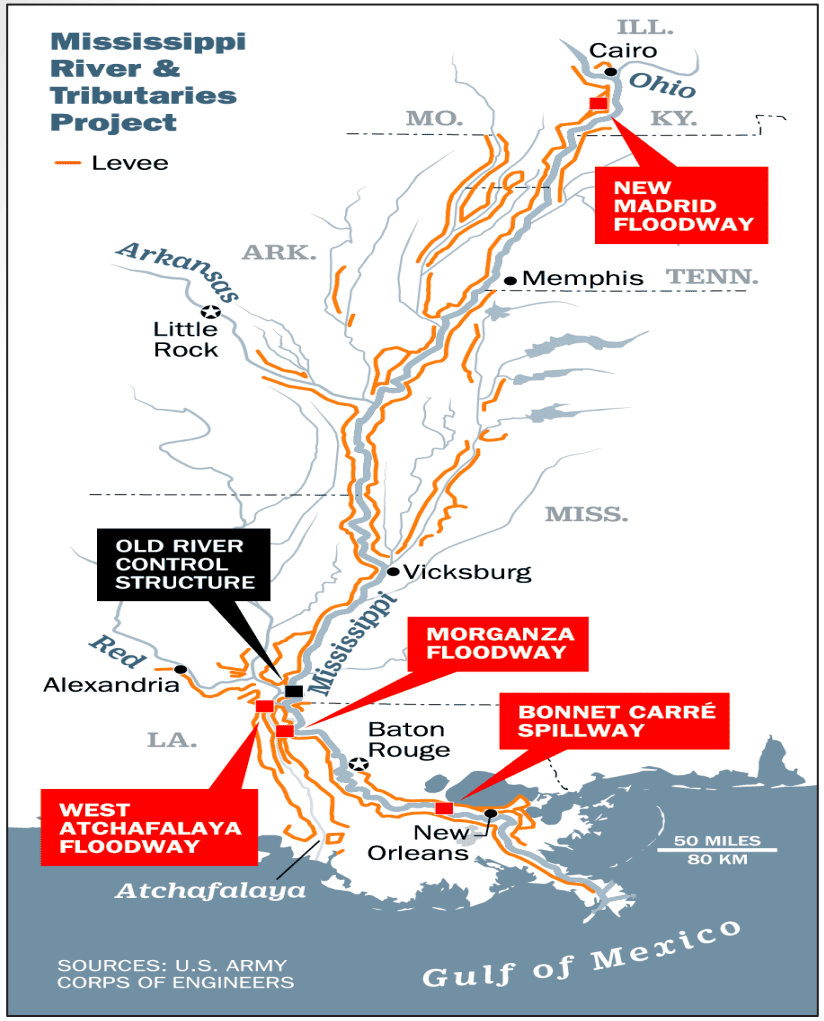
Flood Storage

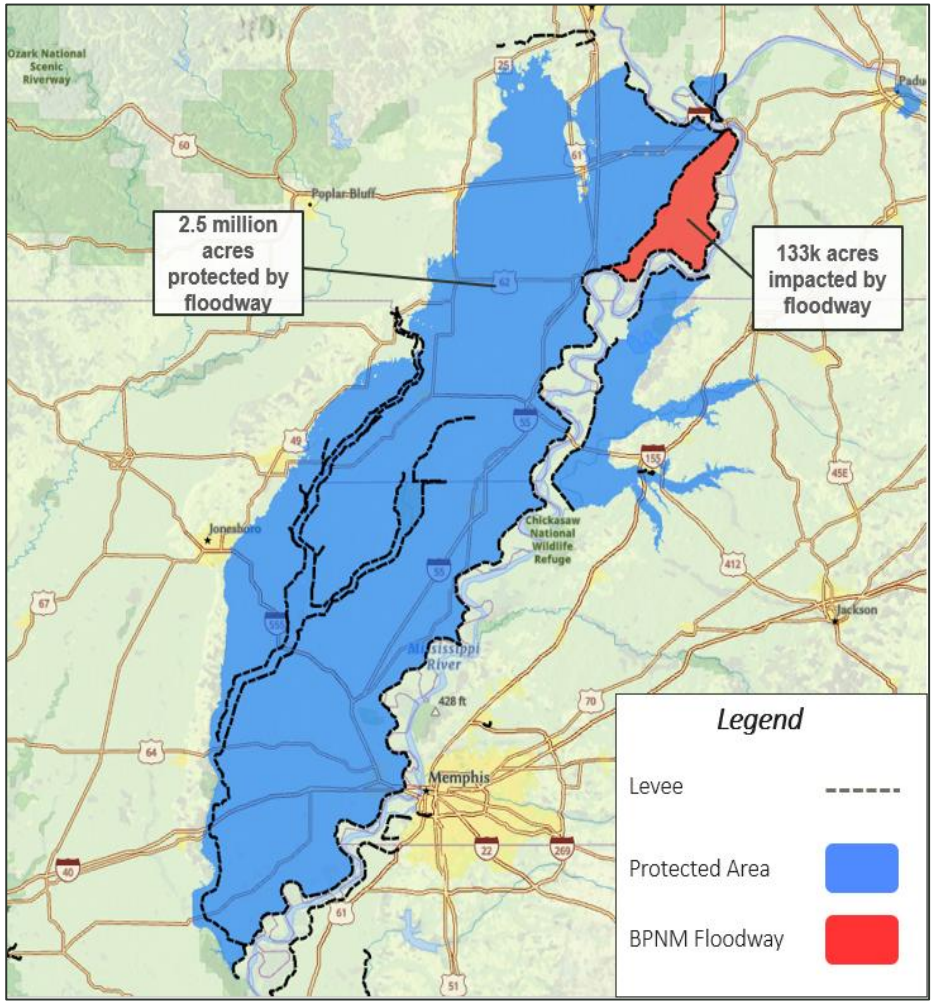


	Feature Acres	Total Acres	Sq Miles
Floodway			
Birds Point - New Madrid	133,000	133,000	208
Backwater Areas			
St. Francis	500,000	633,000	989
White River	145,000	778,000	1,216
Yazoo	634,000	1,412,000	2,206
Red River	373,000	1,785,000	2,789
Floodways			
Morganza	71,500	1,856,500	2,901
Bonnet Carré	7,600	1,864,100	2,913
West Atchafalaya	154,000	**2,018,100**	**3,153**

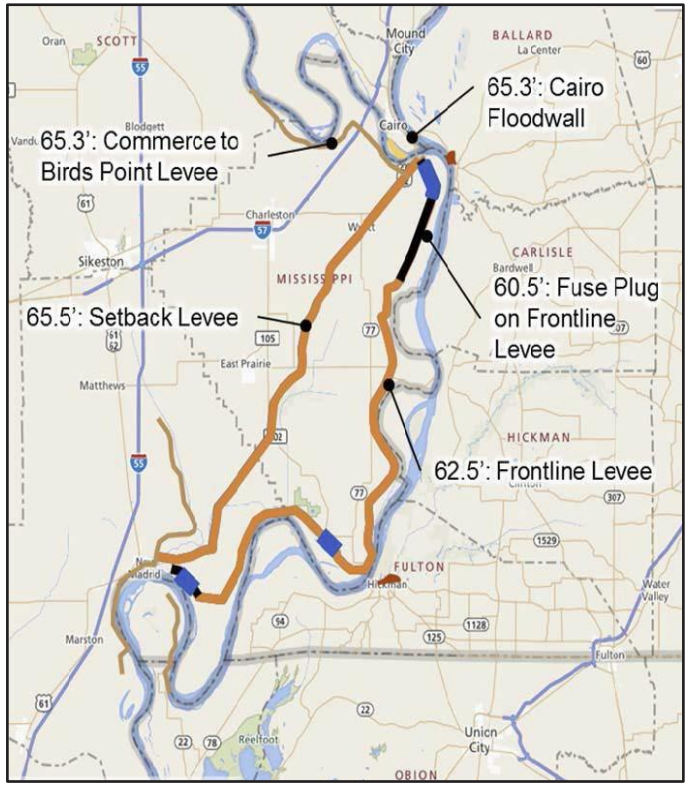

Kentucky & Barkley Lakes
50 miles from confluence
of MS River and Ohio River
1.5 days Travel Time
Mississippi River
Ohio River
Olmstead
Smithland L&D
Thebes
Canal
Paducah
Calvert
City
Cairo
Birds Point -
New Madrid
Floodway
Kentucky Lake
Barkley Lake
Caruthers-
ville
Tiptonville
Mississippi River
Tennessee River
Cumberland River
Obion

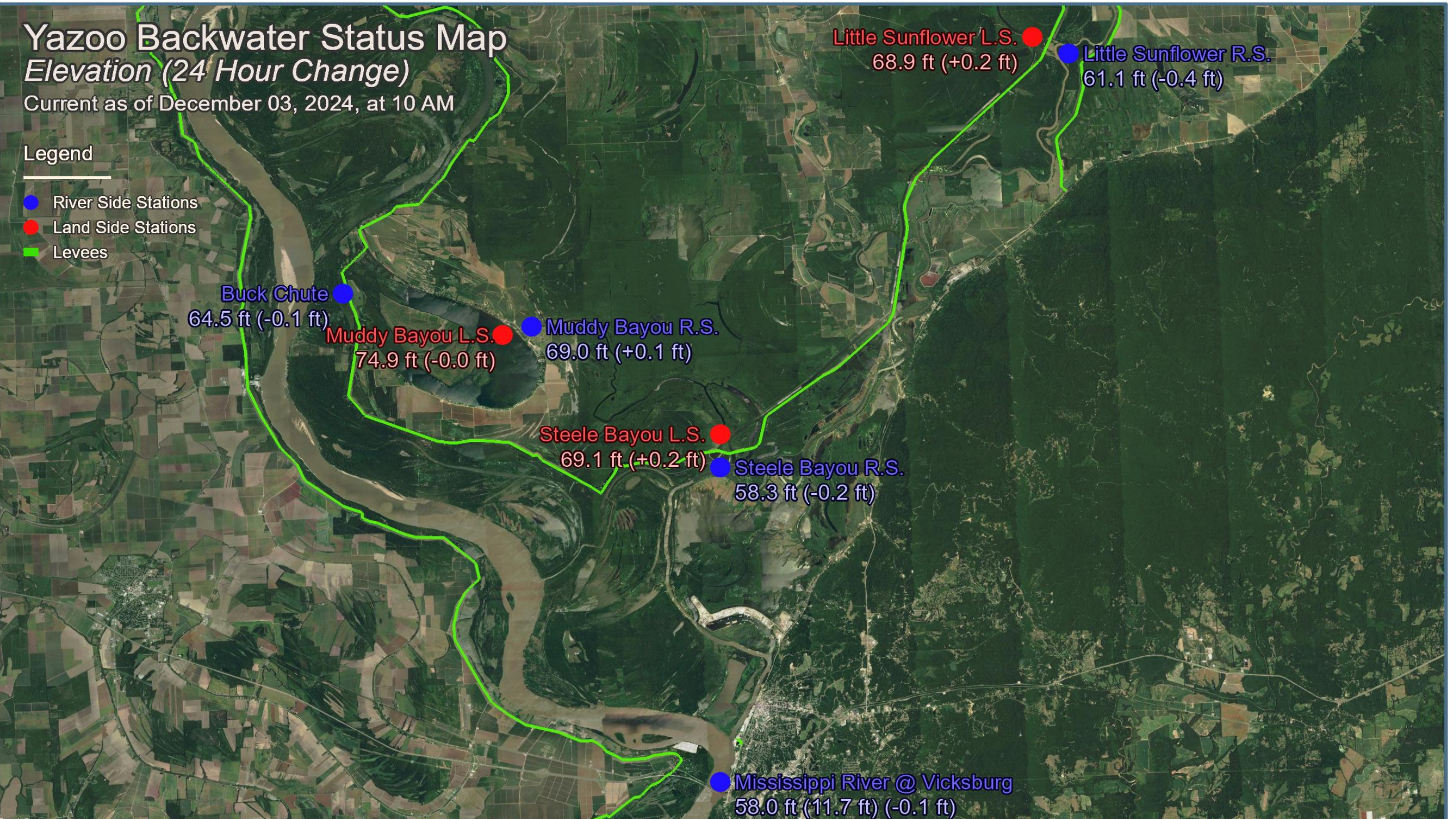
Operating the Birds Point-New Madrid Floodway
PROTECTING A BROAD RANGE OF LAND USES





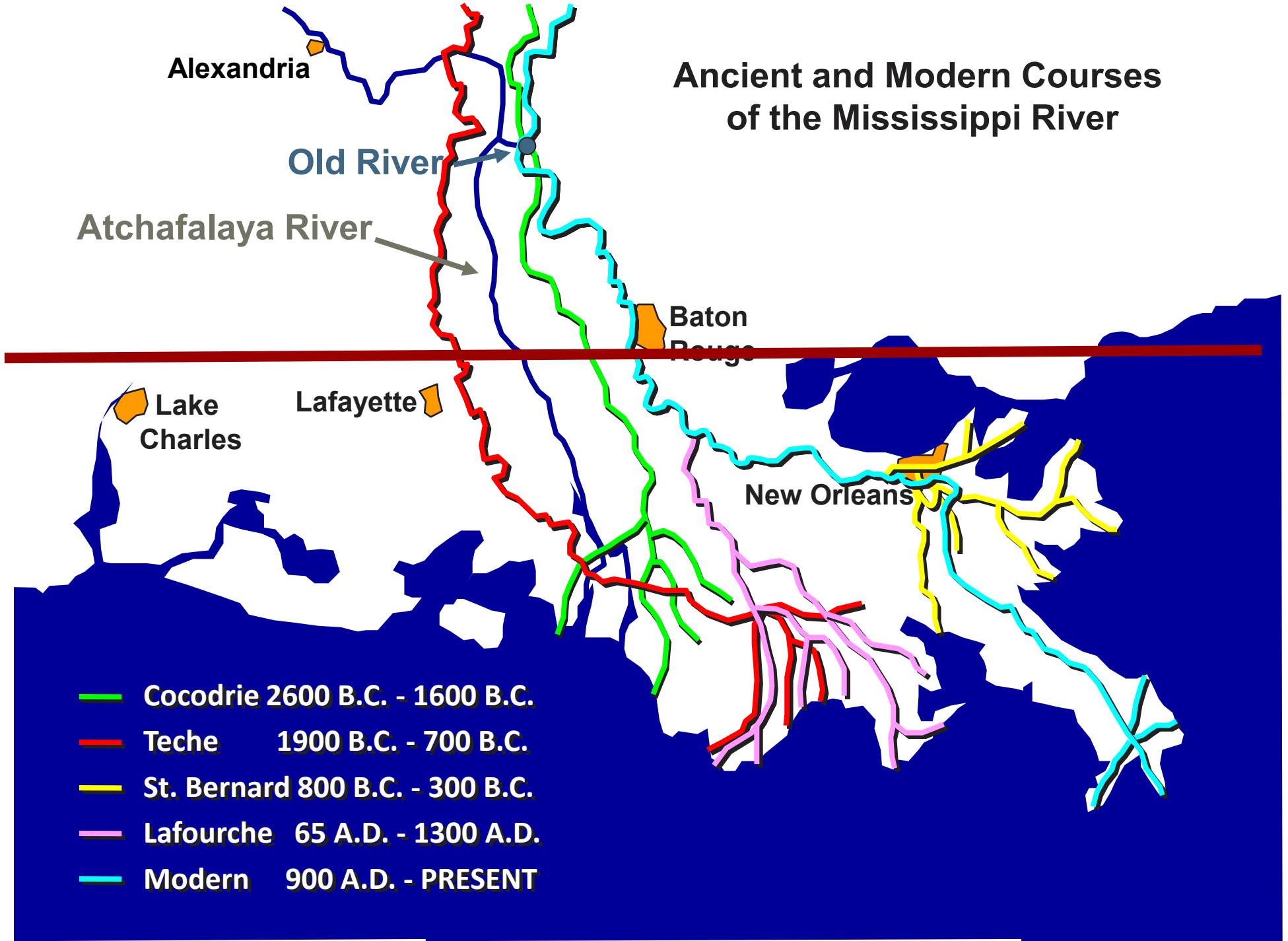
- Completed in 1932
- 133,000 acre floodway – completely flooded in 2011
- Operated (levees breached) in 1937 and 2011
- Design flow of 550,000 cfs




Yazoo Backwater Status Map
Elevation (24 Hour Change)
Current as of December 03, 2024, at 10 AM
Legend
River Side Stations
Land Side Stations
Levees
Little Sunflower L.S.
68.9 ft (+0.2 ft)
Little Sunflower R.S.
61.1 ft (-0.4 ft)
Buck Chute
64.5 ft (-0.1 ft)
Muddy Bayou L.S.
74.9 ft (-0.0 ft)
Muddy Bayou R.S.
69.0 ft (+0.1 ft)
Steele Bayou L.S.
69.1 ft (+0.2 ft)
Steele Bayou R.S.
58.3 ft (-0.2 ft)
Mississippi River @ Vicksburg
58.0 ft (11.7 ft) (-0.1 ft)

Yazoo Backwater Levee 0.3ft Freeboard

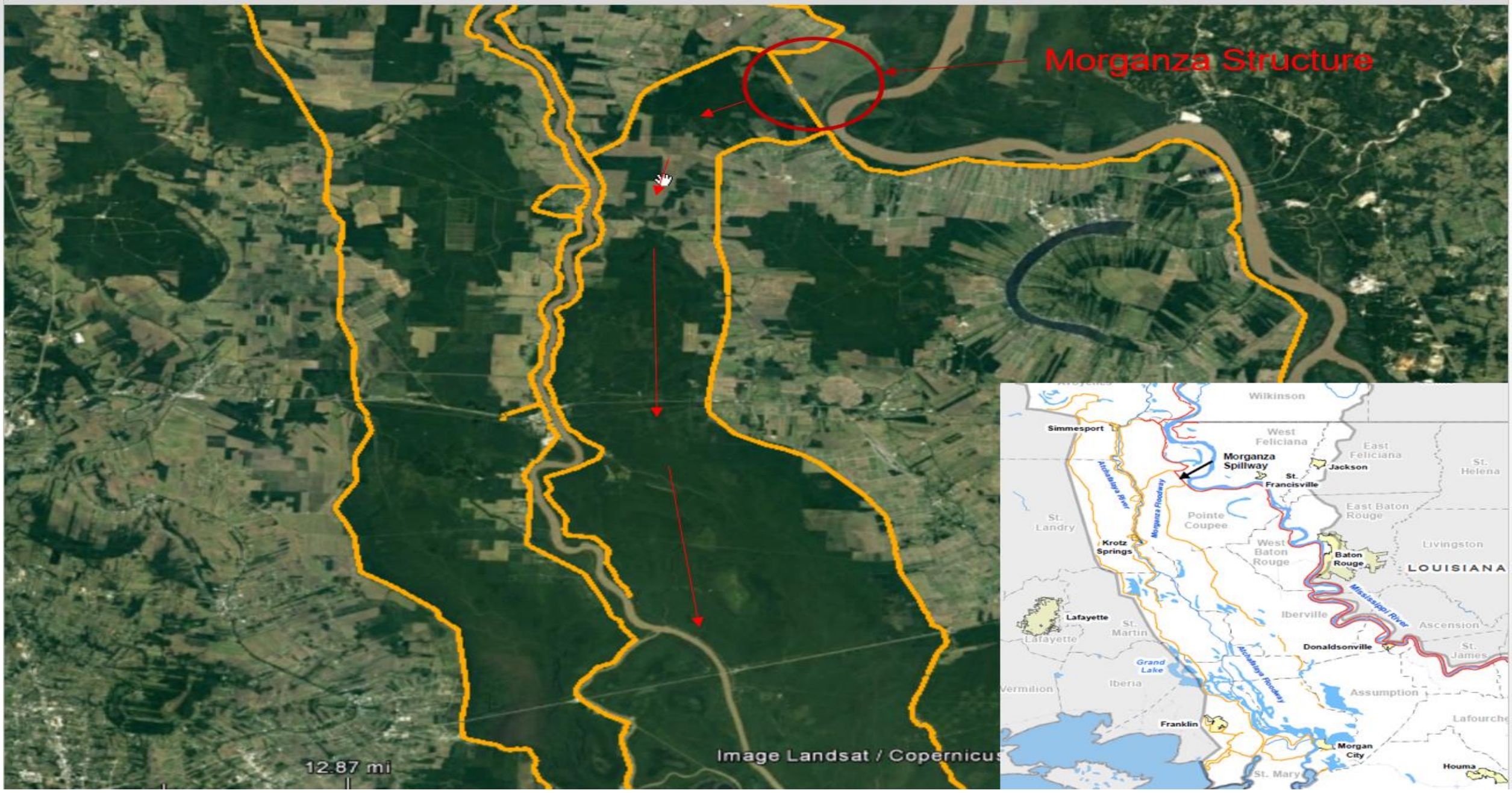
Mississippi River & Tributaries Project


Ancient and Modern Courses
of the Mississippi River
Alexandria
Old River
Atchafalaya River
Baton
Rouge
Lake
Charles
Lafayette
New Orleans
Cocodrie 2600 B.C. - 1600 B.C.
Teche 1900 B.C. - 700 B.C.
St. Bernard 800 B.C. - 300 B.C.
Lafourche 65 A.D. - 1300 A.D.
Modern 900 A.D. - PRESENT


Low Sill & Overbank Structures Completed 1962
Old River Lock Completed 1963
Auxiliary Structure Completed 1986
Hydropower Structure Completed 1988
Complex PDF Design Flow = 620,000 cfs
Old River Complex
Mississippi River
Old River Overbank Structure
Sydney A. Murray Hydropower Plant
Old River Low Sill Structure
Knox Landing
Outflow Channel
Old River Auxiliary Control Structure
Max Discharge 14 May 2011 Total Complex - 671,000 cfs


LA
RED RIVER
ALEXANDRIA
OUACHITA RIVER
MONROE
RED RIVER
ATCHAFALAYA
MISSISSIPPI RIVER
30%
70%

MORGANZA STRUCTURE/FLOODWAY



Morganza Spillway Opening
May 14, 2011

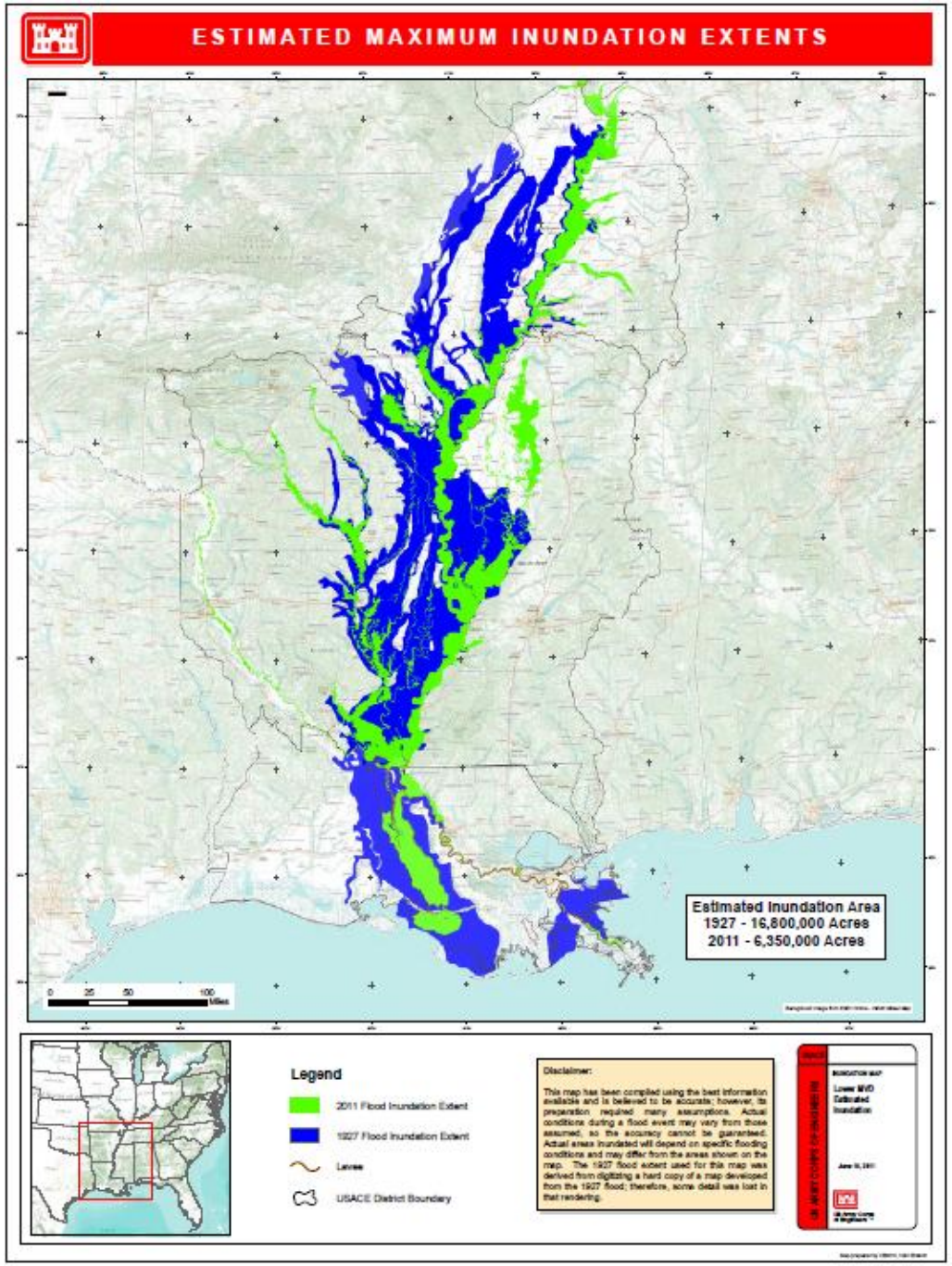
- Completed 1954
- Operated in 1973 & 2011
- April 17th 1973 42 bays = 194,000 cfs
- May 18th 2011 17 bays = 170, 000 cfs
- PDF Capacity = 600,000 CFS

Bonnet Carre spillway operation in 2008

FLOODED AREAS

1927 FLOOD VS 2011 FLOOD

- 1927 Flood
  - 26,000 sq. miles
  - >250 Deaths
- 2011 Flood
  - 9,900 sq. miles
  - More than 16,000 sq. miles NOT flooded
  - No Deaths



UPPER MISS: L&D, HEADWATER RESERVOIRS, LEVEES

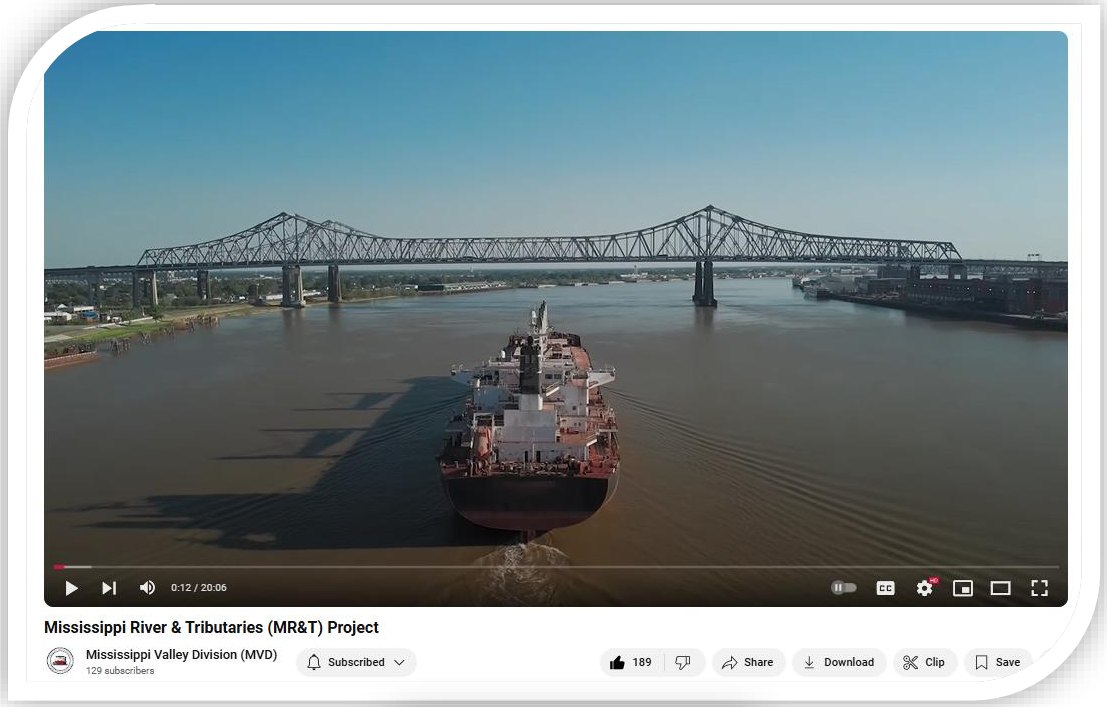
MISSOURI: SYSTEM OF RESERVOIRS, LEVEES

OHIO RIVER: RESERVIORS, TENNESSE/CUMBERLAND CONTROLED, LEVEES, MAIN STEM OHIO NOT MUCH CONTROL.

LOWER MISS: ALLUVIAL VALLEY, DESIGNED TO A HYPOTHETICAL STORM, MRT SYSTEM TO PASS PDF

WATERSHED TOOLS

MVD Watershed App



MR&T Video

QUESTIONS??

US Army Corps of Engineers®

BUILDING STRONG®

APRIL 1965 UPPER MISSISSIPPI

APRIL 1965: ST. PAUL, MN TO LE CLAIRE, IA FRESHET FLOODING

A "Perfect Storm" Setup

- Wet preceding fall.
- **Deep frost development (1-5 feet)** due to quick onset of winter and below normal winter temperatures.
- Above normal winter/early Spring snowfall: **2-11" snow water equivalent** by late March.
- Sudden warm-up in early April after a cold, snowy March lead to **rapid snowmelt**.
- Numerous **heavy rain events in April** on top of melting snowpack

Water Equivalent of Snow on Ground Late March 1965

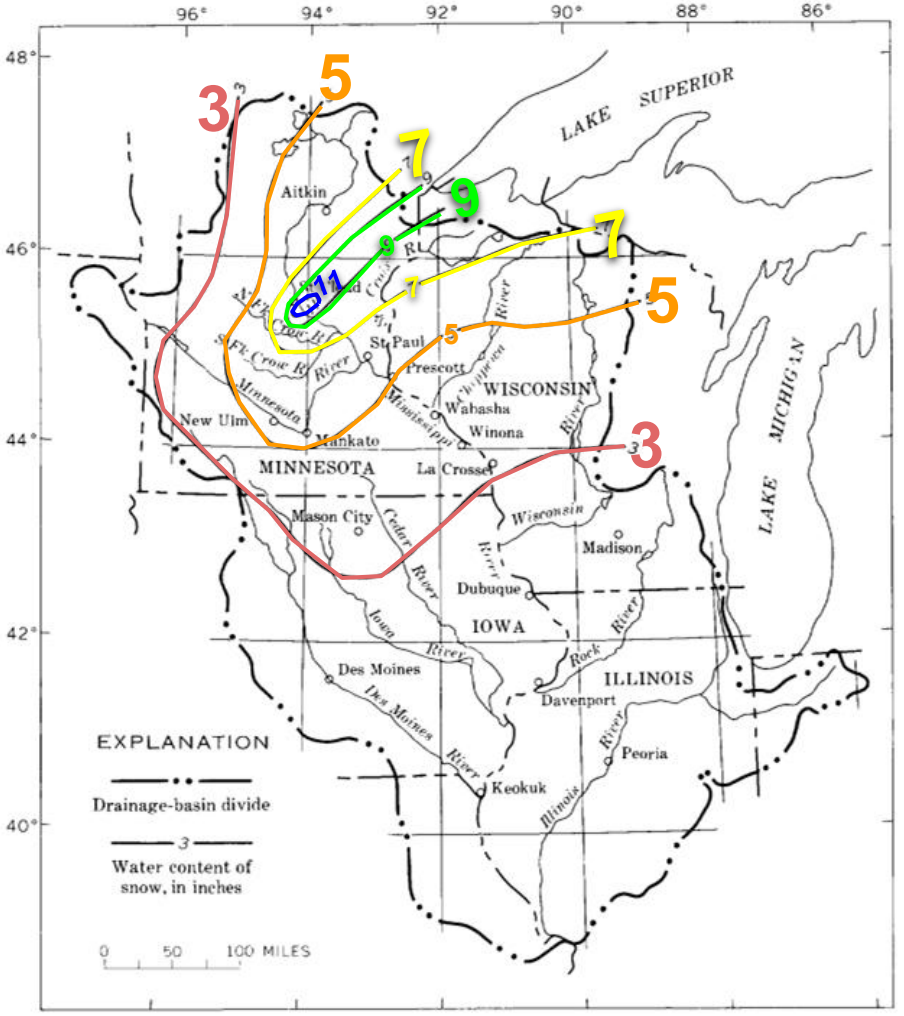
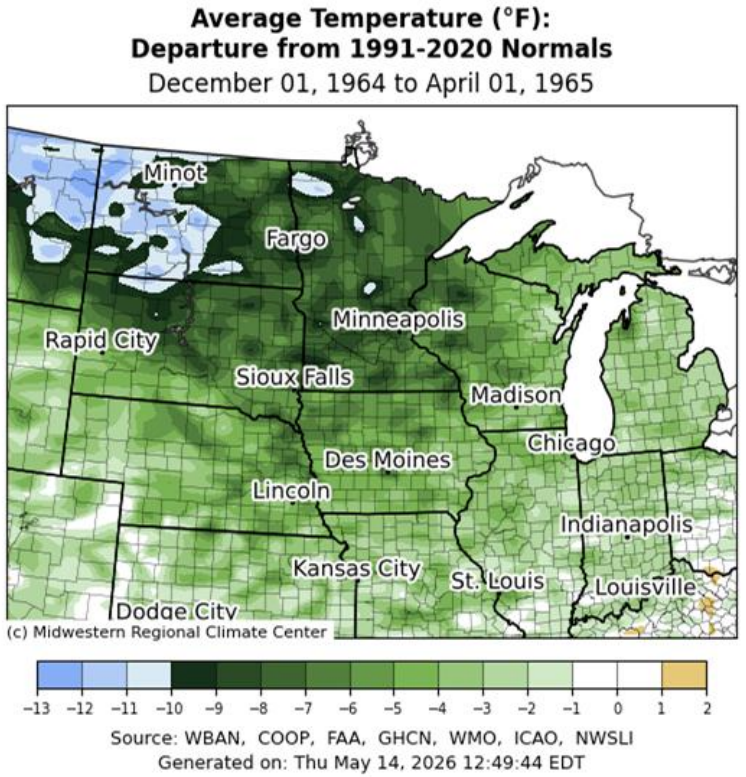


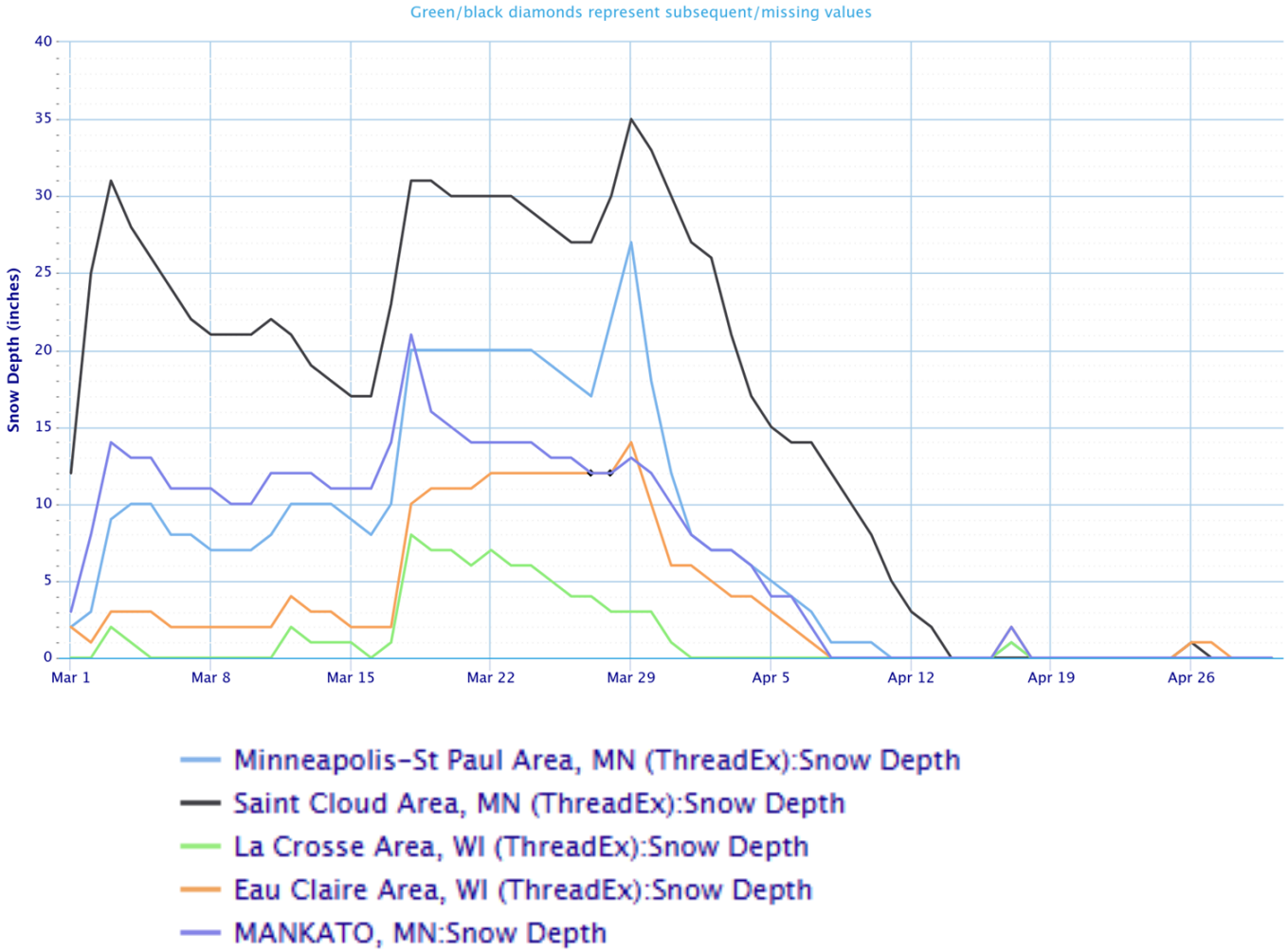
FIGURE 5.—Water equivalent of snow on the ground at the end of March 1965.

Average Temp Departure Dec 1964 - Apr 1965

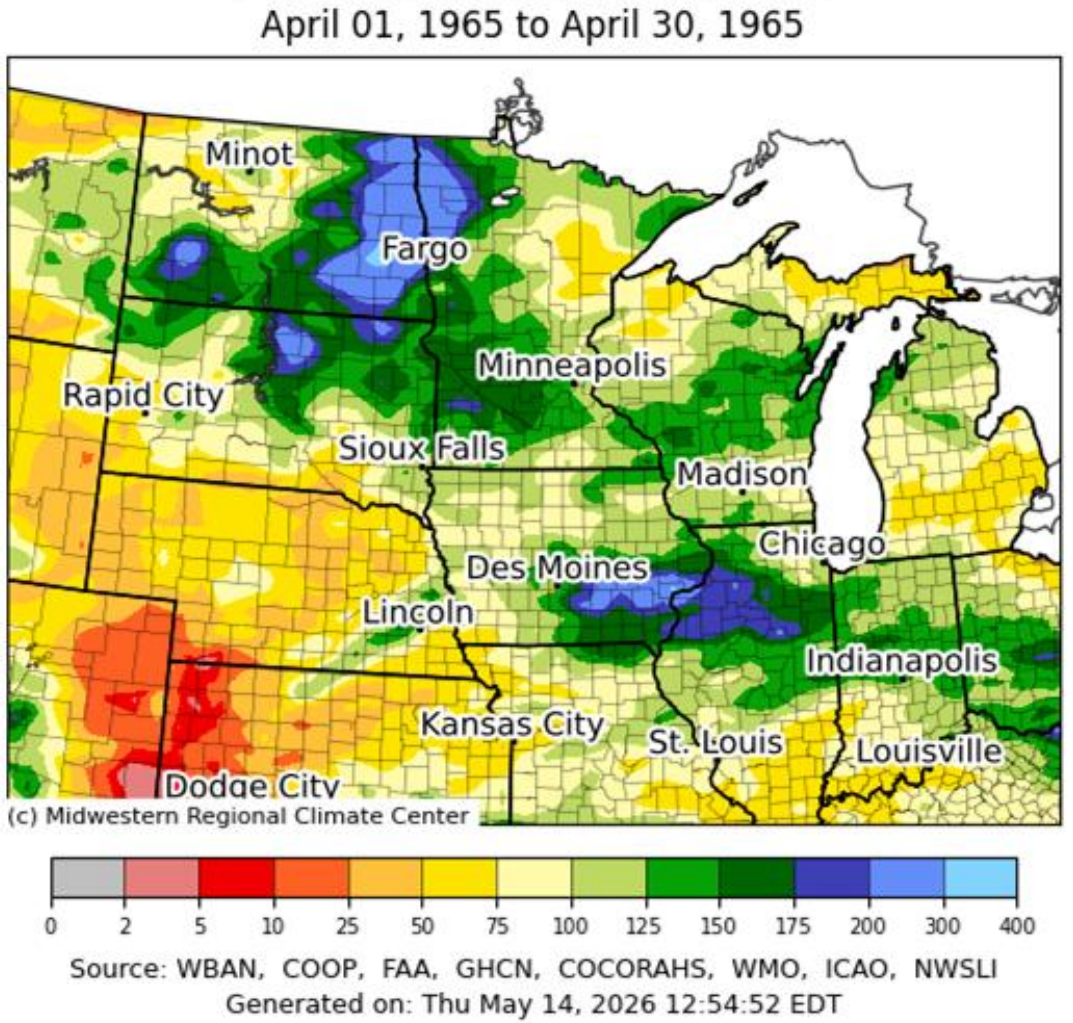


APRIL 1965 - ST. PAUL, MN TO LE CLAIRE, IA

Daily Snow Depth in Upper Mississippi Basin March 1 to April 30, 1965.



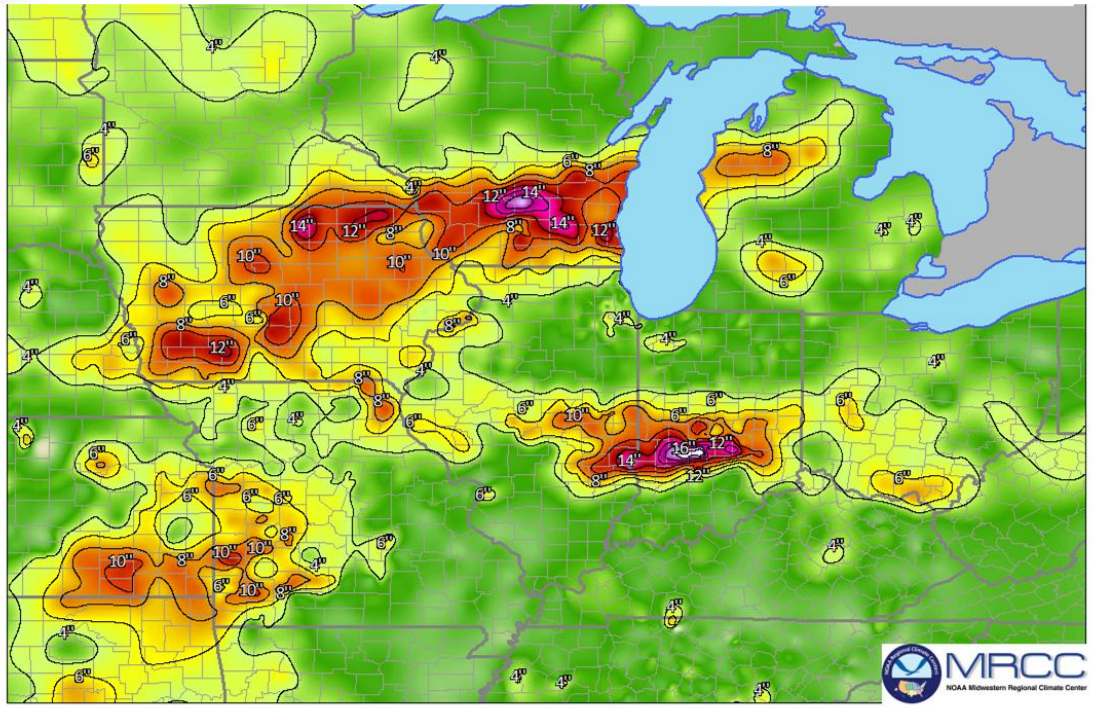
April 1965 Accumulated Precipitation Percent of Normal



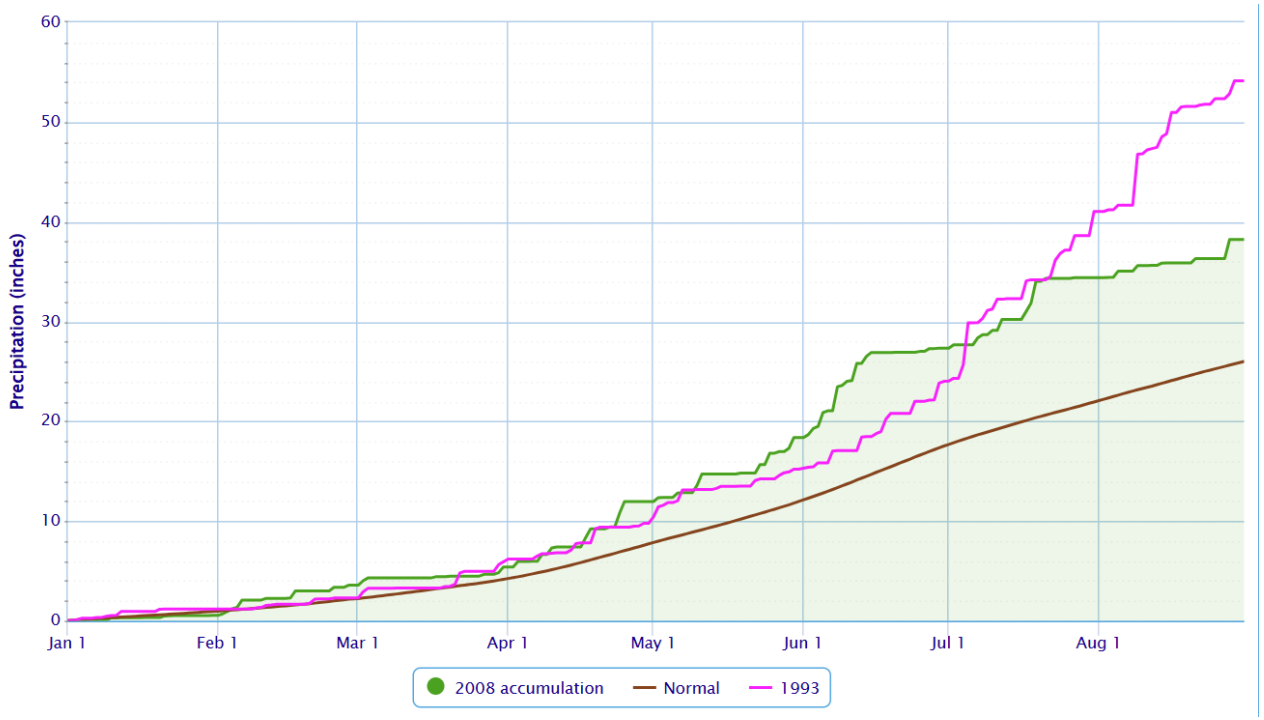
JUNE 2008 UPPER MISSISSIPPI

JUNE 2008: KEITHSBURG, IL TO BURLINGTON, IA HEAVY RAIN FLOODING

Total Precipitation (in)
June 1-15, 2008



Cumulative Precipitation Cedar Rapids, IA
January - August

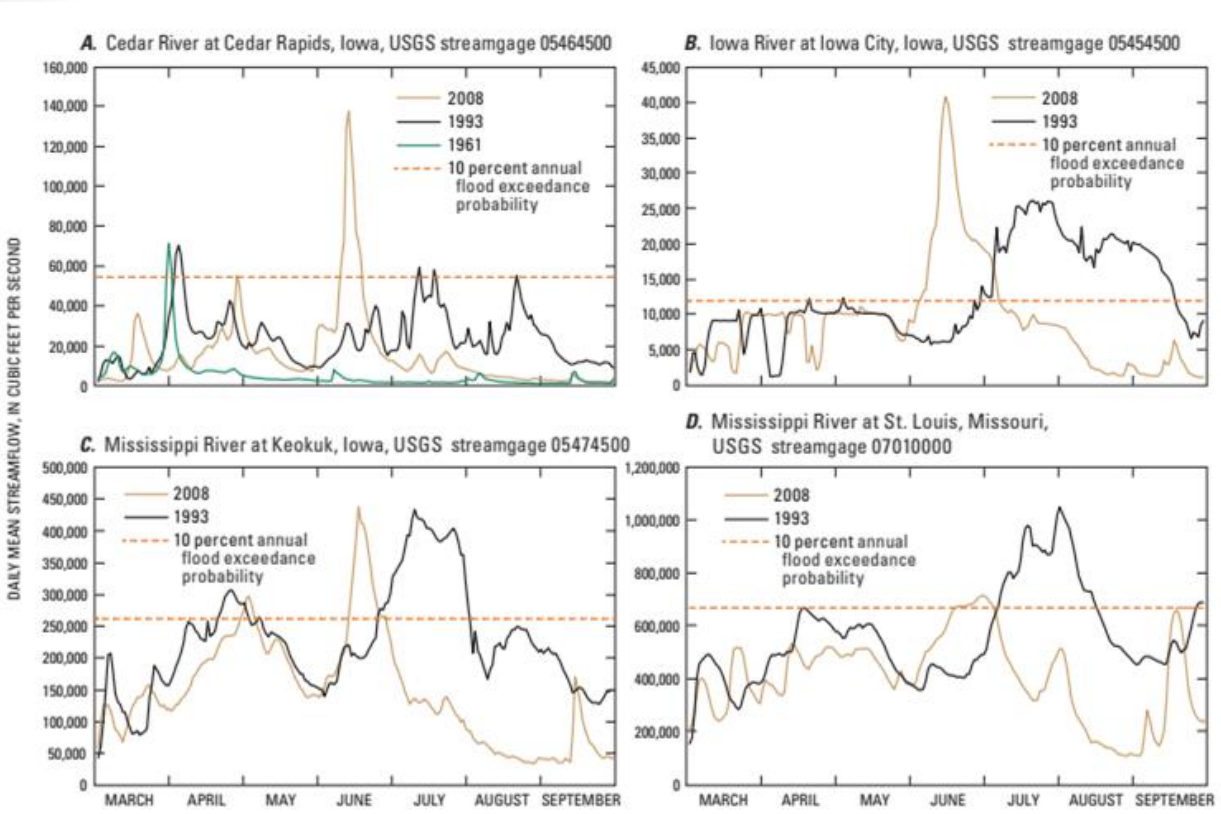


Historic Flooding Driven By:

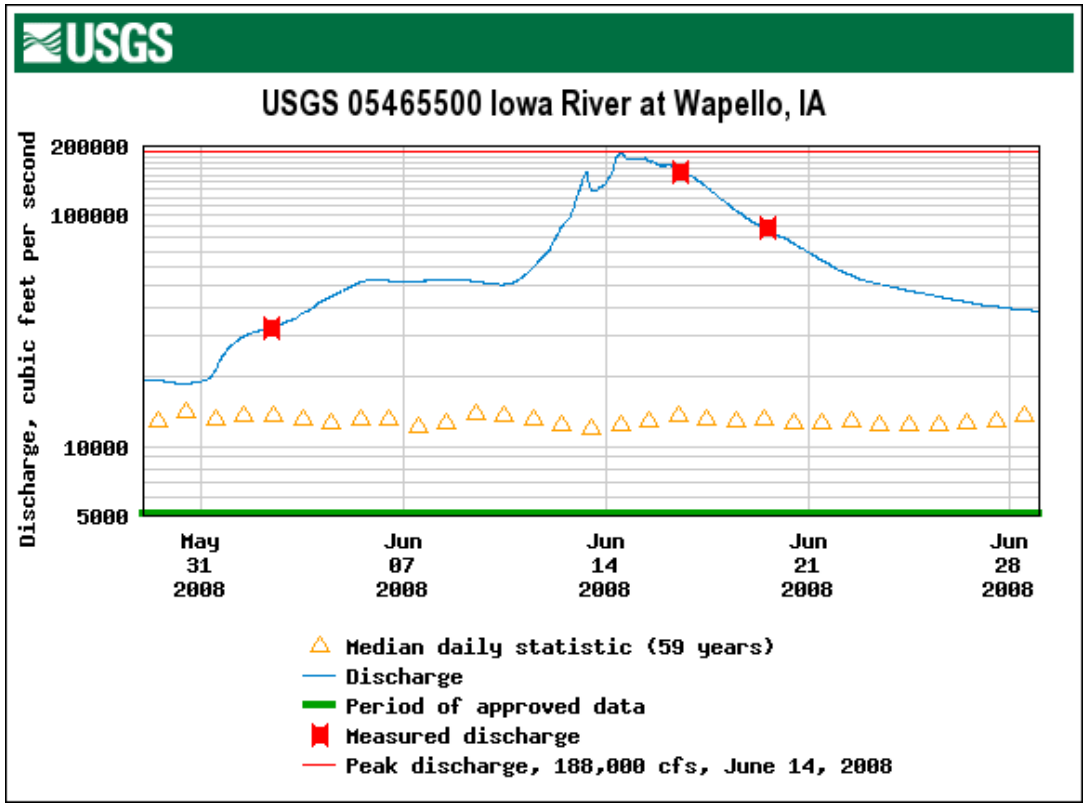
- Heavy snow winter 2007-2008.
- Significant rains and snow melt flooding in April.
- Saturated soils.
- Numerous rain events in May leading to already high river levels.
- Record amounts of rain in the first two weeks of June.
- Flood waves from southern Wisconsin and eastern Iowa tributary flooding arriving around the same time.

JUNE 2008: KEITHSBURG, IL TO BURLINGTON, IA

2008 versus 1993 streamflow and 10% Exceedance Probability March - September

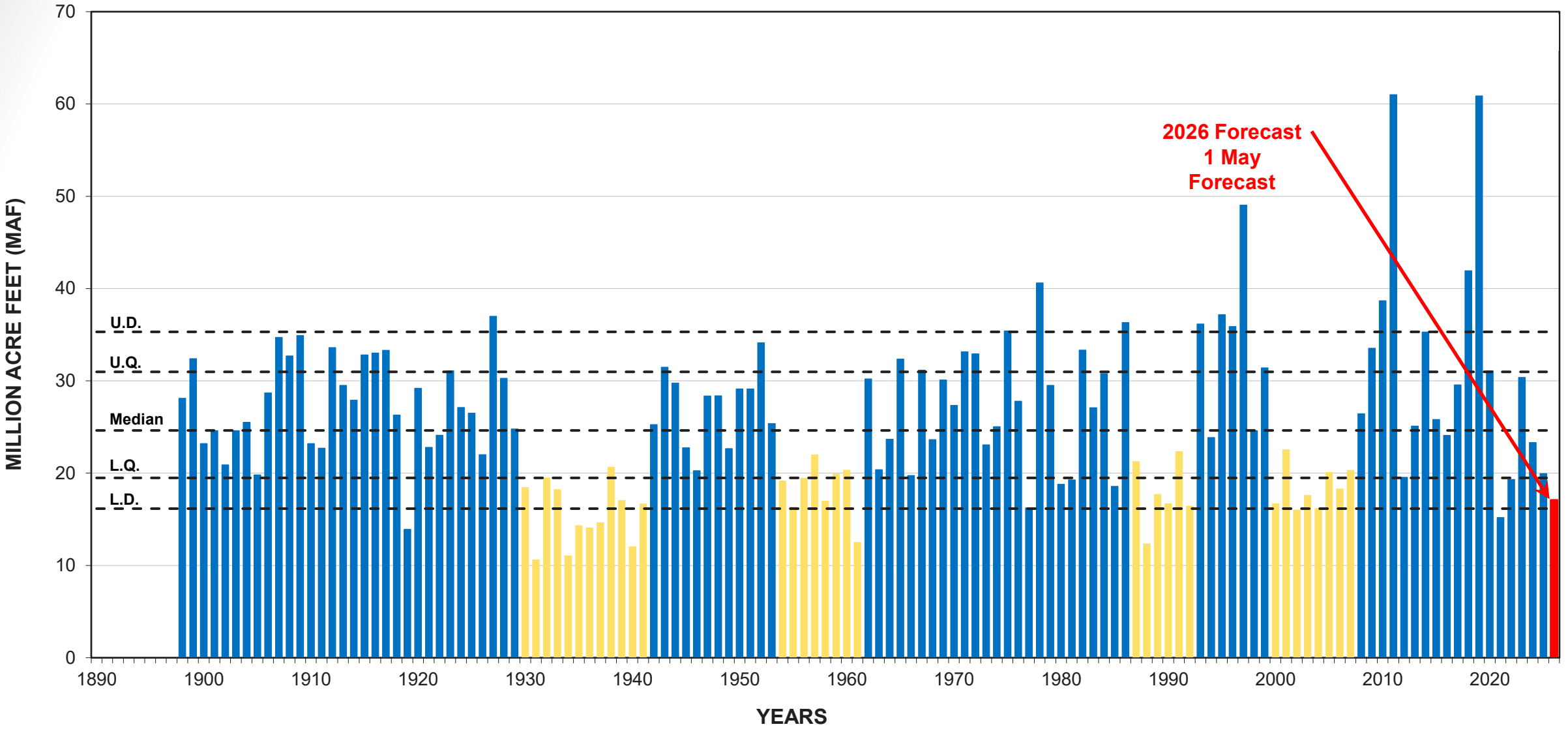


Iowa River at Wapello, IA Streamflow June 2008

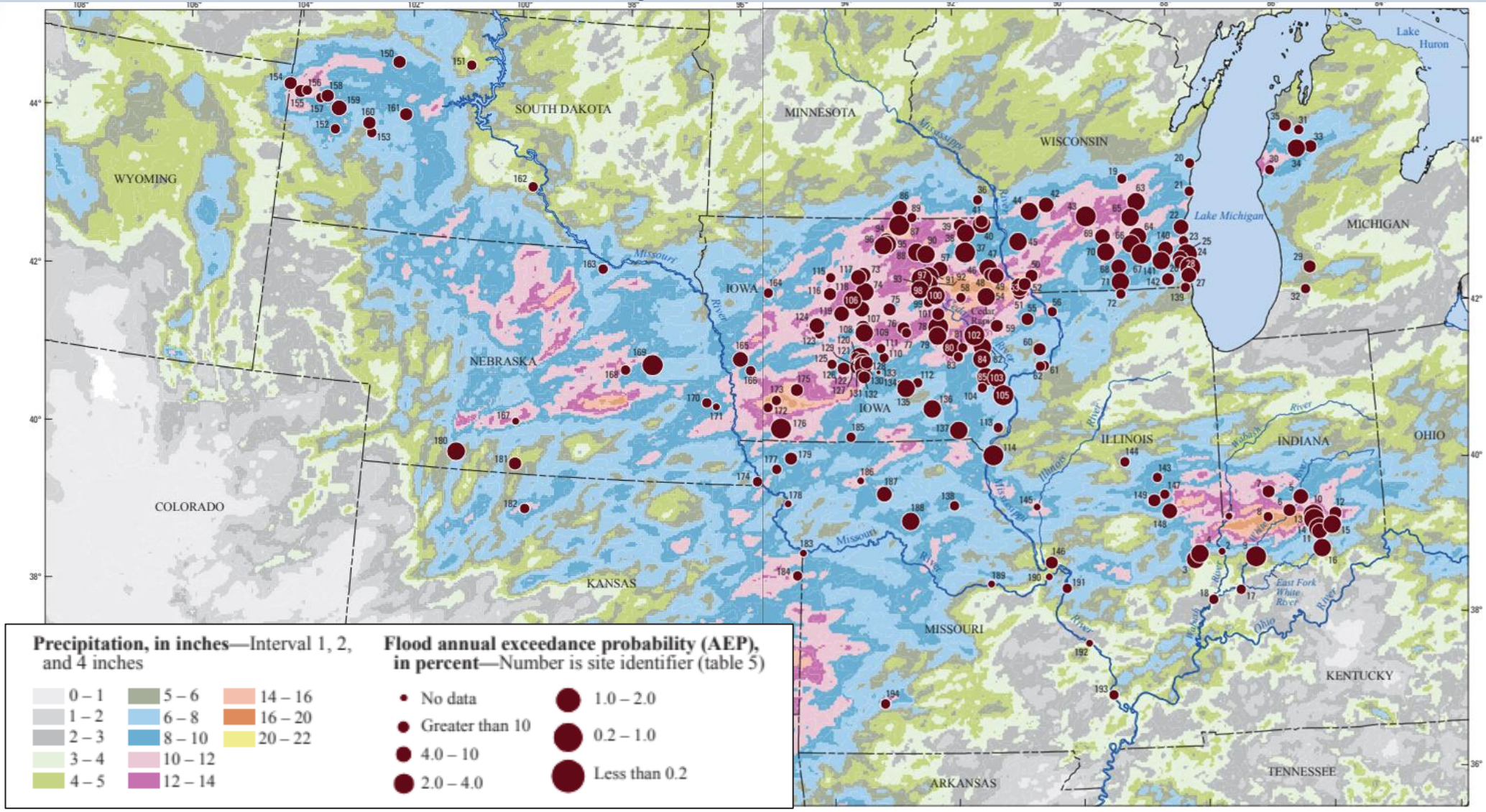


- Flows from southern Wisconsin and eastern Iowa historic flooding contributed to a positively interfering flood wave on the Mississippi River along the Iowa border south of the confluence with the Iowa River.
- Combined flow from Iowa and Cedar rivers was nearly twice that which occurred during the Great Flood of 1993.

ANNUAL RUNOFF ABOVE SIOUX CITY, IA



Cumulative Precipitation and Streamflow Exceedance Values
May 21 - June 14, 2008



Cumulative precipitation totals for May 21 - June 14, 2008 and locations of U.S. Geological Survey streamgages with peak stream flows that had an annual exceedance probability less than 10 percent in that same time range.

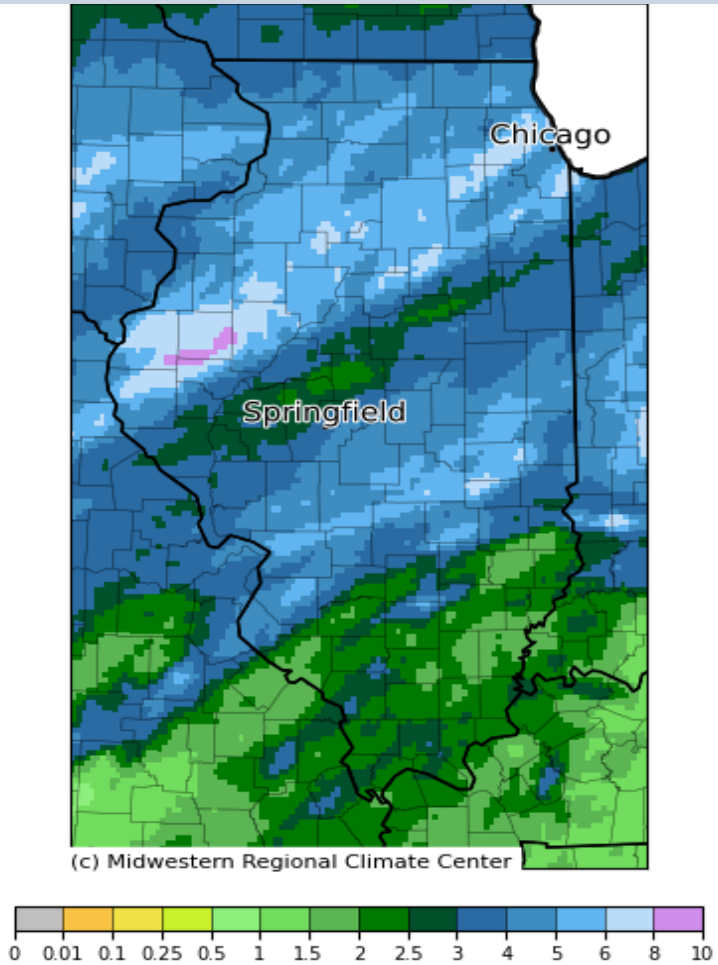
2013 ILLINOIS RIVER

APRIL 2013: MORRIS, IL TO BEARDSTOWN, IL FLOODING

Excessive Rainfall Flooding

- Wet preceding late winter and early spring.
- Sudden pattern switch to hot and wet with training thunderstorms.
- 3-8”+ rain fell the week of April 15, 2013, with most of the rain falling in a short period of time from April 17-18.
- Along the axis of the Illinois River.

7 Day Accumulated Precipitation
April 15 - 21, 2013



7 Day % Normal Precipitation
April 15 - 21, 2013