POST-FLOOD RECONNAISSANCE OF THE UPPER MISSISSIPPI RIVER VALLEY IN 2008

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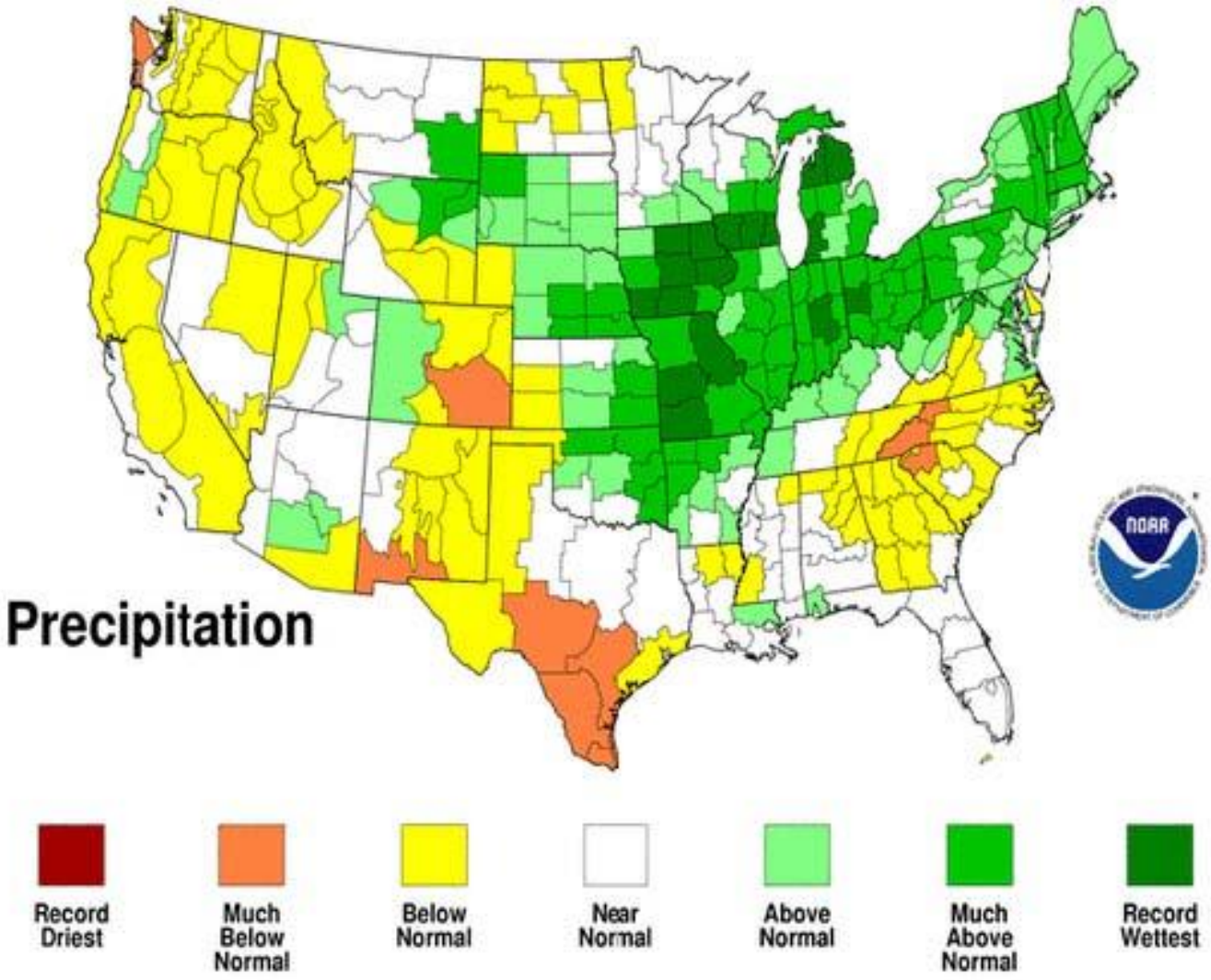
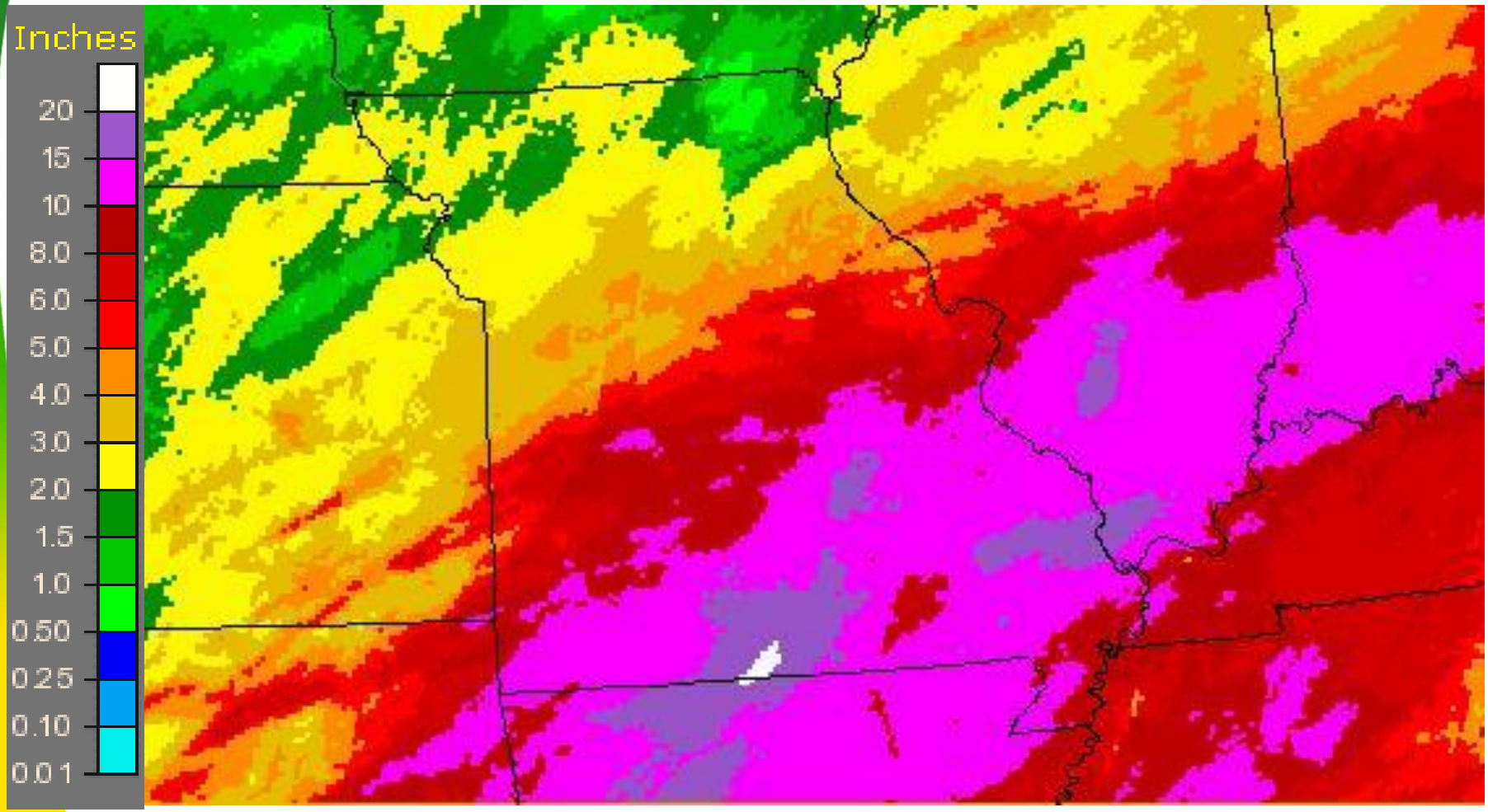
for the symposium on
Geologic Studies for Dams and Levees
Association of Environmental & Engineering Geologists
Lake Tahoe, California
September 25, 2009

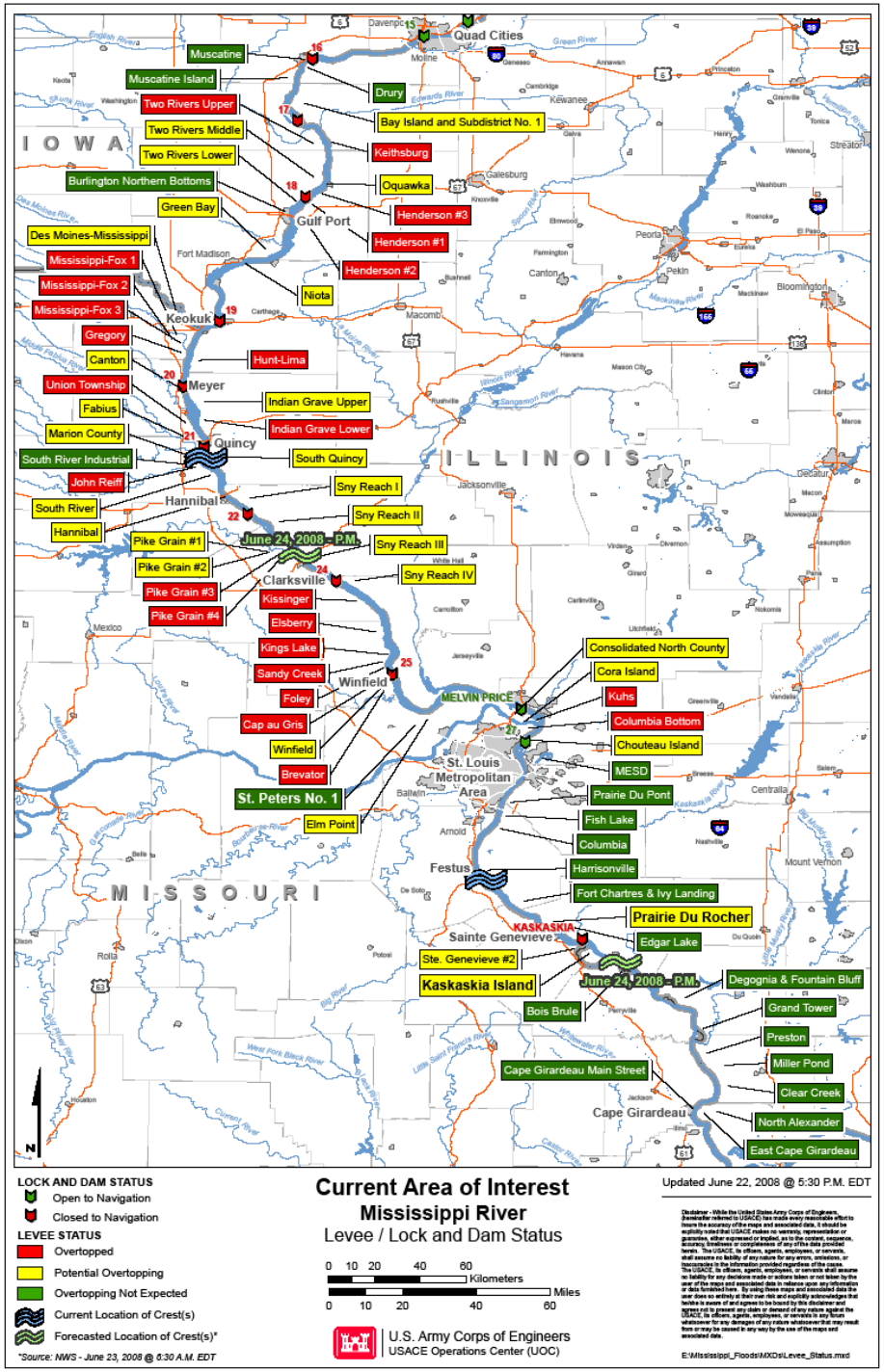
Jan - Jun 2008

National Climatic Data Center/NESDIS/NOAA



Heavy Precipitation in March 2008



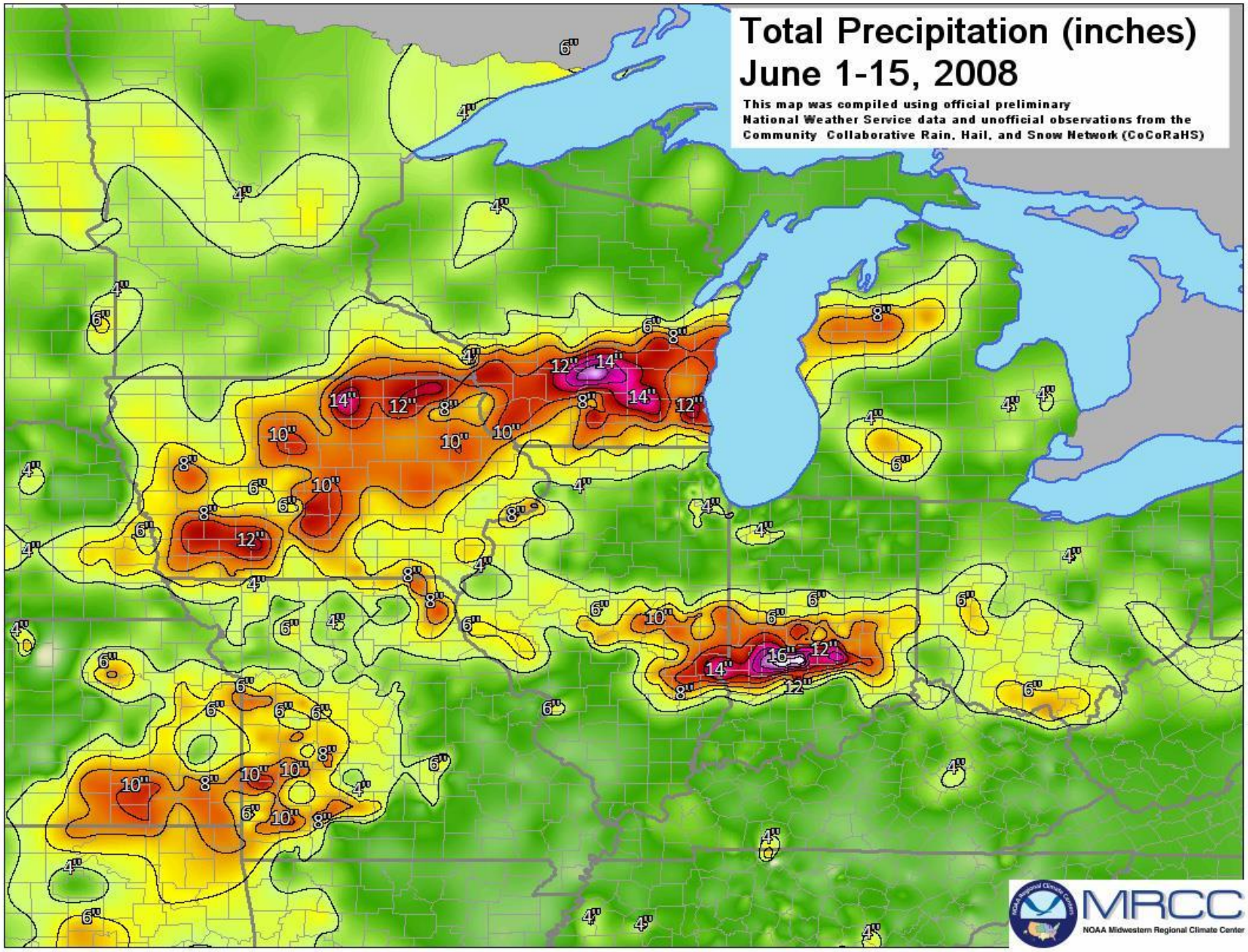


Summer 2008 Midwest Floods

- Largest runoff event since 1993
- Record flows on lower Iowa River in Iowa and Salt Creek near Hannibal, MO
- No significant impacts on flood infrastructure downstream of St Louis
- Corps of Engineers dams probably shaved 1.5 to 3.5 feet off the peak flows

Concrete flood walls often used to protect high-value business districts


ROPOLITAN ST. LOUIS
SEWER DISTRICT


Total Precipitation (inches)
June 1-15, 2008
This map was compiled using official preliminary
National Weather Service data and unofficial observations from the
Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS)
MRCC
NOAA Midwestern Regional Climate Center

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Lock and Dam No. 22 at Saverton closed on June 14th

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L&D 22 re-opened on July 3rd

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Lock and Dam No 25 near Winfield closed down June 15th

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Sandbagged control shed at No 25; re-opened on July 5th

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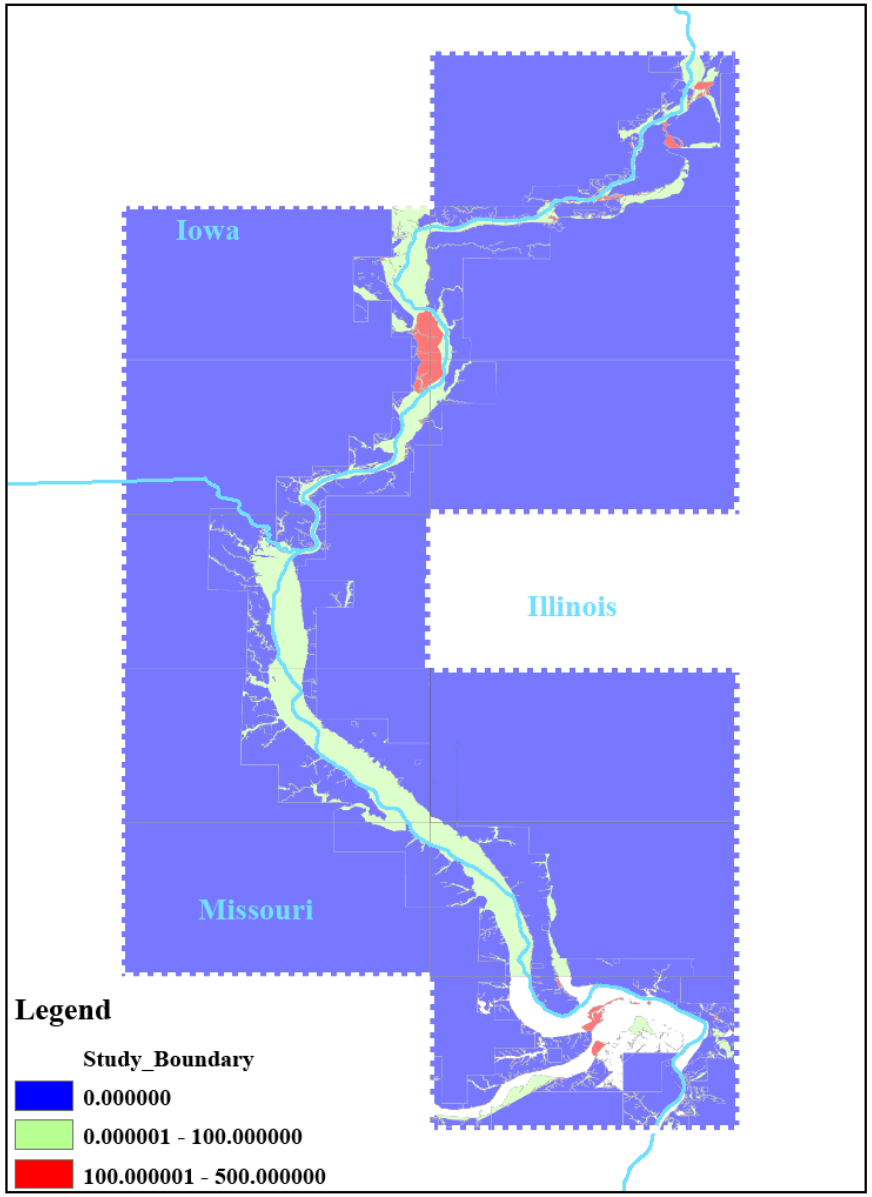
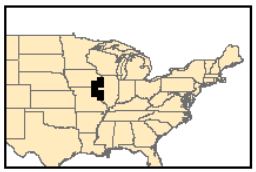
Clarkesville survived using 8 ft high gravel filled bins





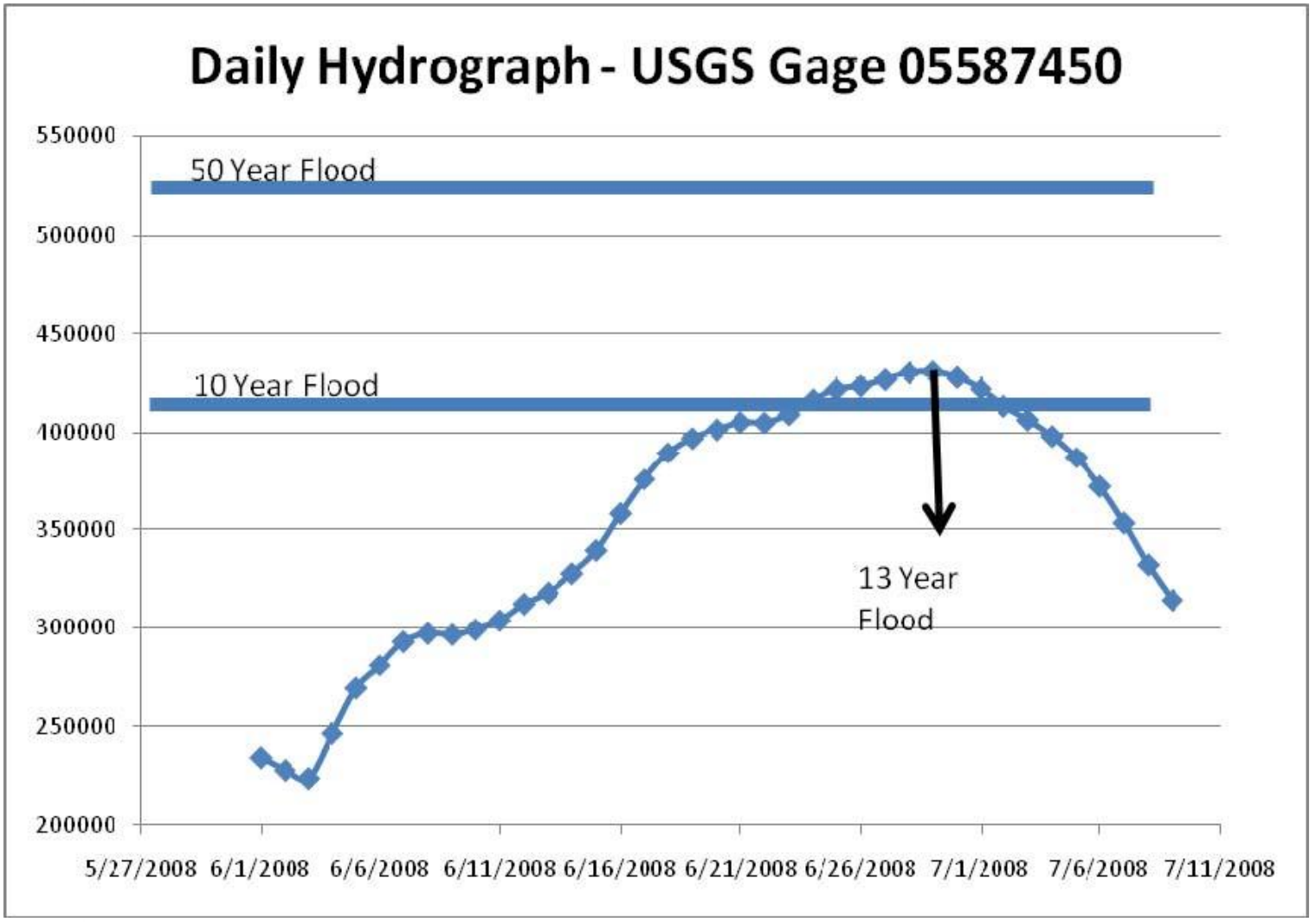
2008 Midwest Levee Investigation
Estimated Flood Return Period(??)

50 25 0 50 Kilometers

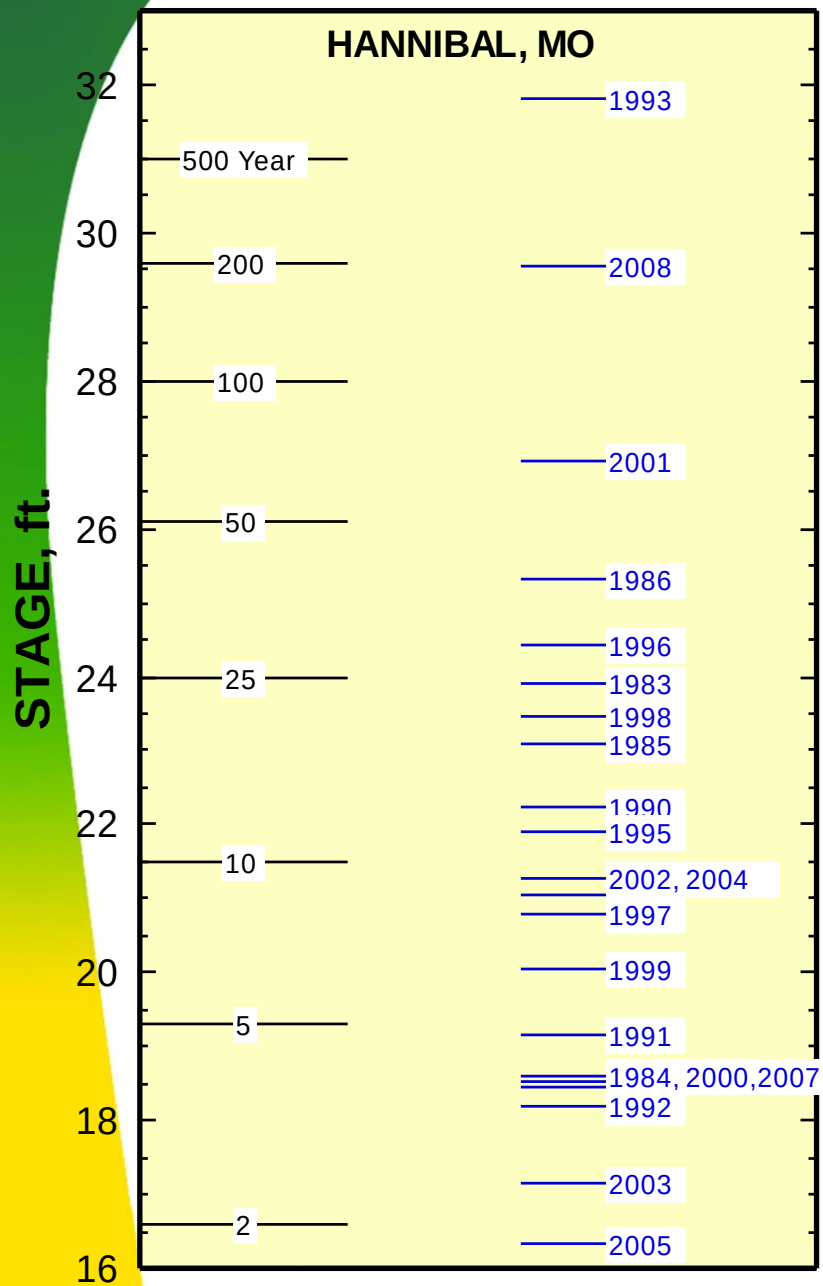
N
W E
S

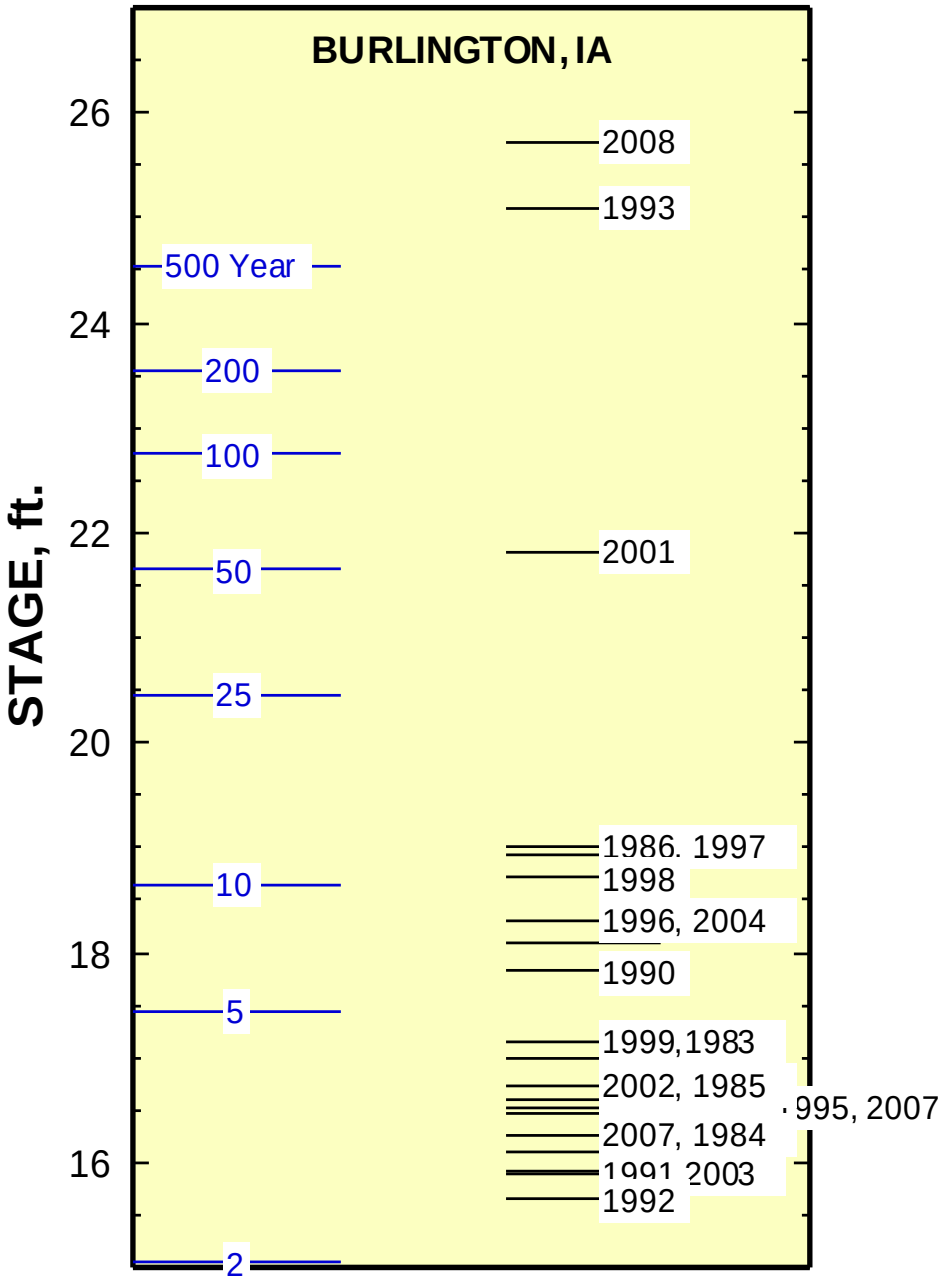
Return Periods according to USACE

- The great majority of the affected area experienced runoff frequencies less than 1-in-100
- The lower Iowa River watershed appears to have suffered an extreme event, likely close to 1-in-200



- **Mississippi River at Nauvoo, Illinois during June-July 2008**





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Data from Criss (2008)

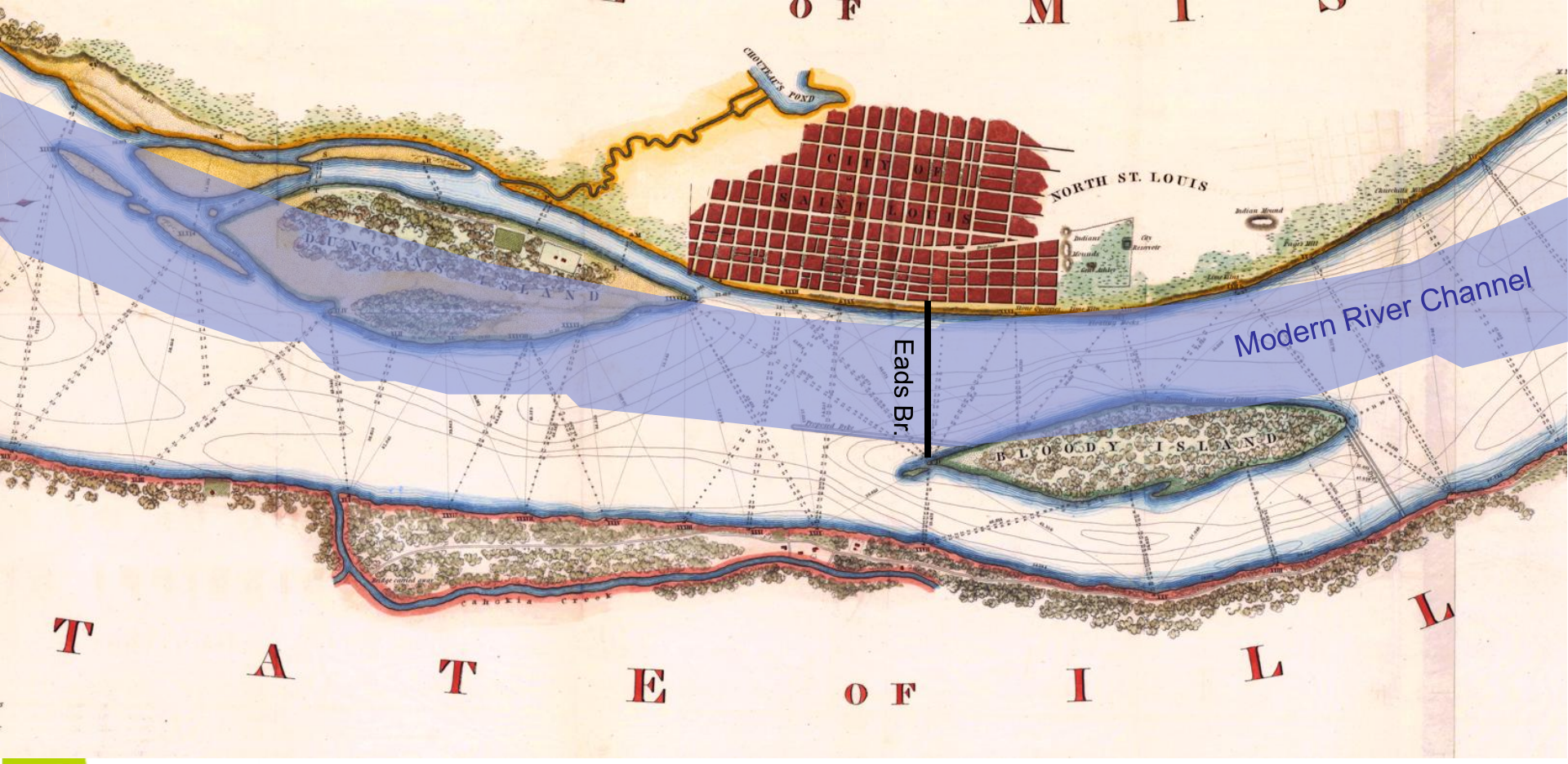
From Criss (2008)

FLOW ≡
WIDTH x ↓
DEPTH x ↑
VELOCITY ↓

Belt, C.B. (1975) The 1973 flood and man's constriction of the Mississippi River. Science v. 89, 681-684

Pinter, N. et al. (2000) Flood-hazard assessment on dynamic rivers. Trans. Am. Geophys. Union, v. 82, 333-339

Criss, R.E. and Shock, E. L. (2001) Flood enhancement through flood control. Geology, v. 29, 875-878



OCT. 1837.

W.J. Stone Sc. Washn City.

Surveyed by Lt. R.E. Lee Corps of Engineers
Assisted by Lt. M.C. Meigs do. do.
J.S. Morehead and H. Kayser

Drawn by Lt. Meigs Corps of Engineers

SCALE 5 INCHES TO 1 MILE

0 10 20 30 40 Chains

Criss et al. (2008 unpub)
Base maps from Lee (1837) and USGS (1954)

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2008 Midwest Levee Investigation
Study Sites

30 15 0 30 Kilometers

Sites selected for further study

- Kehs
- Brevator
- Winfield
- Cap au Gris
- Kings Lake
- Elsberry
- Kickapoo
- Bryants Creek
- Indian Graves
- Two Rivers

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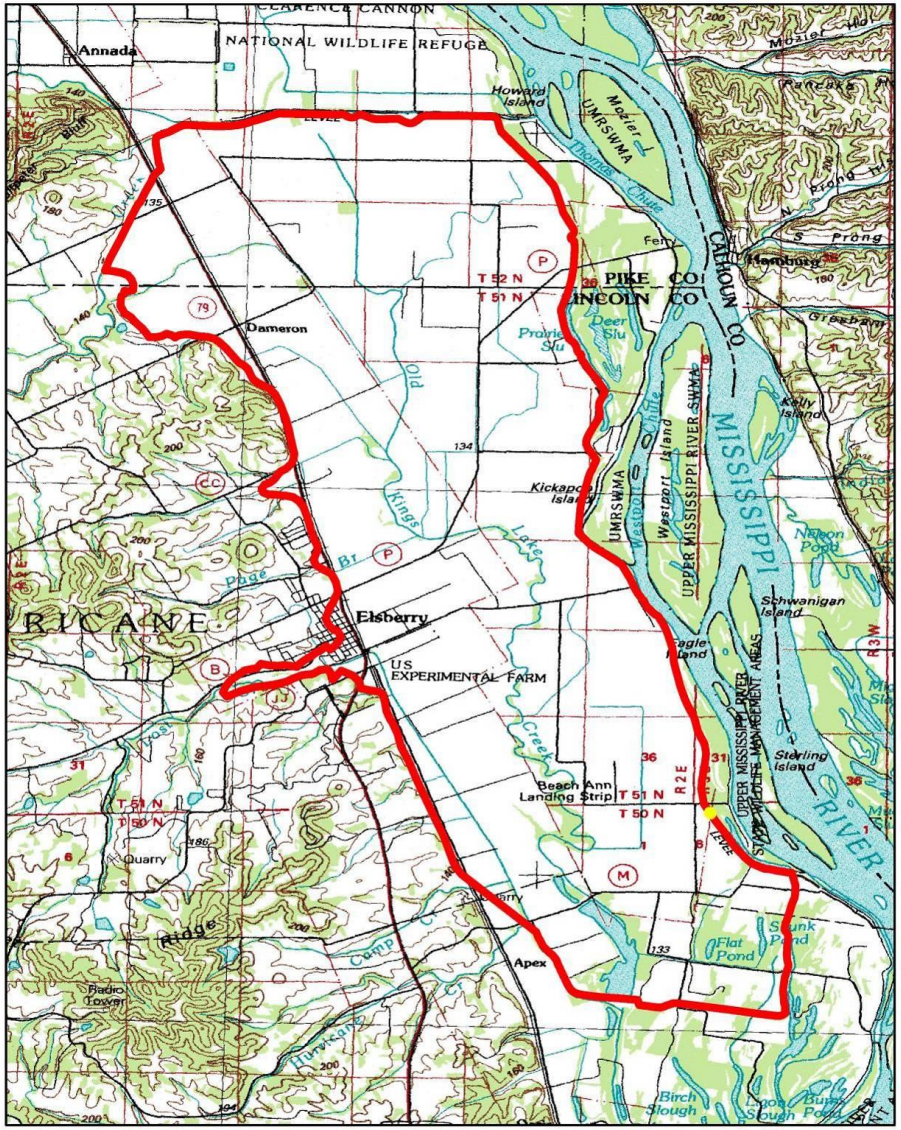
Winfield-Pillsbury breach on June 18th. Note overtopping.

Crossovers

- **Just about every place where a gravel-paved road crossed an agricultural levee, failure ensured by seepage through the gravel, even with sandbagging**



Legend

Elsberry_Breach

Elsberry_Levee

2008 Midwest Levee Investigation - Norton Woods Breach

2,500 1,250 0 2,500 Meters

N W E S

Legend

Elsberry_Breach

Elsberry_Levee

2008 Midwest Levee Investigation - Norton Woods Breach

80 40 0 80 Meters

N W E S

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- **Norton Woods Breach**

- **Norton Woods Breach and scour pool**

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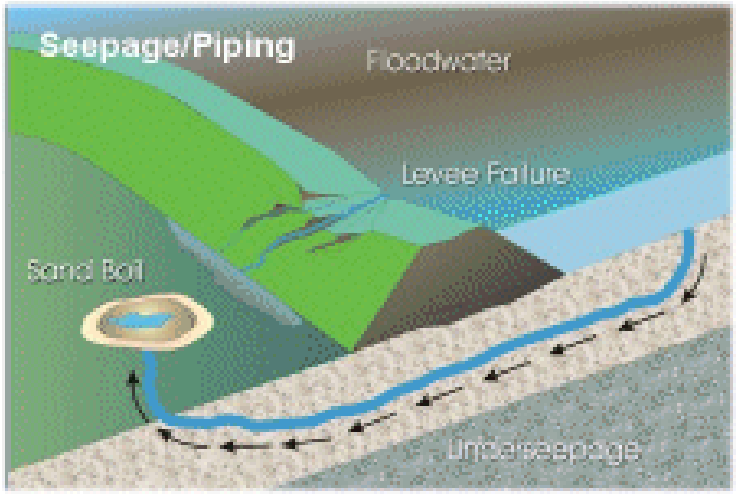
Battling hydraulic piping and seepage boils

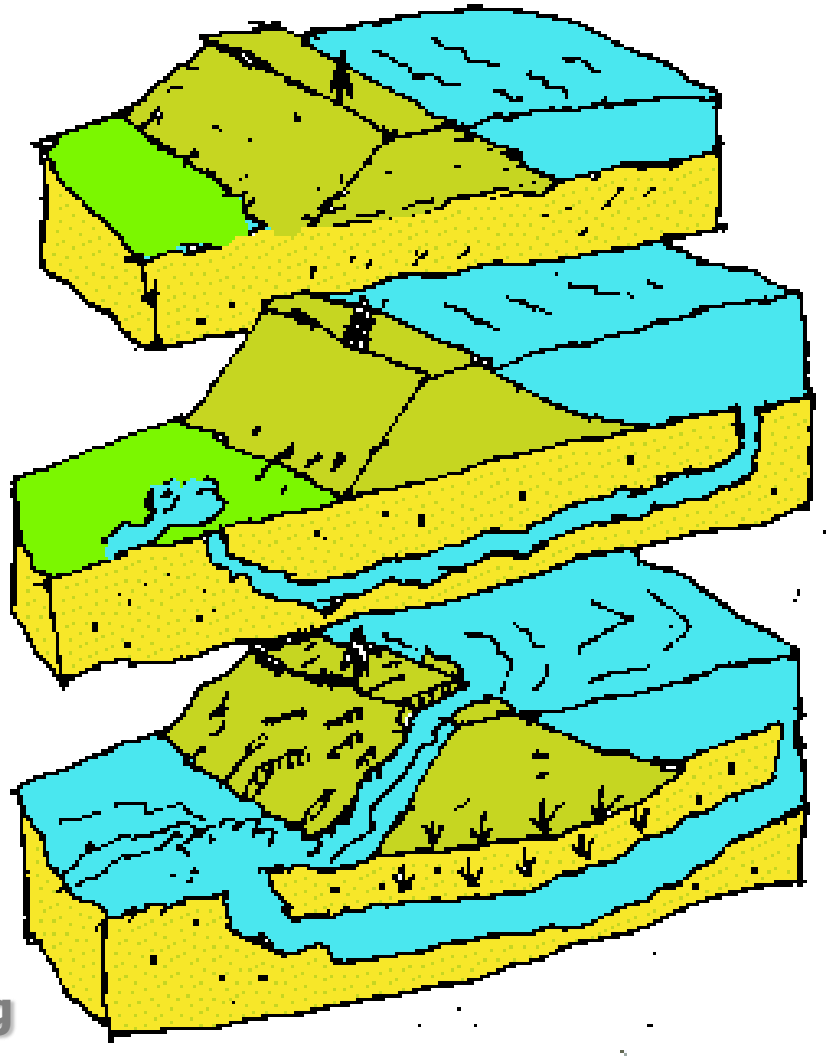
Massive boil

When hydraulic gradients > 1.0, piping of fine grained soils ensues.

The traditional model for piping-induced failure

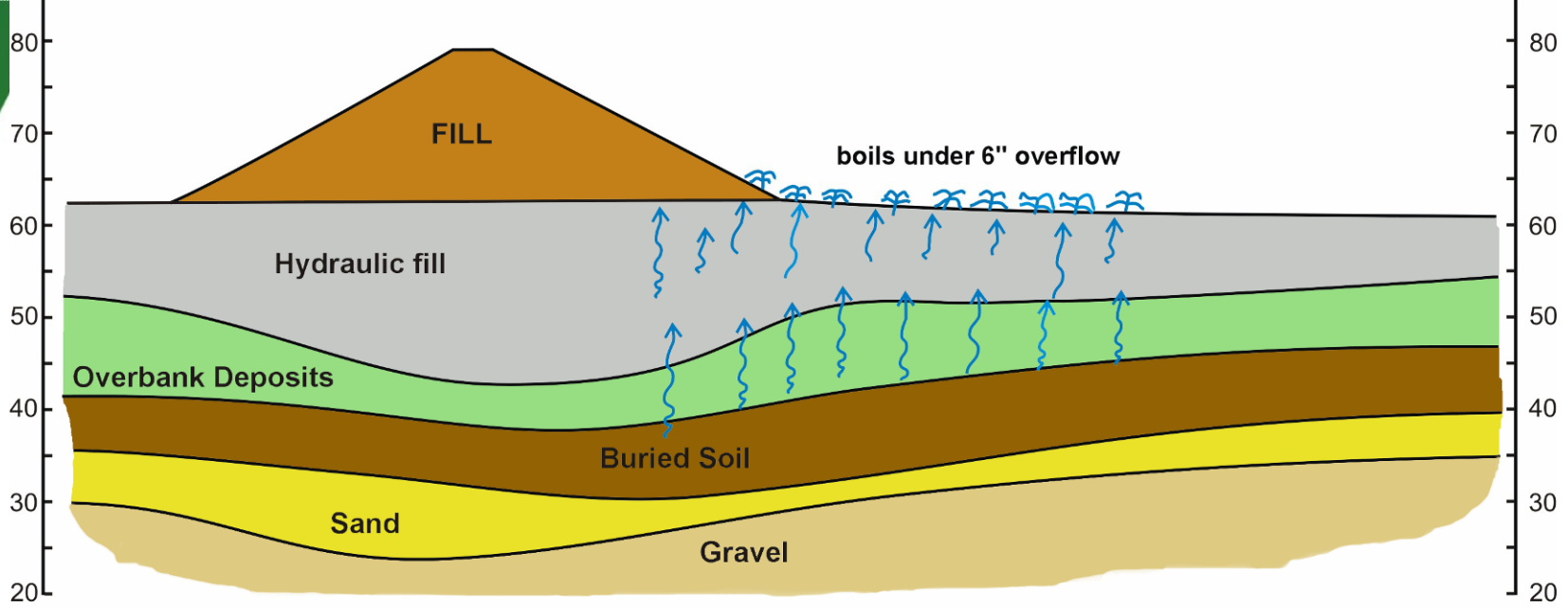


from State of California website in 1997

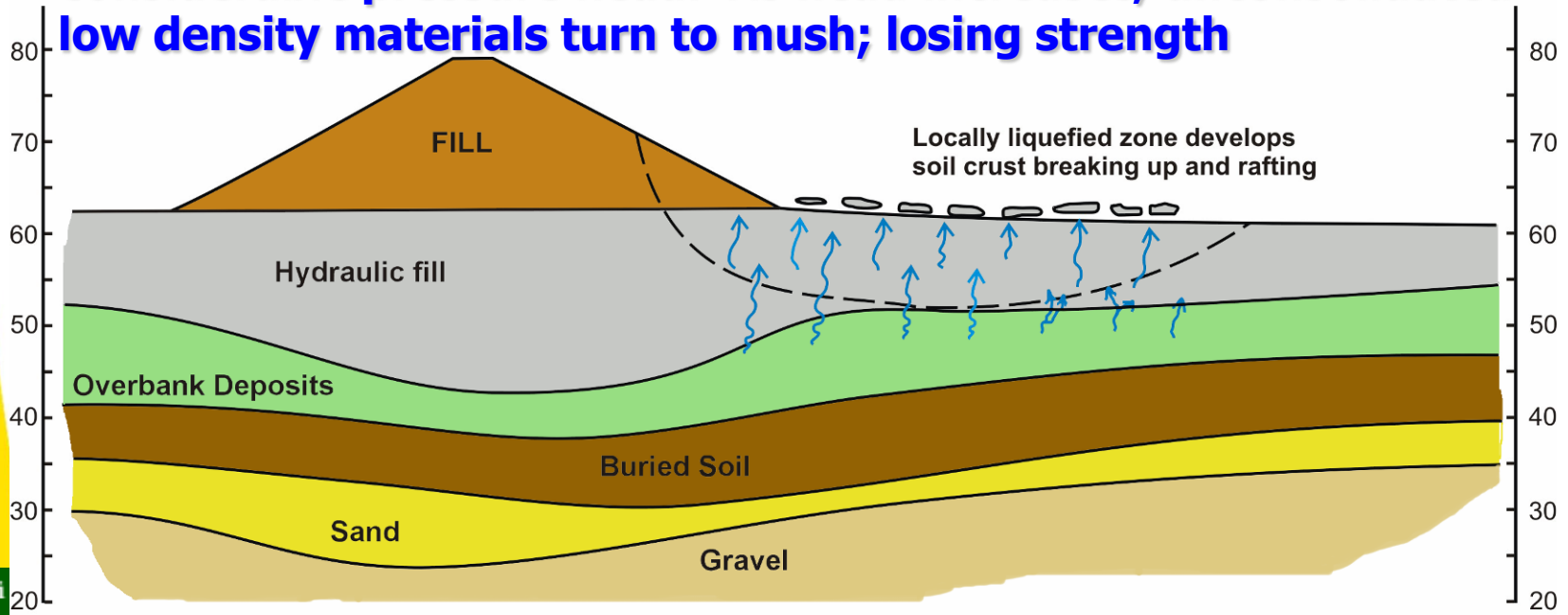


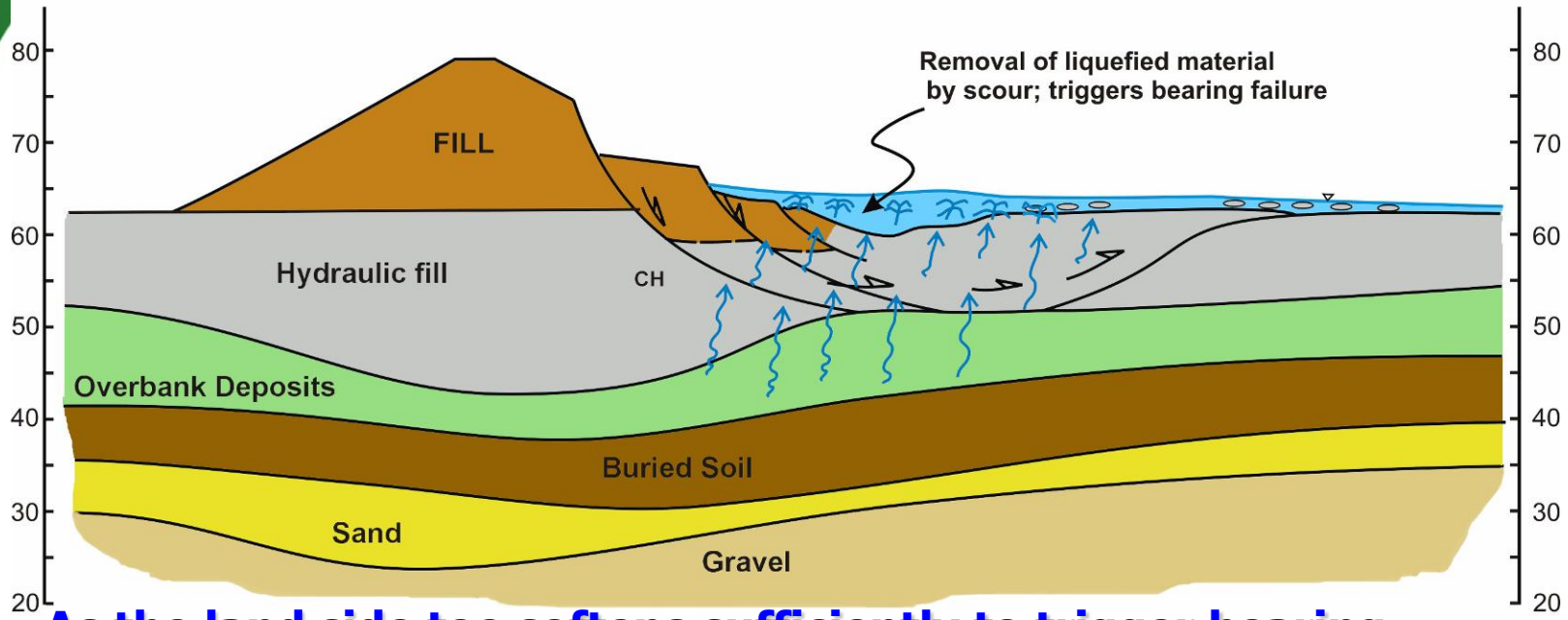
Traditional model for piping

- The traditional model for hydraulic piping envisions a conduit that is progressively eroded and enlarged by turbid seepage. This is a problem for levees founded on porous silts, typical of flood plains.

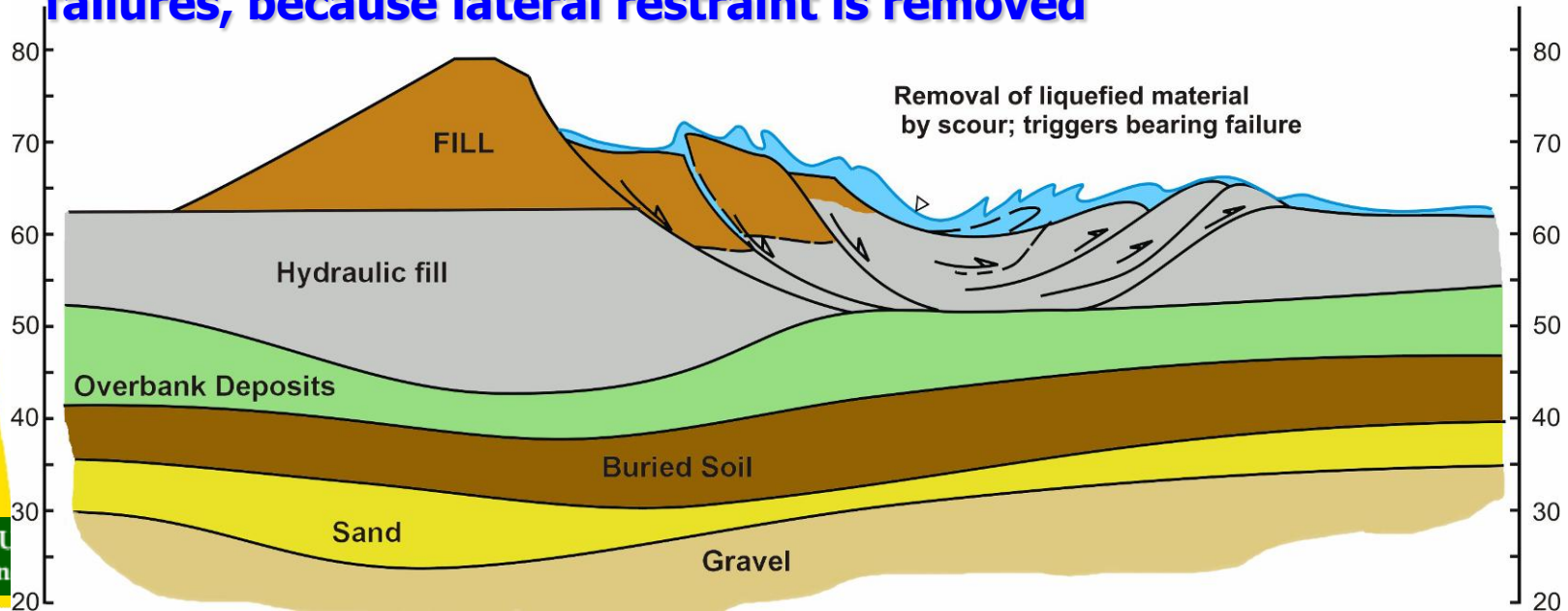


Hydraulic uplift is easily generated from confined aquifers under considerable pressure head. As head increases, unconsolidated low density materials turn to mush; losing strength

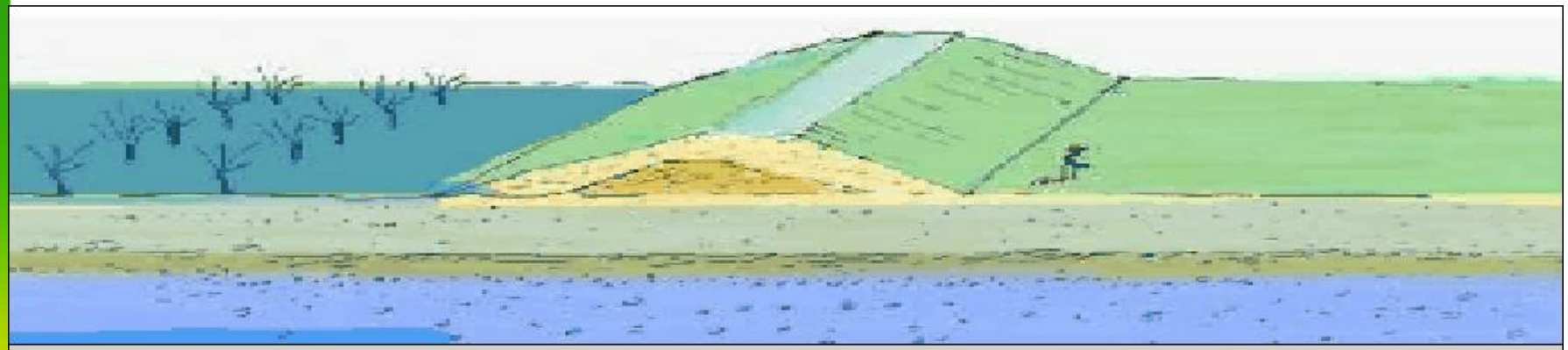




As the land side toe softens sufficiently to trigger bearing capacity failure; this is rapidly followed by retrogressive slope failures, because lateral restraint is removed

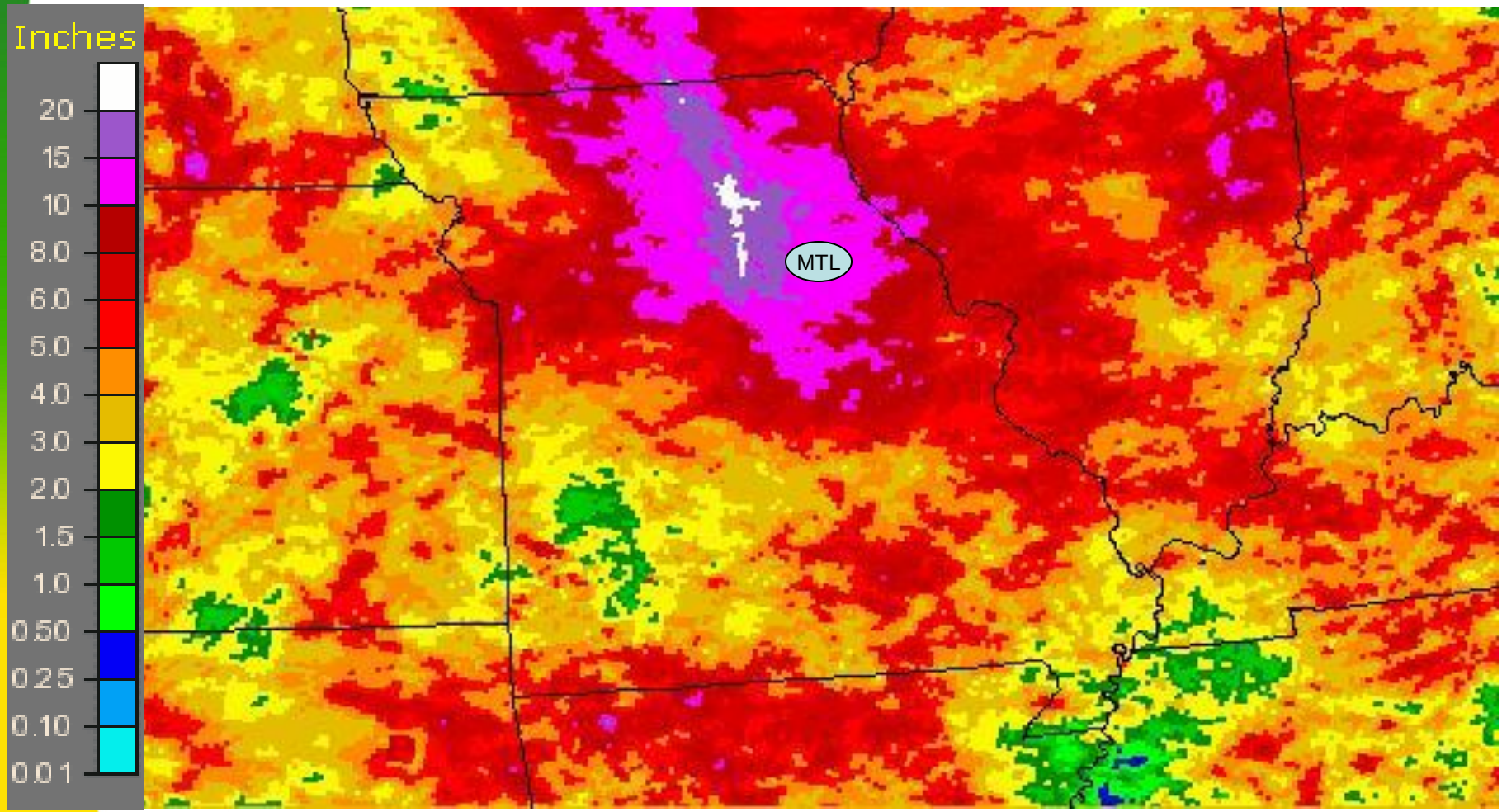


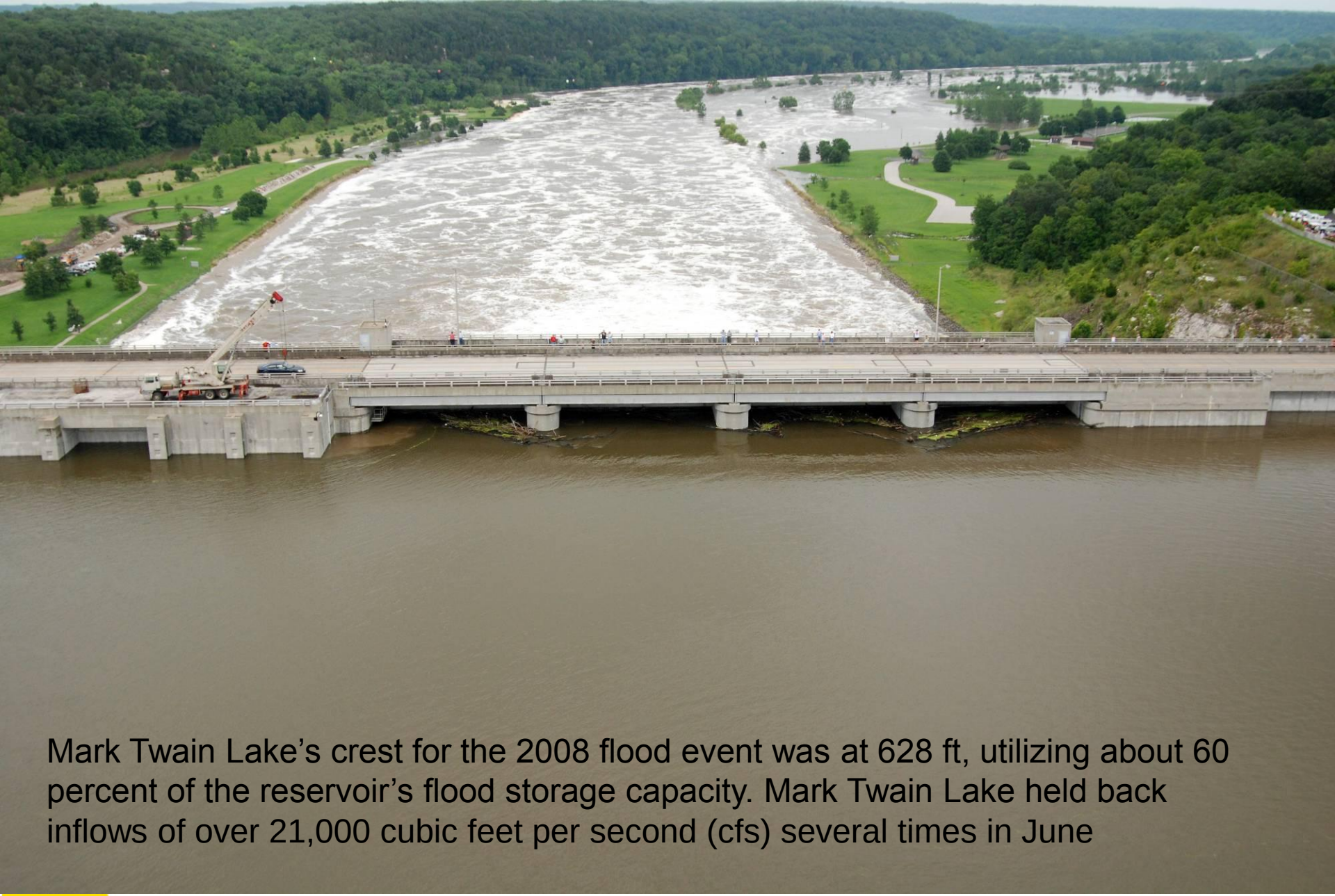
wetting fronts assail an earthen levee simultaneously



The number of wetting fronts depends on the stratigraphy and hydraulic conductitvity [permeability] of the channel deposits beneath the levee

Precipitation in July 2008





Mark Twain Lake's crest for the 2008 flood event was at 628 ft, utilizing about 60 percent of the reservoir's flood storage capacity. Mark Twain Lake held back inflows of over 21,000 cubic feet per second (cfs) several times in June

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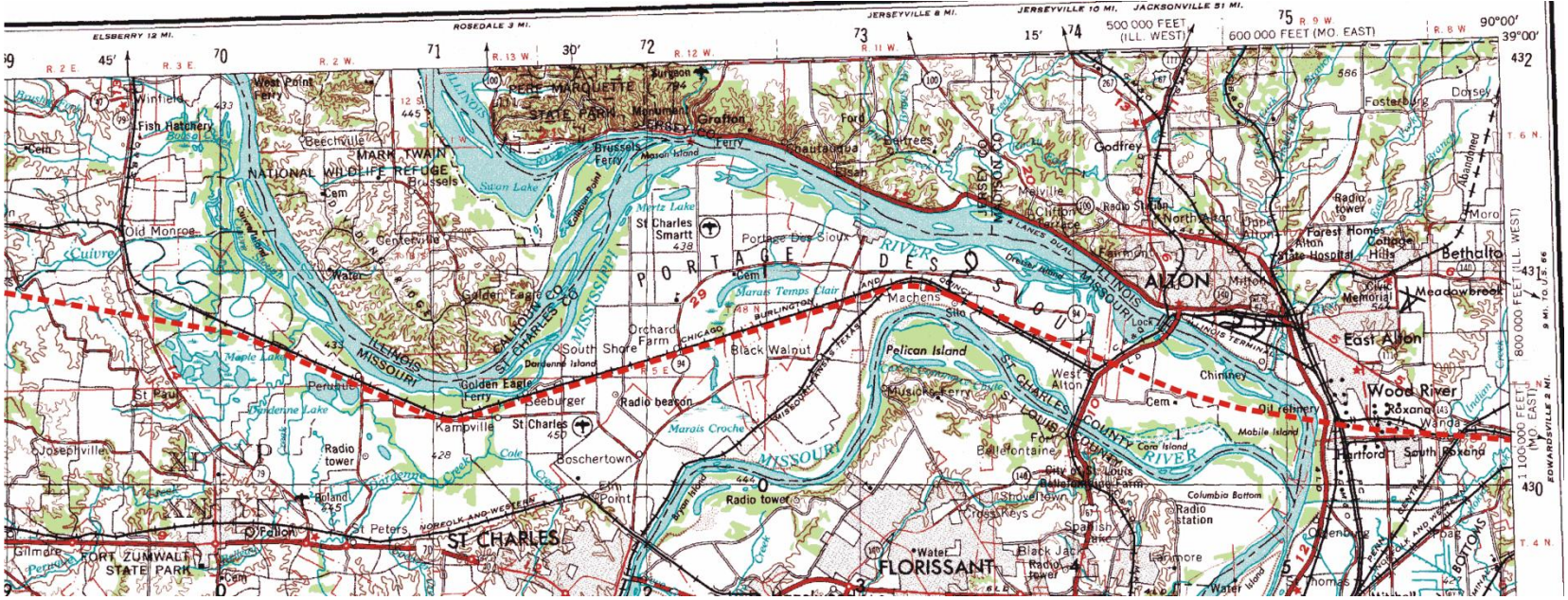
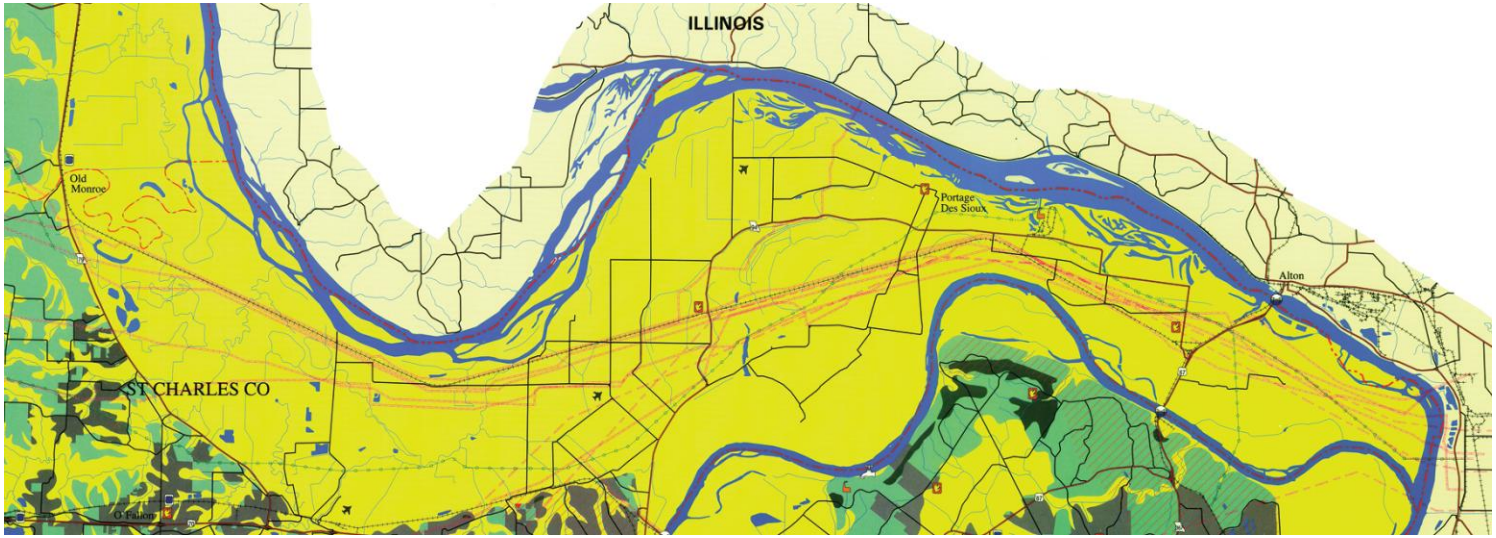
Spilling into Salt Creek at Clarence Cannon Dam

During the height of June's flooding, Mark Twain Lake, in conjunction with Truman Dam and Reservoir (Warsaw, Mo.), contributed to reducing the Mississippi River's stage at St. Louis and points south to Cape Girardeau approximately 3.5 ft.

Map

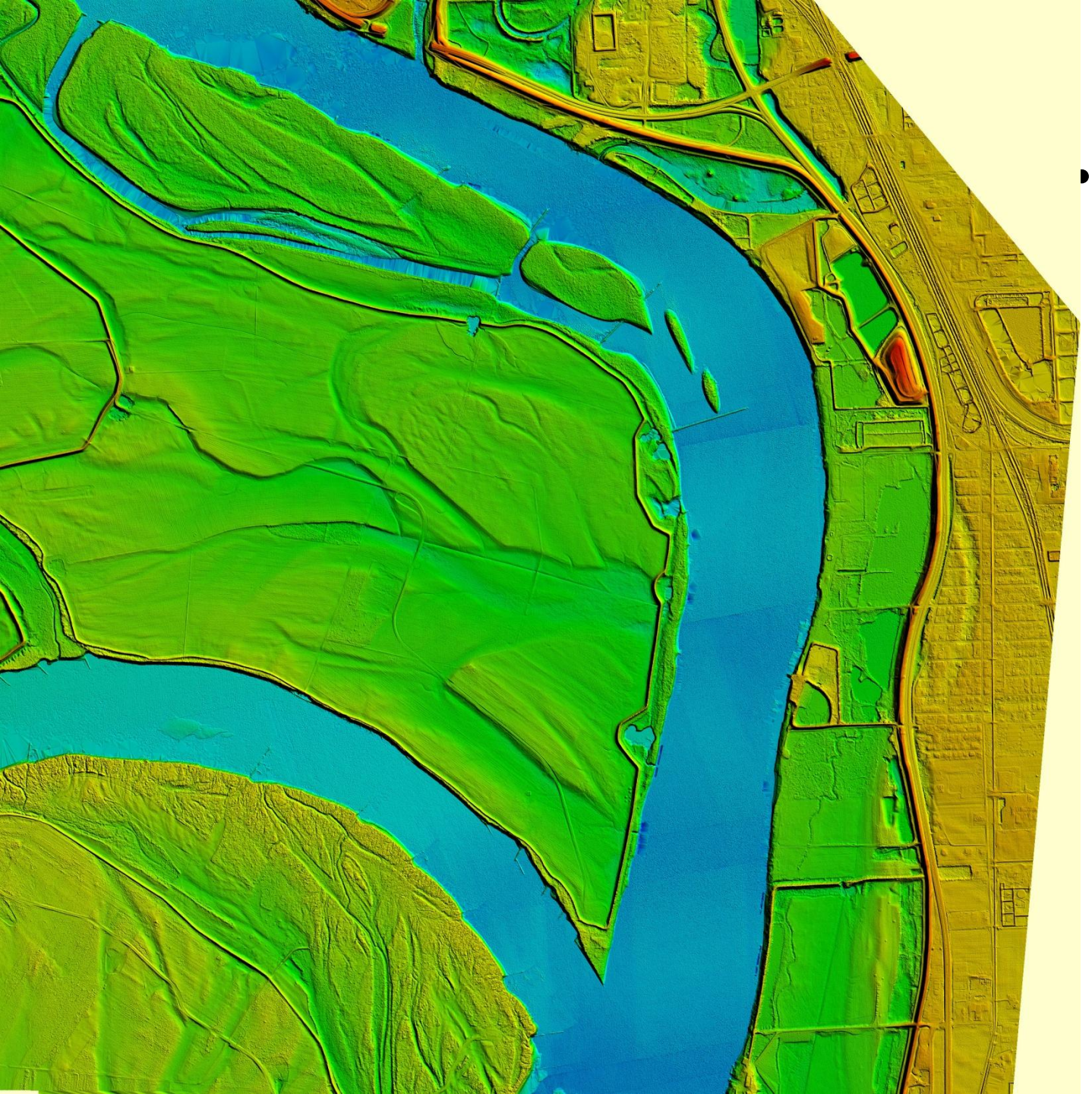




- **Buried pipelines are corridors of potential vulnerability, for floods and earthquakes**

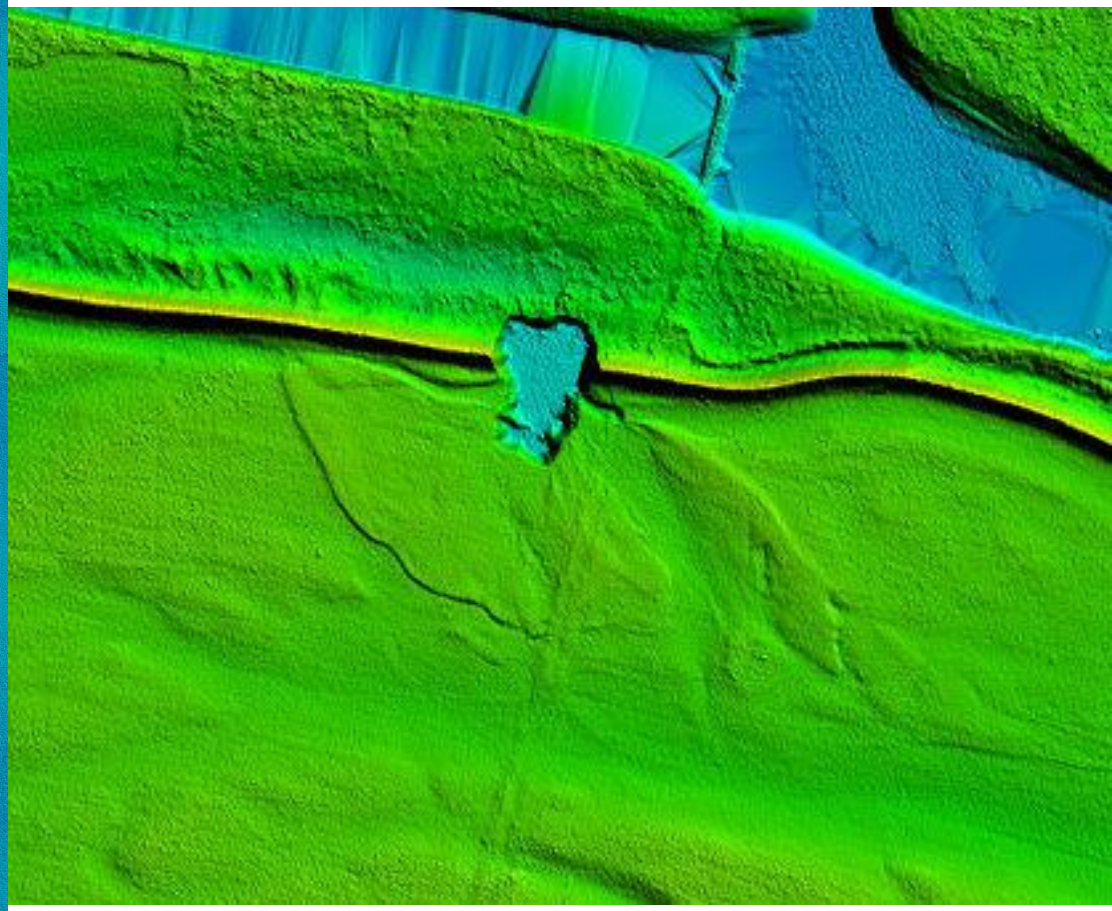
- **Breach near Confluence Point likely influenced by seepage along pipeline trenches. Failures here in 1993 and 2008.**

- **Pipeline breaks in Kuhs Levee District. Note previous repairs, where dike turns in and out**

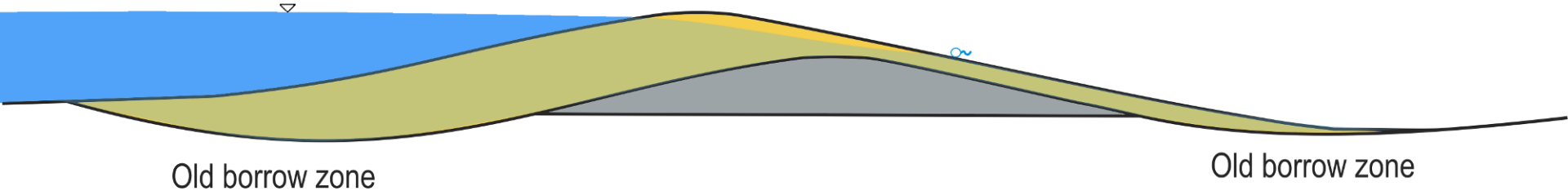


- **LiDAR offers an incredible view of the flood plain topography**

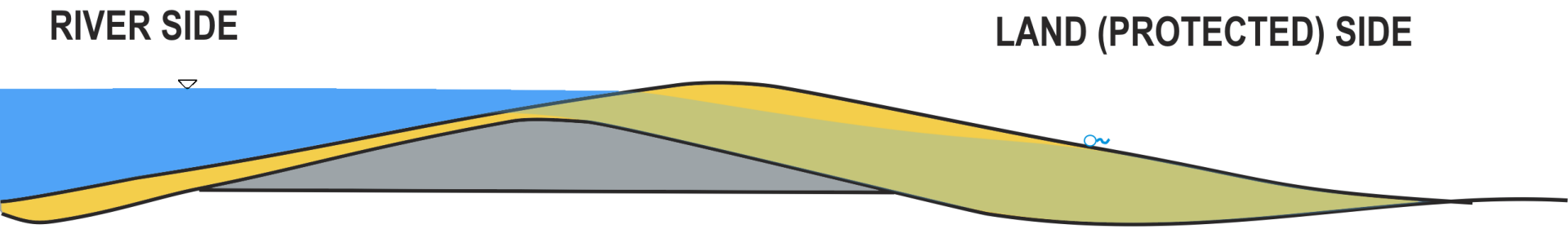
LiDAR images at Kuhs District



TYPICAL EARTH CORE - SAND FILL LEVEE
WITH CENTRIC CORE & 5:1 SIDE SLOPES



TYPICAL EARTH CORE - SAND FILL LEVEE
WITH RIVER SIDE CORE & 5:1 SIDE SLOPES

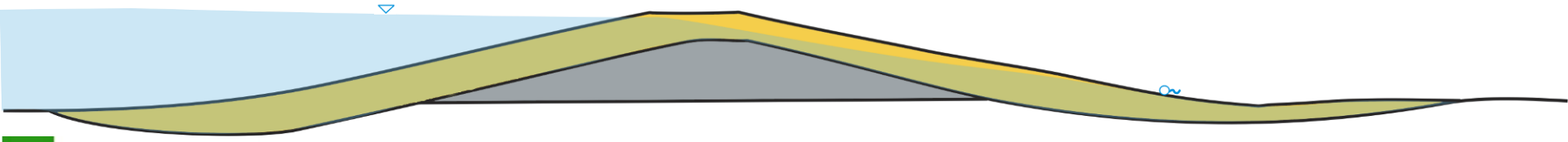


- **After the Spring 1965 floods the Rock Island District began employing sand fill shells over the pre-existing earthen agricultural levees**

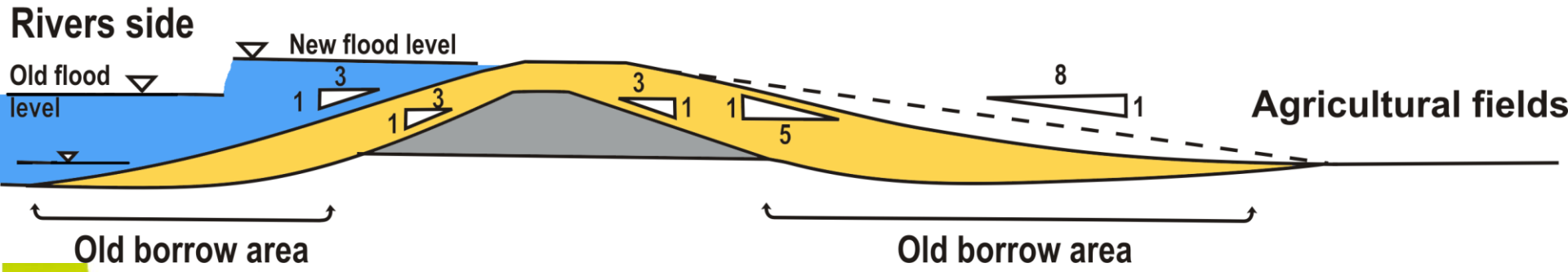
Sand Shell Levees

- Sand shells provided an additional 5 ft
- Push-ups added another 5 ft

TYPICAL EARTH CORE - SAND FILL LEVEE WITH CENTRIC CORE & 5:1 SIDE SLOPES

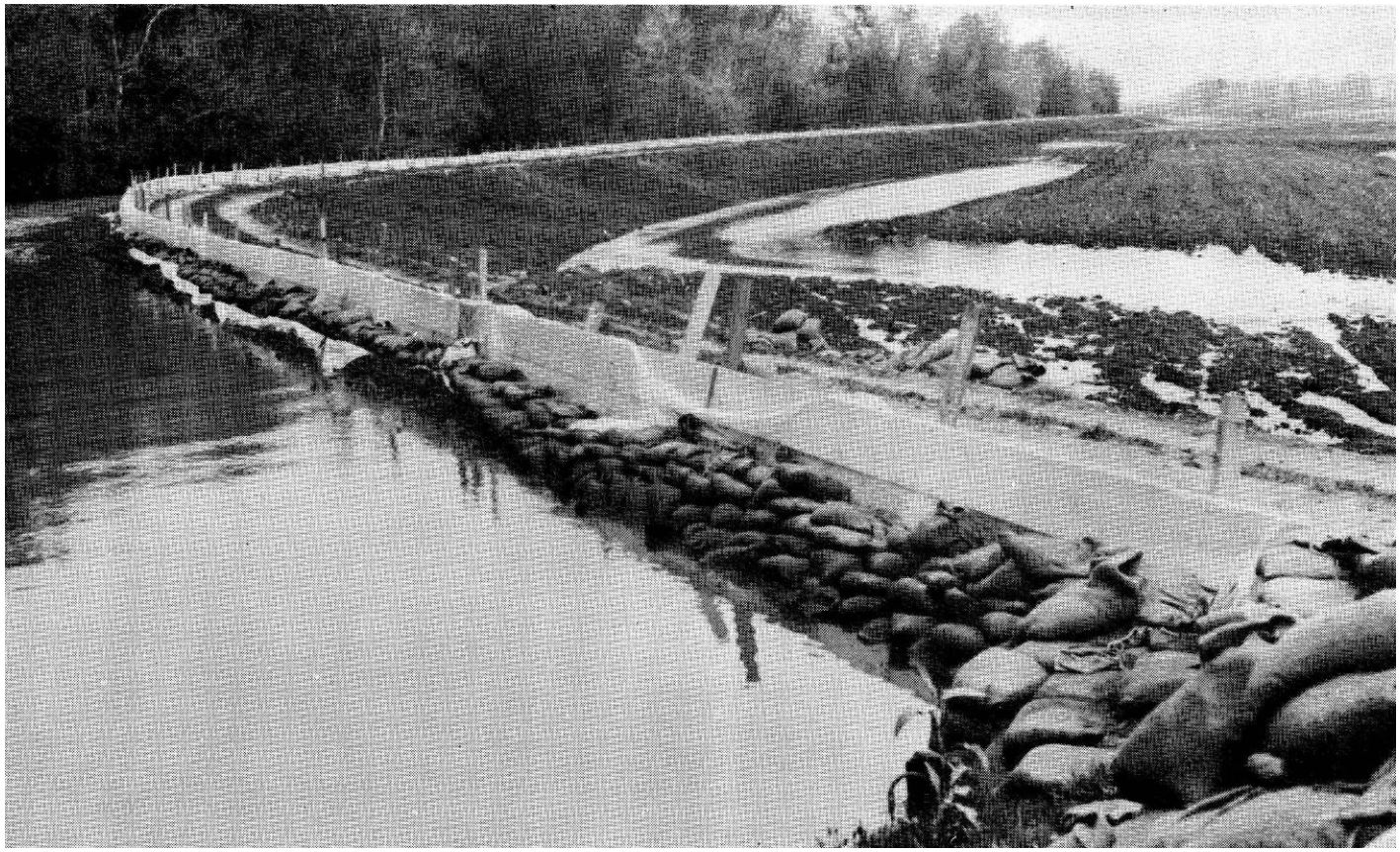


Typical Clay Core Sand Shell Levee



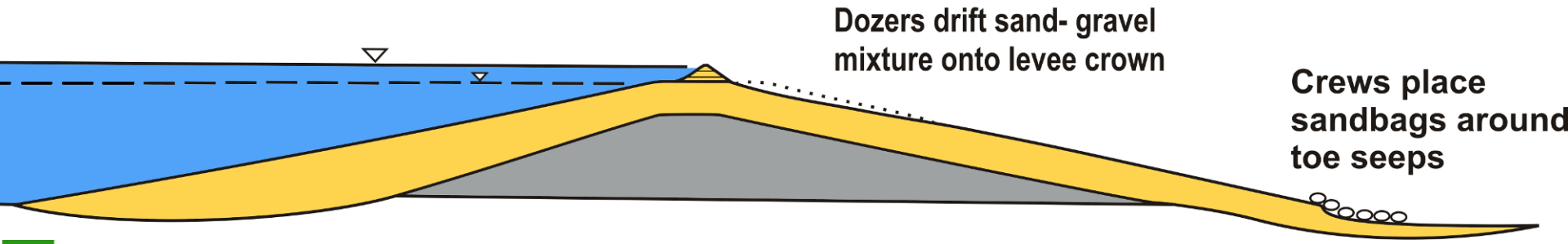
- The sand fill came from dredging of the navigation channel, using the districts O&M budget. This allowed levees to be heightened substantially with little capital outlay, as compared to conventional earthwork

Flash Boards

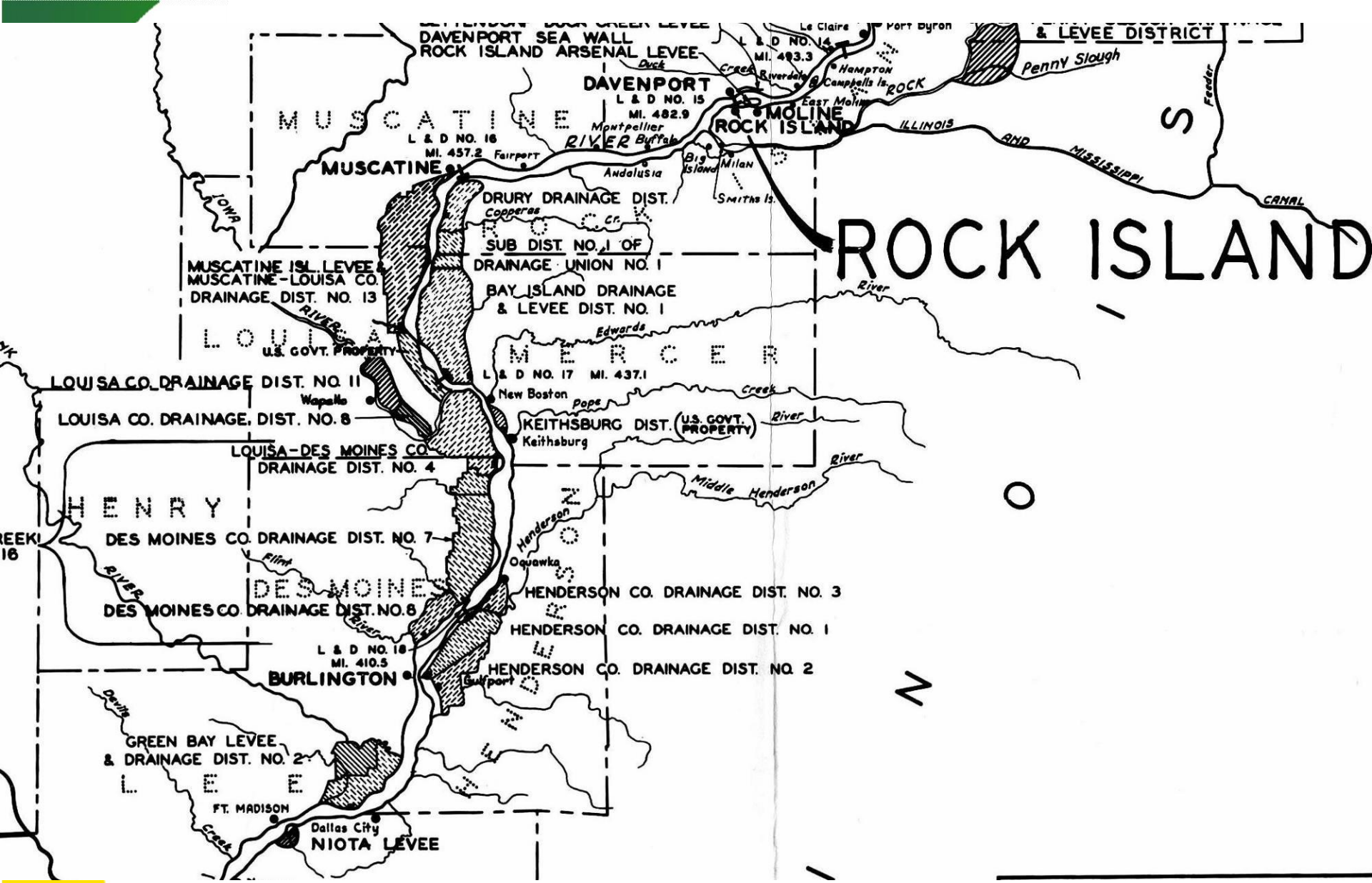


- **Prior to 1993 timber flash boards with plastic sheeting and sandbags were used to heighten levees during flooding**

Increased Flood Storage Using “Push-Ups”



- **After the 1993 floods the Rock Island District began using dozed sand “push-ups” instead of flash boards**



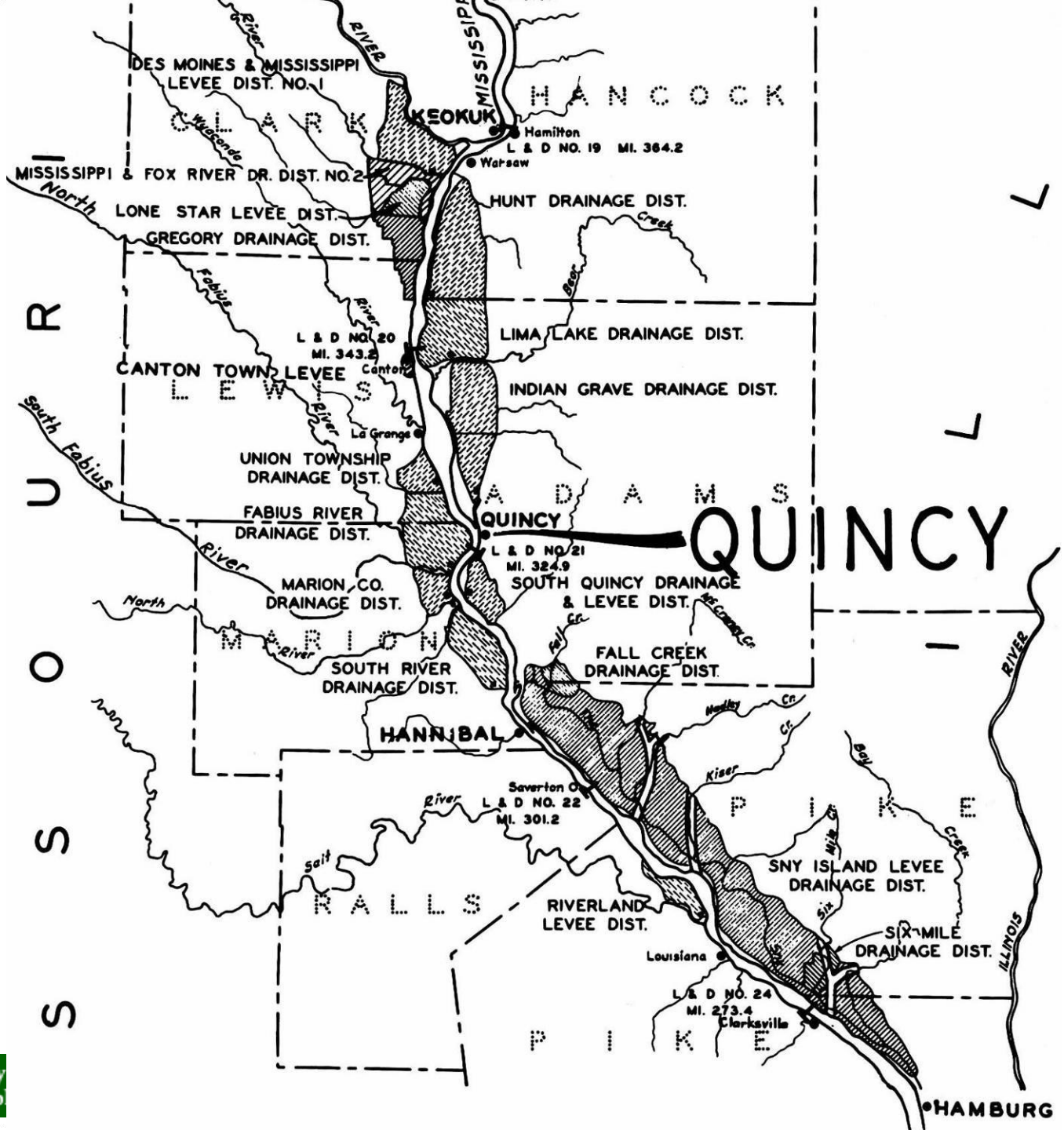
- **The breach along the southern bank of the lower Iowa River in the Two Rivers area southeast of Wapello, IA was one mile long. This break was a result of another break about 10 miles upstream, where US Hwy 61 crosses the river, which bifurcated the maximum flow, which re-joined at this location.**

- **View looking westerly, down the former axis of the right bank levee of the Iowa River, in the Two Rivers Levee & Drainage Association. This was the worst levee breach that occurred in the 2008 Midwest floods.**

Scour holes in a shale foundation testified to a large volume of water sweeping through, leaving almost no trace of the levee behind

Two Rivers Blow-out

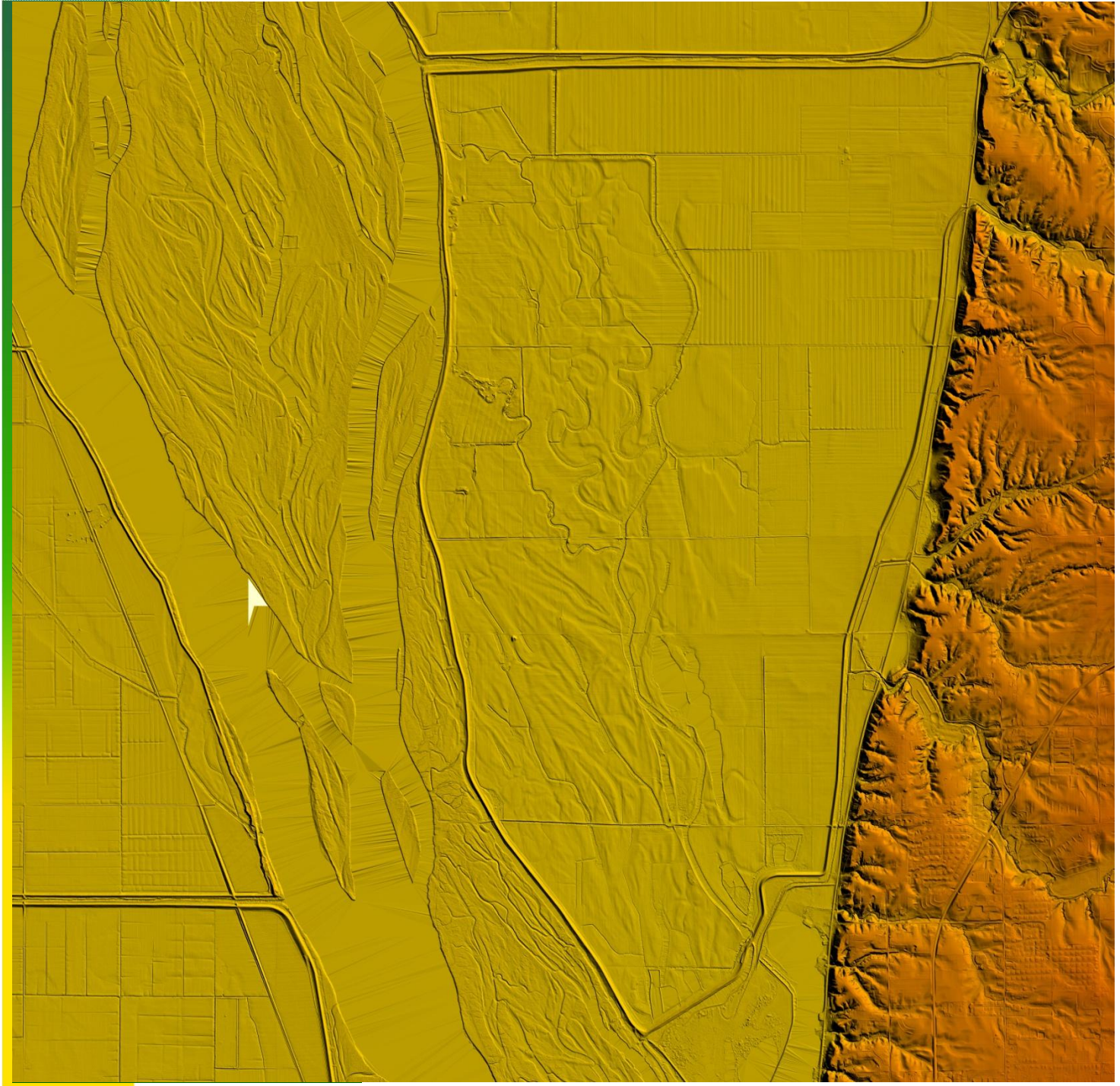
- **Sand push-ups were used to raise the Iowa River dike about 3 feet.**



- **FEMA pays fro the sand push-ups, but does not pay to have them removed after flooding subsides. This cost is born by local levee districts**

- **1300 ft wide breach at Indian Grave, near Quincy, IL. Failures have occurred here in 1947, 1965, 1993, and 2008. Four floods in 61 years is once every ~15 yrs. These agricultural levees are rated by the Corps of Engineers as 14-yr flood protection structures.**

- **Ripple marks in aggraded sands at Indian Graves. Sand blanket up to 6 ft thick**



Setback protective levees needed, beyond the prominent channel networks.
Training levees, fitted with control structures, can remain closer to the main channel.
Consider returning about 25% of the river's floodplain back to flood storage

With Much Appreciation

- National Science Foundation Engineering Directorate-CMMI Division
- U.S. Army Corps of Engineers, St Louis and Rock Island Districts, who provided images, maps, and historical background
- USGS-WRD and NWS for flow data
- Local levee and drainage districts
- University of California, Berkeley geotechnical disaster reconnaissance team
- Texas A&M University Geotechnical Engineering Program
- Prof Robert Criss at Washington University
- Dr. Greg Hempen PE, RG of URS Consultants

This lecture will be posted at

www.mst.edu/~rogersda/levees

in .pdf format for easy downloading and use by others.

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