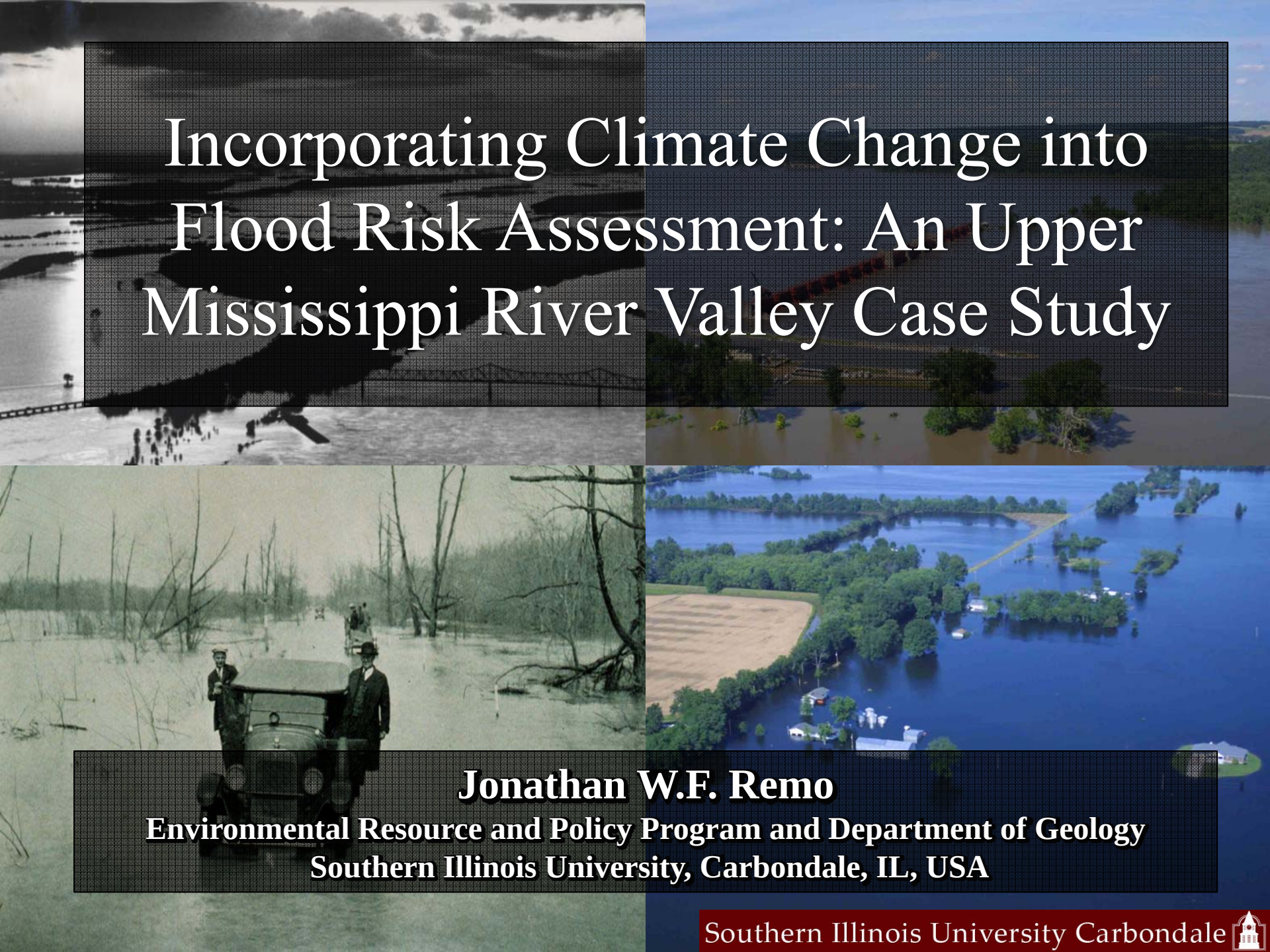

Incorporating Climate Change into Flood Risk Assessment: An Upper Mississippi River Valley Case Study

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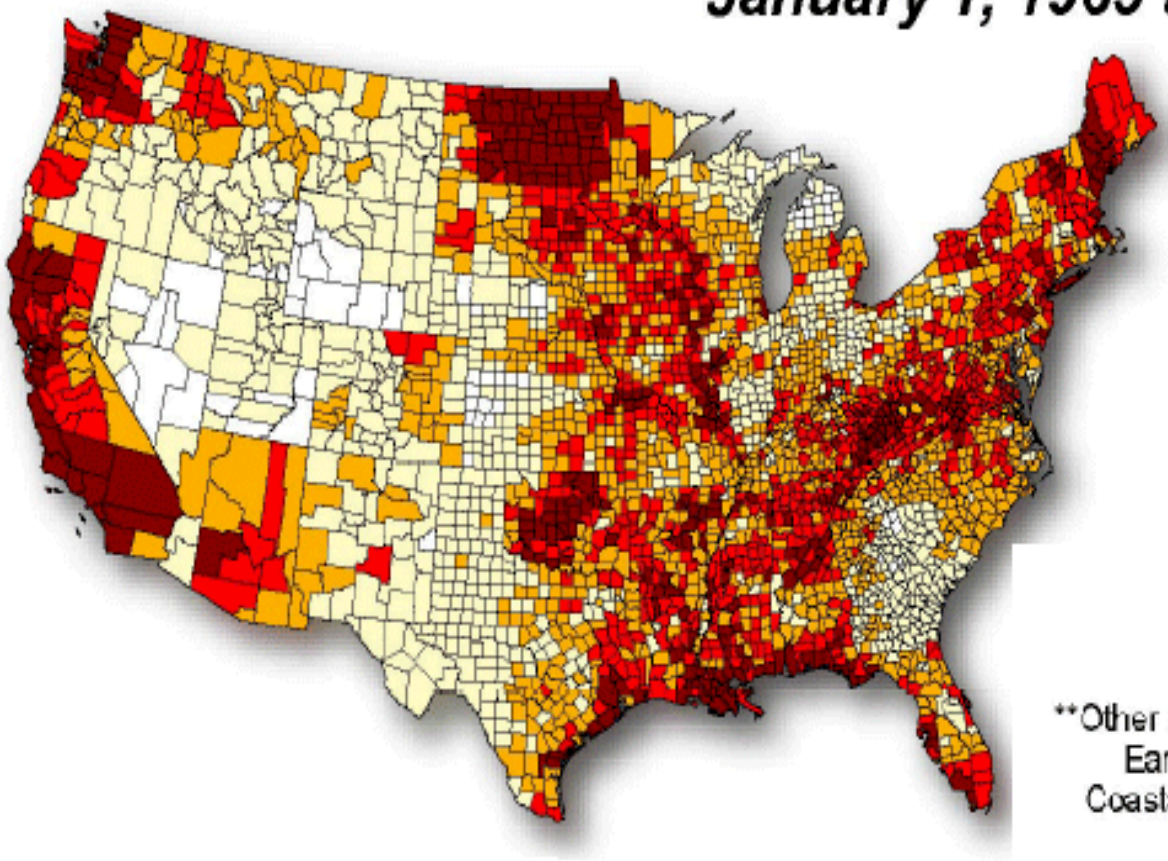
Southern Illinois University Carbondale

Presidential Disaster Declarations

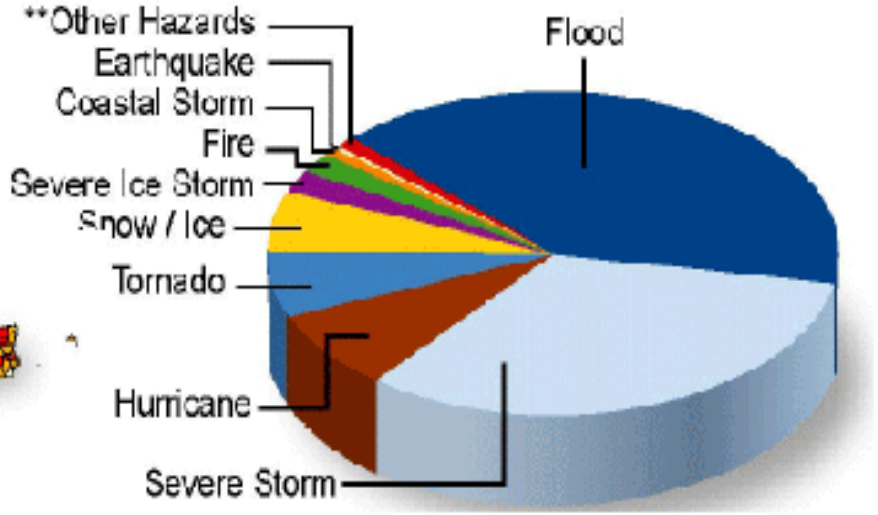
January 1, 1965 to June 1, 2003



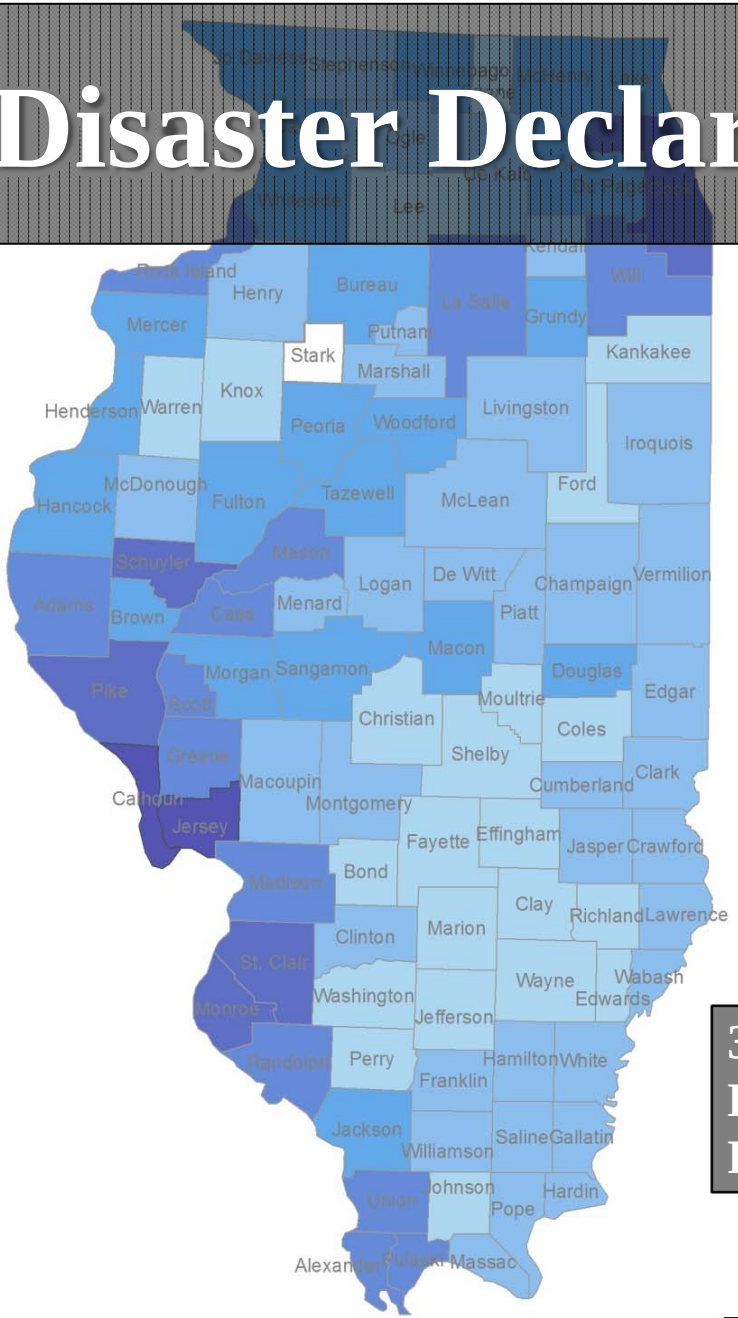
Declarations By County

- 10 - 22
- 7 - 9
- 4 - 6
- 1 - 3
- 0

Disasters By Type



FEMA Disaster Declarations



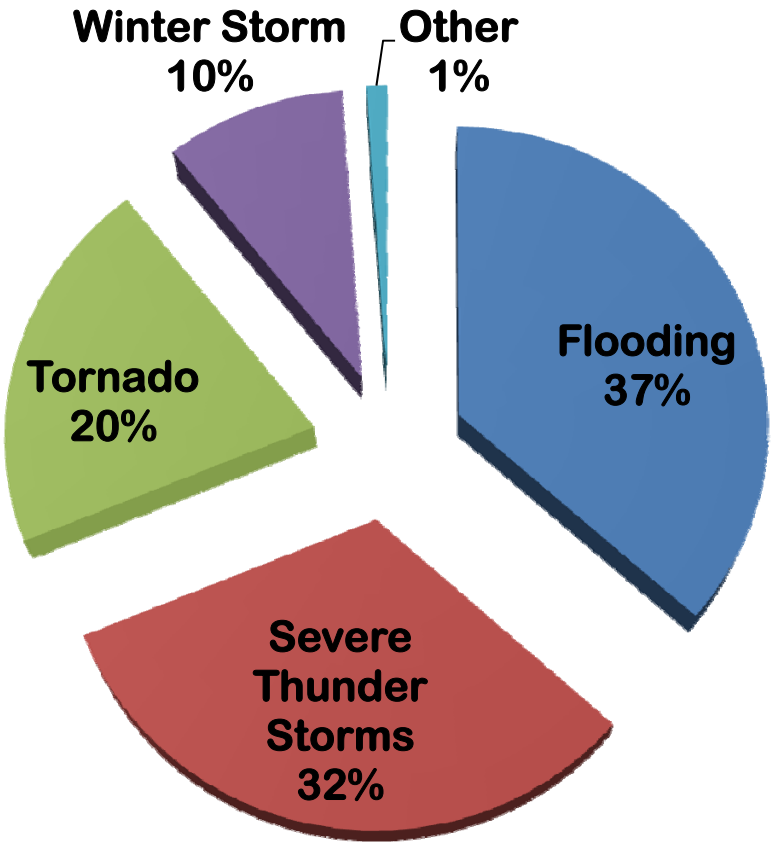
Legend
County of FEMA Declared Disasters by County 1965 - 2009

- 0
- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15
- 16 - 17

34 Presidential Disaster Declarations
RI of 1.2 Years

Southern Illinois University Carbondale

Type of Disaster Declarations: 1965-2008



Factors Affecting Flooding

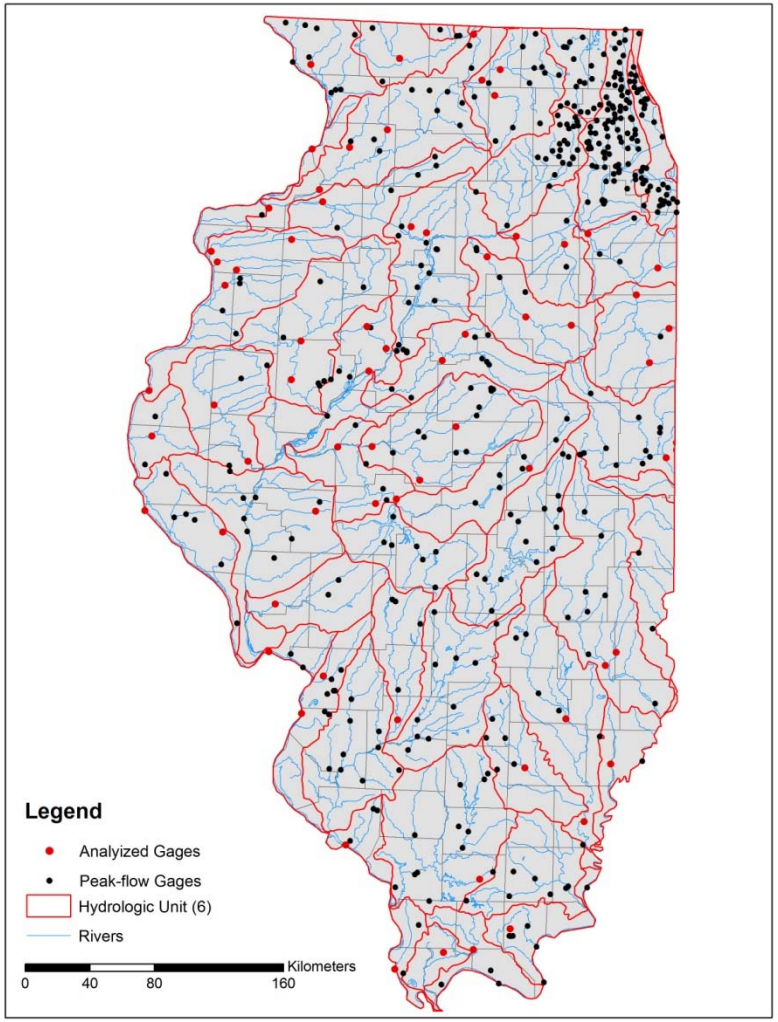
CONTROLS ON

FLOOD MAGNITUDE

UPSTREAM FACTORS:

- Climate
- Land use
- Reservoir impoundment
- Wetlands

Historic Changes in Discharge



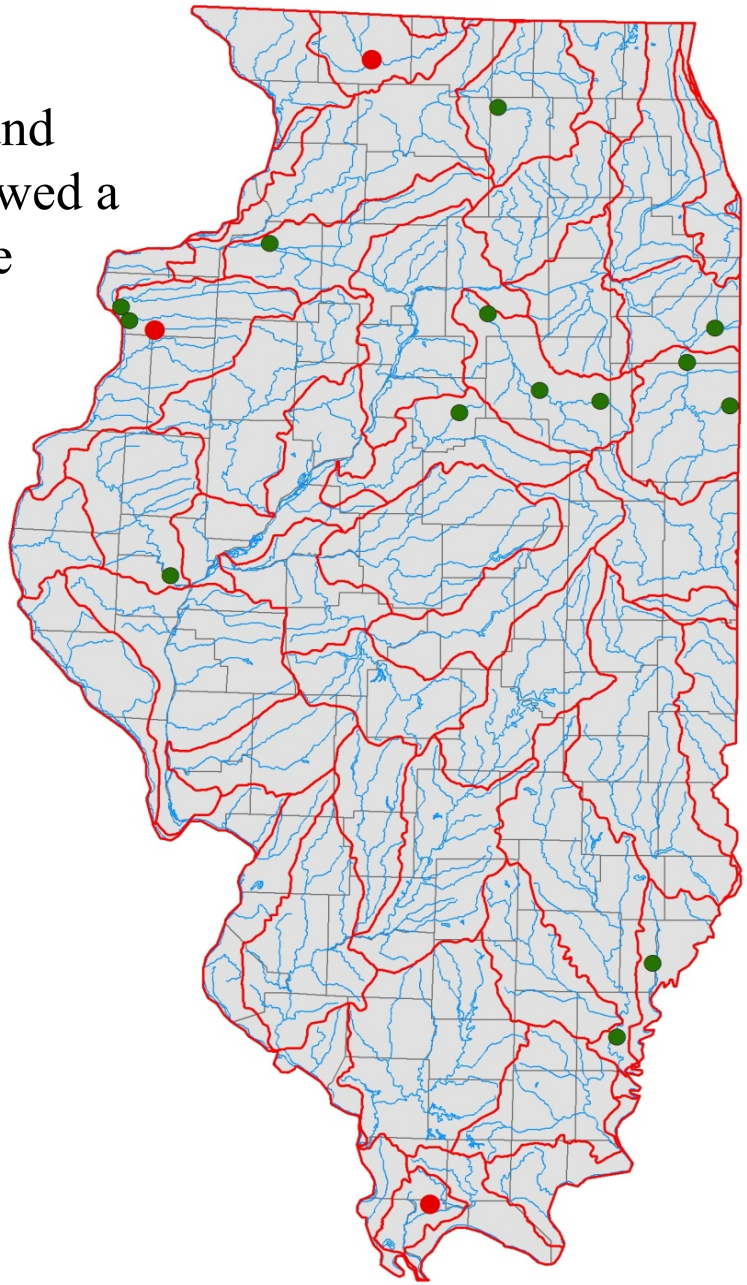
Knapp and Markus, 2003

(Illinois Water Survey)

- 484 gages with peak flow data in Illinois.
- 83 active gages with records >50 years.
- 30 no human impact.
- 53 have minimal human impact.
- Analyzed 61 Gages using Kendall Tau-β Trend Analysis for average and peak discharges.

Results:

- Knapp and Markus, 2003 found 16 of the 61 gages (25%) showed a statistically significant change in peak flows.



Big Creek


Jan 22, 2008
N
Image © 2010 DigitalGlobe
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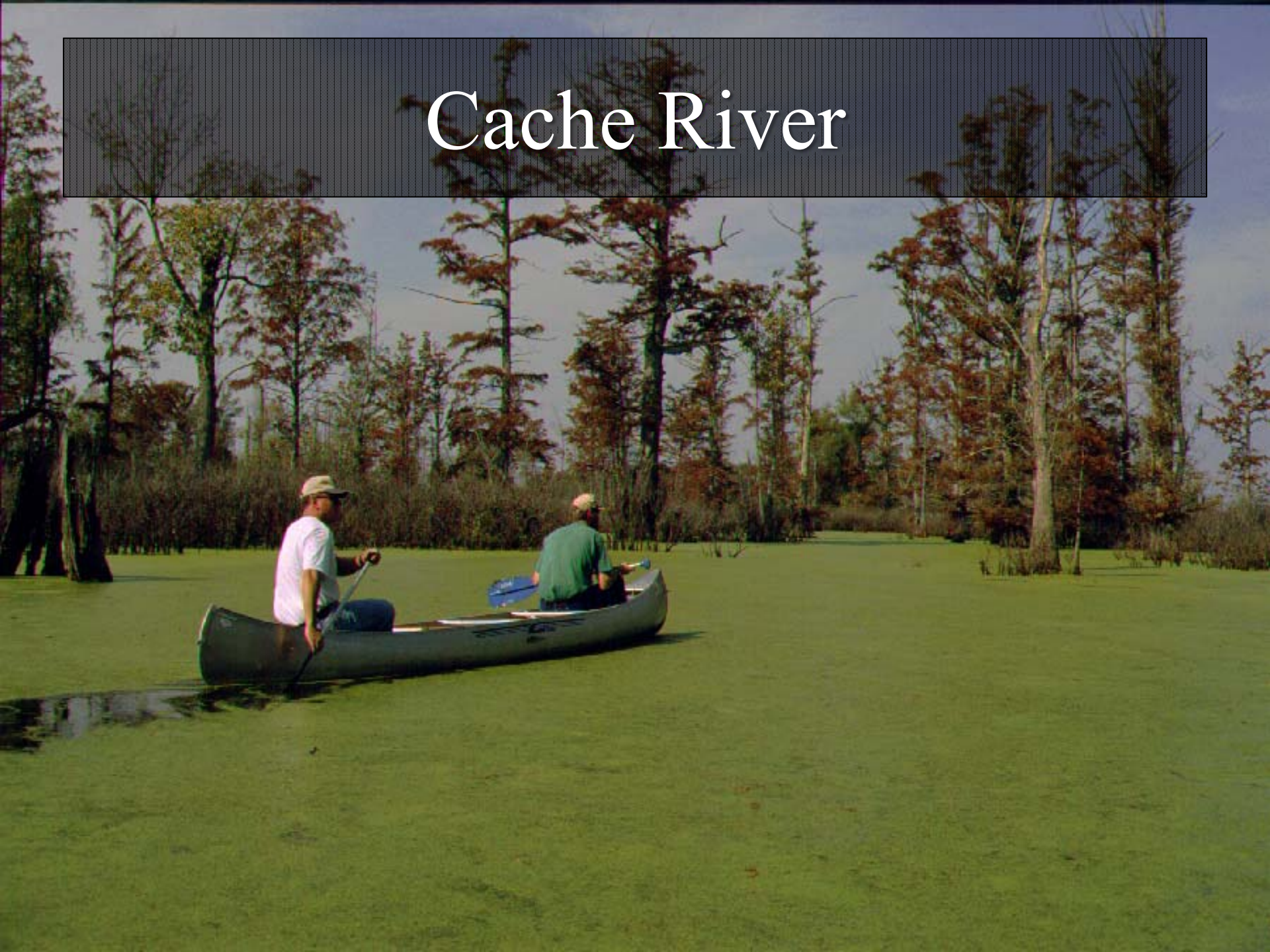
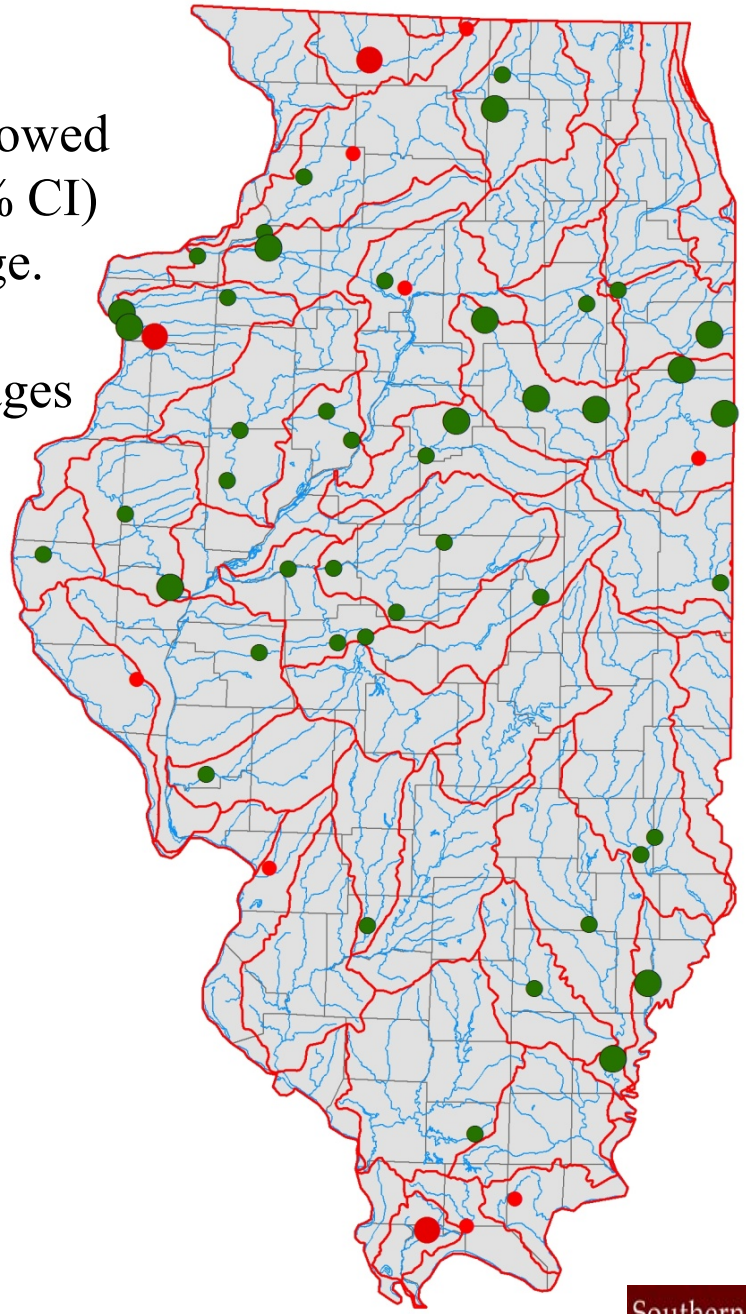
Cache River



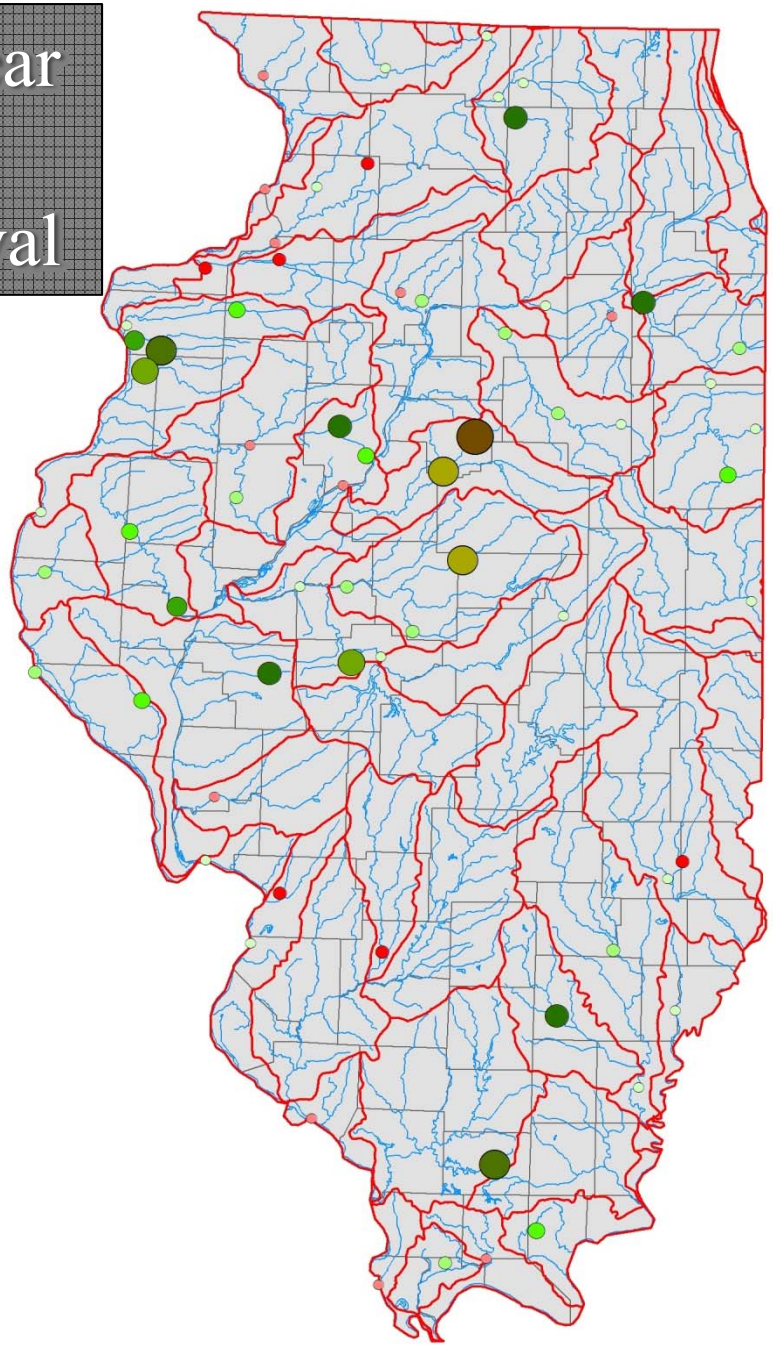
Results:

- ~50% of analyzed gages showed statistically significant (95% CI) increase in average discharge.

- 50 out of the 61 analyzed gages showed increase in peak discharges.



Change in 100-year Discharge Recurrence Interval



Legend

Precent Change in 100 Year Flood Recurrence Interval

- -20.0 - -10.0
- -10.0 - 0.0
- 0.0 - 10.0
- 10.0 - 20.0
- 20.0 - 30.0
- 30.0 - 40.0
- 40.0 - 50.0
- 50.0 - 60.0
- 60.0 - 70.0
- 70.0 - 80.0
- 80.0 - 90.0
- 90.0 - 100.0

Hydrologic Unit (6)

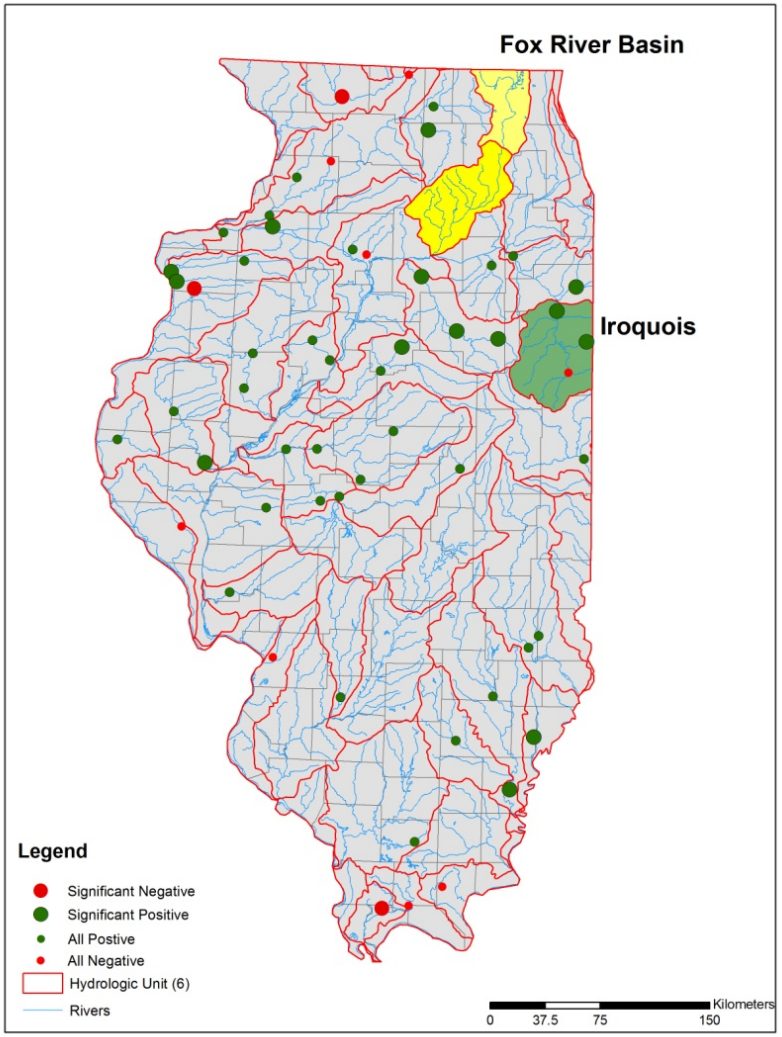
Rivers

- 61 Station From Knapp and Markus, 2003 plus 7 Mississippi River and 3 Illinois River Gages
- Between late the 1970s and circa 2000
  - 44 stations increase
  - 17 stations decrease
- Average change 15%
- Average increase in 100-year discharge 23%
- Average decrease in 100-year discharge 7%

Kilometers

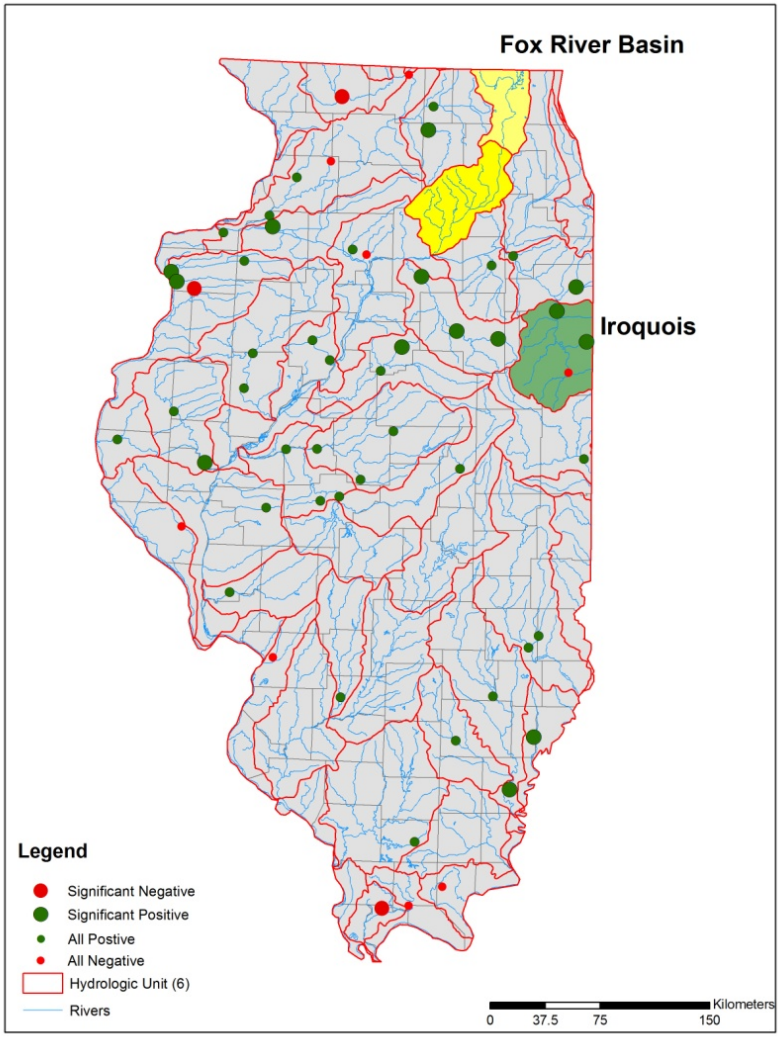
0 40 80 160

Previous Hydrologic Modeling of Climate Scenarios in Illinois



- Knapp et al., 2004 evaluated the response to stream flow to two climate scenarios for the Fox and Iroquois Basins.
- Climate Models
  - Japan model dry
  - Hadley model wet
- Hydrologic Model
  - Iroquois Basin - SWAT
  - Fox River Forecast Model

Previous Hydrologic Modeling of Climate Scenarios in Illinois



	Present	Wet 2050	Wet 2100
Fox River Basin			
Max Daily Flow (cfs)	6,825	6,307	6,551
% Change	-	-8%	-4%
Iroquois River			
Max Daily Flow (cfs)	27,569	28,452	29,758
% Change	-	3%	8%

Project Overview

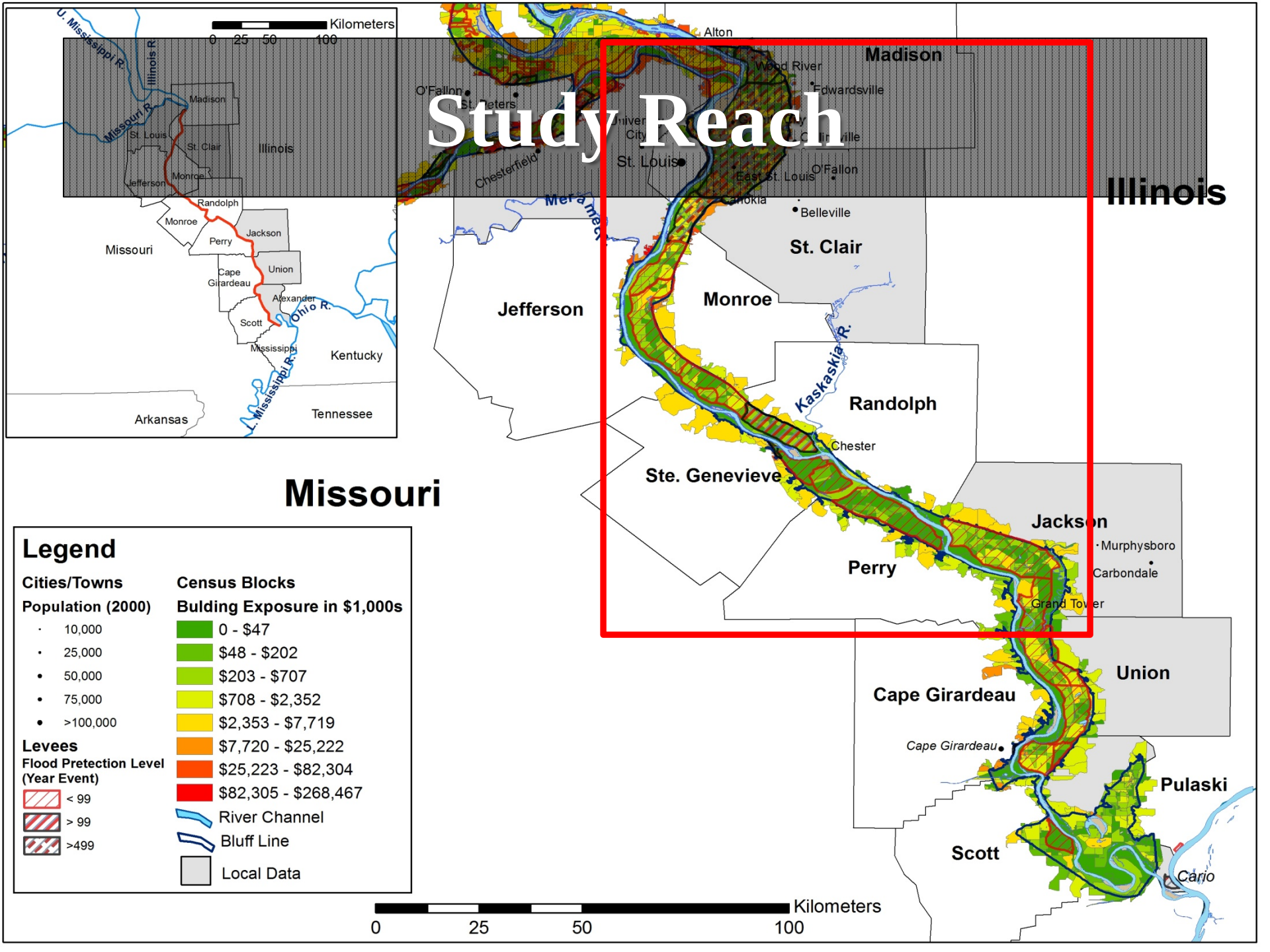
- Purpose: Develop a framework from which to incorporate climate change projections into flood risk assessment.
  - Implement downscaled and bias corrected projections of future climate change (temperature and precipitation to drive large-scale hydrologic model.
  - Use hydrologic model, Variable Infiltration Capacity Model (VIC), to estimate daily discharges in order to establish new flood recurrence intervals (i.e., 100-year event).

Project Overview

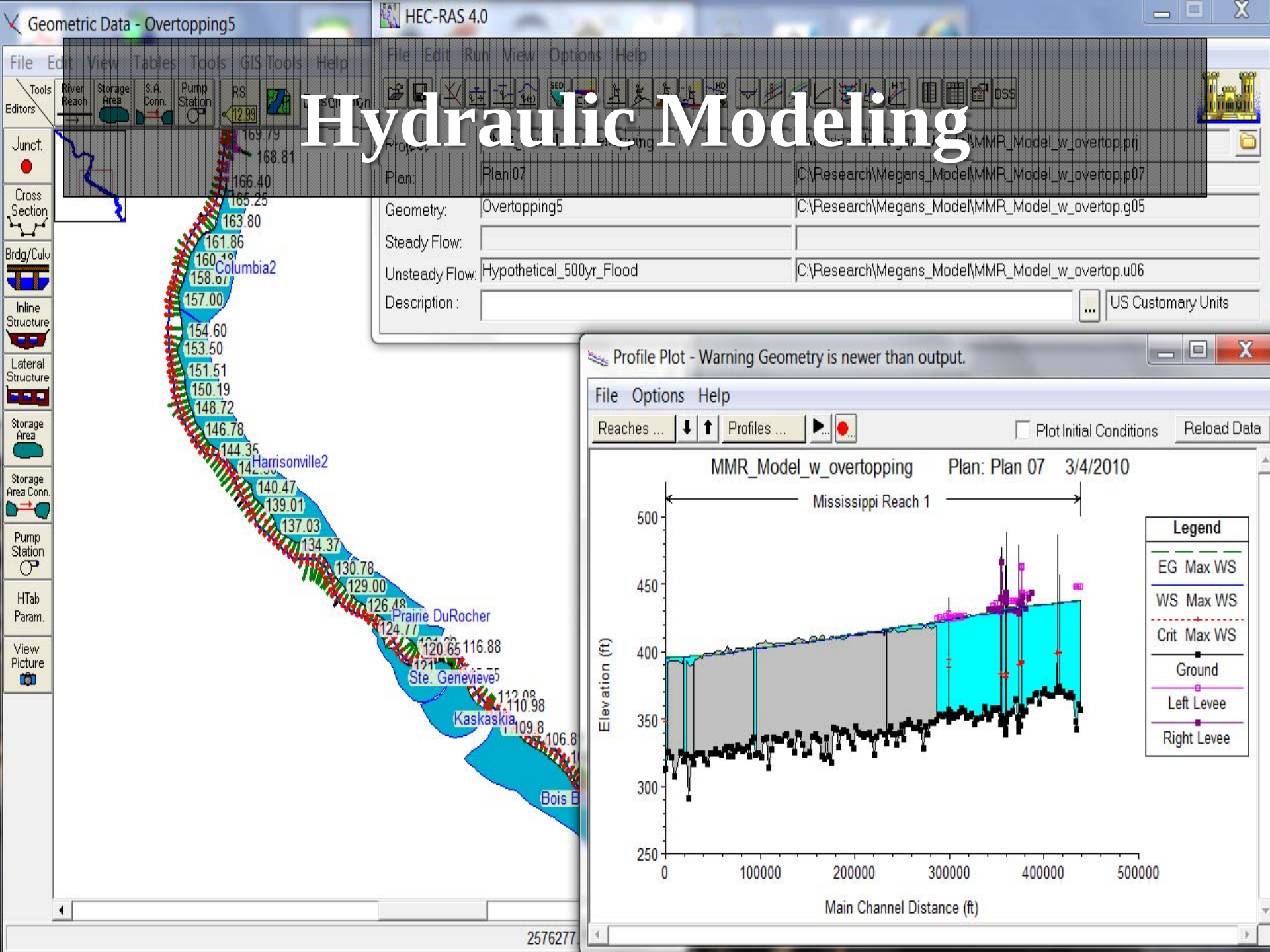
- **Use 1-D hydrodynamic modeling using HEC-RAS to establish water surface elevations for the new 100-year flood discharges.**
- **Perform flood loss modeling using FEMA's HAZUS-MH flood loss estimation tool to estimate potential economic losses for the present day and future 100-year flood using current floodplain infrastructure data.**

Climate Scenarios

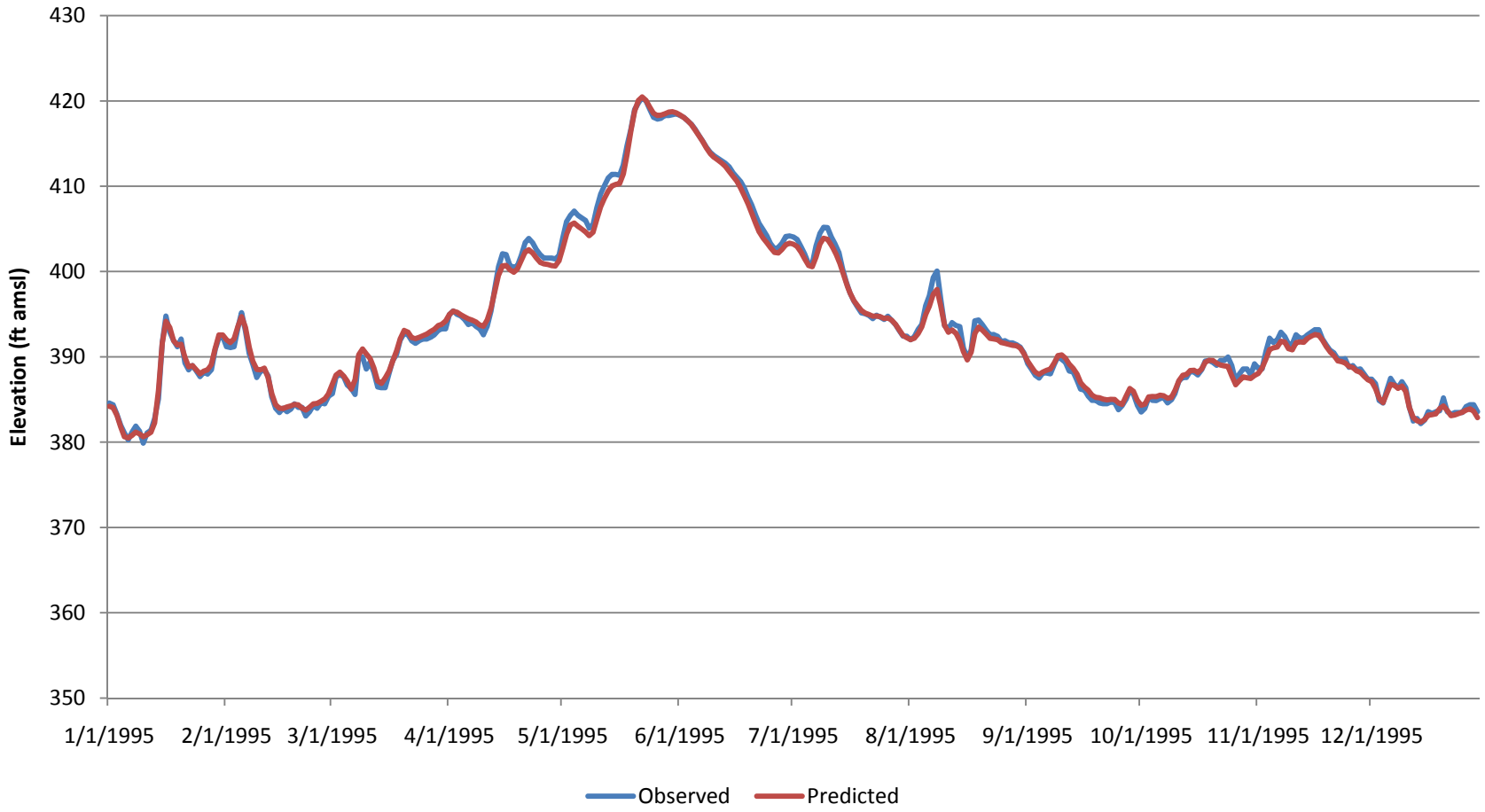
- Use projected future climate datasets from the Intergovernmental Panel on Climate Change (IPCC).
- Models
  - HadCM3
  - GFDL
  - PCM
- Scenarios
  - A2
  - A1B
  - B1
  - SRES


Study Reach
Kilometers
0 25 50 100
Illinois
Missouri
Madison
St. Clair
Monroe
Jefferson
Randolph
Ste. Genevieve
Perry
Jackson
Union
Cape Girardeau
Scott
Pulaski
Alton
Wood River
Edwardsville
O'Fallon
St. Peters
Chesterfield
St. Louis
East St. Louis
Belleville
Chester
Murphysboro
Carbondale
Grand Tower
Cape Girardeau
Cario
Kentucky
Tennessee
Arkansas
Mississippi R.
Ohio R.
Kaskaskia R.
Meramec
Missouri R.
Illinois R.
Legend
Cities/Towns
Population (2000)
10,000
25,000
50,000
75,000
>100,000
Levees
Flood Pretection Level (Year Event)
< 99
> 99
>499
Census Blocks
Bulding Exposure in $1,000s
0 - $47
$48 - $202
$203 - $707
$708 - $2,352
$2,353 - $7,719
$7,720 - $25,222
$25,223 - $82,304
$82,305 - $268,467
River Channel
Bluff Line
Local Data
Kilometers
0 25 50 100

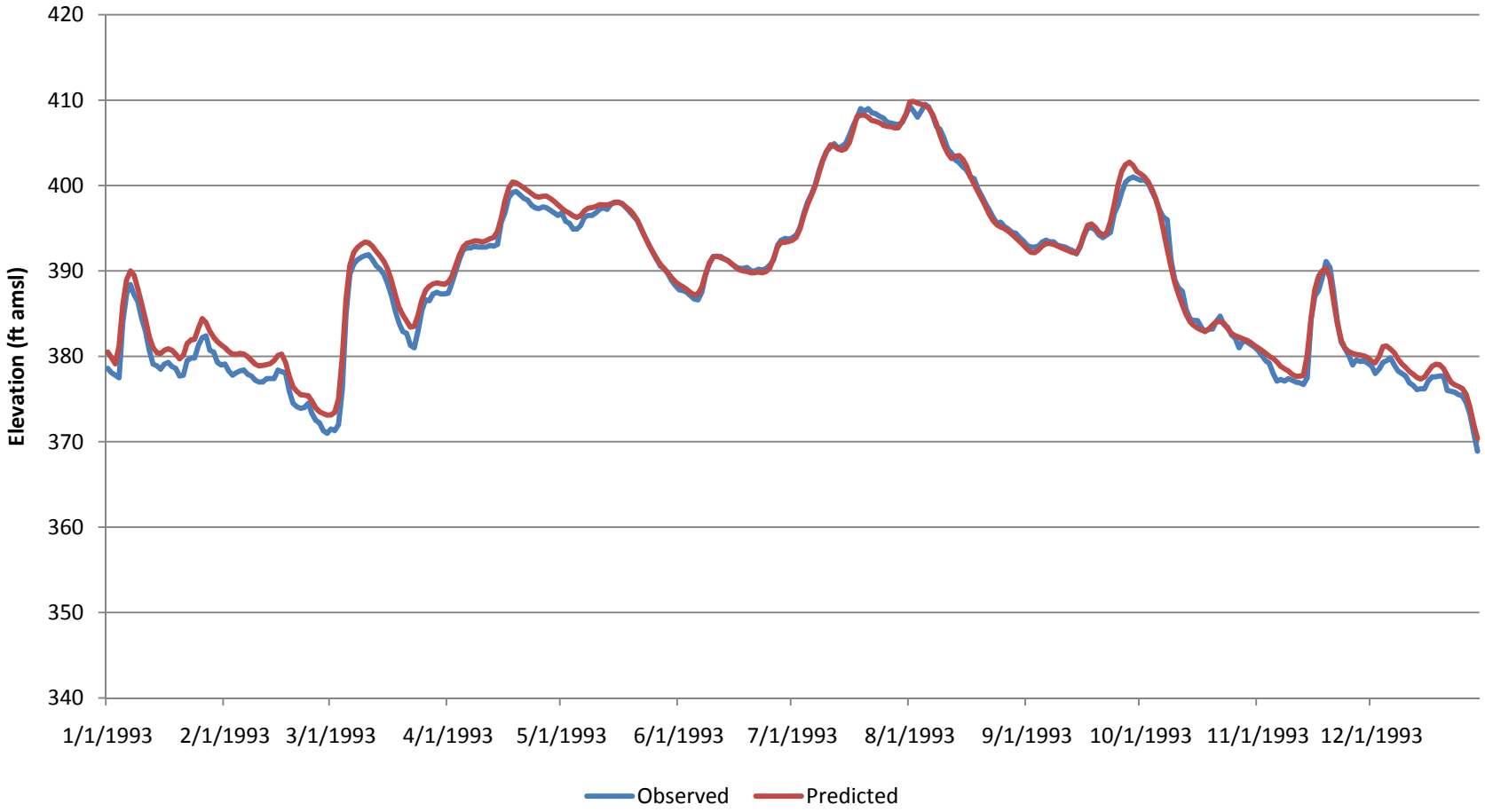
Hydraulic Modeling



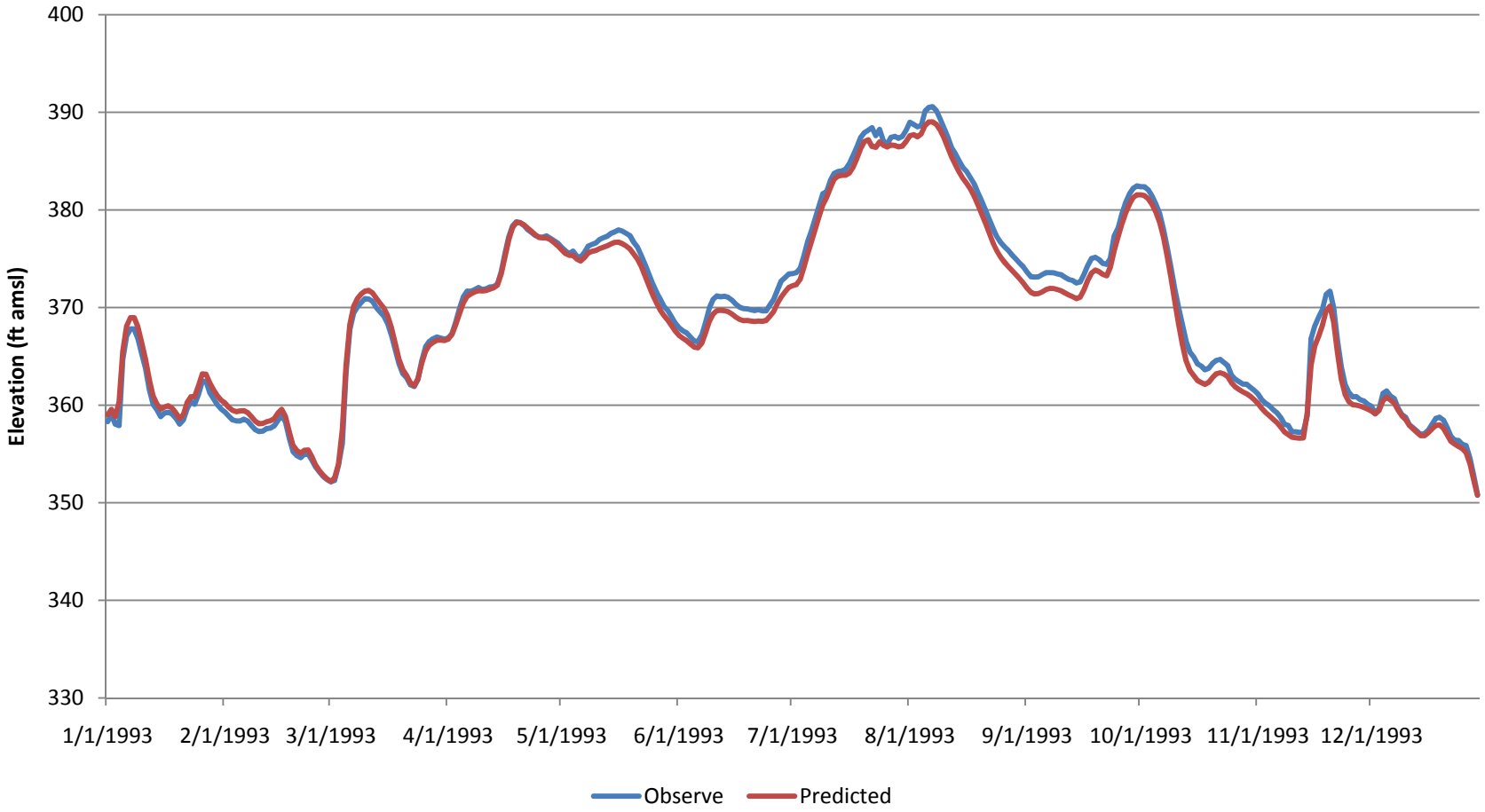
Calibration 1995
Engineers Depot, MO

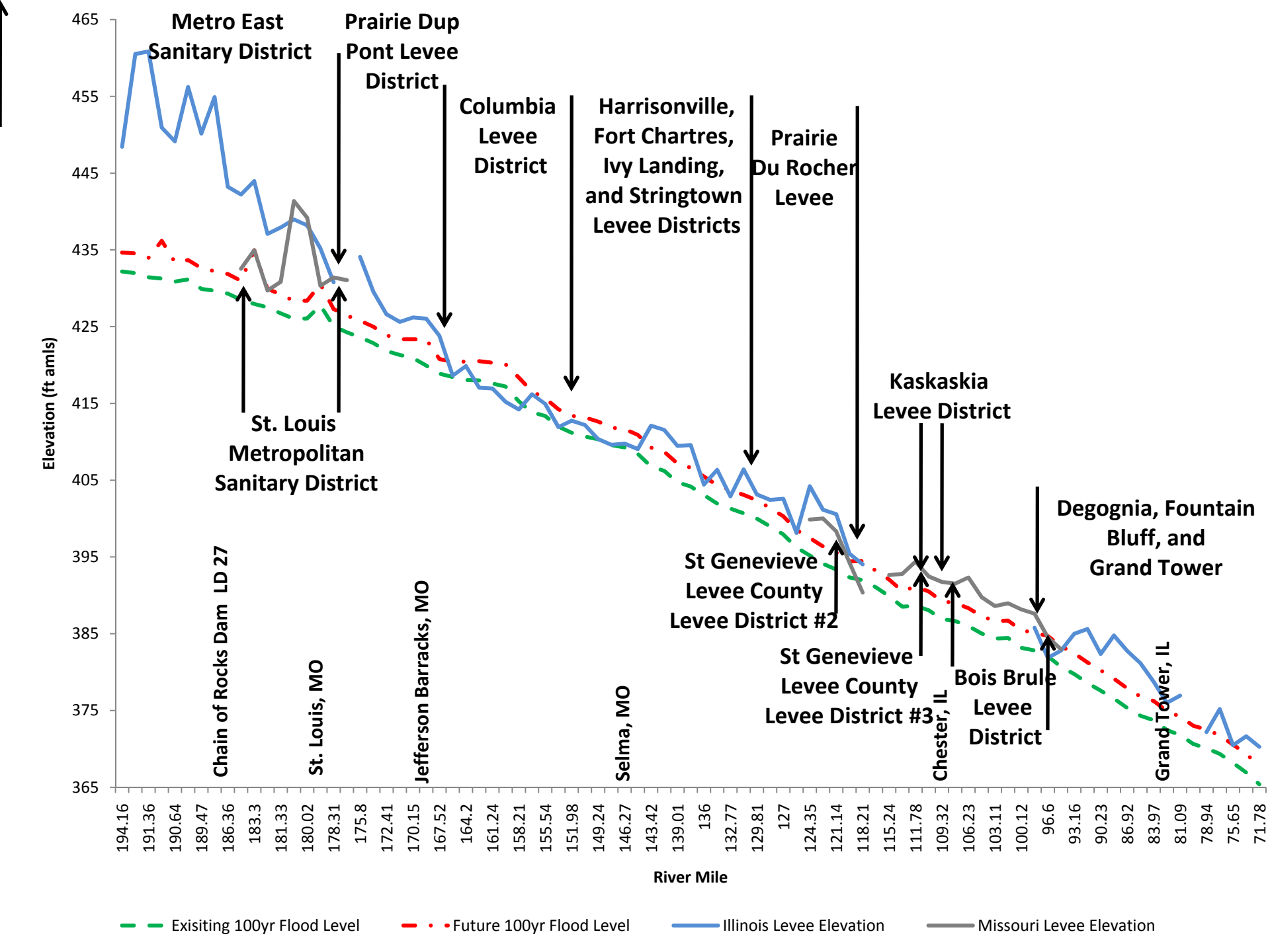


Validation 1993?
Selma, MO

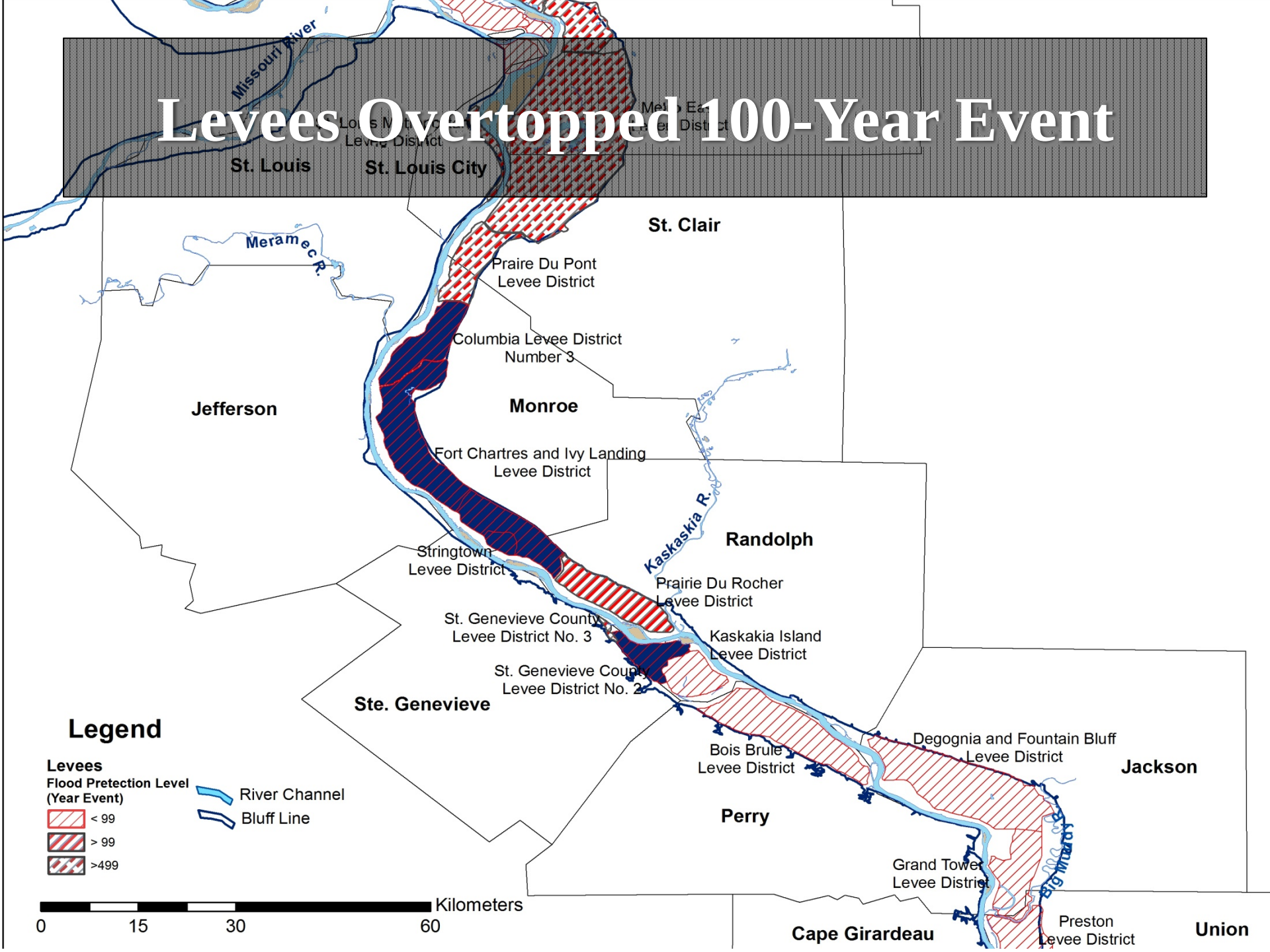


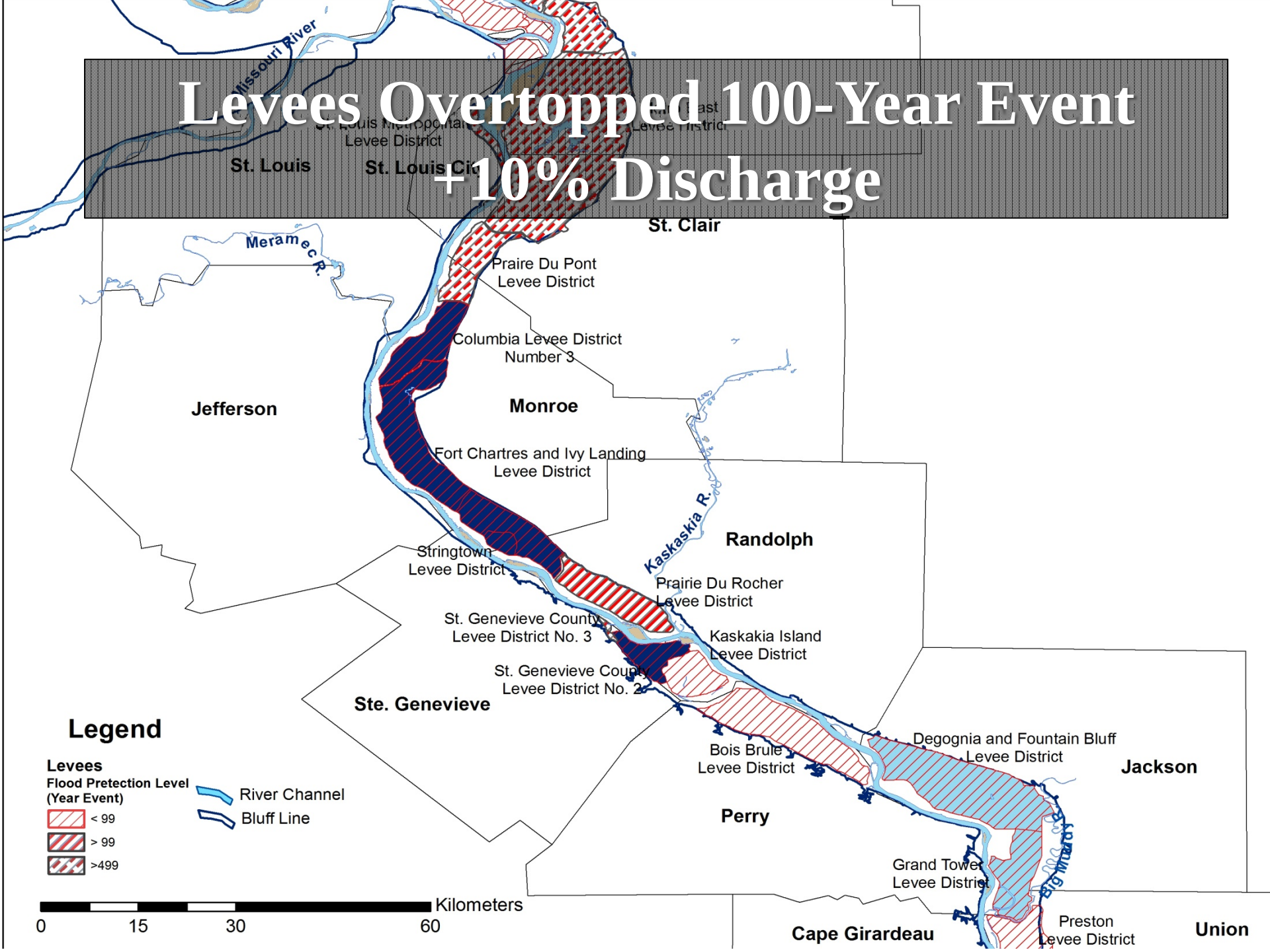
Validation 1993?
Chester, IL




Metro East Sanitary District
Prairie Dup Pont Levee District
Columbia Levee District
Harrisonville, Fort Chartres, Ivy Landing, and Stringtown Levee Districts
Prairie Du Rocher Levee
Kaskaskia Levee District
Degognia, Fountain Bluff, and Grand Tower
St. Louis Metropolitan Sanitary District
St Genevieve Levee County Levee District #2
St Genevieve Levee County Levee District #3
Bois Brule Levee District
Chain of Rocks Dam LD 27
St. Louis, MO
Jefferson Barracks, MO
Selma, MO
Chester, IL
Grand Tower, IL
Elevation (ft amls)
River Mile
Exisiting 100yr Flood Level
Future 100yr Flood Level
Illinois Levee Elevation
Missouri Levee Elevation

Levees Overtopped 100-Year Event




Levees Overtopped 100-Year Event
+10% Discharge
Missouri River
St. Louis
St. Clair
Meramec R.
Praire Du Pont
Levee District
Columbia Levee District
Number 3
Jefferson
Monroe
Fort Chartres and Ivy Landing
Levee District
Kaskaskia R.
Randolph
Stringtown
Levee District
Prairie Du Rocher
Levee District
St. Genevieve County
Levee District No. 3
Kaskakia Island
Levee District
St. Genevieve County
Levee District No. 2
Ste. Genevieve
Degognia and Fountain Bluff
Levee District
Bois Brule
Levee District
Jackson
Perry
Big Muddy R.
Grand Tower
Levee District
Preston
Levee District
Cape Girardeau
Union
Legend
Levees
Flood Pretection Level
(Year Event)
< 99
> 99
>499
River Channel
Bluff Line
Kilometers
0
15
30
60

HAZUS-MH Loss Estimation Methodology

5. Estimated economic/social losses

4. Determine damage

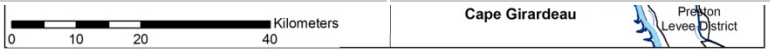
3. Define and overlay inventory data

2. Define hazard and flood depth grid

1. Define study region and DEM

Flood Losses

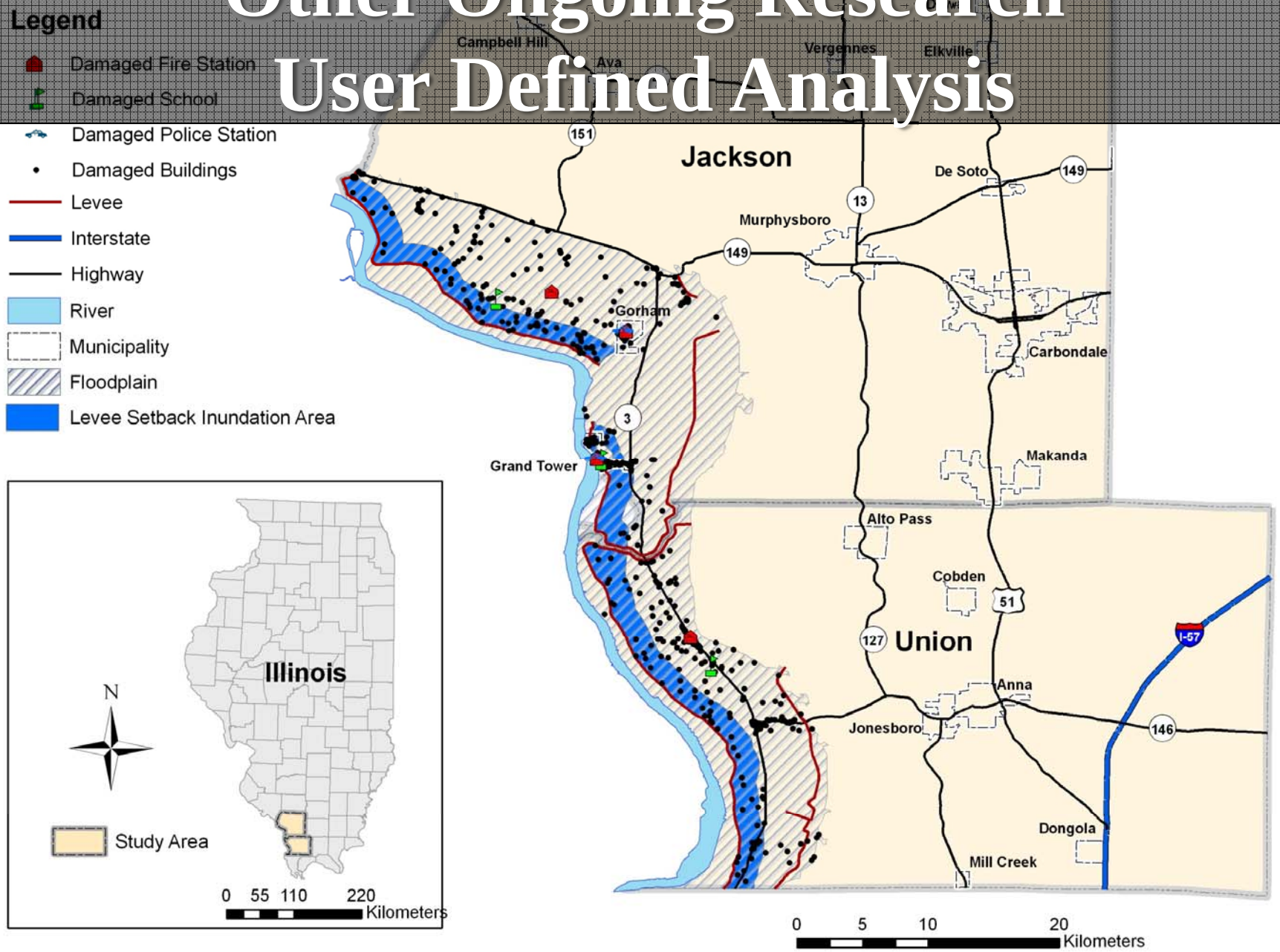
Scenario	Building Losses	Business Interruption Losses	Total Losses
100-Year Flood	$312.92	$1.42	$ 314.34
100-Year Flood +10%	$332.45	$1.5	$ 333.95
Change	6.2%	5.6%	6.2%



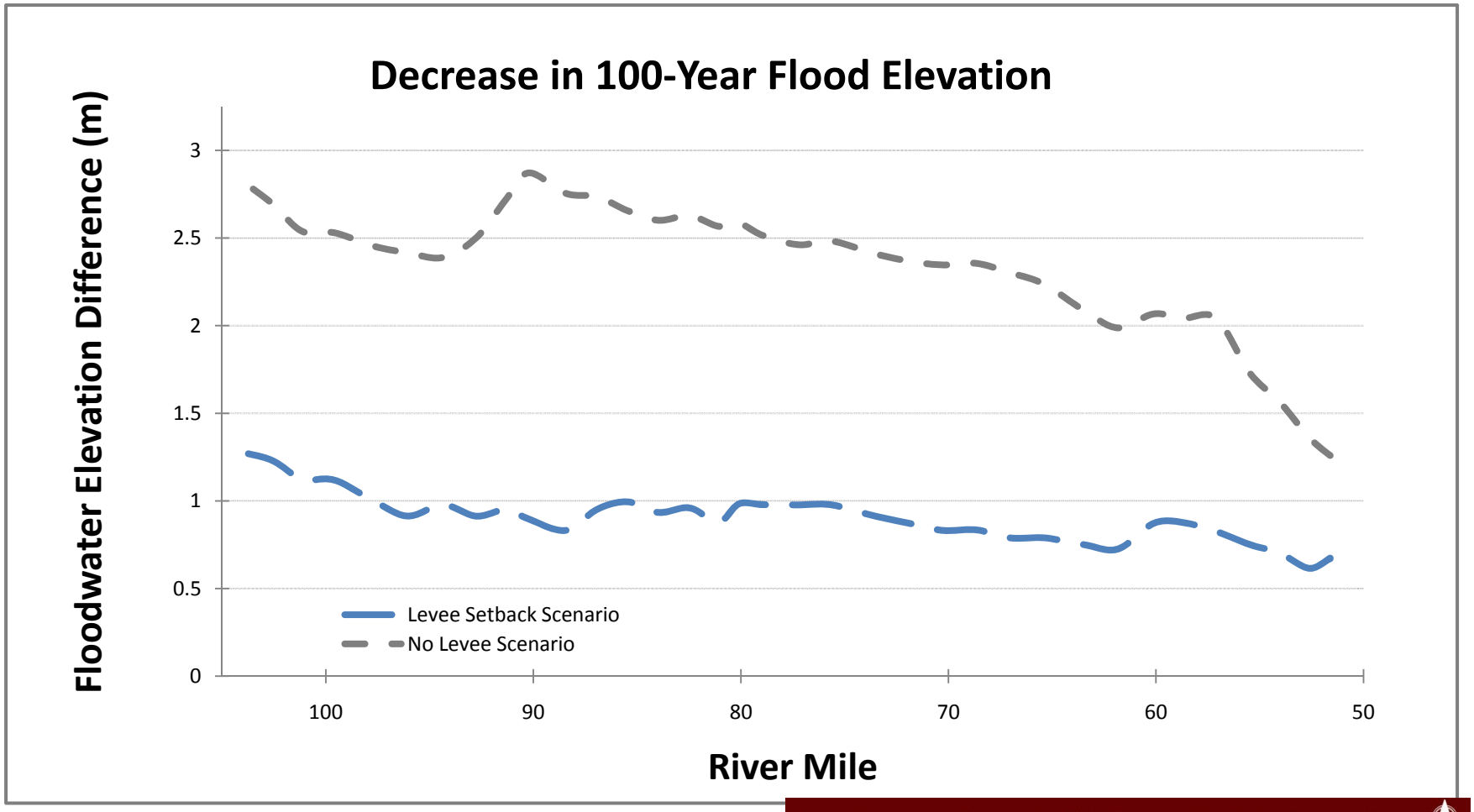
On Going and Future Research

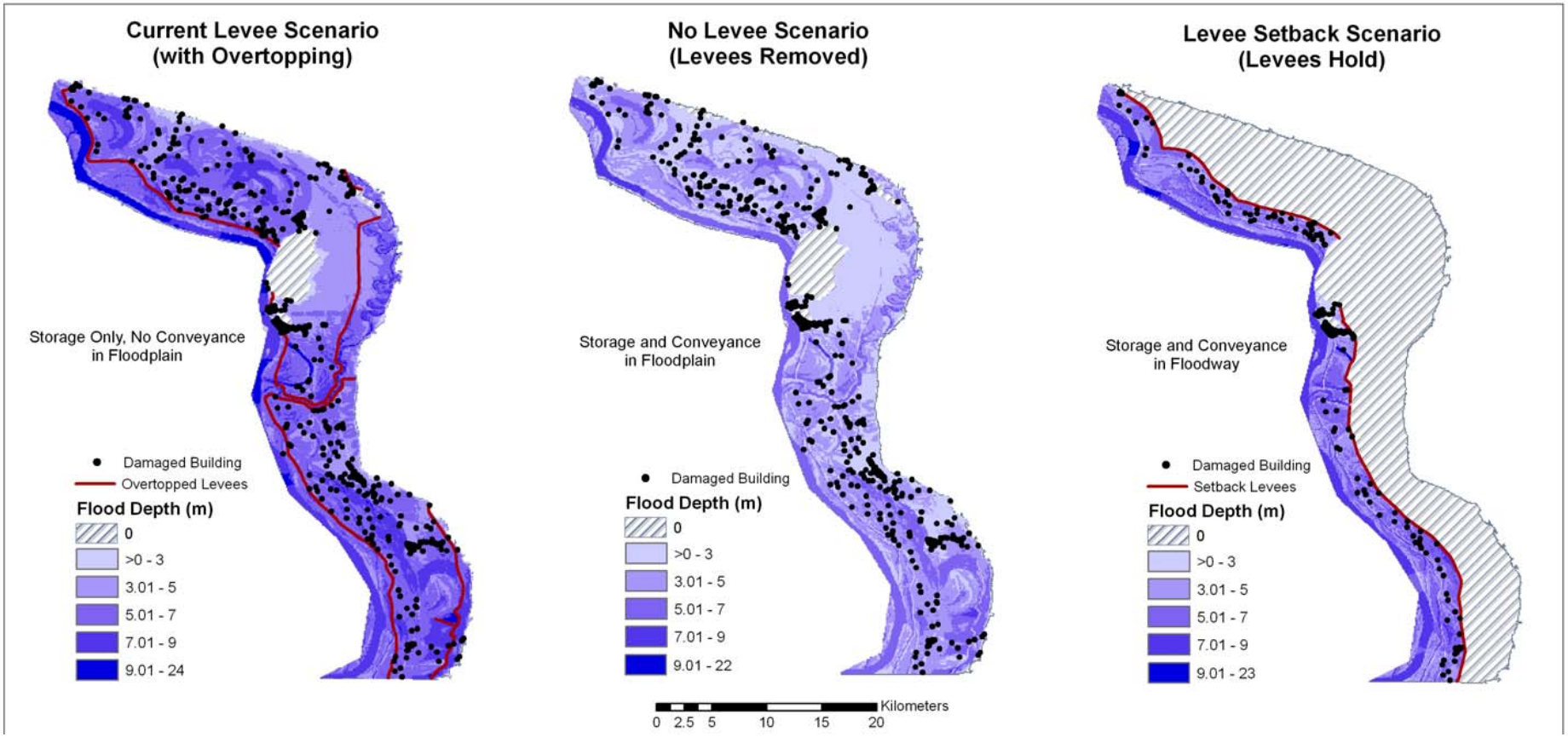
- **Optimum configuration for levee setbacks or removal along the Middle Mississippi River.**
- **Evaluation of cost and benefits of structural flood control along the Large Engineered Rivers**
- **Improving Floodplain Management and Policy Tools:** Stacking Ecosystem Services in Reconnected Floodplains: Linking Socioeconomic and Biophysical Analysis to Improve Floodplain Management.

Other Ongoing Research
User Defined Analysis



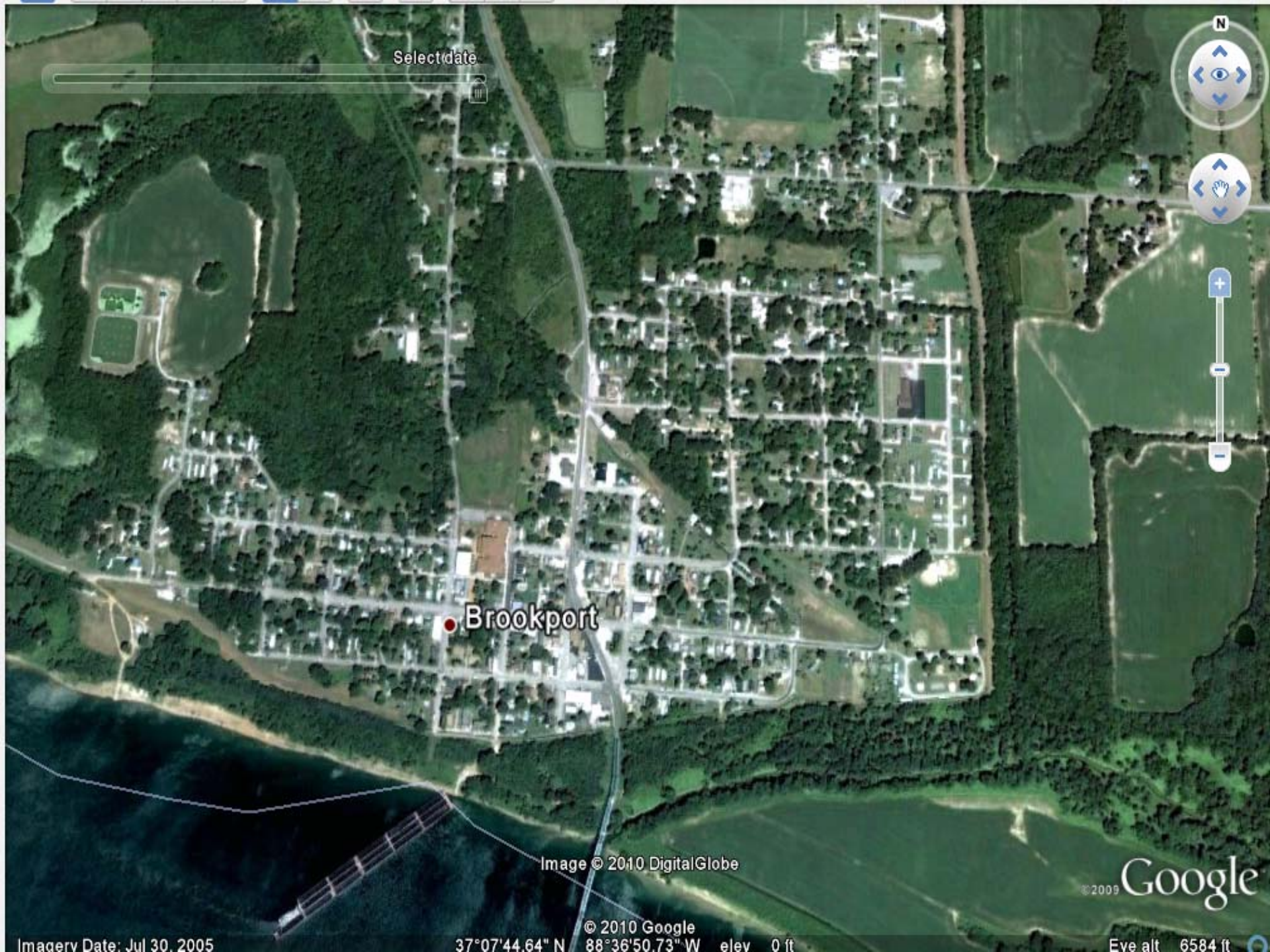
Change in Flood Stages Relative to Current Conditions (HEC-RAS Modeling)





Scenario	With Levees		No Levees		Levee Setback
Recurrence	100 Years	50 Years	100 Years	50 Years	Buyout
Building Losses	$20,156,473	0	$13,014,290	$11,007,597	
Content Losses	$23,966,561	0	$18,841,948	$17,636,770	
Inventory Losses	$15,715,664	0	$13,740,159	$13,427,788	
Total Losses	$59,838,698	0	$45,596,397	$42,072,154	$10,394,632
Buildings Damaged	902	0	841	712	366

Brookport Levee Failure


Select date
N
Brookport
Image © 2010 DigitalGlobe
©2009 Google
© 2010 Google
Imagery Date: Jul 30, 2005
37°07'44.64" N 88°36'50.73" W elev 0 ft
Eye alt 6584 ft

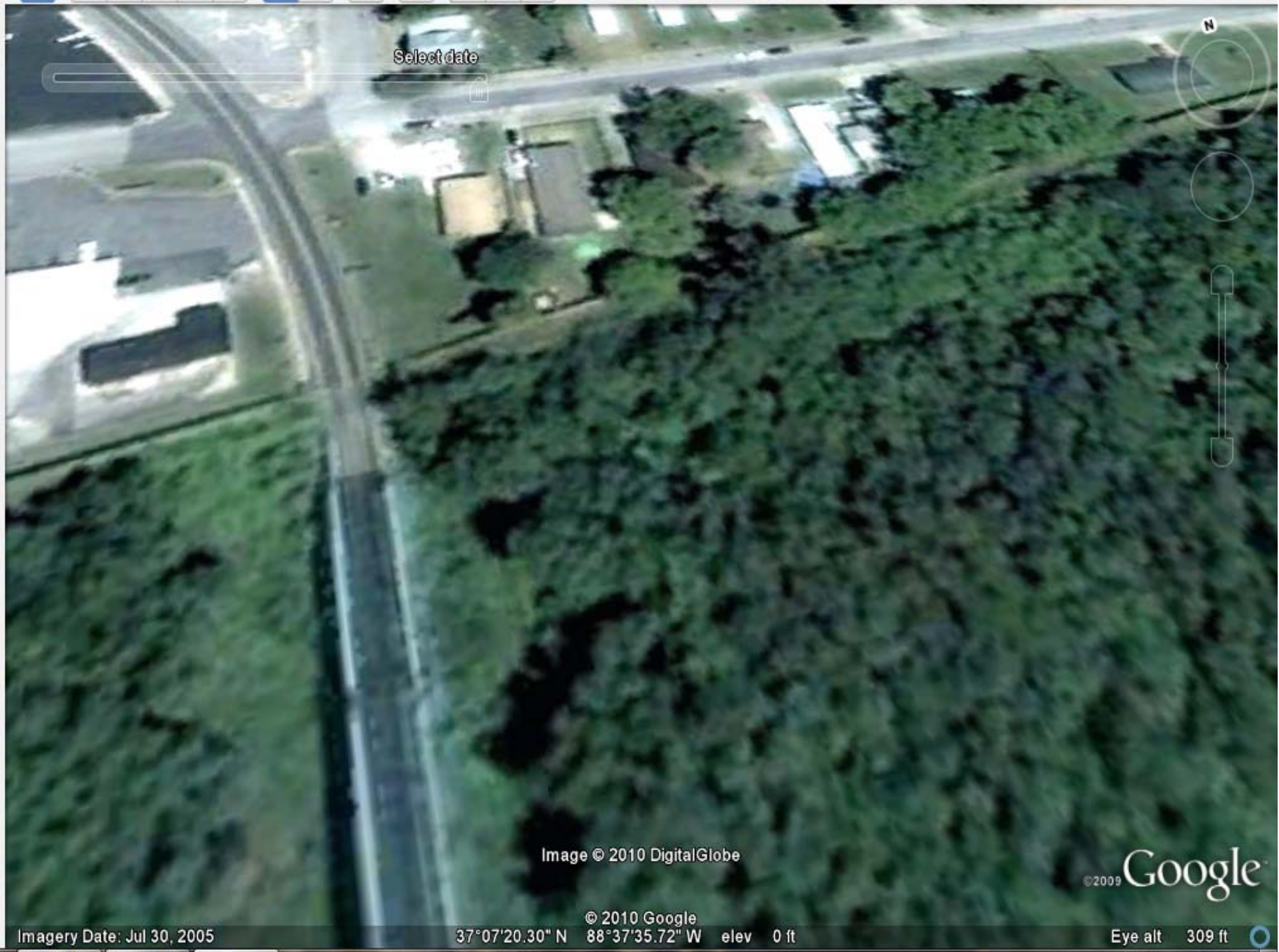

Select date
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Image © 2010 DigitalGlobe
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© 2010 Google
Imagery Date: Jul 30, 2005
37°07'20.30" N 88°37'35.72" W elev 0 ft
Eye alt 309 ft

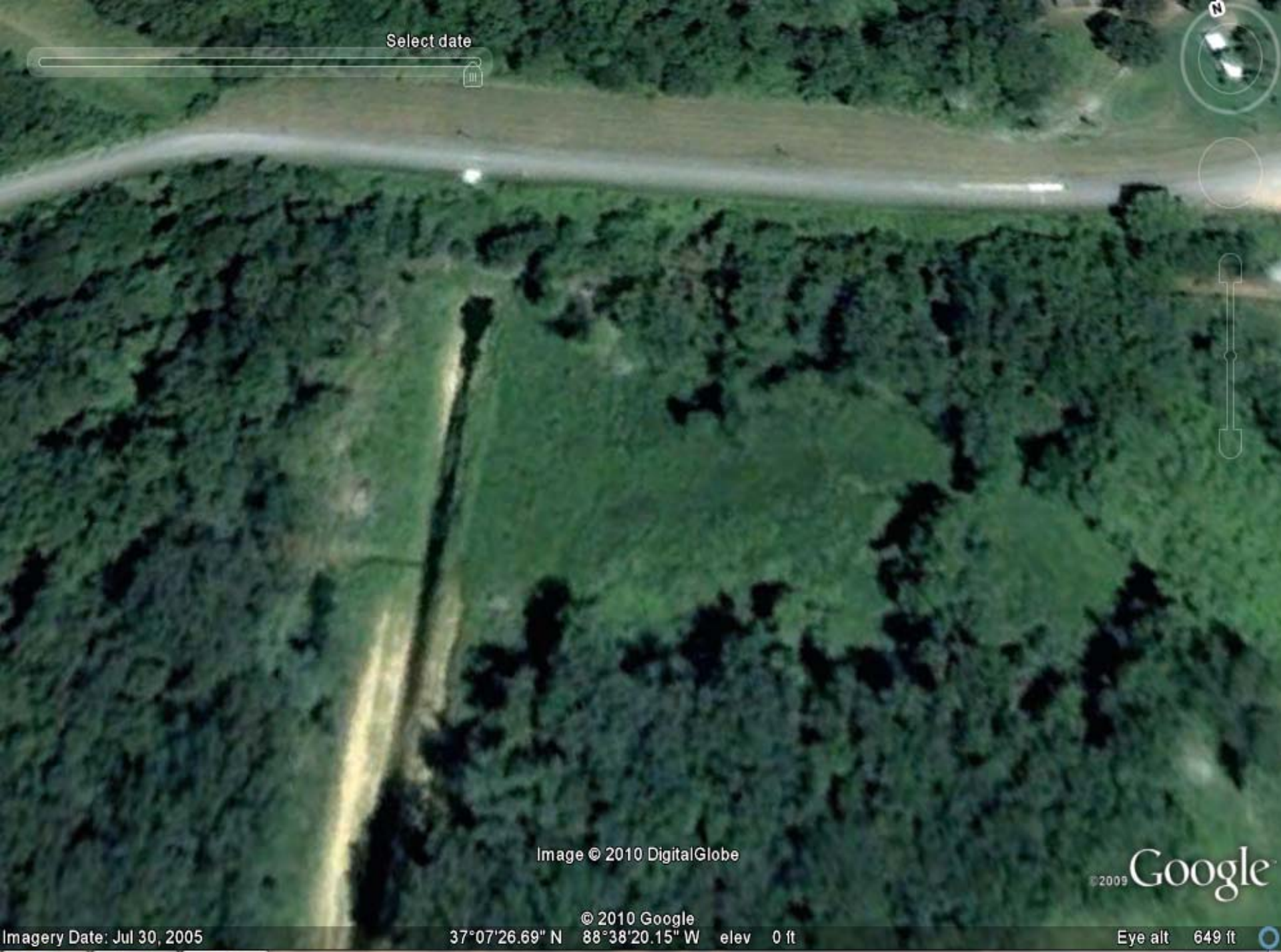
Select date
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Image © 2010 DigitalGlobe
©2009 Google
© 2010 Google
Imagery Date: Jul 30, 2005
37°07'26.69" N 88°38'20.15" W elev 0 ft
Eye alt 649 ft

Brookport Levee Failure: Flood Losses

General Occupancy	Total Damaged Buildings	Total Economic Loss (X $1000)
Agricultural	2	$90
Commercial	21	$510
Exempt	4	$86,968
Industrial	2	$41
Residential	343	$1,578
Total	372	$89,187