# Why Do We Need the Fargo-Moorhead Area Diversion?

2024 Fargo-Moorhead Area Diversion Conference

North Dakota Water Resources Research Institute

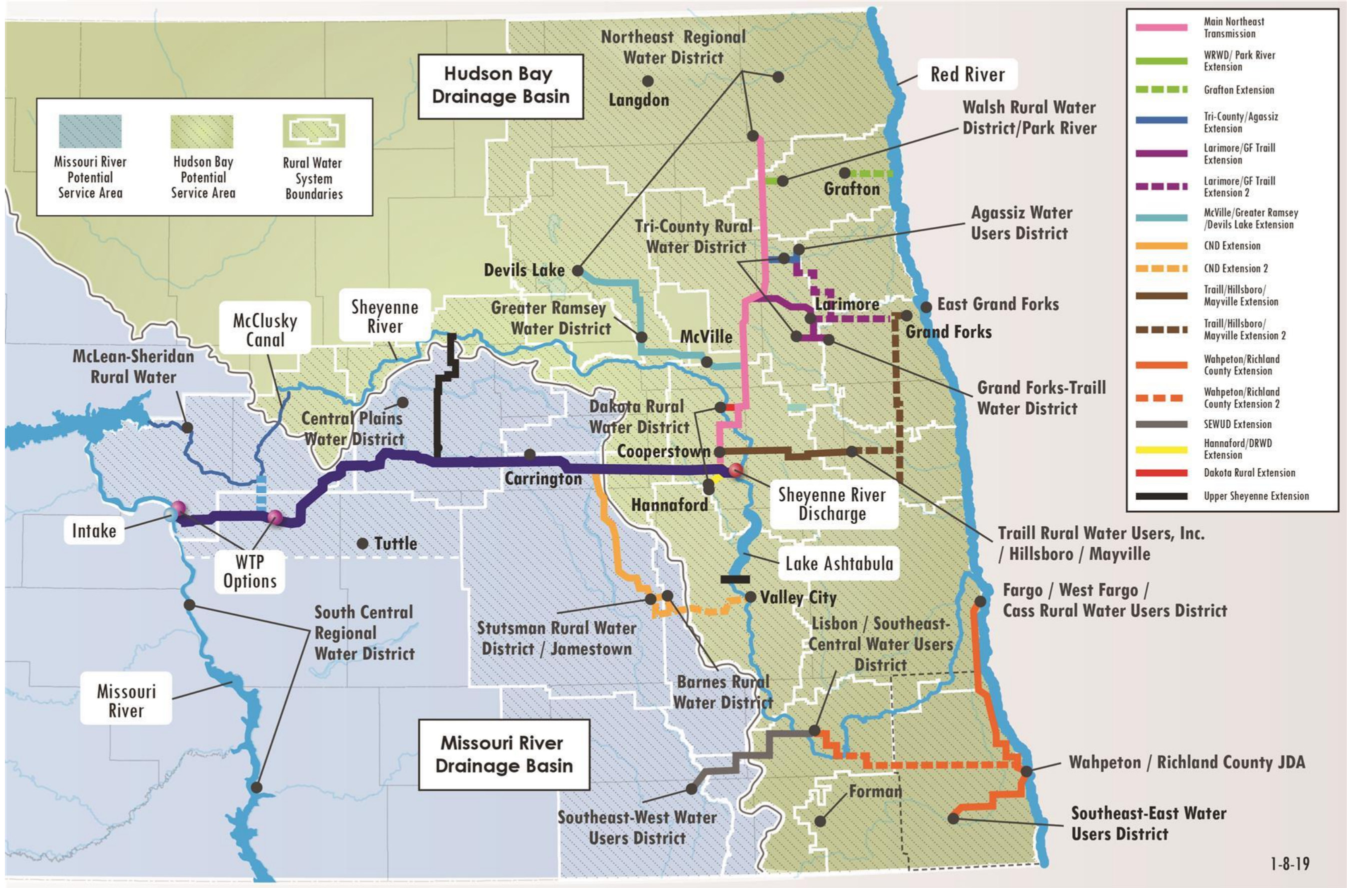
Karen R. Ryberg

August 19, 2024

U.S. Department of the Interior
U.S. Geological Survey

# Why do we need a diversion?

- Why do we need the FM Area Diversion at the same time we are building the Red River Valley Water Supply Project to bring Missouri River water to the Red River Valley?




https://www.rrvwsp.com/about/

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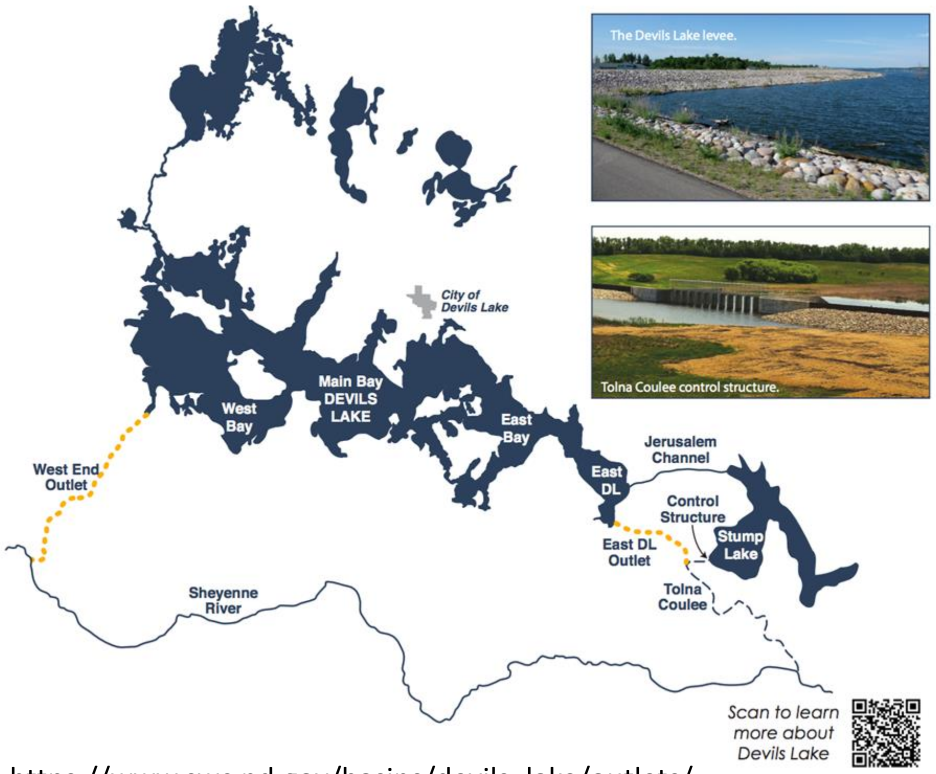
# Why do we need a diversion?

And outlets, from Devils Lake to the Sheyenne River, which bring more water to the Red River?




https://www.swc.nd.gov/basins/devils_lake/outlets/

# Why do we need a diversion?

And the Mouse (Souris) River Flood Protection Plan?

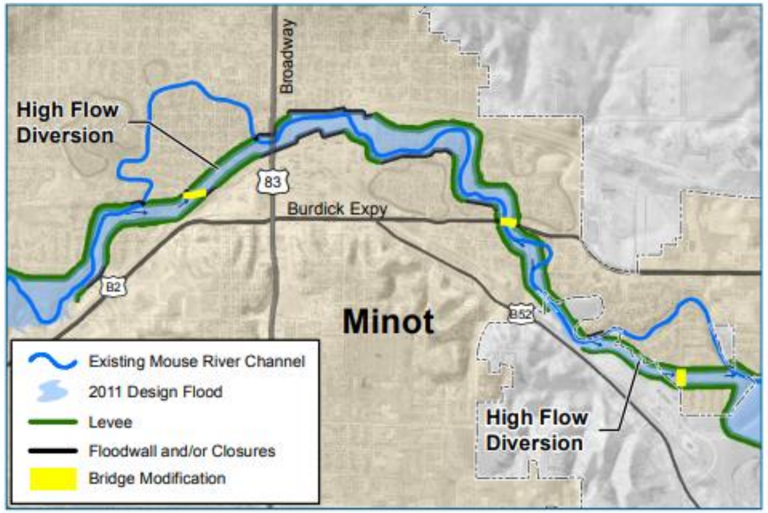



*Figure 3: The Project features defined in the Preliminary Engineering Report include levees, floodwalls, channel excavations, channel realignments, bridge modifications, and two high-flow diversion channels in Minot.*

https://www.mouseriverplan.com/_files/ugd/511e24_733fdf9b13264e5d8401d18e72b36d4a.pdf

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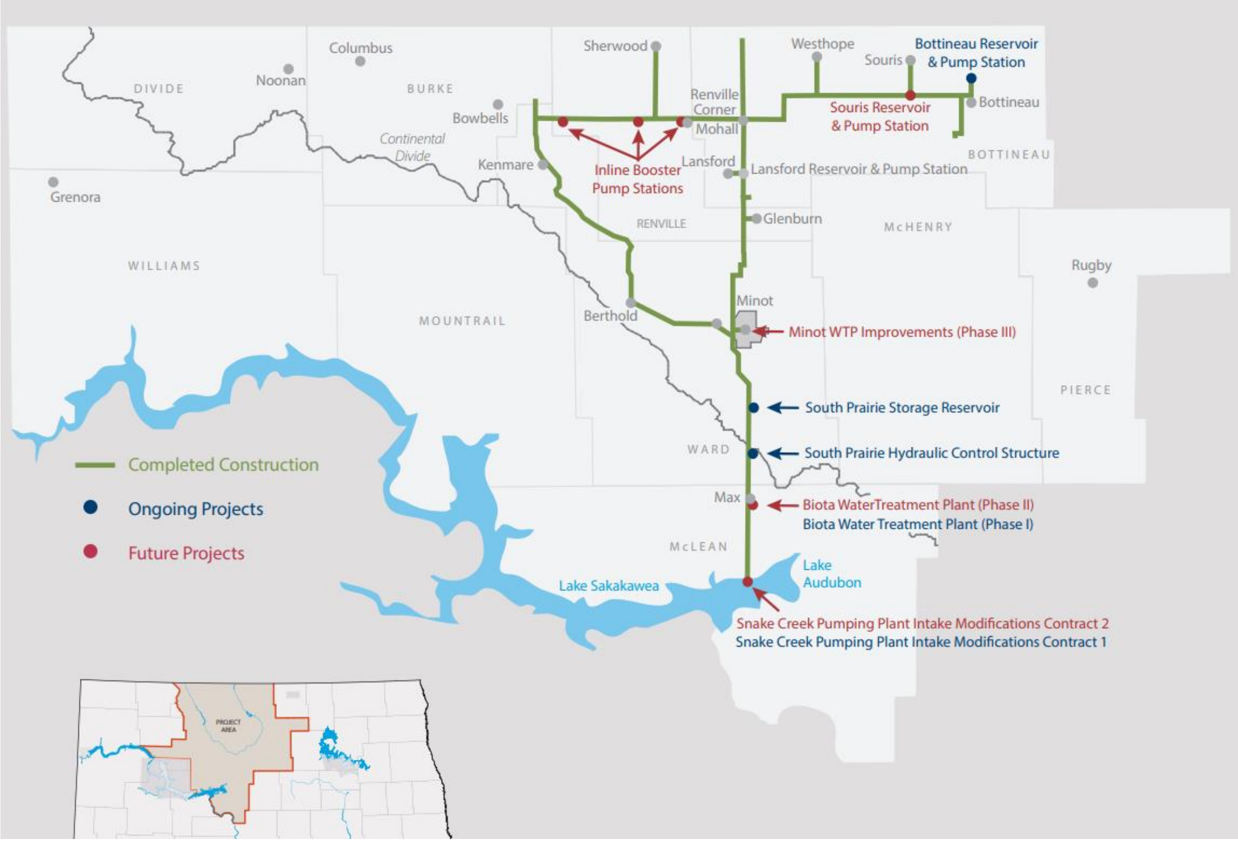
# Why do we need a diversion?




https://www.swc.nd.gov/pdfs/naws_brochure.pdf

While the Northwest Area Water Supply Project bring Missouri River Water to the Souris River Basin?

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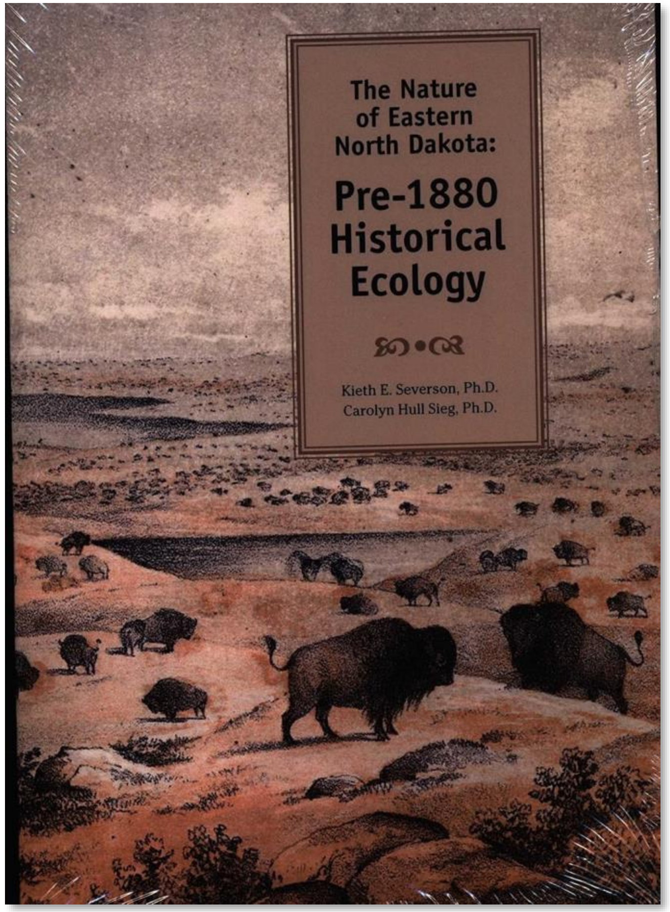
**The Nature of Eastern North Dakota: Pre-1880 Historical Ecology**. By Keith E. Severson and Carolyn Hull Sieg. Fargo: North Dakota Institute for Regional Studies, 2006. viii + 308 pp. Maps, illustrations, references, index.

# NDSU Answered That Question

"Early explorers and settlers had the same complaints about weather as we do today: too dry, too wet, too cold, too hot, too windy."

(Severson and Sieg, 2006, p. 37)

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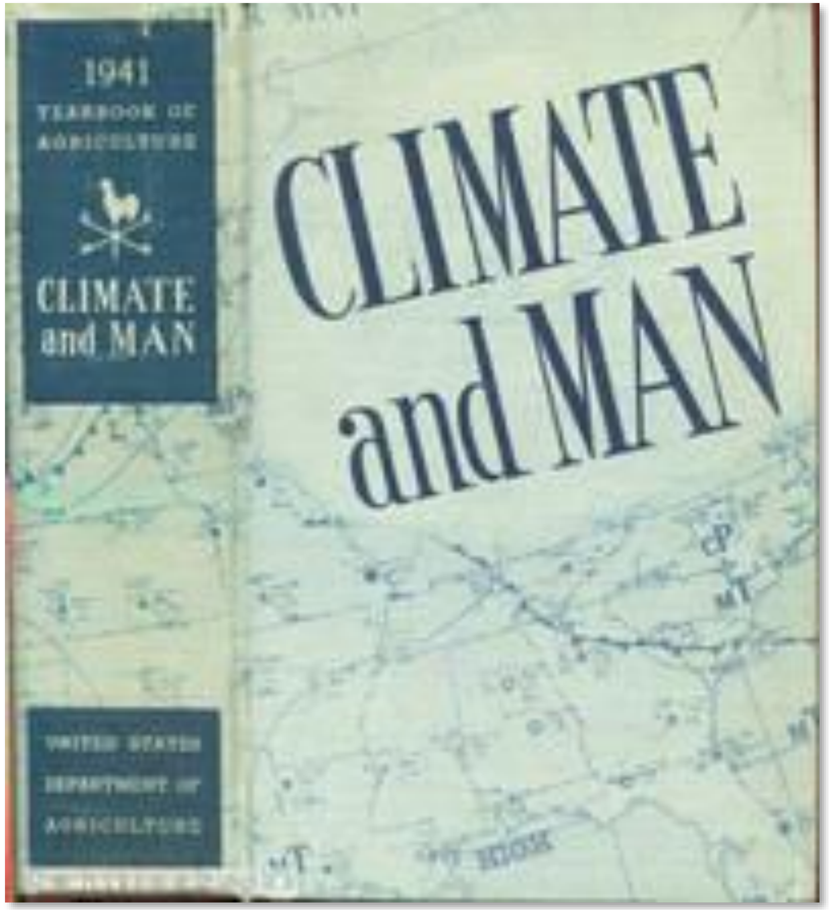
# A More Scientific Way of Saying That

“The Great Plains, so situated as to be inundated successively by moist and dry, cold and hot air masses, suffer meteorological excesses and in consequence experience large fluctuations in climate.

Although the climate is classed as semiarid, there are years when other climatic types prevail—in fact, every type from humid to arid may occur.”

Thornthwaite (1941, p. 180)




Thornthwaite, C.W., 1941, Settlement in the Great Plains, in Climate and man yearbook of agriculture: United States Government Printing Office, Washington, D.C., p. 177-187., https://archive.org/details/yoa1941.

"The fluctuation of the climate within wide limits, as at Jamestown [ND] and Fort Stanton [NM], creates one of the most serious of the climatic risks to agriculture."

Thornthwaite (1941, p. 180)

TABLE 1.—*Climatic variability at Jamestown, N. Dak., Fort Stanton, N. Mex., and Independence and Indio, Calif.*

| Station | Length of record | Climatic type [1] | Climatic distribution | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Super-humid | Humid | Moist sub-humid | Dry sub-humid | Semi-arid | Arid |
| | *Years* | | *Years* | *Years* | *Years* | *Years* | *Years* | *Years* |
| Jamestown, N. Dak. | 35 | Dry subhumid | 0 | 1 | 15 | 13 | 5 | 1 |
| Fort Stanton, N. Mex | 37 | Semiarid | 0 | 1 | 1 | 5 | 25 | 5 |
| Independence, Calif. | 37 | Arid | 0 | 0 | 1 | 1 | 1 | 34 |
| Indio, Calif. | 36 | do. | 0 | 0 | 0 | 0 | 0 | 36 |

[1] Based on effective precipitation as determined in Thornthwaite's classification of climates (7).

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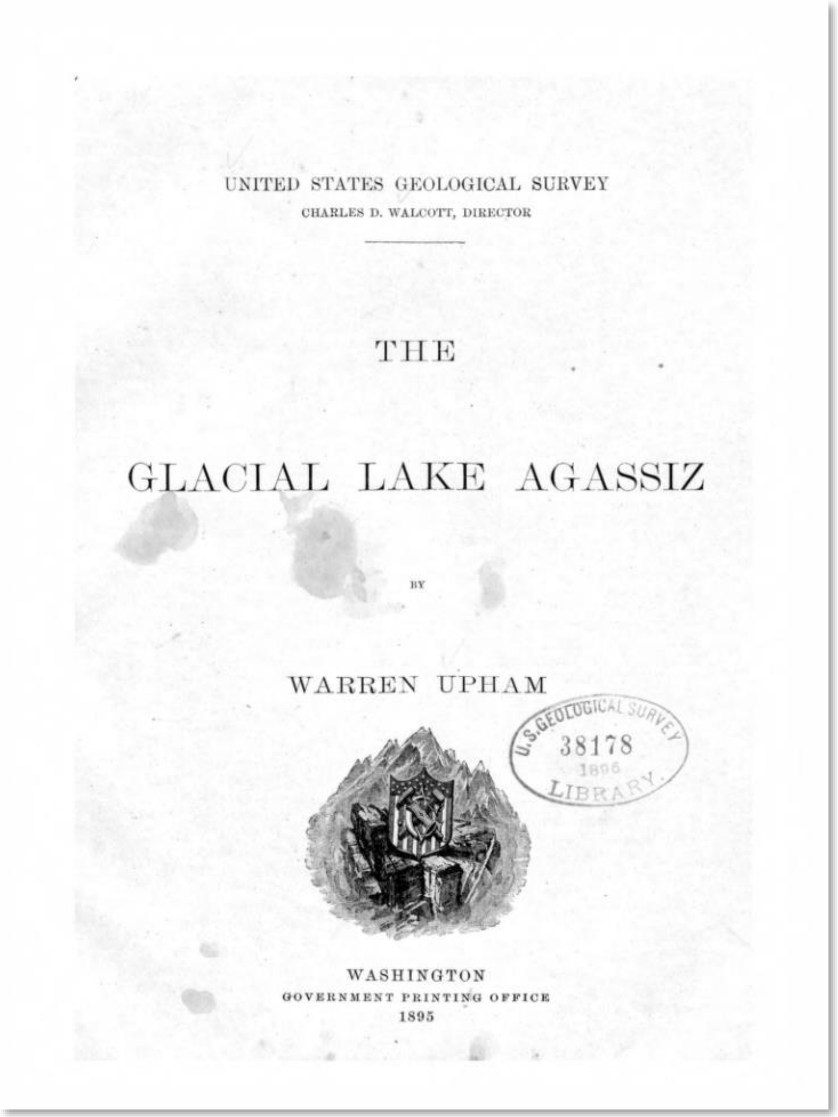
We suffer meteorological excesses and in consequence experience large fluctuations in climate.

# Flood Prone

# Flooding

The study of flooding in what is now the Red River Basin starts at the end of the last glaciation when Glacial Lake Agassiz, formed during retreat of the Laurentide Ice Sheet, was the largest Pleistocene lake in North America.


UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE

GLACIAL LAKE AGASSIZ

BY

WARREN UPHAM



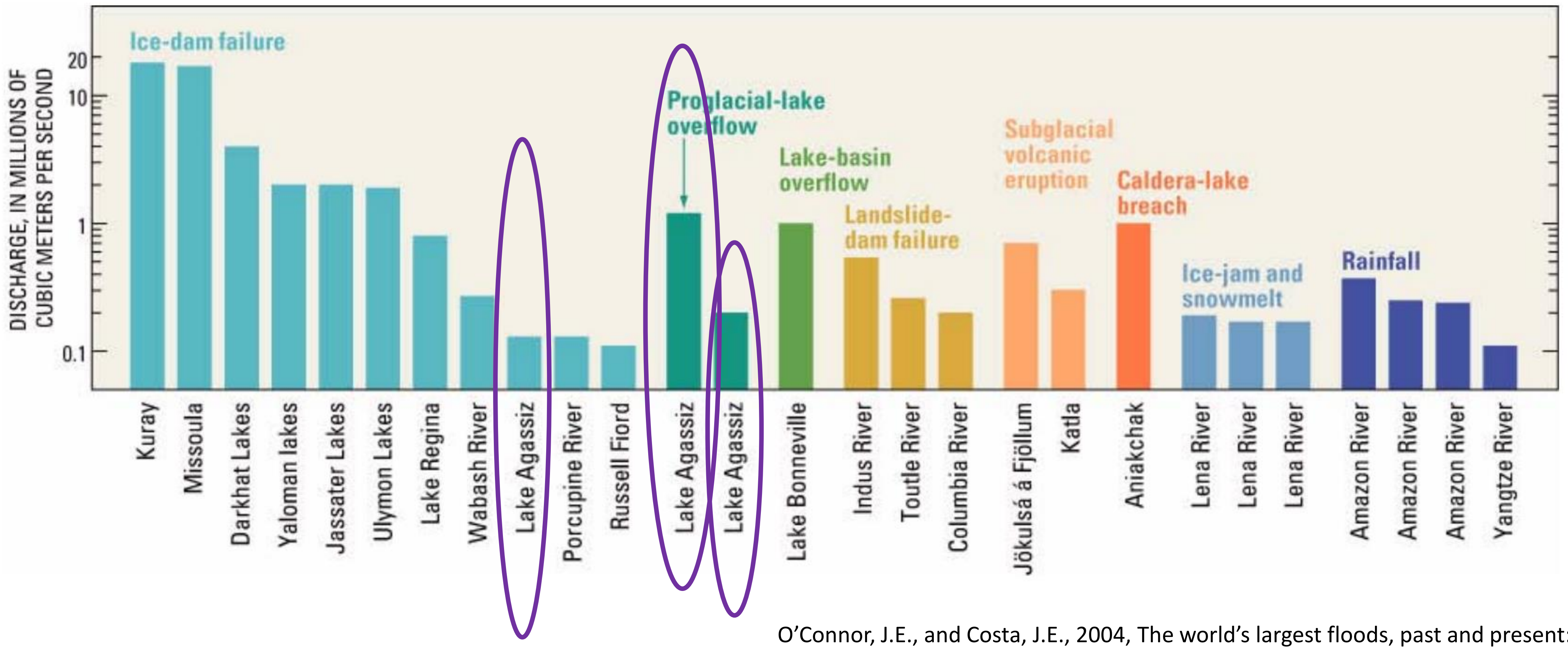
WASHINGTON
GOVERNMENT PRINTING OFFICE
1895

USGS

Upham, W., 1895, The Glacial Lake Agassiz: U. S. Geological Survey Monograph 25, 658 p., https://doi.org/10.3133/m25.

# The World's Largest Floods

- In the Quaternary Period, about 1.8 million years to present, three of 27 known freshwater floods with flows greater than 3.53 million cubic feet per second (100,000 cubic meters per second), were associated with Glacial Lake Agassiz.




O'Connor, J.E., and Costa, J.E., 2004, The world's largest floods, past and present: Their causes and magnitudes: U.S. Geological Survey Circular 1254, 19 p., https://doi.org/10.3133/cir1254.

GeoScienceWorld

From: **Southern outlet and basin of glacial Lake Agassiz**

Archean to AnthropoceneField Guides to the Geology of the Mid-Continent of North America, 2011

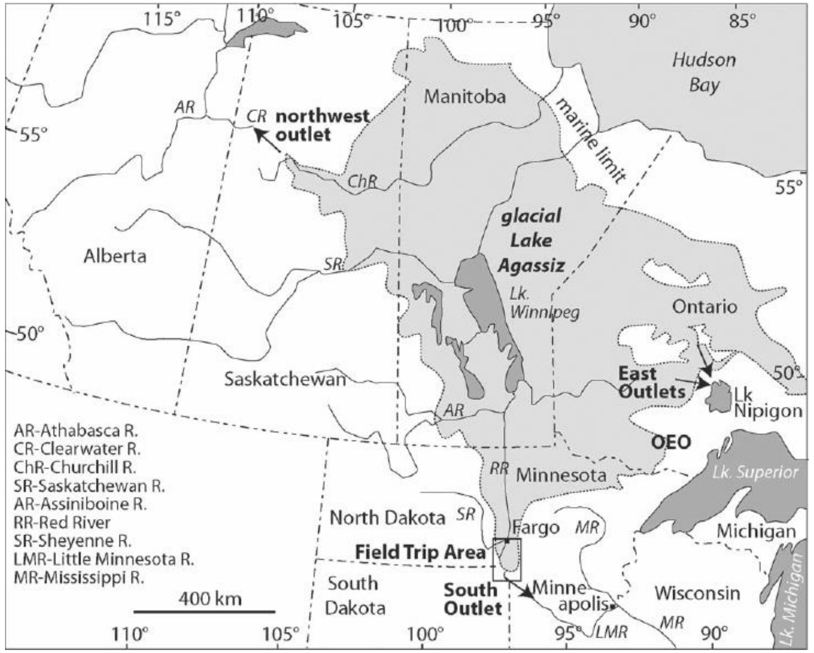



**Figure Legend:**

Maximum coverage area of glacial Lake Agassiz during its ~6000 calendar year history. OEO—older eastern outlets.

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Fisher, T.G., Lepper, K., Ashworth, A.C., and Hobbs, H.C., 2011, Southern outlet and basin of glacial Lake Agassiz, in Archean to Anthropocene: Field Guides to the Geology of the Mid-Continent of North America: Geological Society of America, p. 379–400.

# Northwest Outlet

- About 9,900 years before present, Lake Agassiz overtopped a drainage divide near the Alberta-Saskatchewan border and discharged to the lower Clearwater and Athabasca Rivers in Alberta, Canada (Smith and Fisher, 1993).
- The discharge was estimated as 42.4 million to 84.8 million cubic feet per second (1,200,000–2,400,000 cubic meters per second; O’Connor and Costa, 2004; Smith and Fisher, 1993).

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O’Connor, J.E., and Costa, J.E., 2004, The world’s largest floods, past and present: Their causes and magnitudes: U.S. Geological Survey Circular 1254, 19 p., https://doi.org/10.3133/cir1254.

Smith, D.G., and Fisher, T.G., 1993, Glacial Lake Agassiz: The northwestern outlet and paleoflood: Geology, v. 21, no. 1, p. 9–12.

# East Outlets

- In the Late Pleistocene, as the Laurentide Ice Sheet retreated, water from Lake Agassiz began to flow east into the Great Lakes and this discharge increased abruptly when a glacial dam failed.
- Maximum flow was estimated as 7.06 million cubic feet per second (200,000 cubic meters per second; O’Connor and Costa, 2004; Teller and Thorliefson, 1987).

USGS

O’Connor, J.E., and Costa, J.E., 2004, The world’s largest floods, past and present: Their causes and magnitudes: U.S. Geological Survey Circular 1254, 19 p., https://doi.org/10.3133/cir1254.

Teller, J.T., and Thorliefson, L.H., 1987, Catastrophic flooding into the Great Lakes from Lake Agassiz, *in* Mayer, L. and Nash, D. eds., Catastrophic Flooding: Routledge, 18 p.

# South Outlet

- Also in the Late Pleistocene, another ice dam failure occurred through a southern outlet named River Warren, the valley of which is now occupied by Lake Traverse, Big Stone Lake, and the Minnesota River (Fisher and others, 2011; O'Connor and Costa, 2004; Upham, 1895).
- This resulted in a discharge estimated as 4.59 million cubic feet per second (130,000 cubic meters per second; O'Connor and Costa, 2004).


Fisher, T.G., Lepper, K., Ashworth, A.C., and Hobbs, H.C., 2011, Southern outlet and basin of glacial Lake Agassiz, in Archean to Anthropocene: Field Guides to the Geology of the Mid-Continent of North America: Geological Society of America, p. 379–400.

O'Connor, J.E., and Costa, J.E., 2004, The world's largest floods, past and present: Their causes and magnitudes: U.S. Geological Survey Circular 1254, 19 p., https://doi.org/10.3133/cir1254.

Upham, W., 1895, The Glacial Lake Agassiz: U. S. Geological Survey Monograph 25, 658 p., https://doi.org/10.3133/m25.


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# Lake Agassiz Plain

- Glacial Lake Agassiz has left a legacy making the Red River Basin especially flood prone.
- What is commonly referred to is the Red River Valley, is the Lake Agassiz Plain.
- Thick beds of Lake Agassiz sediments on top of glacial till create the extremely flat floor of the Lake Agassiz Plain.

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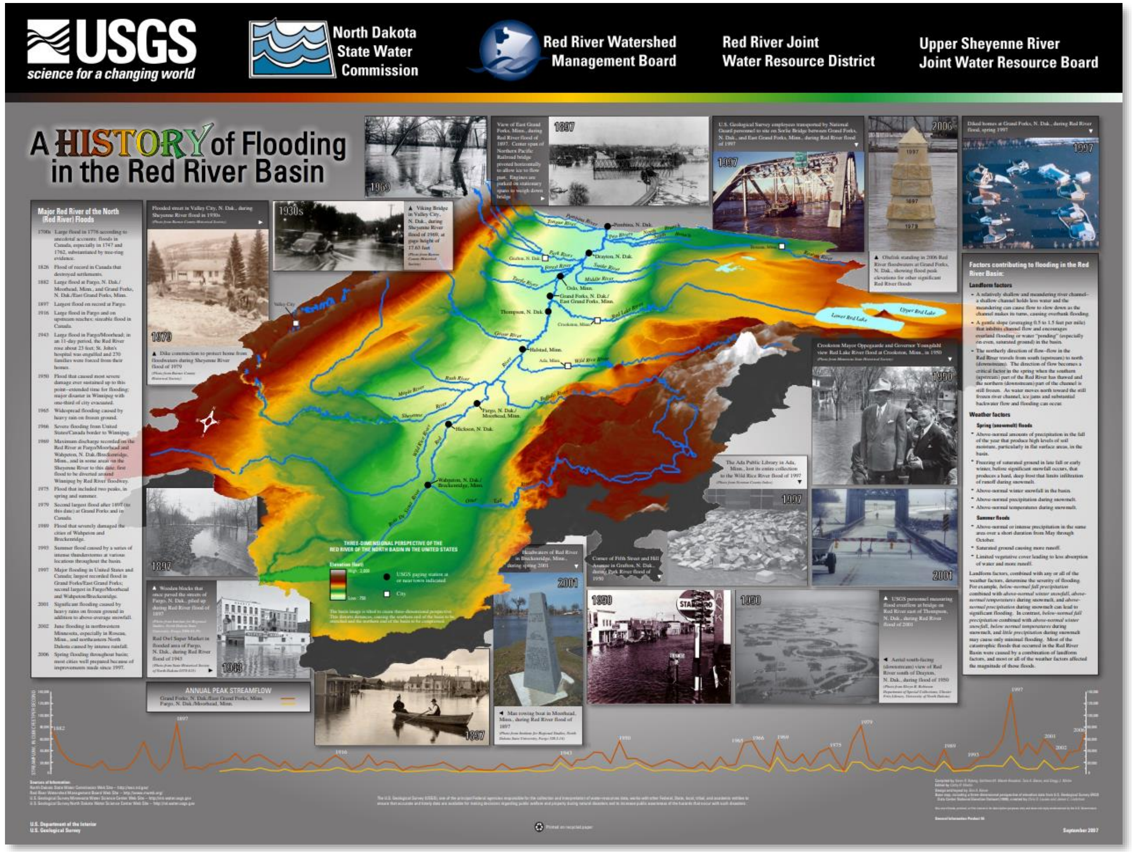
# Landform Factors for Flooding

- The Red River transects the plain from south to north.
- Rivers in this ecoregion are flood prone because a gentle slope (averaging 0.5 to 1.5 feet per mile for the Red River) inhibits channel flow and encourages overland flooding.
- The northerly direction of flow is also a critical factor in the spring flooding when the southern (upstream) part of the river has thawed and the northern (downstream) part of the channel is still frozen, leading to ice-jam flooding.




Ryberg, K.R., Macek-Rowland, K.M., Banse, T.A., and Wiche, G.J., 2007, A history of flooding in the Red River Basin: U.S. Geological Survey General Information Product 55, 1 p., https://pubs.er.usgs.gov/publication/gip55.

# Back to Climate

- This region is susceptible to persistent periods of relatively wet and relatively dry conditions.
- These distinct periods of hydroclimatic persistence, that lack an intermediate state (a state in which conditions persist at or near long-term average precipitation or temperature), are a characteristic of  the north central United States and southern Manitoba and Saskatchewan, Canada.

# Hydroclimatic Variability

Wet and dry periods are visible in the sediments of Devils Lake, North Dakota, for the past 4,000 years (Bluemle, 1996) and in the sediments of Waubay Lakes in northeastern South Dakota for the last 1,000 years (Shapley and others, 2005).

Bluemle, J.P., 1996, From the State Geologist: North Dakota Geological Survey Newsletter, v. 23, no. 1, p. 1–2.

Shapley, M.D., Johnson, W.C., Engstrom, D.R., and Osterkamp, W.R., 2005, Late Holocene flooding and drought in the Northern Great Plains, reconstructed from tree rings, lake sediments and ancient shorelines: The Holocene, v. 15, no. 1, p. 29–41.

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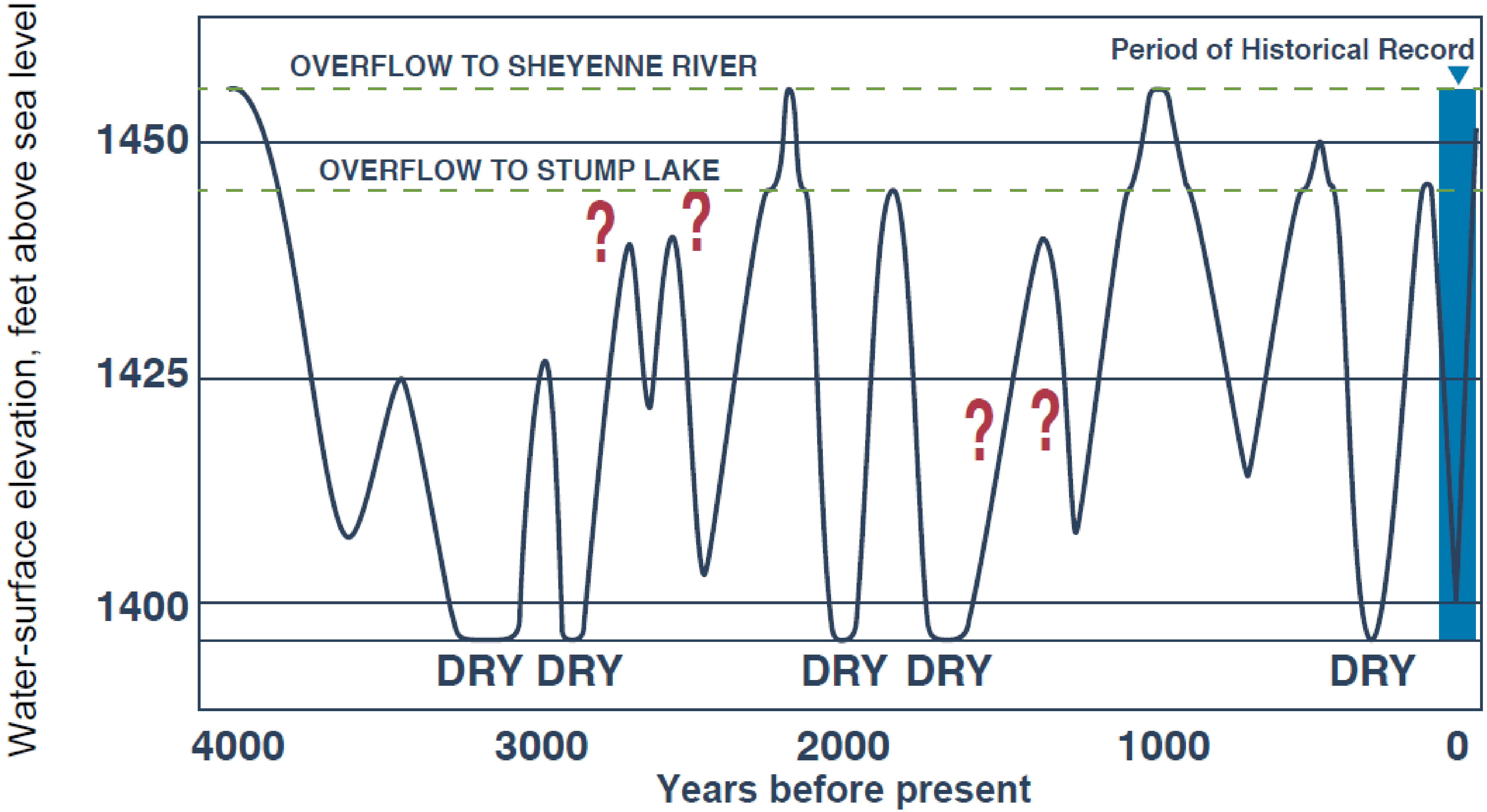



Explanation

— Devils Lake water-surface elevation estimate

? periods of greater uncertainty regarding lake level

--- Water-surface elevations at which the lake, normally a closed basin, connects to Stump Lake or overflows such that it drains to the Sheyenne River.

Estimates of Devils Lake water-surface elevation over the last 4,000 years, based on sediment-core data (Callender, 1968) and radio-carbon dating of soils (Bluemle, 1991). Modified from North Dakota Department of Water Resources, https://www.dwr.nd.gov/basins/devils_lake/dl_basin.html.

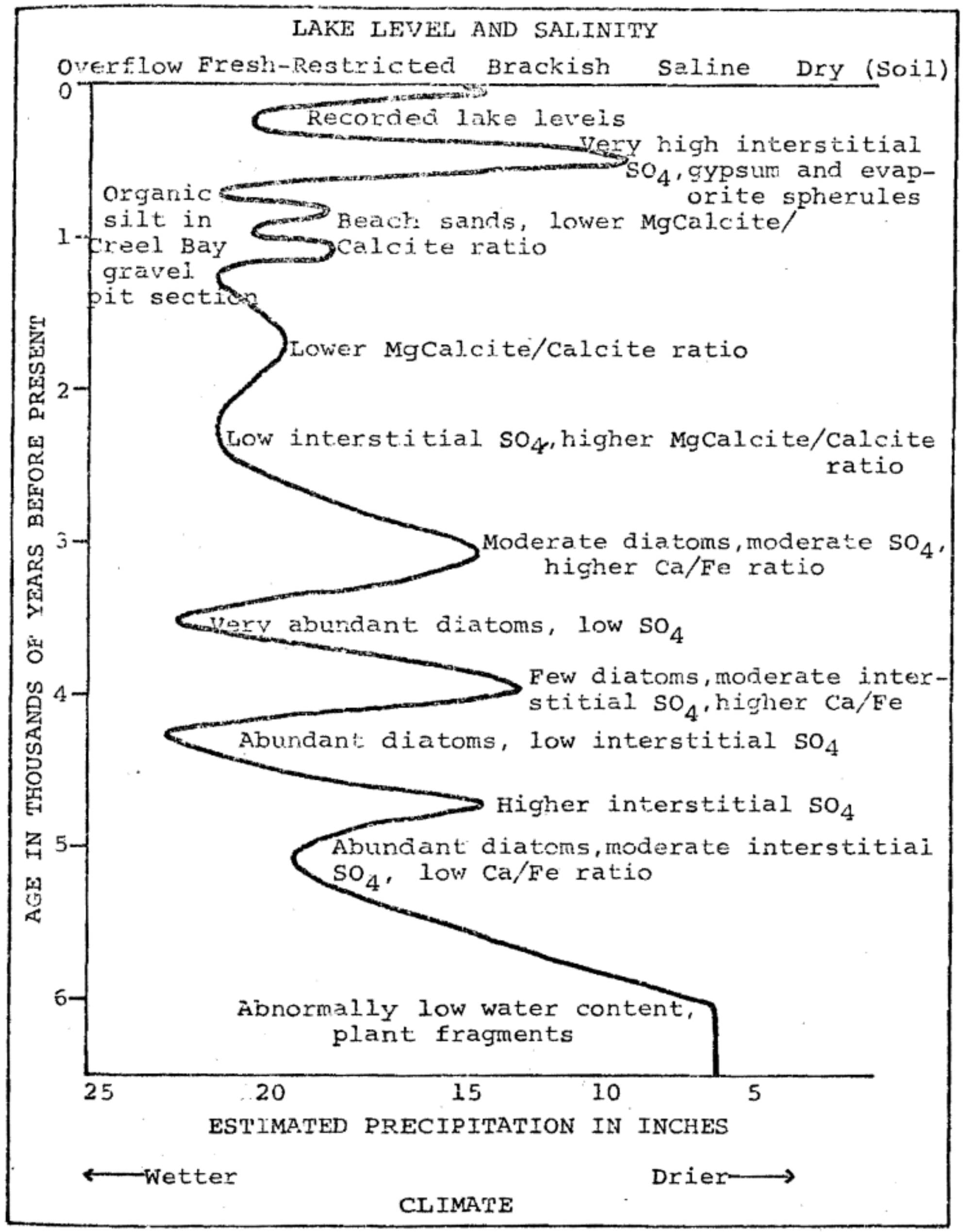



Figure 45.--Chronology of fluctuating lacustrine conditions in Devils Lake, North Dakota.

Callender, E., 1968, The postglacial sedimentology of Devils Lake, North Dakota: Grand Forks, North Dakota, University of North Dakota, Ph.D. dissertation, 312 p., https://commons.und.edu/theses/46/.

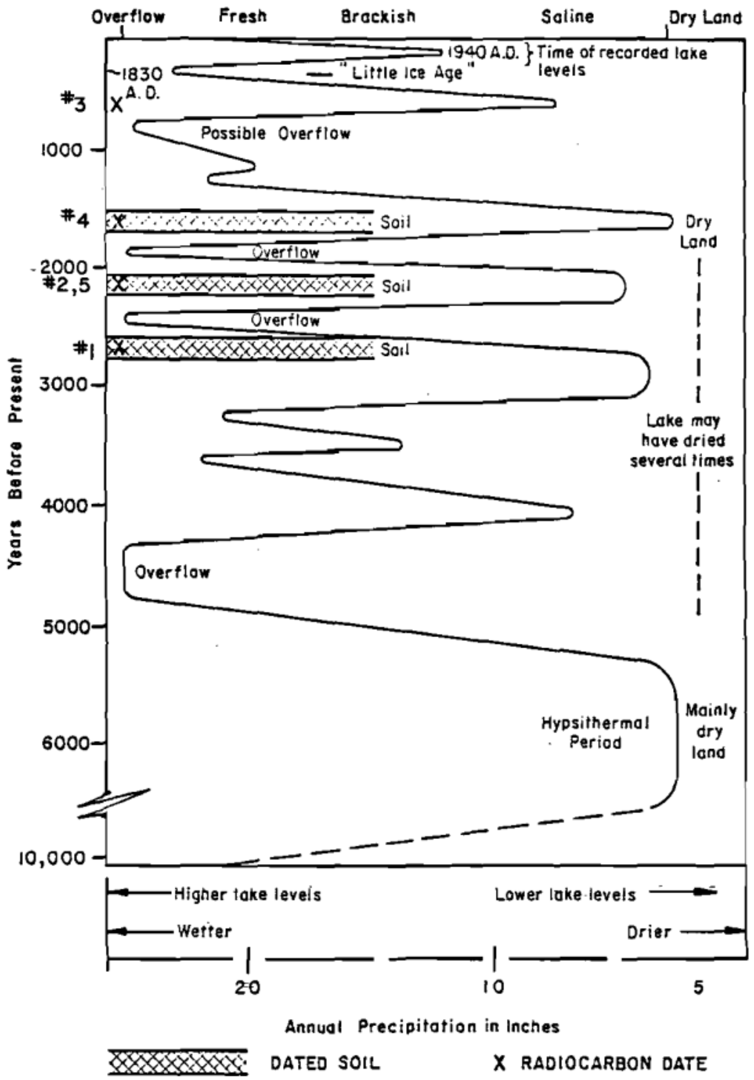
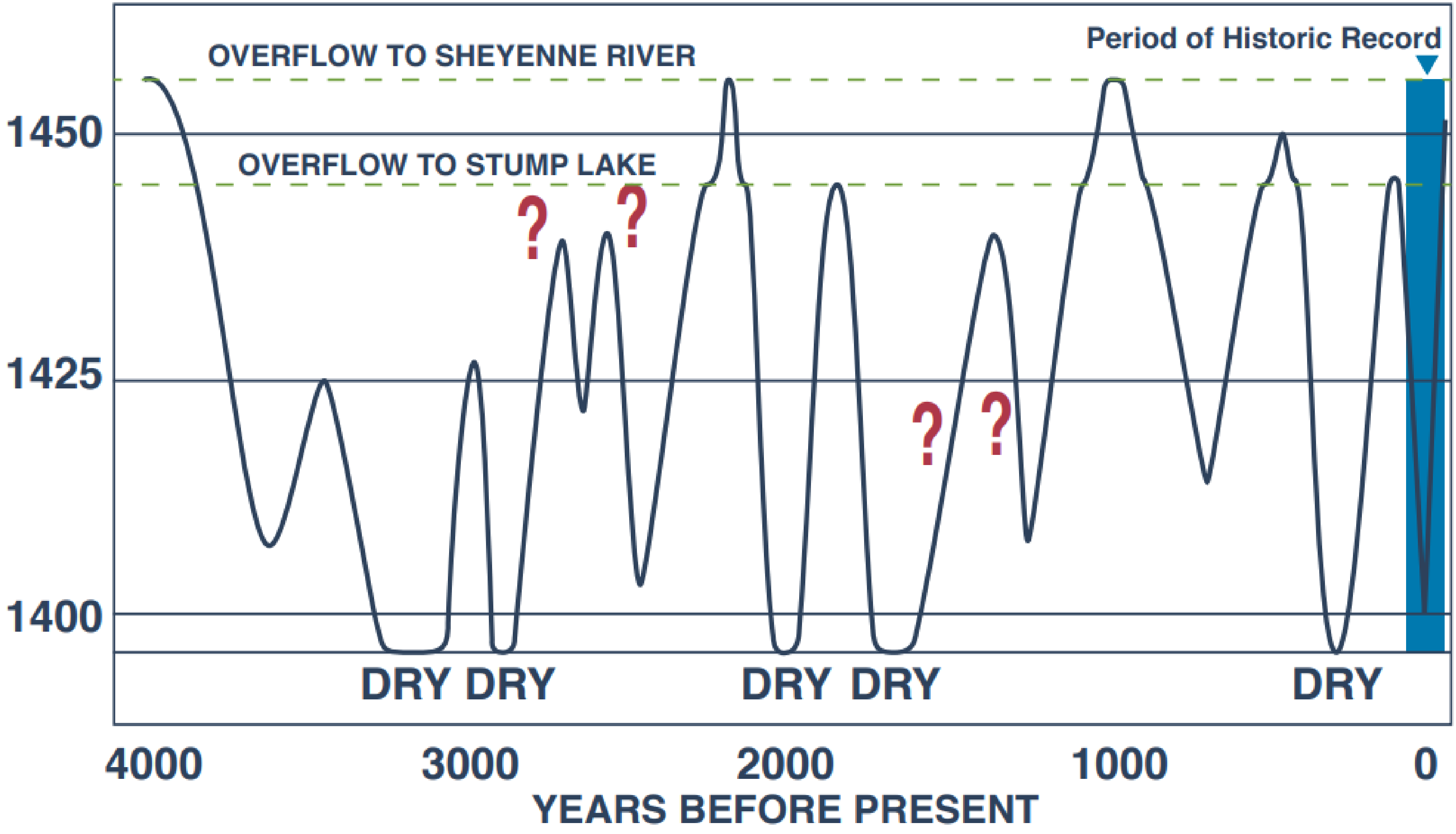



Figure 7. Time/event diagram for Devils Lake. The lake has dried comletely a number of times and it has overflowed to Stump Lake several times. Geologic evidence obtained during the present study---radiocarbon dates on soils covered by beach deposits--prove that the lake overflowed to Stump Lake about 1,800 years ago.

Bluemle, J.P., 1991, Radiocarbon dating of beaches and outlets of Devils Lake: North Dakota Geological Survey Miscellaneous Series No. 75, 10 p., https://www.dmr.nd.gov/ndgs/documents/Publication_List/pdf/MiscSeries/MS-75.pdf.




https://www.swc.nd.gov/pdfs/4000_year_levels.pdf

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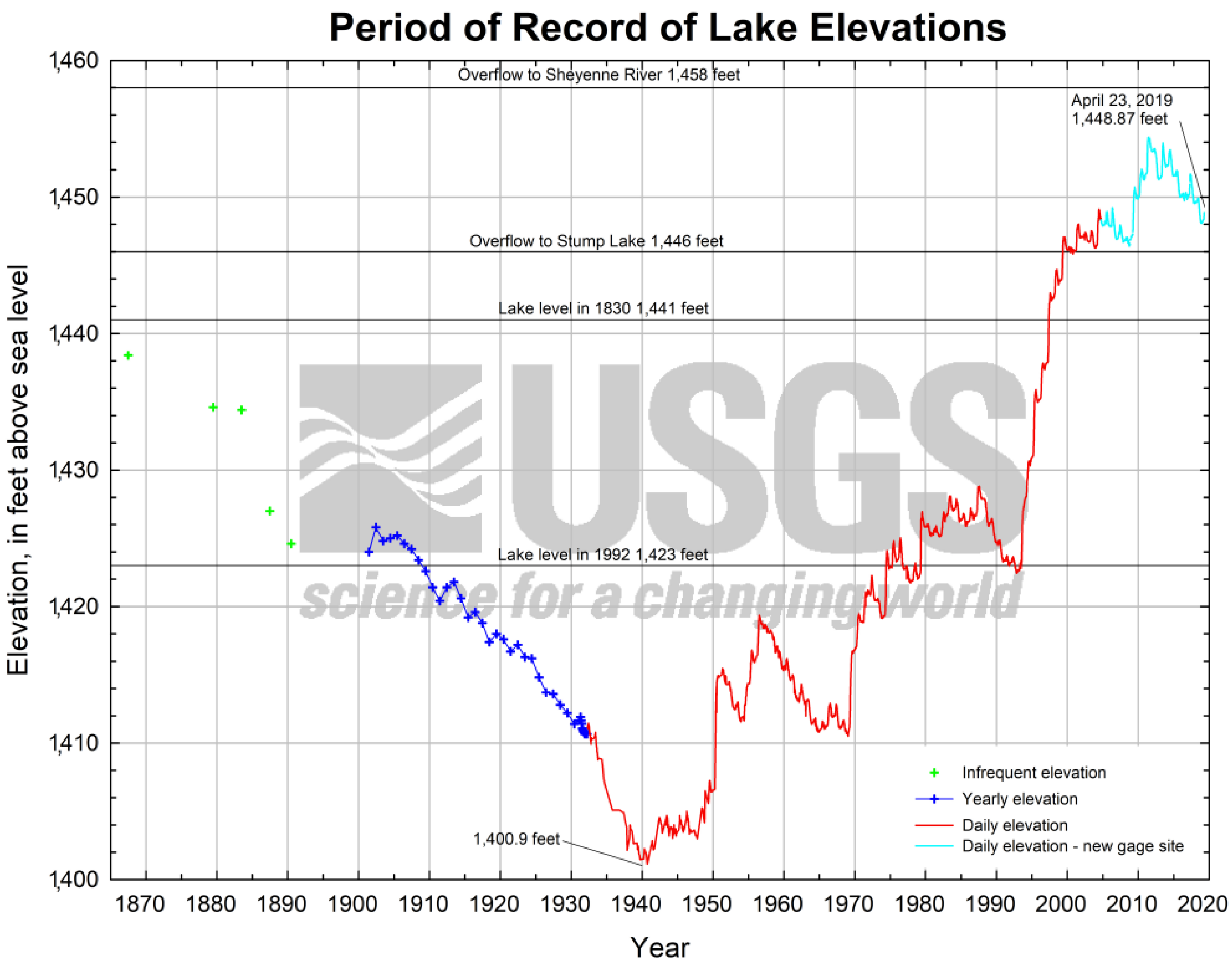

Period of Record of Lake Elevations
Overflow to Sheyenne River 1,458 feet
April 23, 2019
1,448.87 feet
Overflow to Stump Lake 1,446 feet
Lake level in 1830 1,441 feet
Lake level in 1992 1,423 feet
1,400.9 feet
Elevation, in feet above sea level
Year
1,460
1,450
1,440
1,430
1,420
1,410
1,400
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Infrequent elevation
Yearly elevation
Daily elevation
Daily elevation - new gage site
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science for a changing world

# Devils Lake Fishery

- The Devils Lake fishery began diminishing in 1888 and prompted a government study by the Bureau of Fisheries in 1907.
- Excessive evaporation that resulted in the "loss of vast spawning and feeding grounds" was noted.
- According to Pope (1908):

  "Records of former years indicate that the level of the lake fluctuates to a considerable extent and a substantial increase may occur at any future date, but in view of the deficient precipitation disclosed by recent records for this section, the increasing development of surrounding territory, and the history of the lake for the past twenty-five years, it is extremely doubtful whether it will ever regain its former level."

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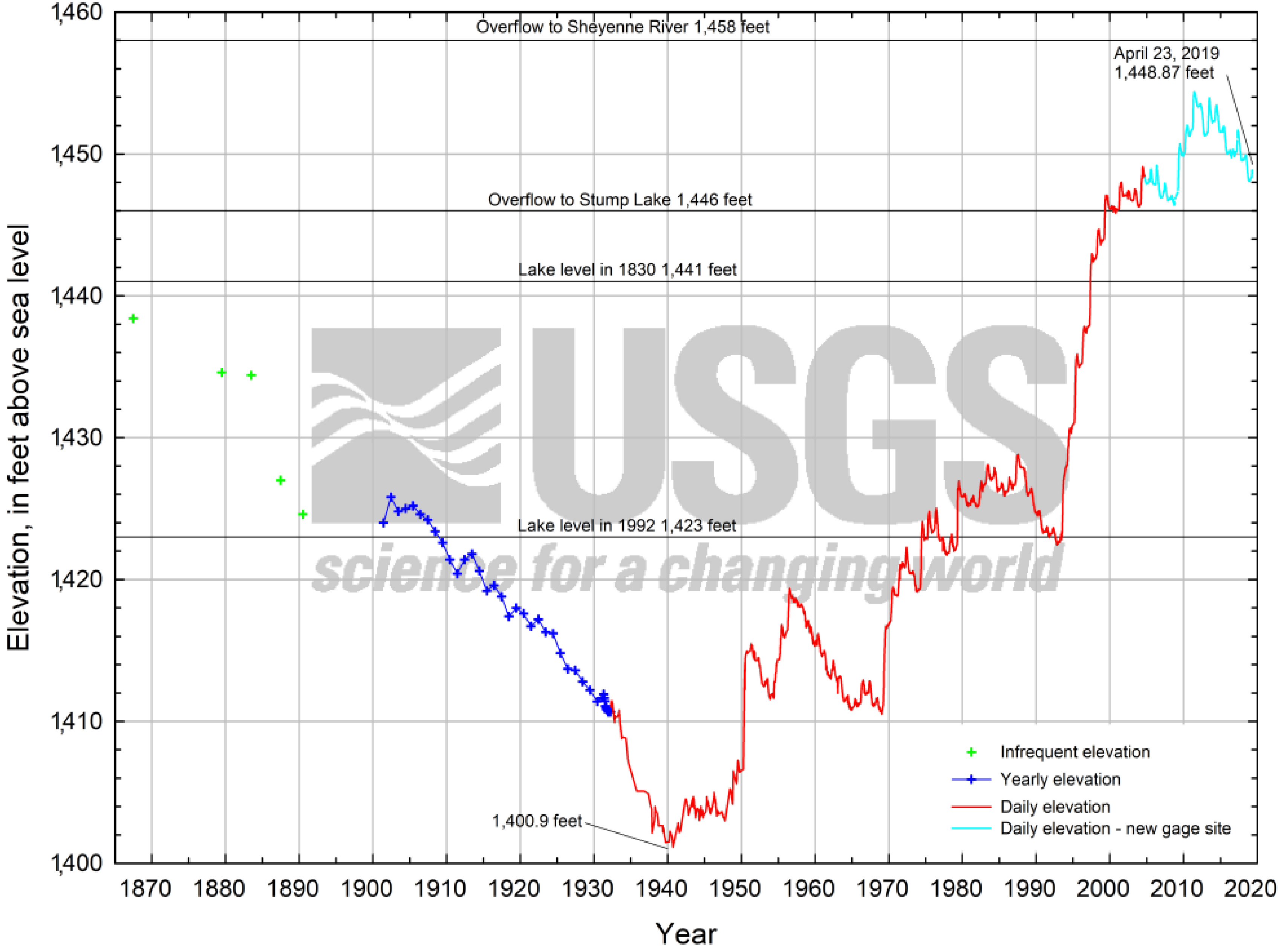


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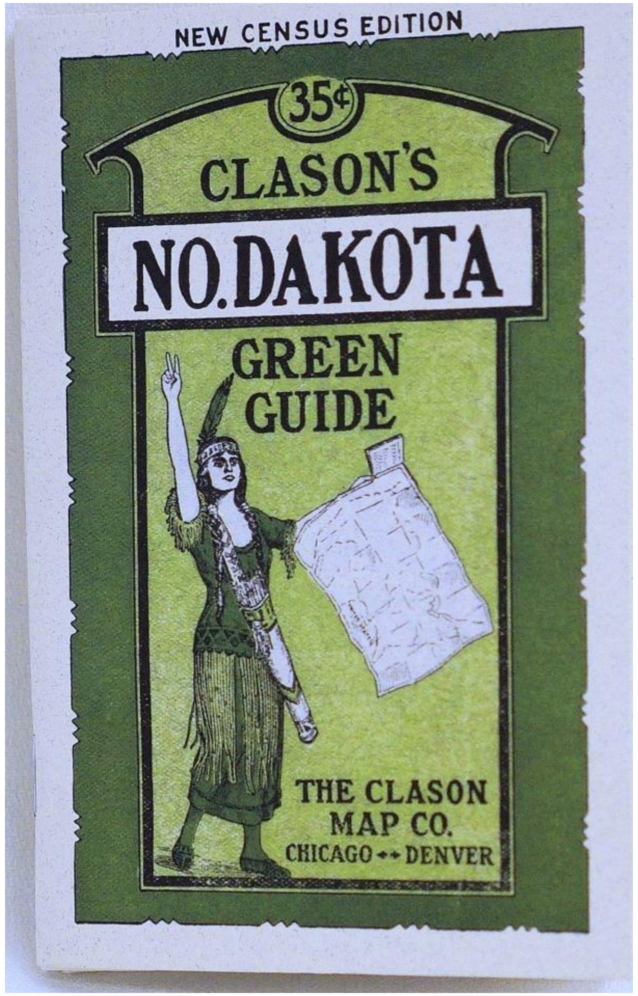
# 1920




Credit: State Historical Society of North Dakota

- Distributed by the Commissioner of Immigration to attract residents, said of Devils Lake:

  "It is salty, but unlike the famous Great Salt Lake of Utah, its water is very similar to that of the ocean. Bathing here offers all the exhilaration of ocean bathing. The lake is used for sailing, and on its banks is the club house of the Devil's Lake Yacht club, having a membership of over one hundred.

  As only salt water fish can live in this water, the Biological Department of the State University is stocking it. Let us hope they put in a few young whales and a walrus or two for variety."

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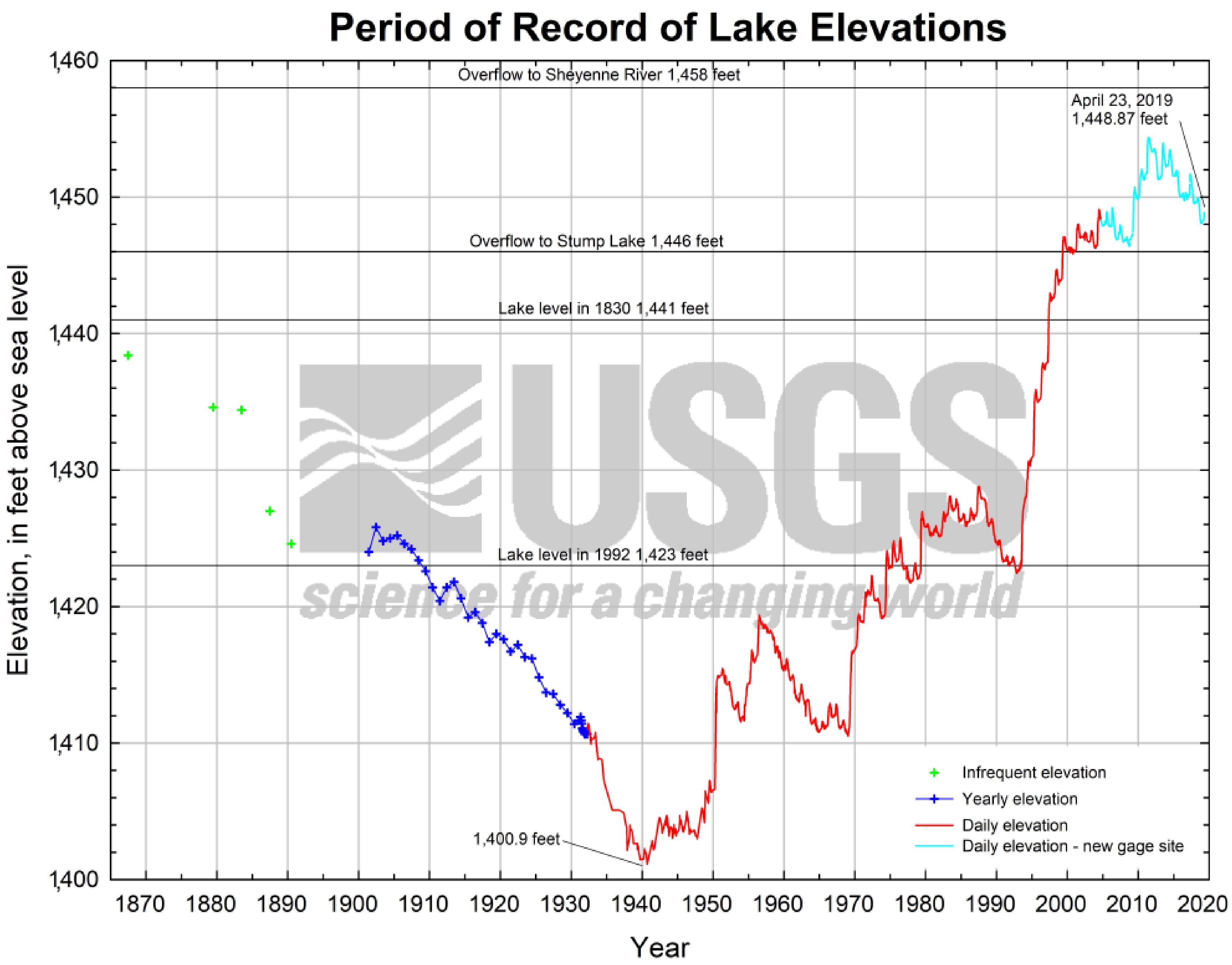

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Daily elevation - new gage site
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# FDR visits Devils Lake in 1934

INFORMAL REMARKS OF THE PRESIDENT
DEVILS LAKE, NORTH DAKOTA
August 7, 1934

Senator Nye, my friends of North Dakota: I cannot honestly say that my heart is happy today, because I have seen with my own eyes some of the things that I have been reading and hearing about, for a year and more. The reason I came here was that I wanted to see something at first hand of a problem that has perplexed me and perplexed many other people ever since I have been in office. It is a problem. I would not try to fool you by saying we know the solution of it. We don't.

I believe in being frank, and what I can tell you from the bottom of my heart, truthfully, is this: If it is possible for us to solve the problem, we are going to do it.

I saw some signs along the road that said: "You gave us beer, now give us water."

Well, the beer part was easy.

That was something that could be controlled very definitely by human agency. It was a question of what the people of this country wanted and when they made it clear they wanted beer back again, they got it. But, when you come to this water problem through here, you are up against two things. In the first place you are up against the forces of nature and, secondly, you are up against the fact

- 2 -

that man, in his present stage of development cannot definitely control those forces.

I think it was more than a year ago that the delegation of this State, in the Senate and the House, first talked to me about the problem of this watershed in northern North Dakota. I have been studying it ever since.

It is all very well to say, "Let's have a dam across the Missouri River." I would love to do it, but when a great many engineers tell me they haven't found a safe place for that dam, there isn't a man or woman in the Devils Lake area that would ask me to build a dam that might go out and drown many thousand people.

In other words, I have a responsibility. I cannot build a dam unless I have the best engineering assurance that it is not only the right thing to do, but the safe thing to do.

And, the result is, my friends, that today there is more of what you might call government talent -- experts from different departments in the Government service -- fine people with good knowledge and training -- and they are getting the views of civilians and State employees and trying to find a solution of this problem.

Soon after I get back to Washington many of the studies being made this summer by engineering and agricultural officials will be completed. I expect to confer

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*The Cullen–Harrison Act, signed by President Franklin D. Roosevelt on March 22, 1933, authorized the sale of 3.2 percent beer (thought to be too low an alcohol concentration to be intoxicating).

Informal Remarks of the President at Devils Lake, North Dakota, pages 1 and 2, August 7, 1934; SA32; First Carbon Files; 1820; PPF; Franklin D. Roosevelt Library (NLR), 4079 Albany Post Road, Hyde Park, NY 12538; Retrieved from the National Archives and Records Administration, URL: http://www.nara.gov/, July 25, 2002.

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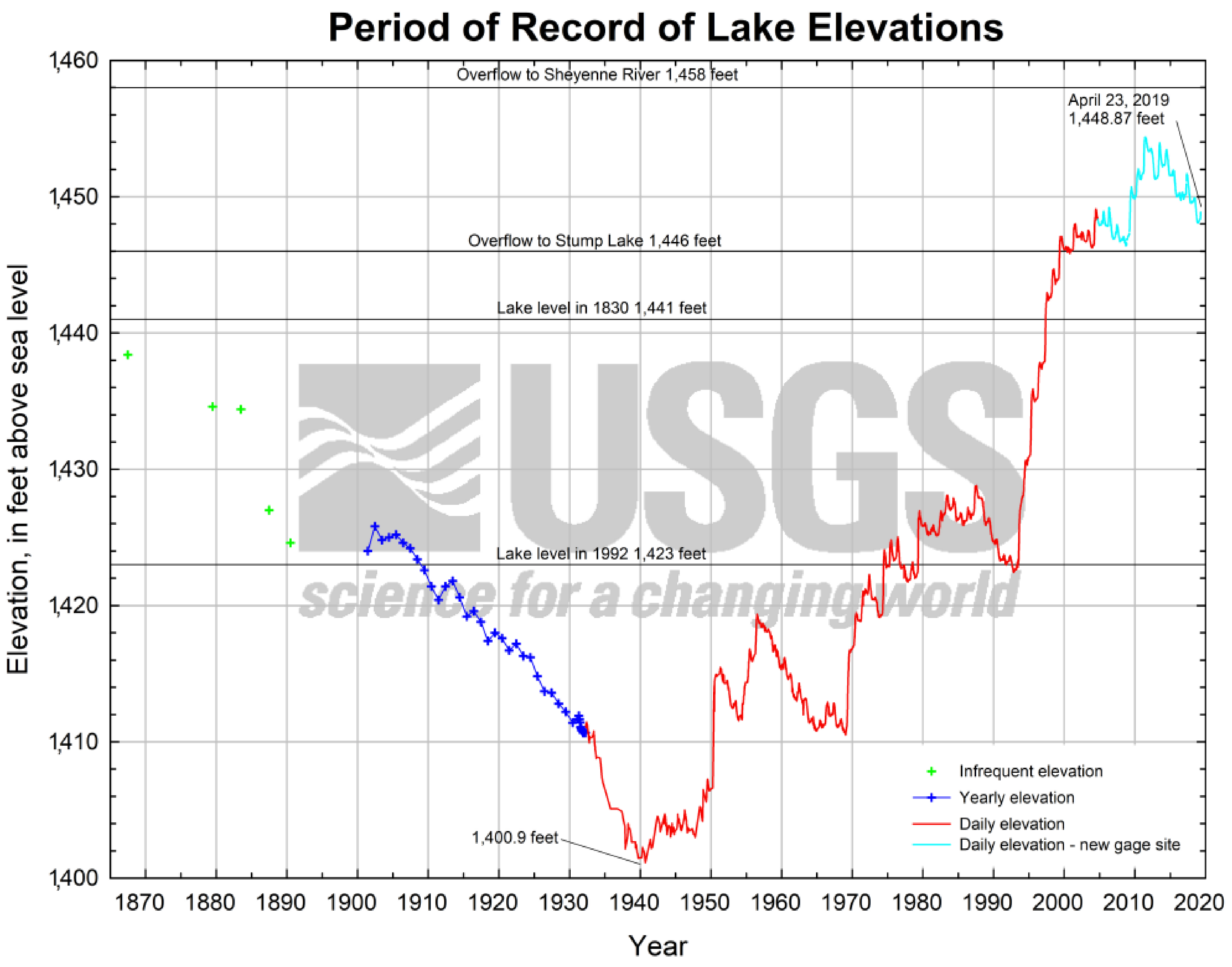
GRAHAMS ISLAND STATE PARK
is dedicated to
SIVERT W. THOMPSON
whose personal commitment
to bringing Missouri River
water to stabilize the level of
Devils Lake and provide multiple
benefits to North Dakota earned
him the affectionate title of
"FATHER OF MISSOURI RIVER DIVERSION"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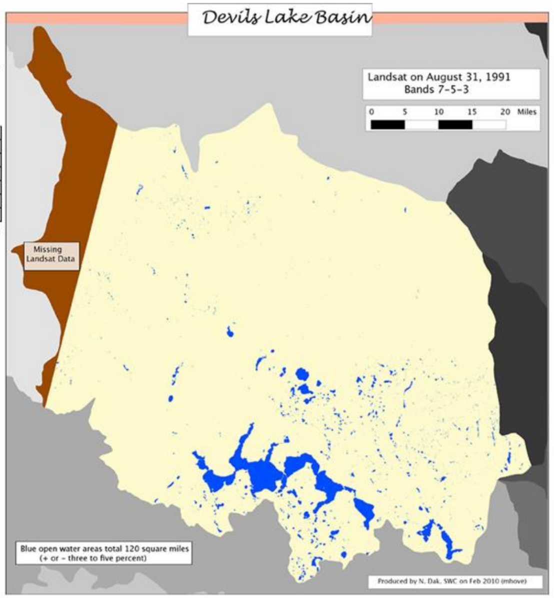
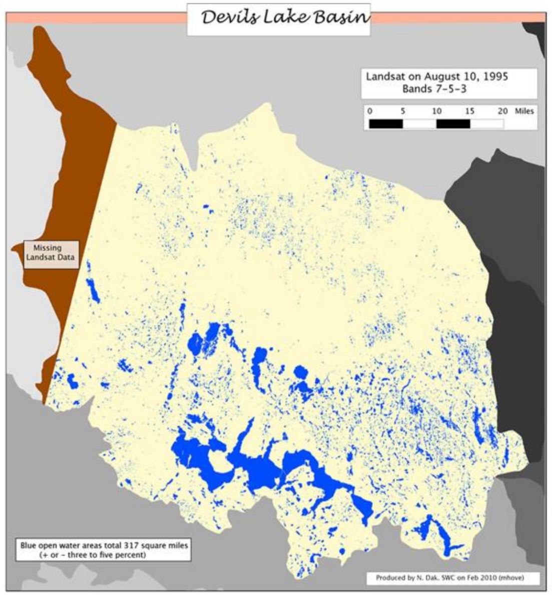
17
W
Dry Lake
(breakout on west)

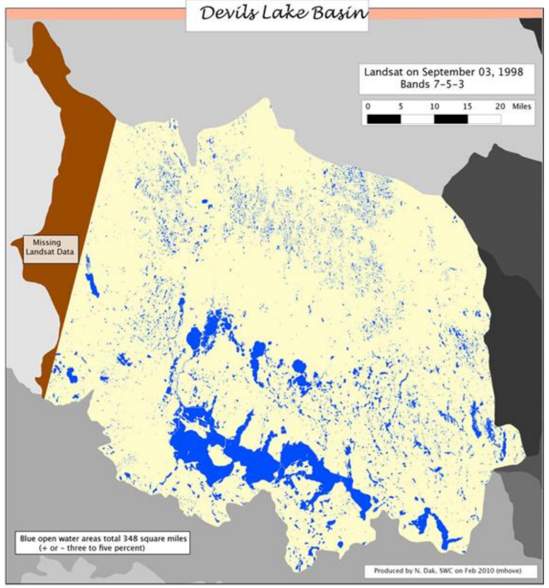

Edmore, ND
50

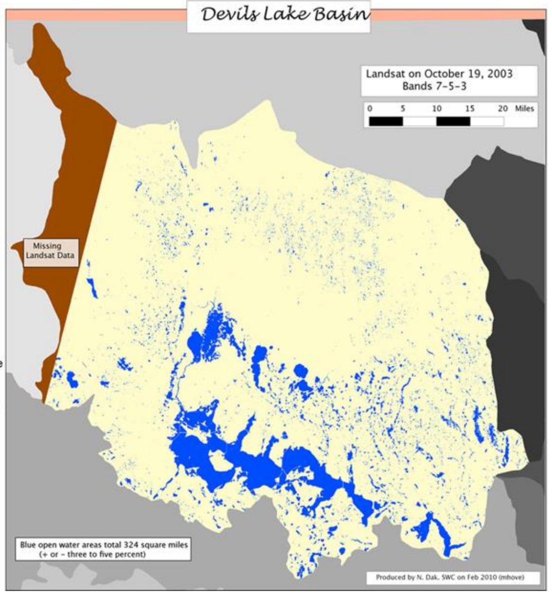

39
S
Edmore Coulee
tributary

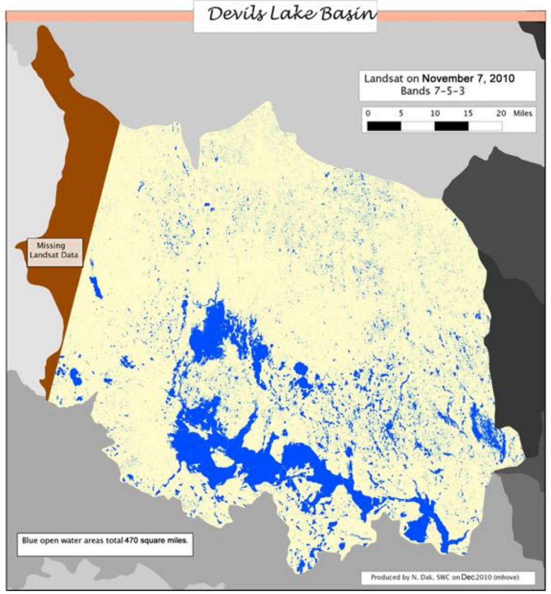
USGS

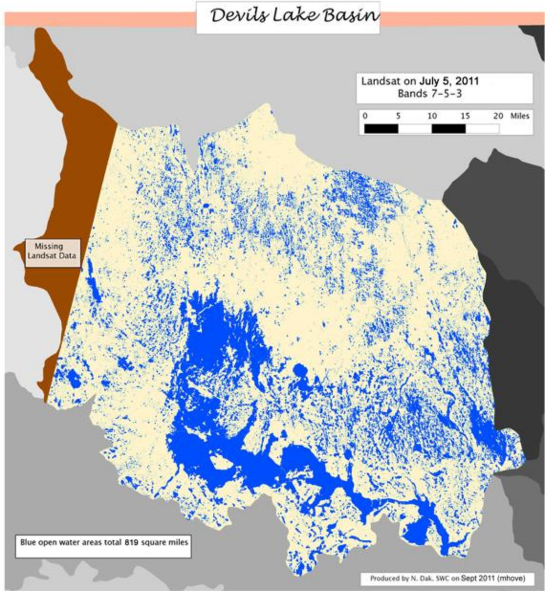


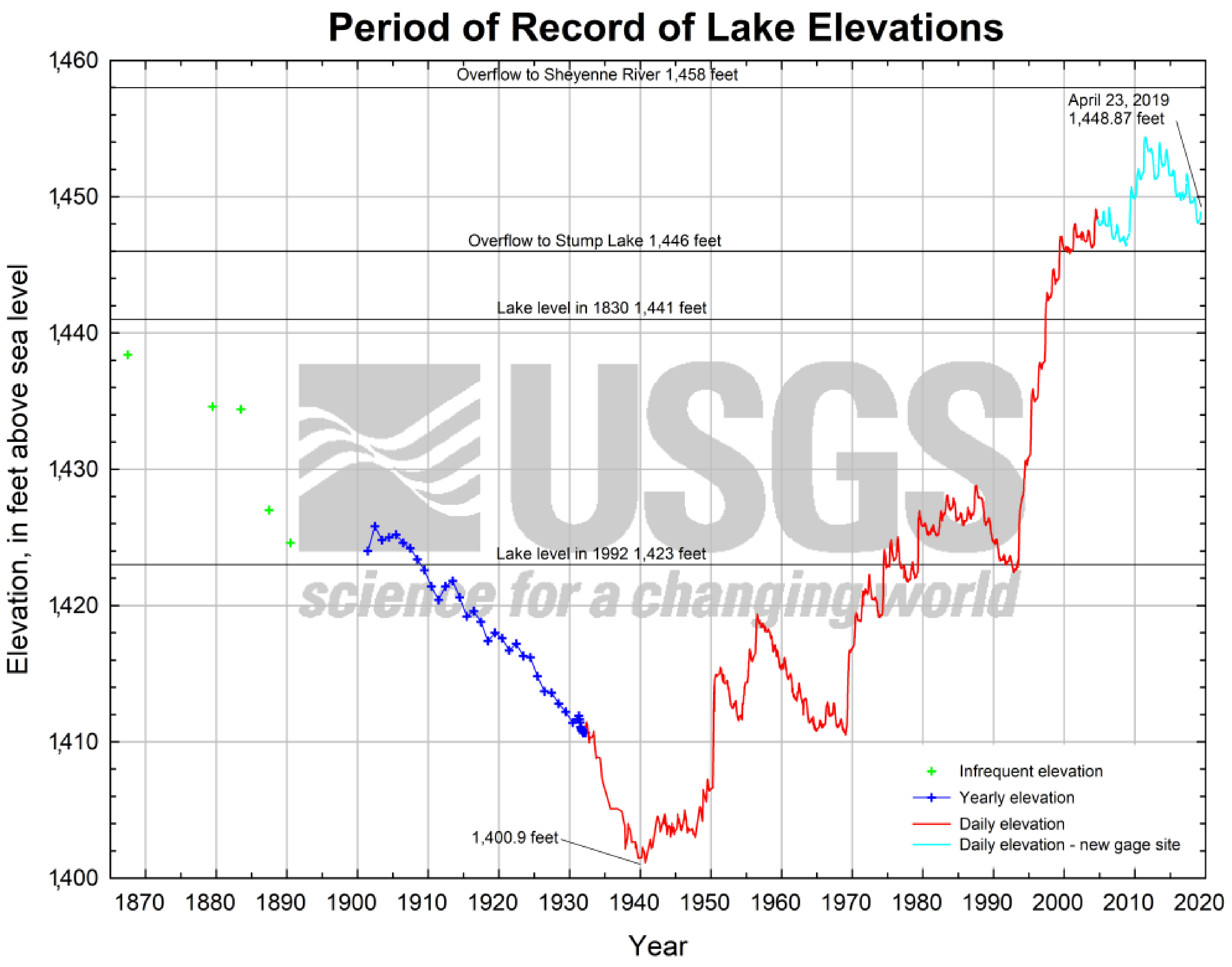

USGS

https://www.swc.nd.gov/graphic_files/h2o_cover_final_map.png

# Vecchia

- Devils Lake flooding depends on long-term climatic conditions in the basin.
- In about 1980, a large, abrupt increase in precipitation occurred in the Devils Lake Basin and wetter-than-normal conditions have persisted through the present.
- Climatic conditions in the Devils Lake Basin may consist of two equilibrium states: a dry state similar to 1950–79 and a wet state similar to 1980–2006.
- Existence of any intermediate states is unlikely.
- The average duration of the wet states estimated to be 30 years and the average duration of the dry states estimated to be 120 years.


USGS

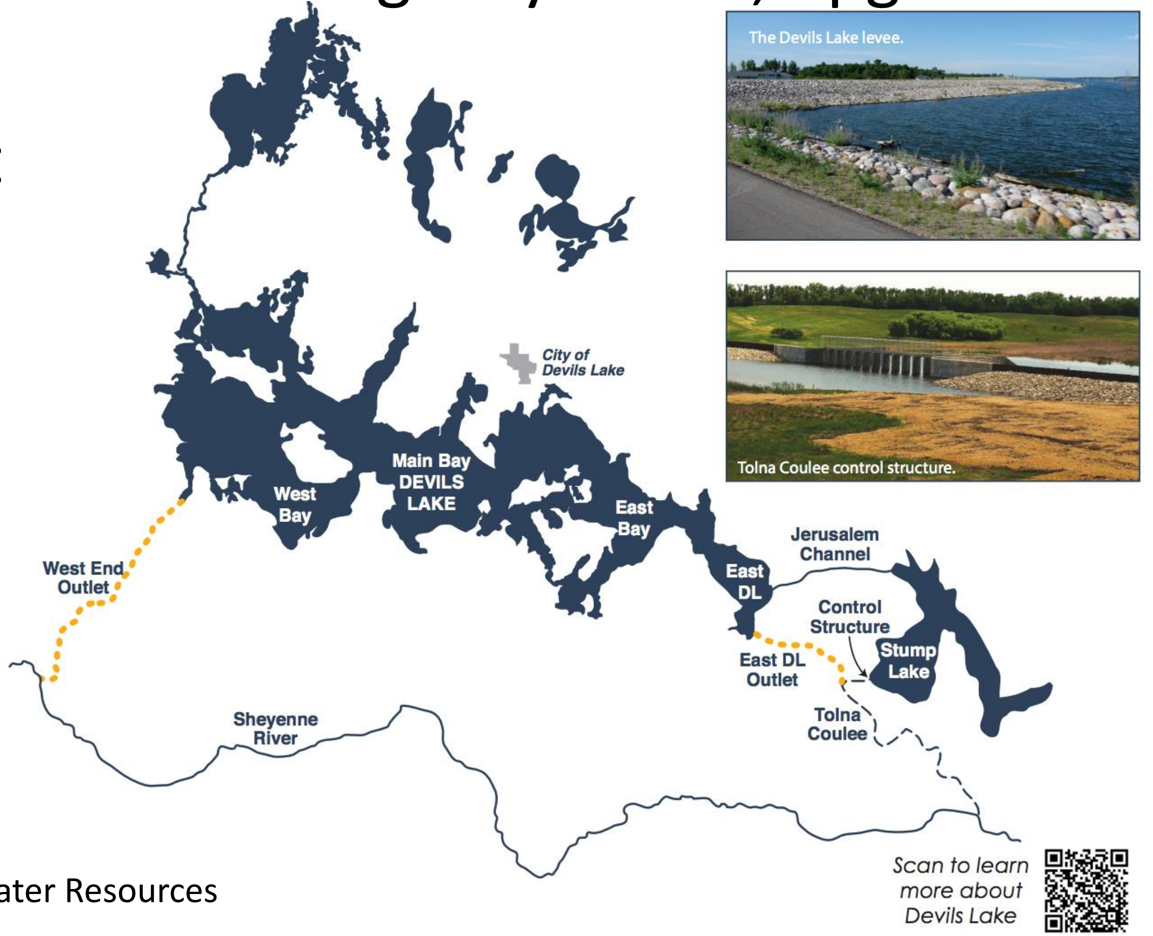


Period of Record of Lake Elevations
Overflow to Sheyenne River 1,458 feet
April 23, 2019
1,448.87 feet
Overflow to Stump Lake 1,446 feet
Lake level in 1830 1,441 feet
Lake level in 1992 1,423 feet
1,400.9 feet
Elevation, in feet above sea level
Year
1,400
1,410
1,420
1,430
1,440
1,450
1,460
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Infrequent elevation
Yearly elevation
Daily elevation
Daily elevation - new gage site
USGS
science for a changing world


USGS

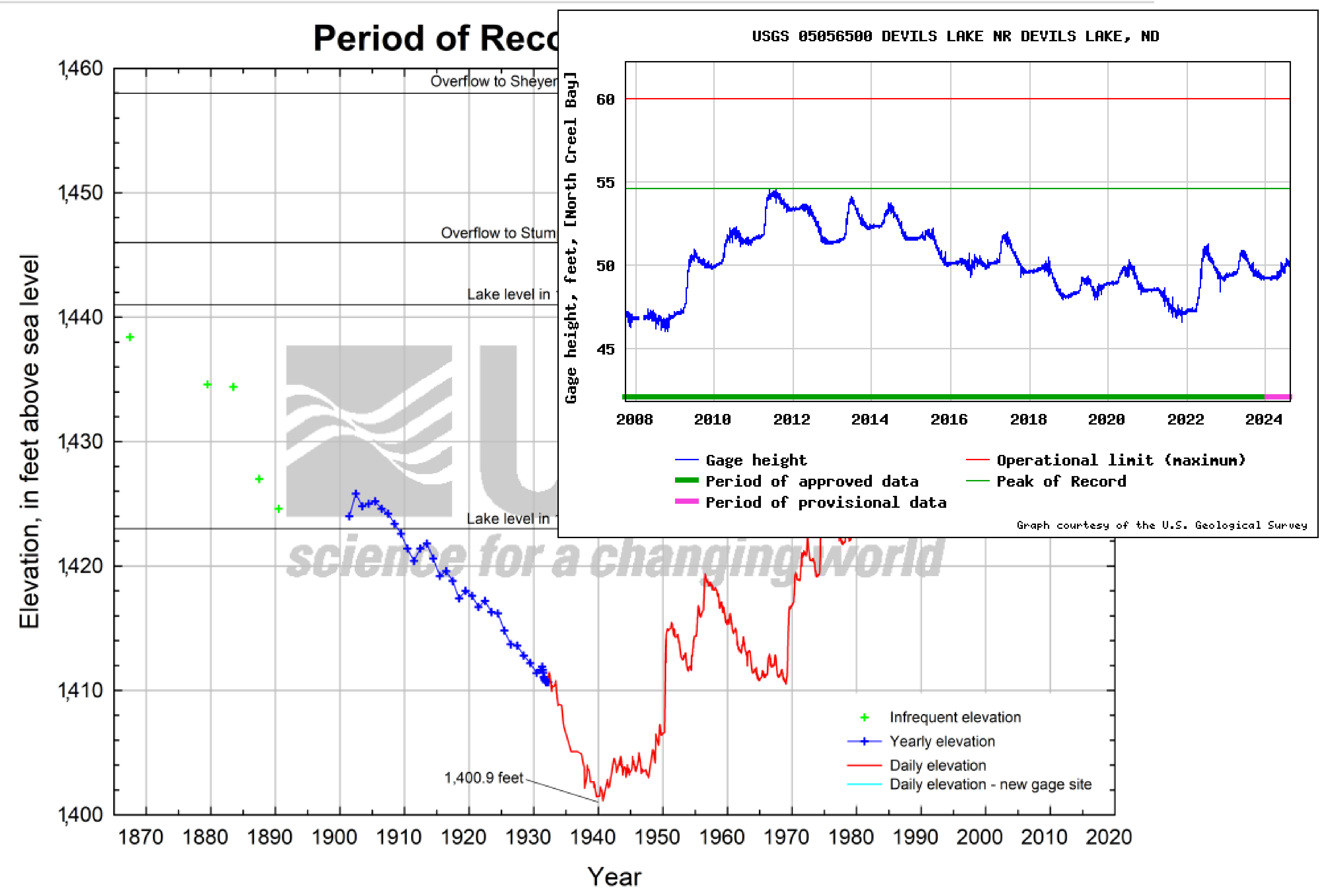
# Outlets

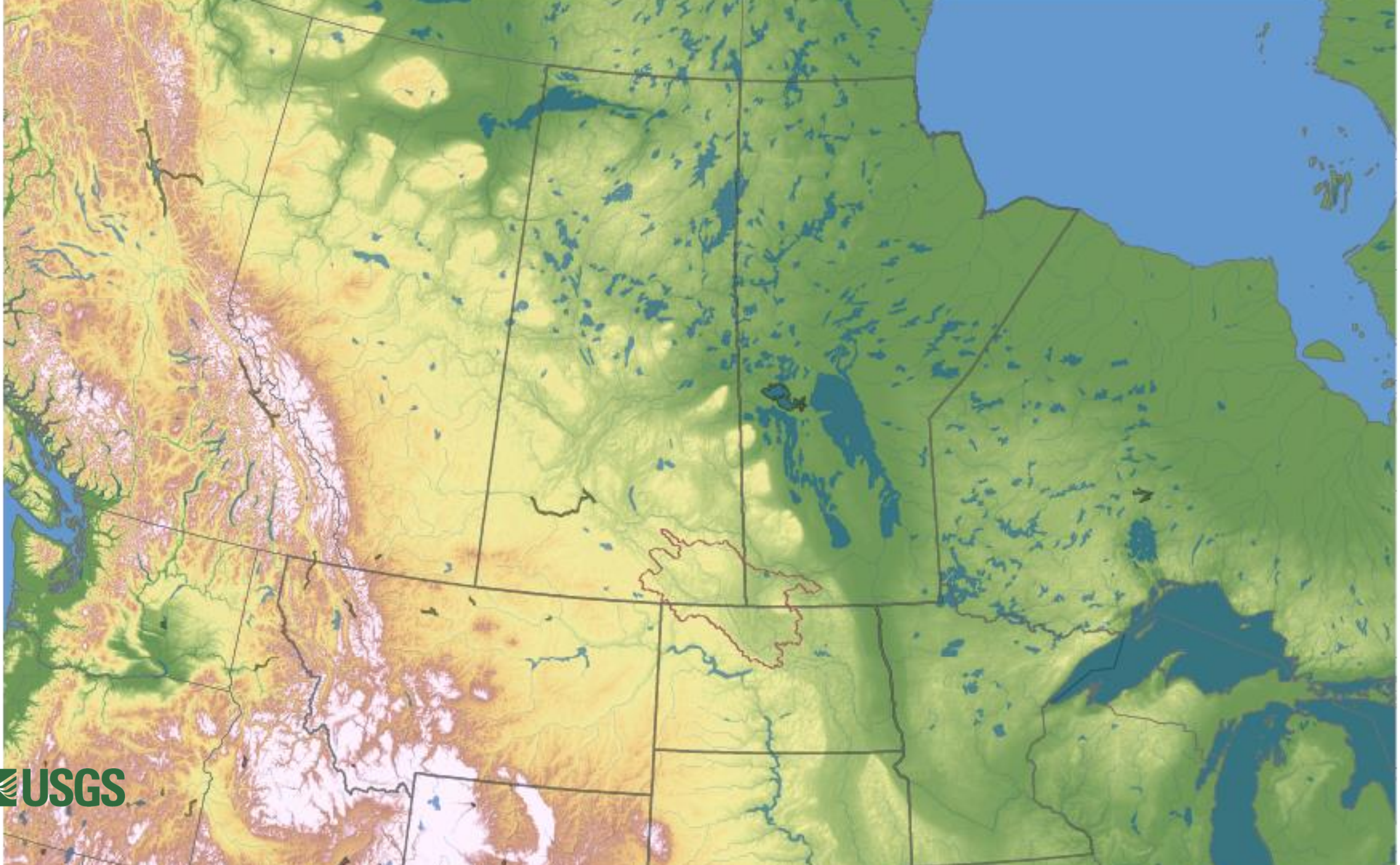
- West Devils Lake Outlet, 100 cfs emergency outlet, upgraded to 250 cfs
- East Devils Lake Outlet, 350 cfs emergency outlet
- Stump Lake Emergency Control Structure

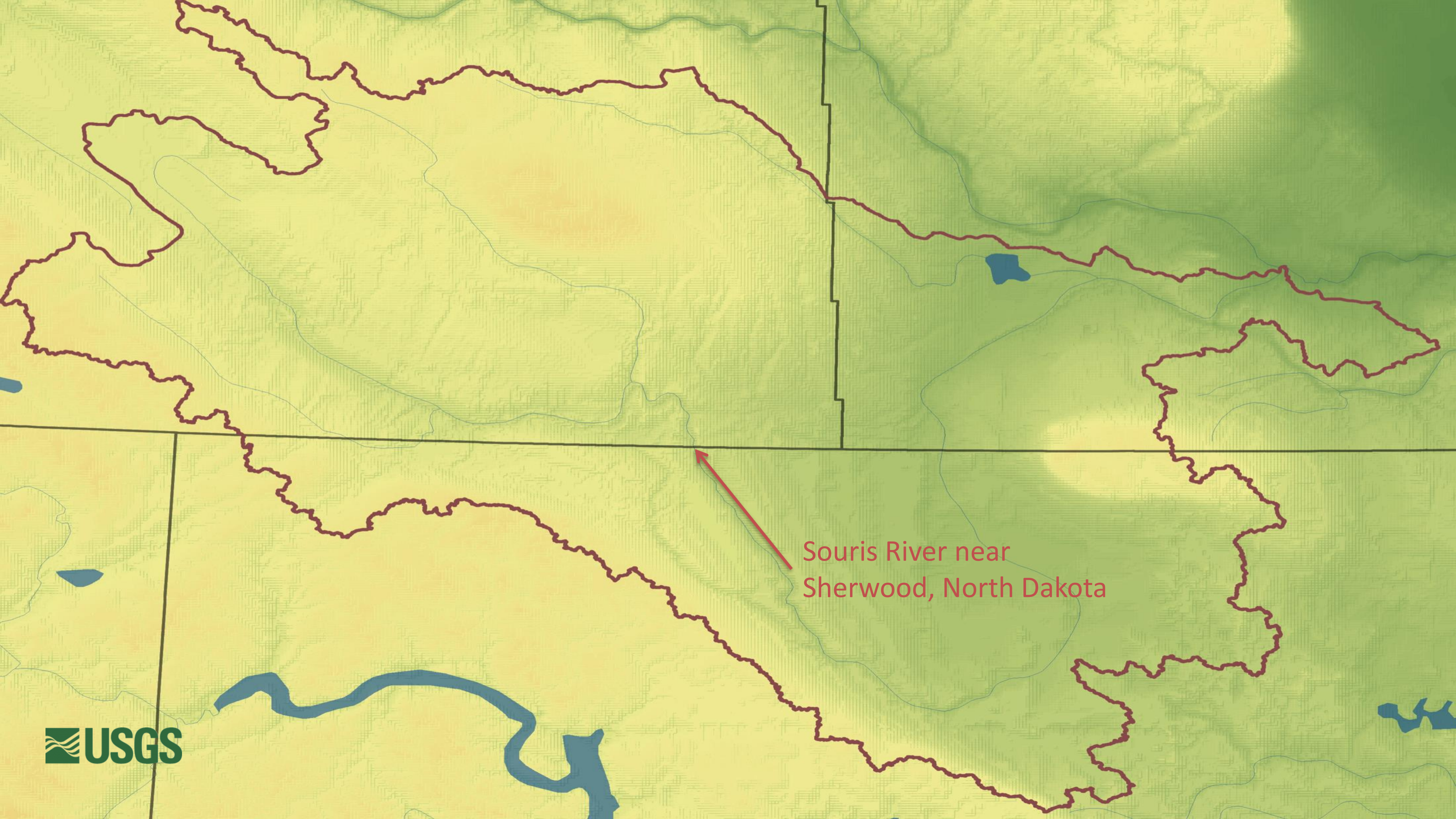


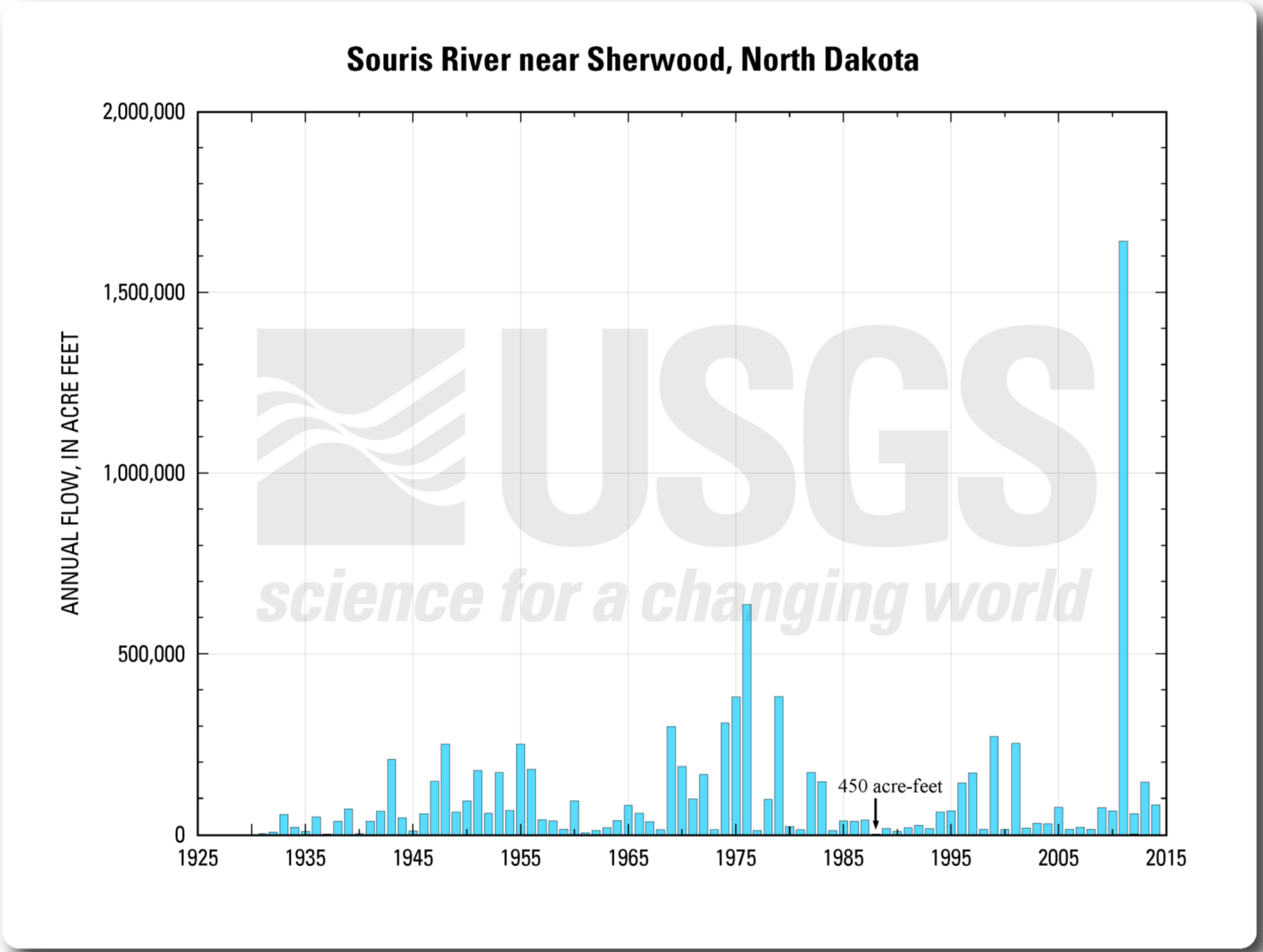

USGS

Credit: North Dakota Department of Water Resources


Period of Reco
Overflow to Sheyen
Overflow to Stum
Lake level in
Lake level in
1,460
1,450
1,440
1,430
1,420
1,410
1,400
Elevation, in feet above sea level
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year
1,400.9 feet
Infrequent elevation
Yearly elevation
Daily elevation
Daily elevation - new gage site
science for a changing world
USGS 05056500 DEVILS LAKE NR DEVILS LAKE, ND
Gage height, feet, [North Creel Bay]
60
55
50
45
2008
2010
2012
2014
2016
2018
2020
2022
2024
Gage height
Period of approved data
Period of provisional data
Operational limit (maximum)
Peak of Record
Graph courtesy of the U.S. Geological Survey




Souris River near
Sherwood, North Dakota
USGS


Souris River near Sherwood, North Dakota
ANNUAL FLOW, IN ACRE FEET
2,000,000
1,500,000
1,000,000
500,000
0
1925
1935
1945
1955
1965
1975
1985
1995
2005
2015
450 acre-feet
USGS
science for a changing world


USGS
USGS
USGS
USGS
U.S. Geological Survey/photos by Joel Galloway

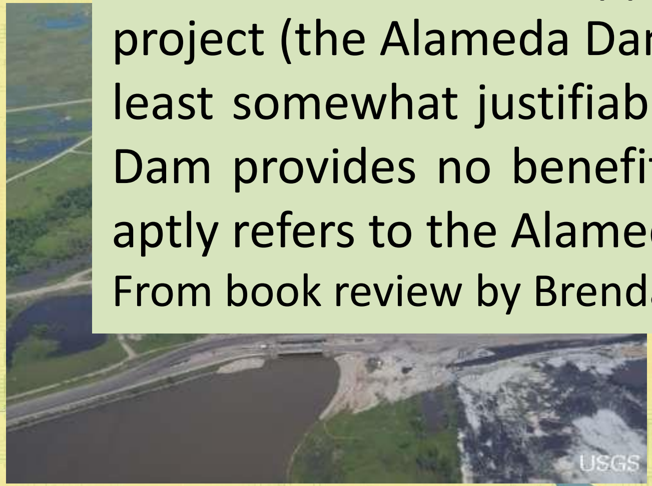


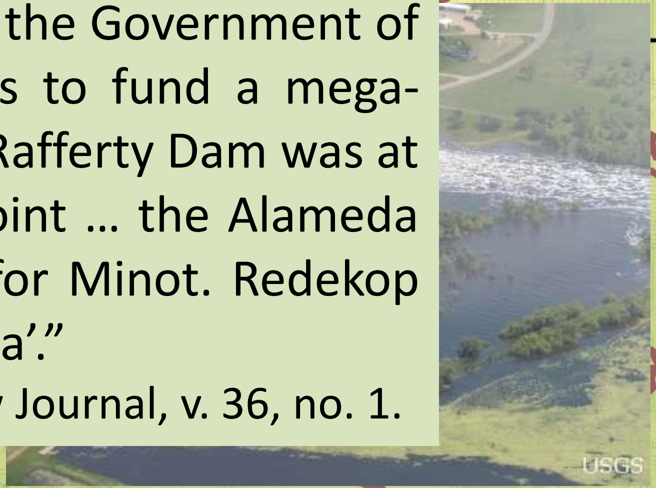
# Dams of Contention: The Rafferty-Alameda Story and the Birth of Canadian Environmental Law

2012, by Bill Redekop

“Saskatchewan Deputy Premier Eric Berntson is cast as the autocratic mastermind of the project, squarely in the pocket of the Government of North Dakota and happy to waste taxpayer dollars to fund a mega-project (the Alameda Dam) in his riding… While the Rafferty Dam was at least somewhat justifiable from a Canadian standpoint … the Alameda Dam provides no benefit beyond flood protection for Minot. Redekop aptly refers to the Alameda reservoir as ‘Lake America’.”

From book review by Brendan Jowett, 2012, Manitoba Law Journal, v. 36, no. 1.



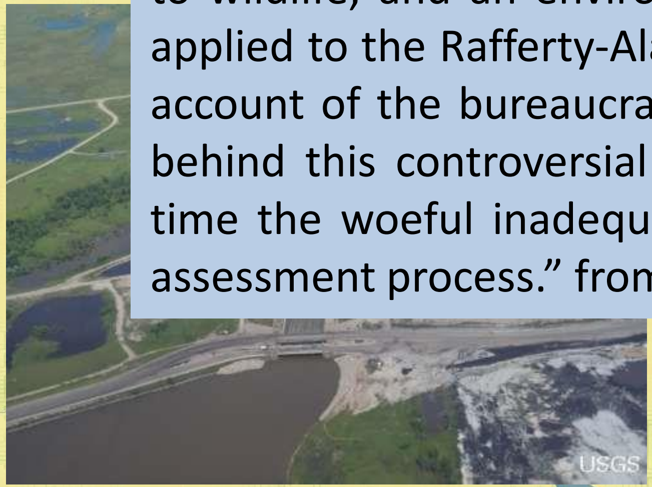

U.S. Geological Survey/photos by Joel Galloway

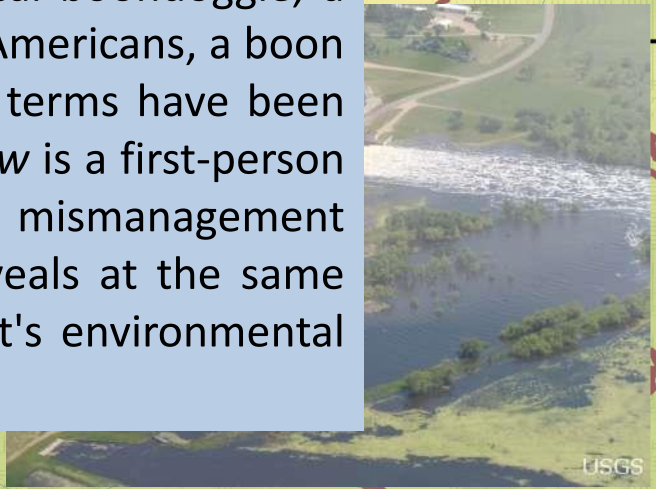


# Against the Flow: Rafferty-Alameda and the Politics of the Environment

## 1994, by George Hood, one of the "principals" involved in the project

"A landmark legal case, an economic panacea, a political boondoggle, a solution to the drought of the century, a sell-out to the Americans, a boon to wildlife, and an environmental holocaust - all these terms have been applied to the Rafferty-Alameda project. *Against the Flow* is a first-person account of the bureaucratic incompetence and political mismanagement behind this controversial dam development, which reveals at the same time the woeful inadequacy of the federal government's environmental assessment process." from back cover of book

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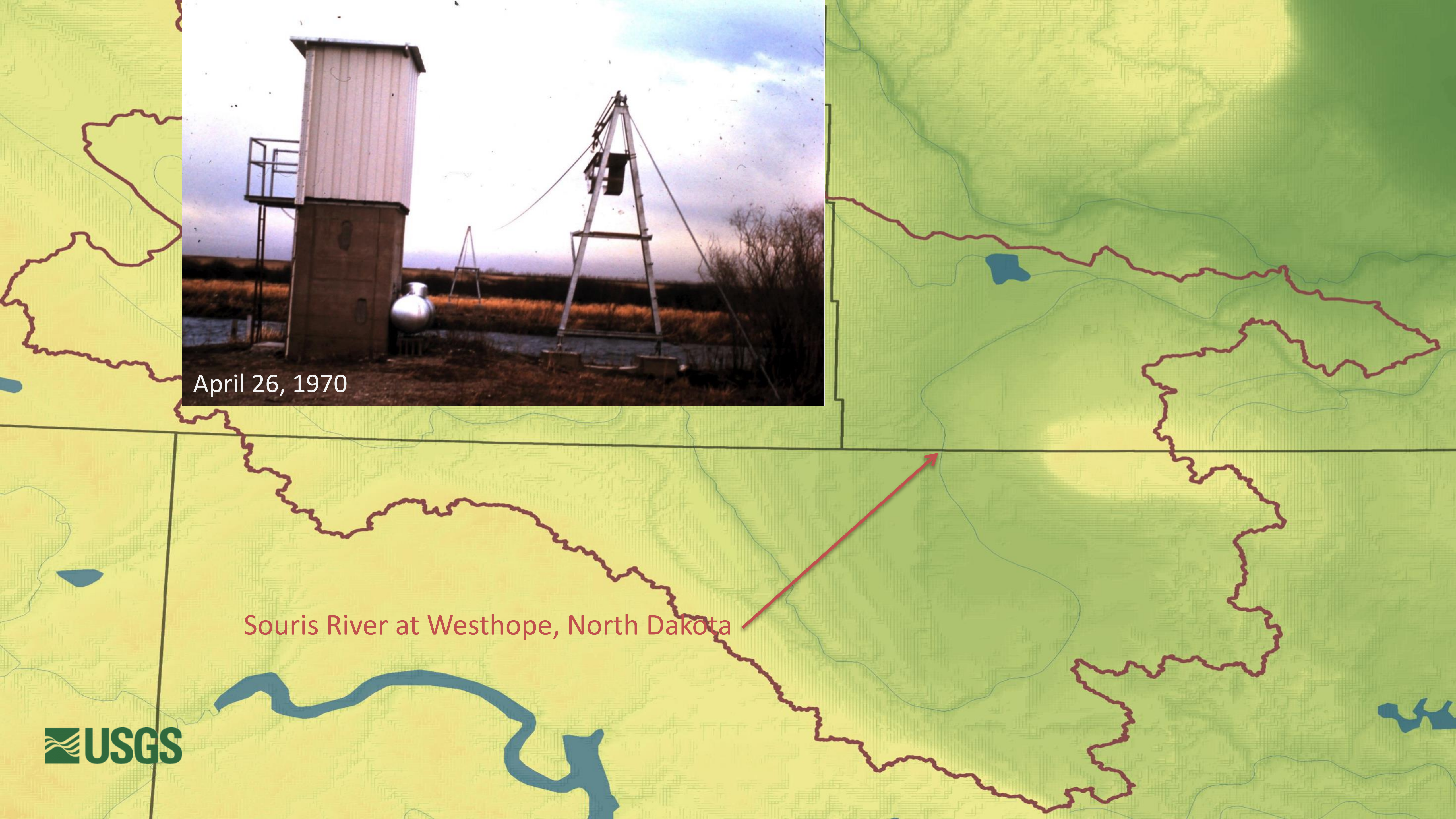
U.S. Geological Survey/photos by Joel Galloway


April 26, 1970
Souris River at Westhope, North Dakota

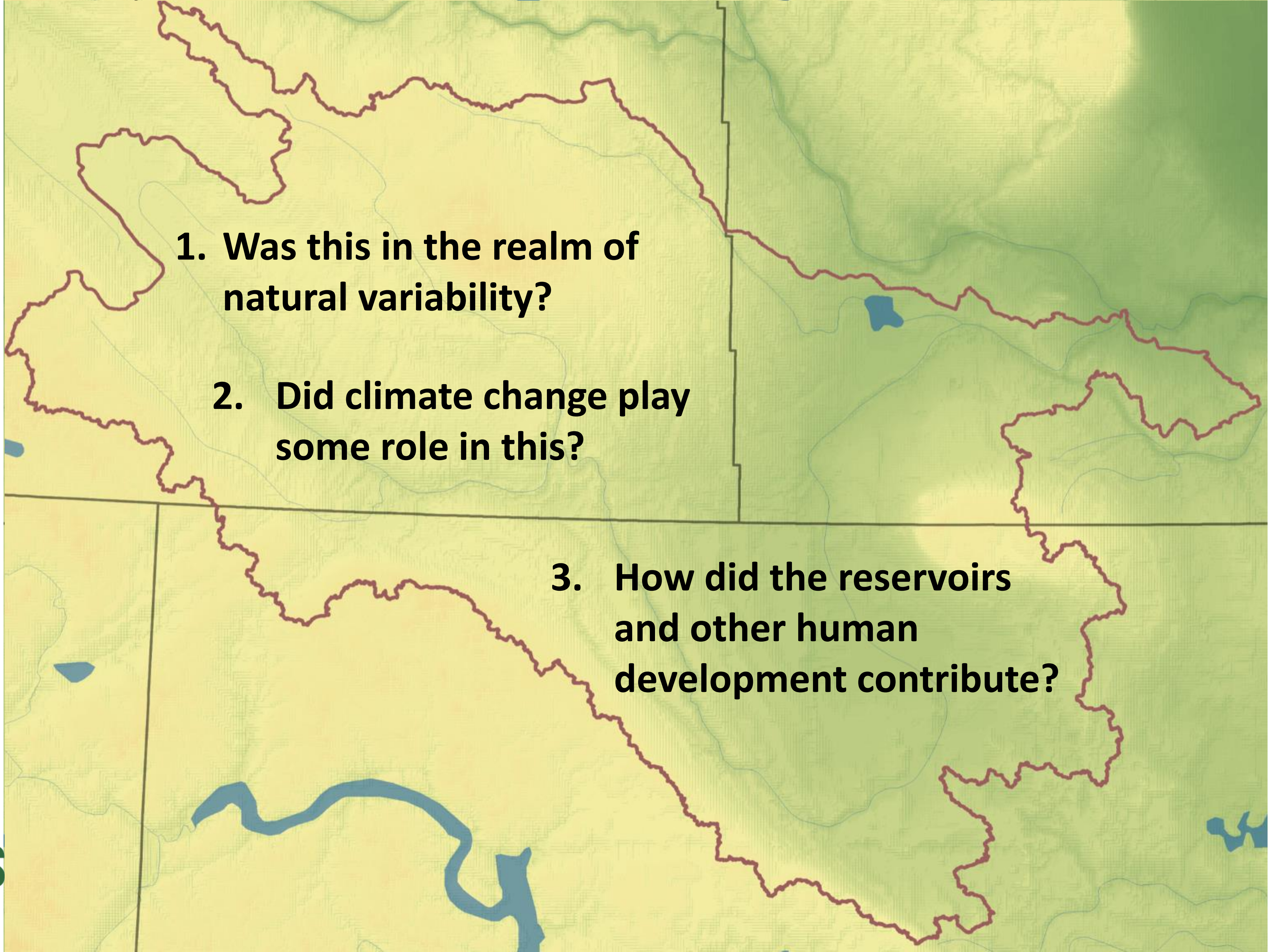




U.S. Geological Survey/photos by Brent Hanson and other USGS personnel

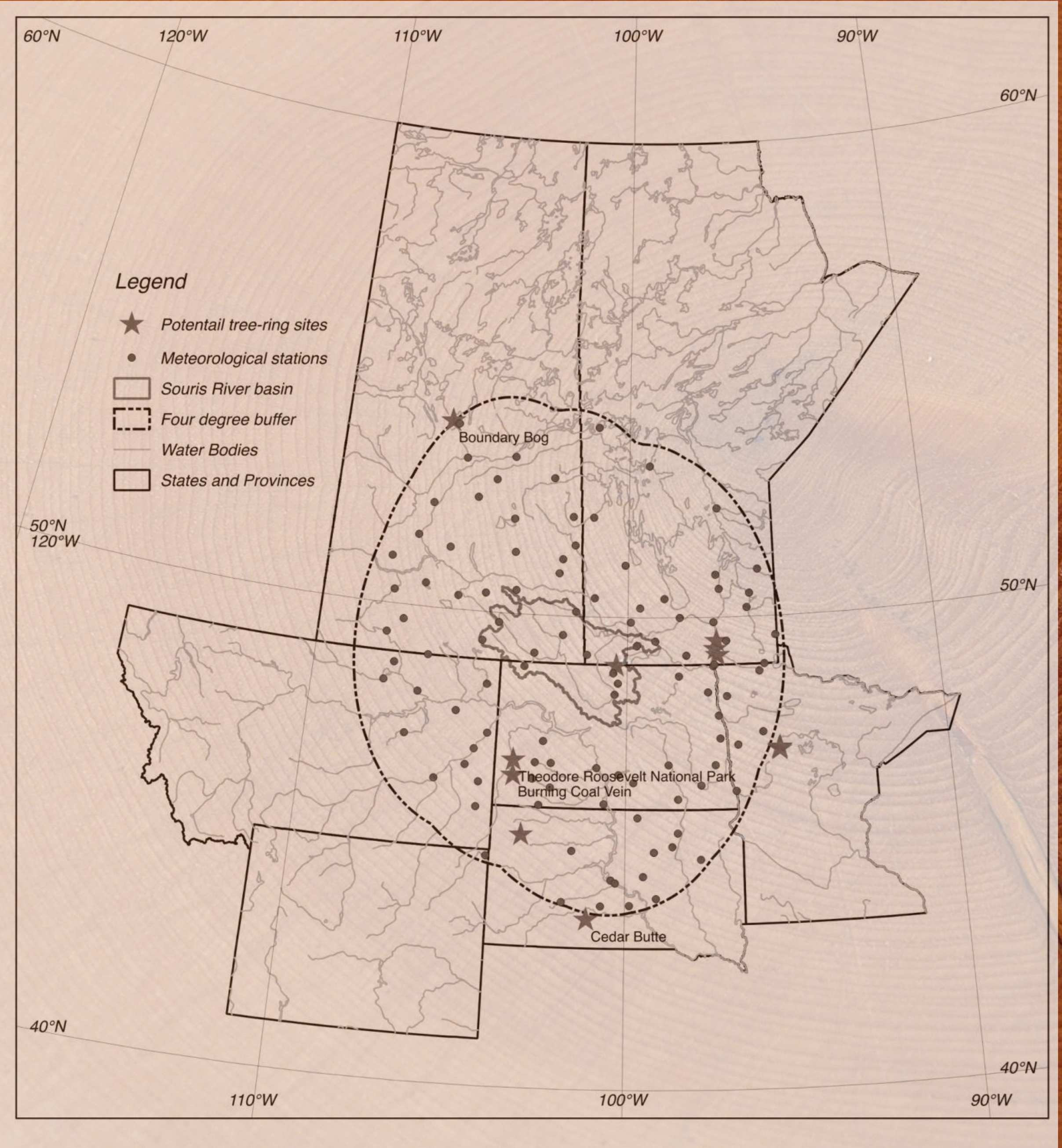
Souris River Basin in Saskatchewan
Credit: USGS/Galloway


Flooding in city of Minot, ND
Credit: USGS/Hanson



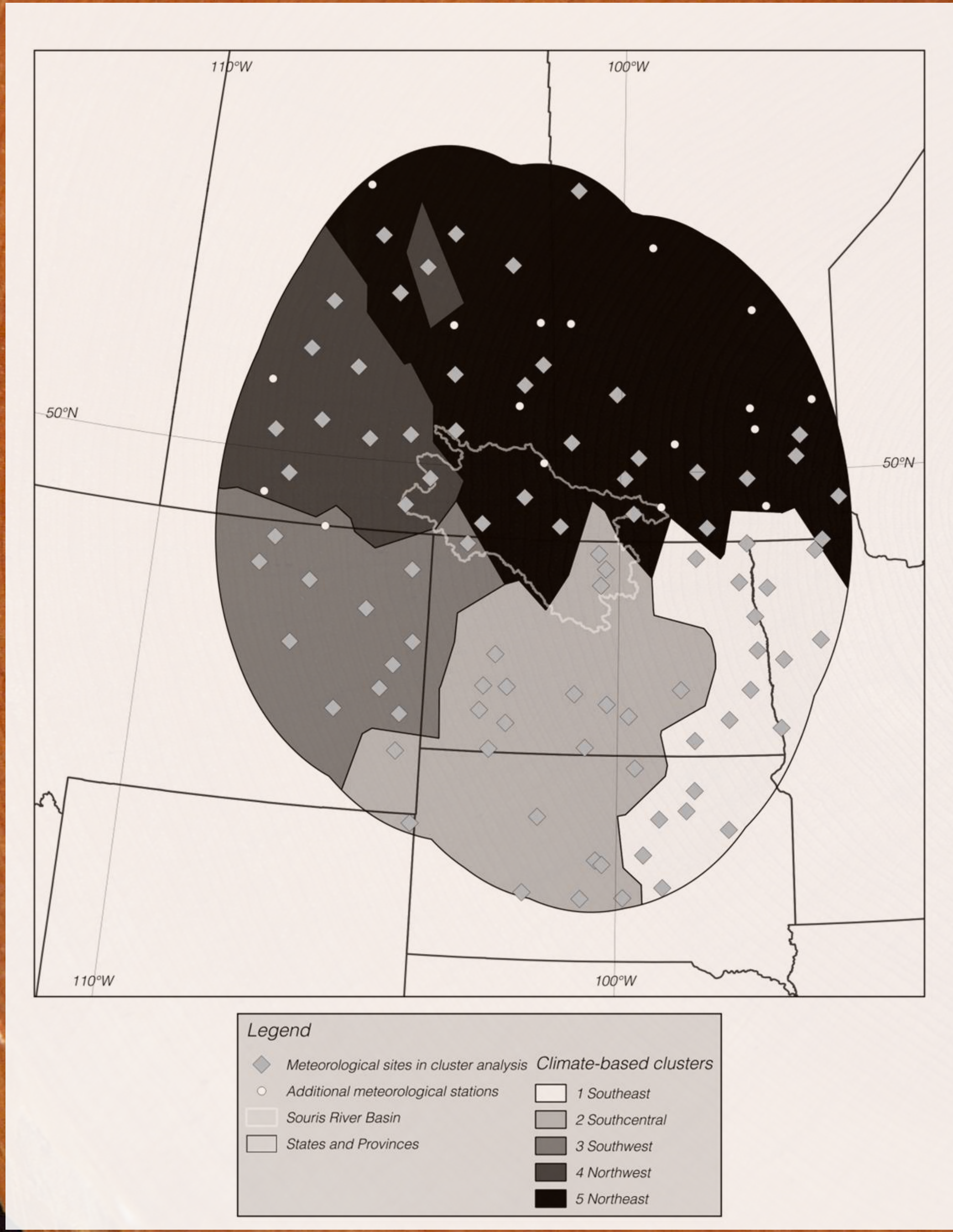
1. Was this in the realm of natural variability?
2. Did climate change play some role in this?
3. How did the reservoirs and other human development contribute?

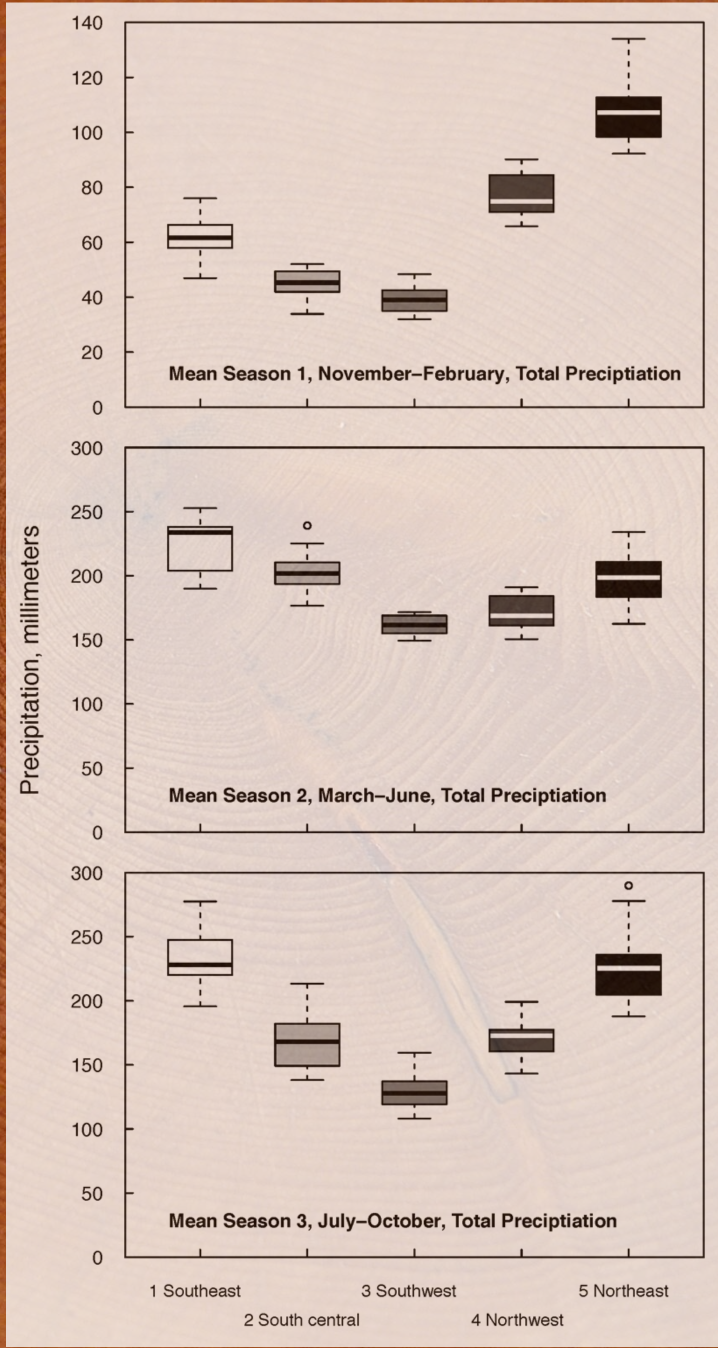
USGS



60°N
120°W
110°W
100°W
90°W
60°N
Legend
Potentail tree-ring sites
Meteorological stations
Souris River basin
Four degree buffer
Water Bodies
States and Provinces
Boundary Bog
50°N
120°W
50°N
Theodore Roosevelt National Park
Burning Coal Vein
Cedar Butte
40°N
40°N
110°W
100°W
90°W

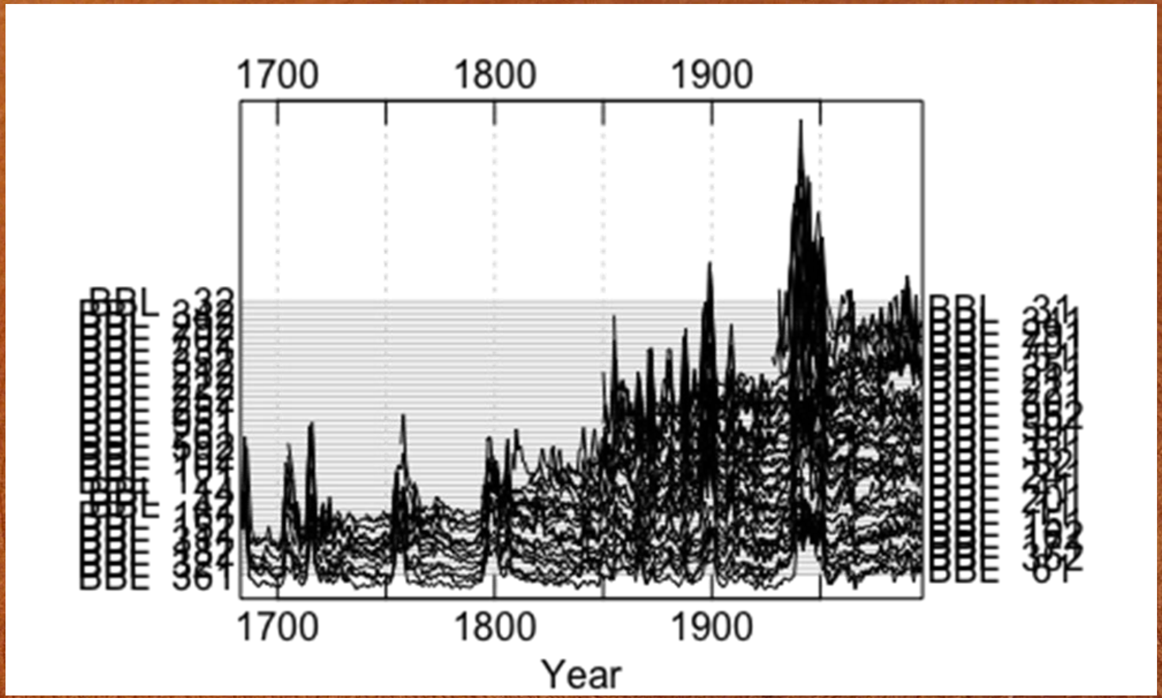

USGS

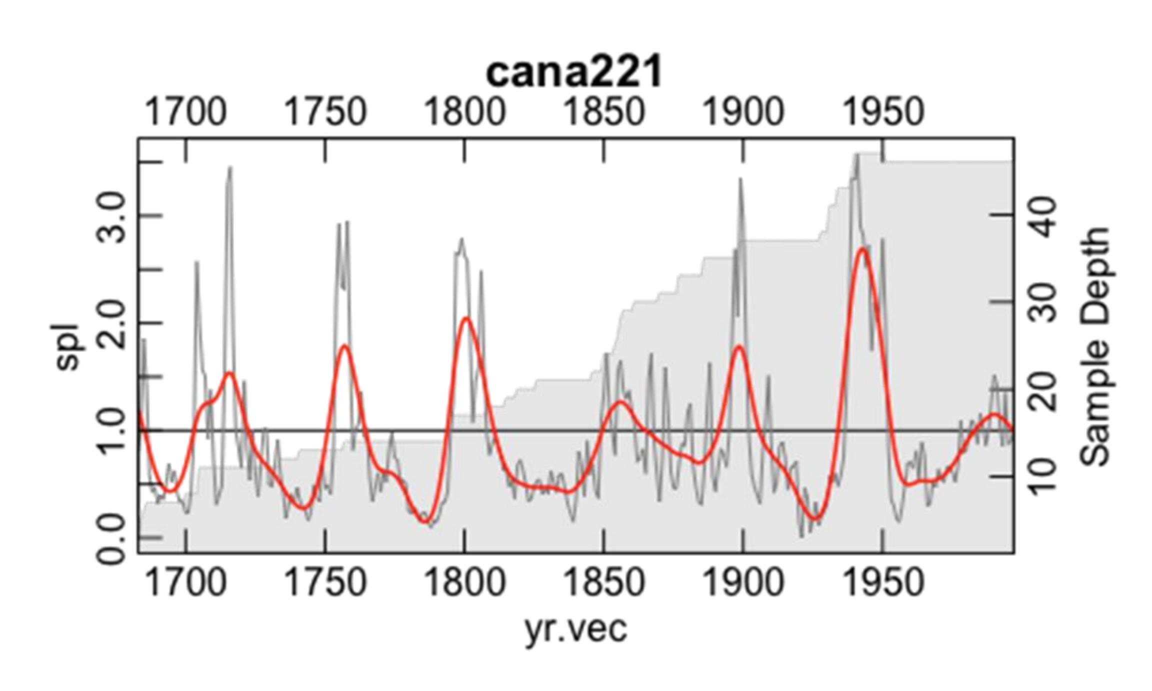

110°W
100°W
50°N
50°N
110°W
100°W
Legend
Meteorological sites in cluster analysis
Additional meteorological stations
Souris River Basin
States and Provinces
Climate-based clusters
1 Southeast
2 Southcentral
3 Southwest
4 Northwest
5 Northeast


Precipitation, millimeters
Mean Season 1, November–February, Total Precipitation
Mean Season 2, March–June, Total Precipitation
Mean Season 3, July–October, Total Precipitation
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300
1 Southeast
2 South central
3 Southwest
4 Northwest
5 Northeast

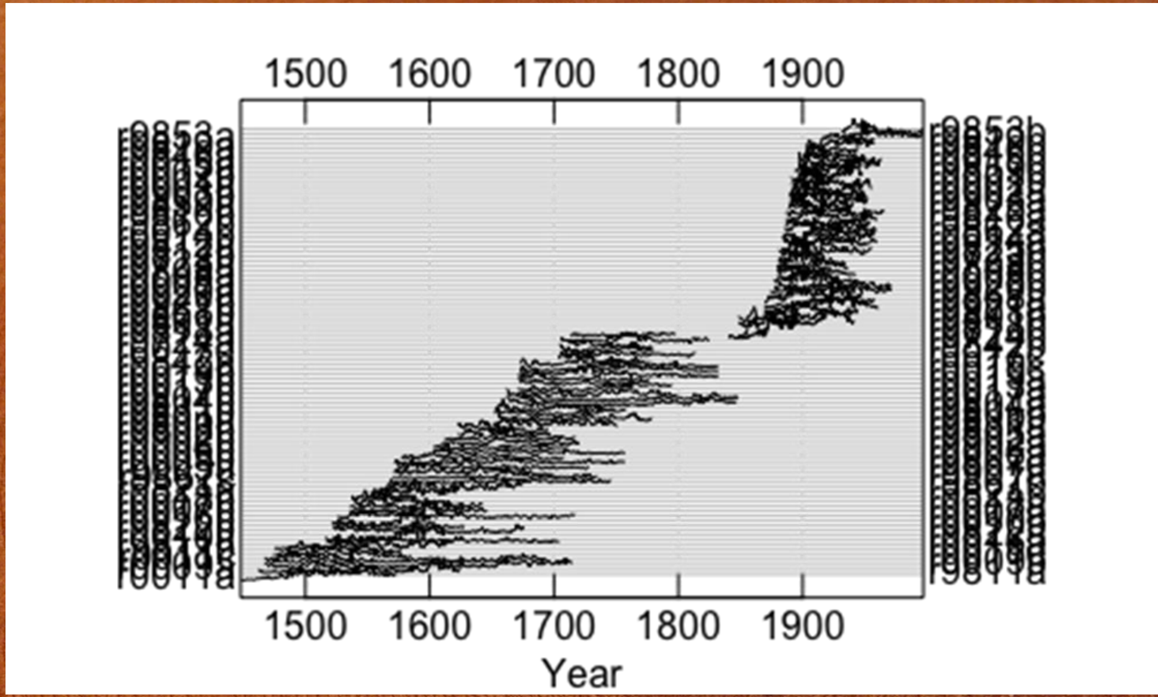
USGS

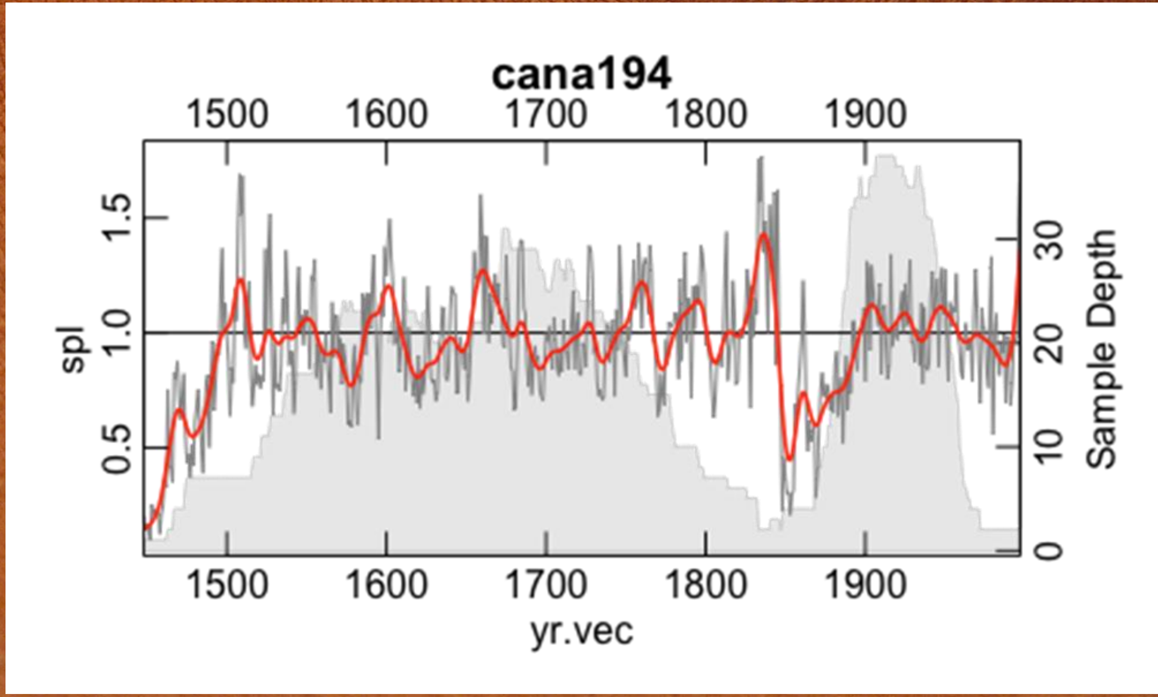
**MacDonald - Boundary Bog - LALA - ITRDB CANA221**
https://www.ncdc.noaa.gov/paleo/study/3899

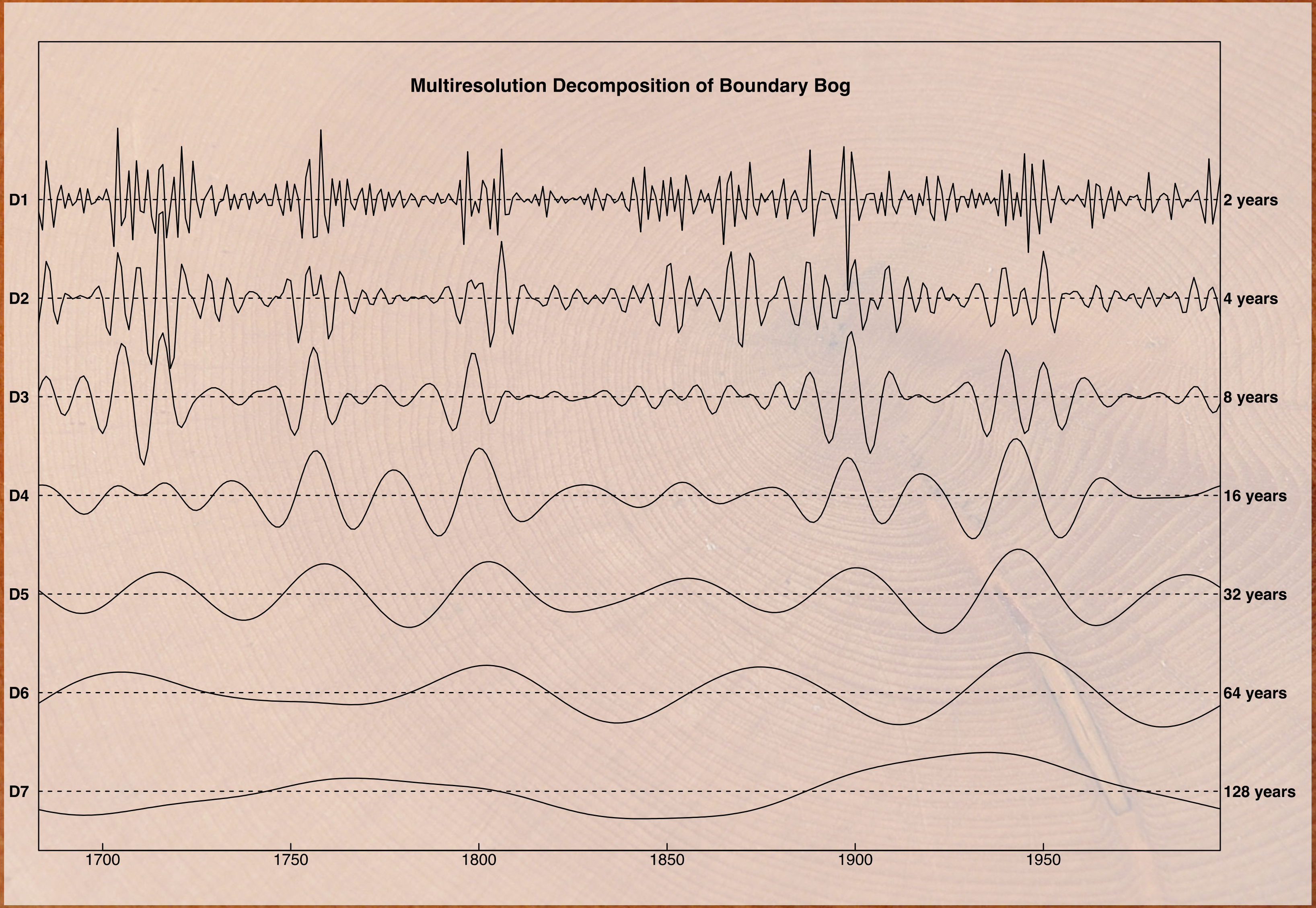


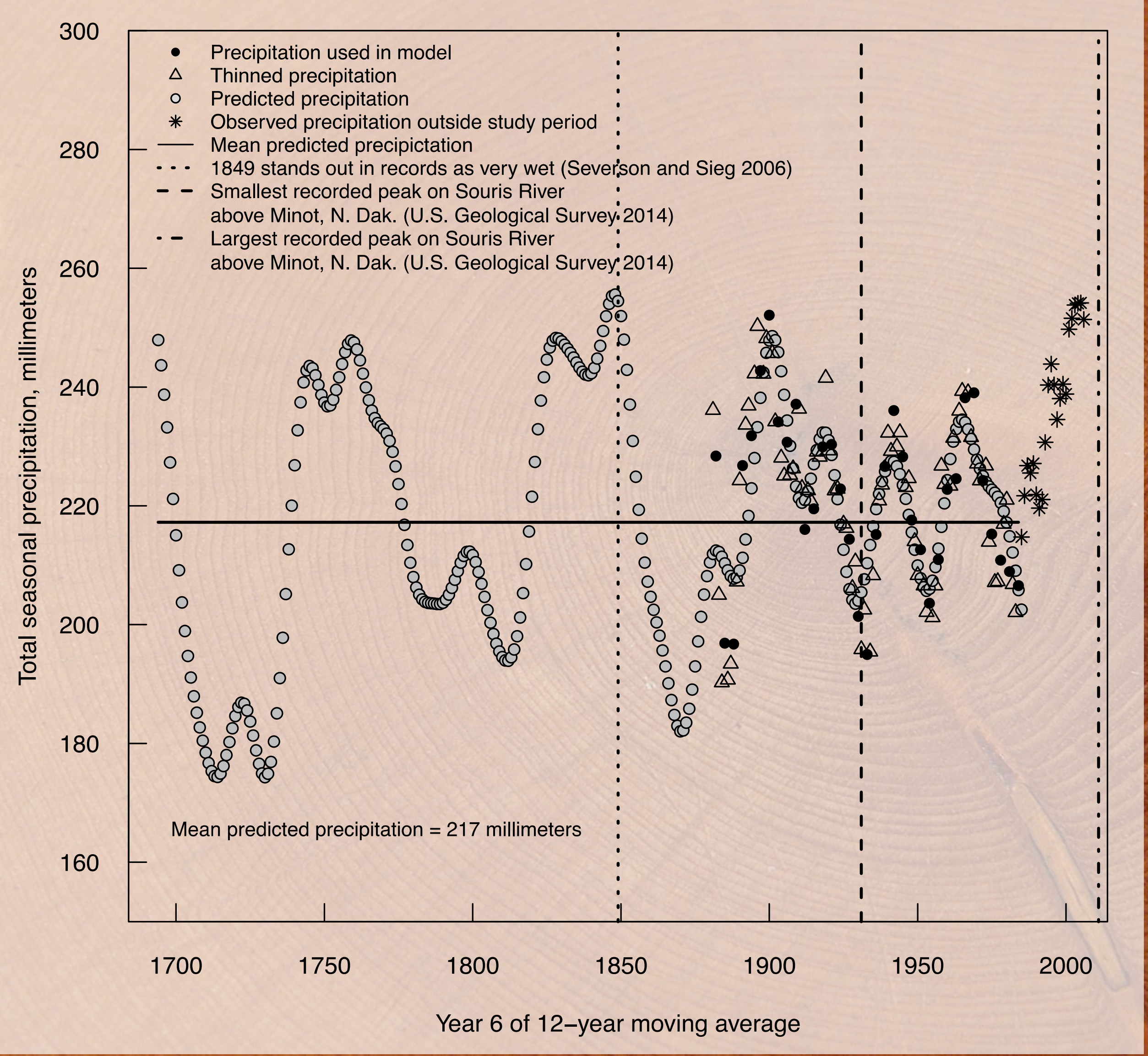
**St. George - Red River Alluvial Logs - QUMA - ITRDB CANA194**
https://www.ncdc.noaa.gov/paleo/study/4798




Multiresolution Decomposition of Boundary Bog
D1
D2
D3
D4
D5
D6
D7
2 years
4 years
8 years
16 years
32 years
64 years
128 years
1700
1750
1800
1850
1900
1950

USGS




Season 2 (March-June), group 1 (southeast) modeled and observed 12-year moving average precipitation.

# Conclusions

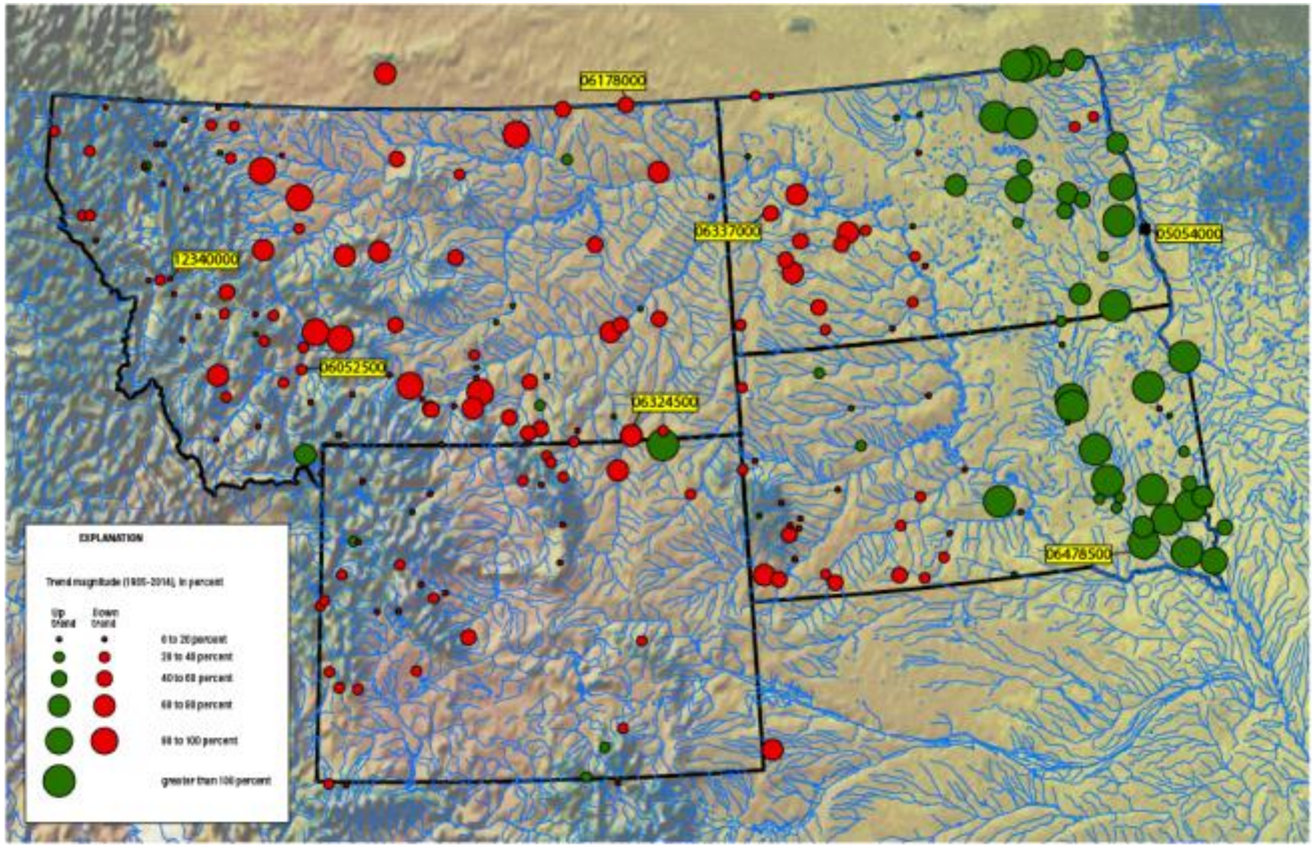
- Souris River region precipitation varies on long-term, multi-decadal to centennial, time scales.
- The time scales vary with location in the region and with season.
- The most frequently used explanatory variables were those representing the 64-year time scale.
- While an extreme flood was the motivation for this work, extreme drought is an important part of the history of this basin.

Ryberg, K.R., 2015, The impact of climate variability on streamflow and water quality in the North Central United States: **North Dakota State University Dissertation**, 277 p.

Ryberg, K.R., Vecchia, A.V., Akyüz, F.A., and Lin, W., 2016, Tree-ring-based estimates of long-term seasonal precipitation in the Souris River Region of Saskatchewan, North Dakota and Manitoba: Canadian Water Resources Journal / Revue canadienne des ressources hydriques, v. 41, no. 3, p. 412–428.

USGS

# Switching Between Wet and Dry is Not an Isolated Phenomenon

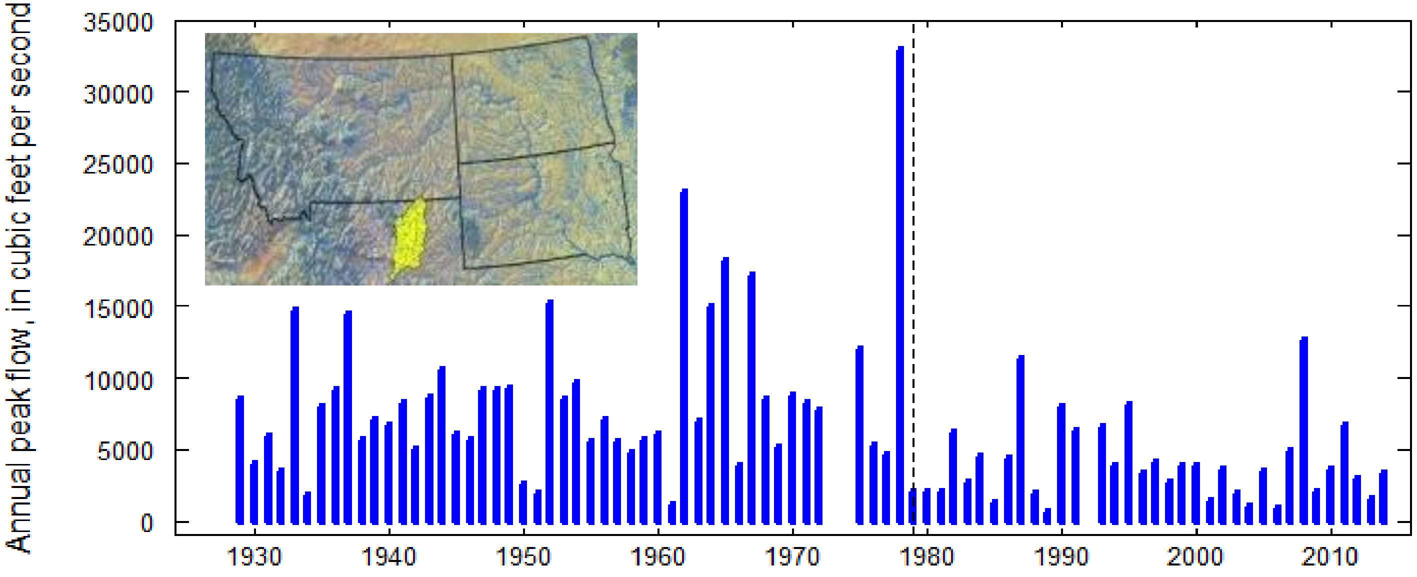



USGS

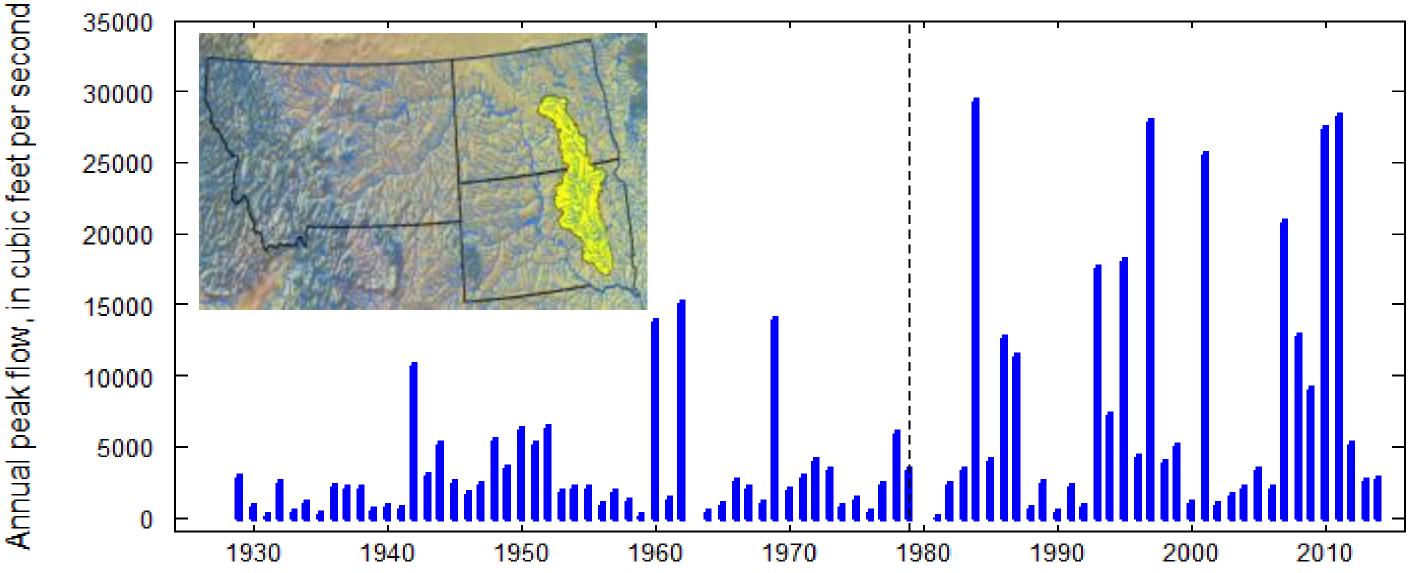
Courtesy: Steve Sando, USGS WY-MT Water Science Center

# Annual Peak Flows

**Powder River at Moorhead, Montana**




**James River at Scotland, South Dakota**

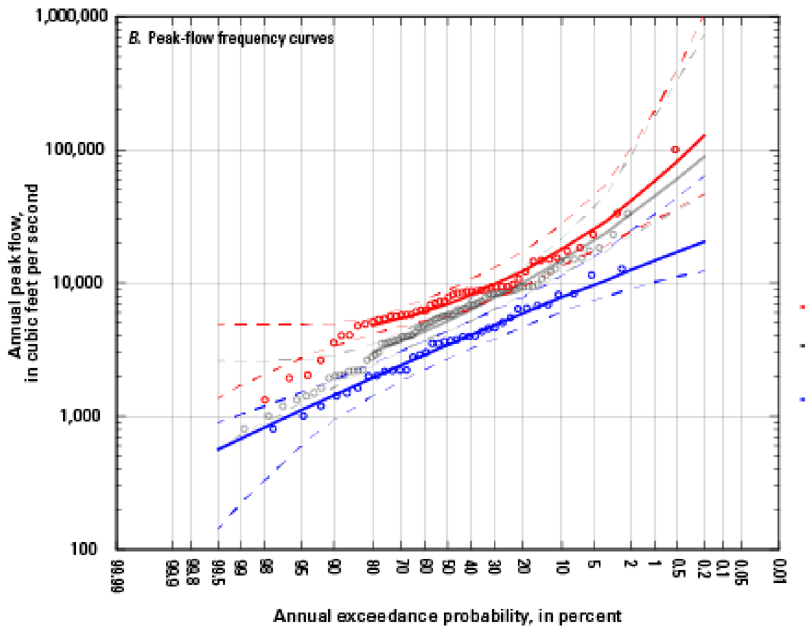



USGS

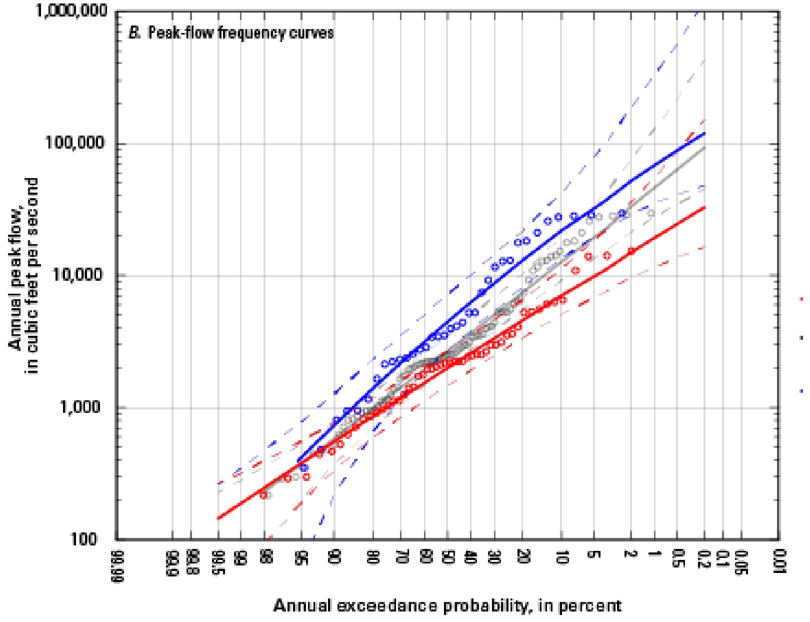
Courtesy: Steve Sando, USGS WY-MT Water Science Center

# Peak-flow Frequency Curves

**Powder River at Moorhead, Montana**




**James River at Scotland, South Dakota**




Courtesy: Steve Sando,
USGS WY-MT Water Science Center

# Regional Patterns and the 5th National Climate Assessment

November 2023

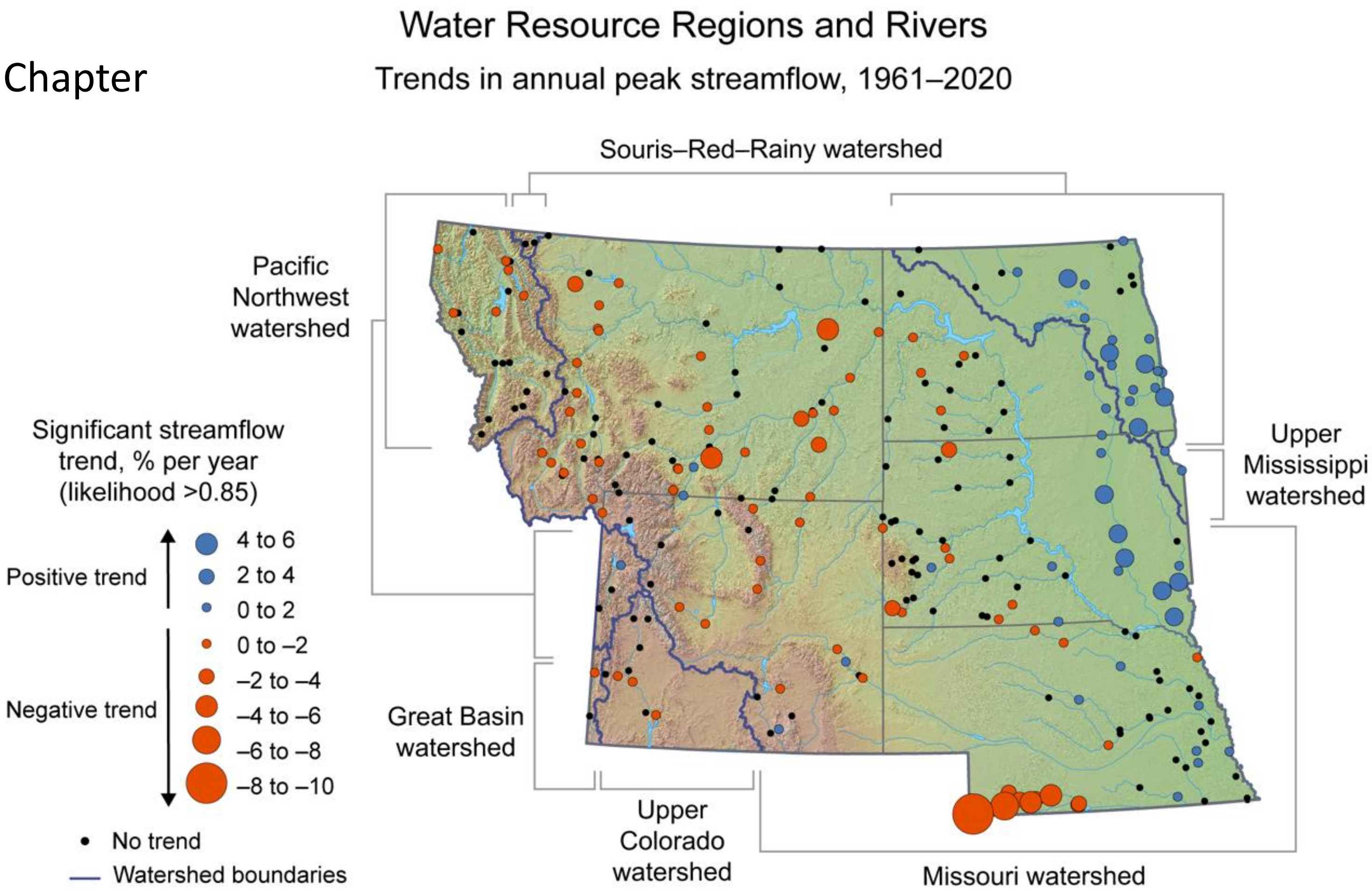



**Figure 25.4. Annual peak streamflow—a proxy for flooding—has been rising in eastern portions of the region and declining in the west.**

KEY MESSAGE

# 1 Climate Change Is Compounding the Impacts of Extreme Events

The Northern Great Plains region is experiencing unprecedented extremes related to changes in climate, including severe droughts (*likely*, *high confidence*), increases in hail frequency and size (*medium confidence*), floods (*very likely*, *high confidence*), and wildfire (*likely*, *high confidence*). Rising temperatures across the region are expected to lead to increased evapotranspiration (*very likely*, *very high confidence*), as well as greater variability in precipitation (*very likely*, *high confidence*).

Northern Great Plains Chapter

"The fluctuation of the climate within wide limits, as at Jamestown [ND] and Fort Stanton [NM], creates one of the most serious of the climatic risks to agriculture."

Thornthwaite (1941, p. 180)

TABLE 1.—*Climatic variability at Jamestown, N. Dak., Fort Stanton, N. Mex., and Independence and Indio, Calif.*

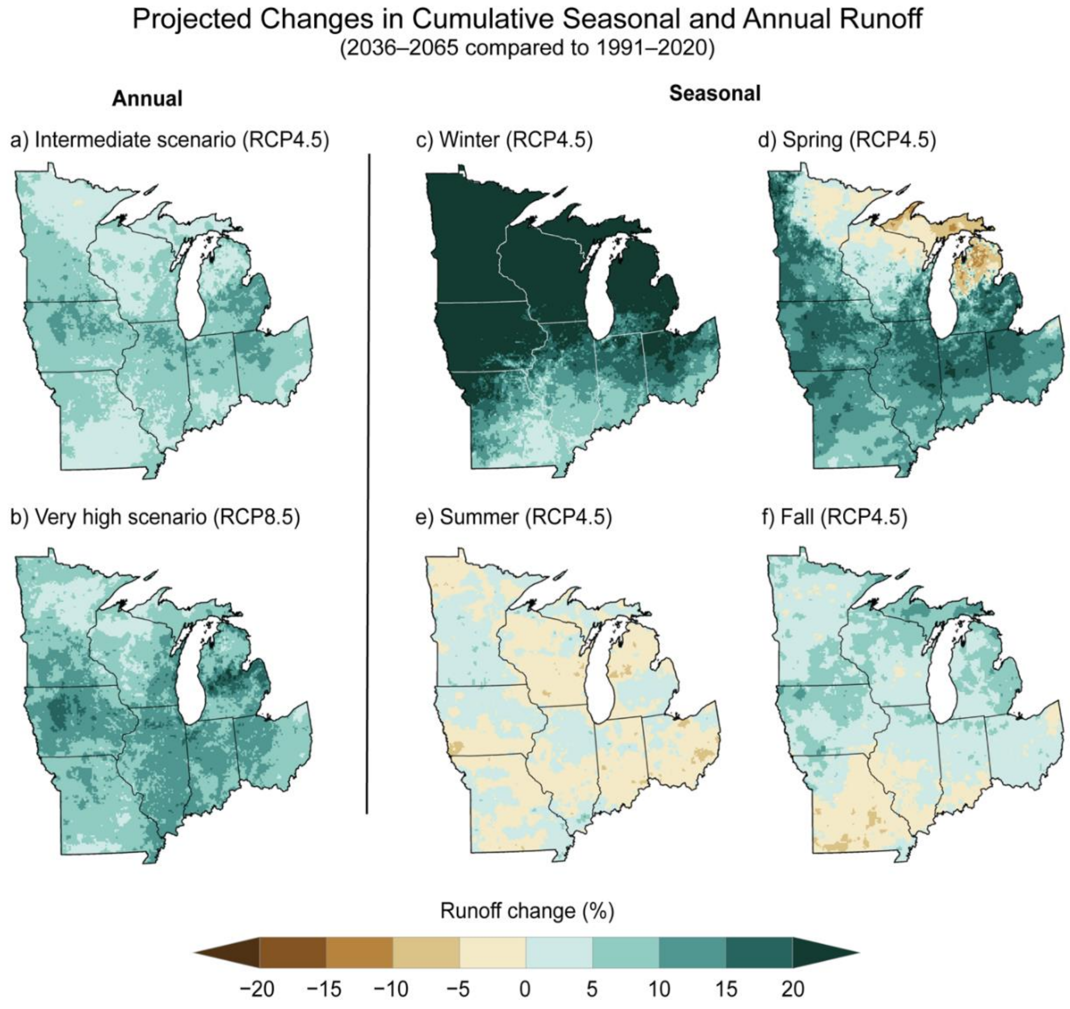
| Station | Length of record | Climatic type [1] | Climatic distribution: Super-humid | Humid | Moist sub-humid | Dry sub-humid | Semi-arid | Arid |
|---|---|---|---|---|---|---|---|---|
| | *Years* | | *Years* | *Years* | *Years* | *Years* | *Years* | *Years* |
| Jamestown, N. Dak. | 35 | Dry subhumid | 0 | 1 | 15 | 13 | 5 | 1 |
| Fort Stanton, N. Mex | 37 | Semiarid | 0 | 1 | 1 | 5 | 25 | 5 |
| Independence, Calif. | 37 | Arid | 0 | 0 | 1 | 1 | 1 | 34 |
| Indio, Calif. | 36 | do. | 0 | 0 | 0 | 0 | 0 | 36 |

[1] Based on effective precipitation as determined in Thornthwaite's classification of climates (7).

USGS

Thornthwaite, C.W., 1941, Settlement in the Great Plains, in Climate and man yearbook of agriculture: United States Government Printing Office, Washington, D.C., p. 177-187., https://archive.org/details/yoa1941.

**Figure 24.11. Projected changes in cumulative local runoff will lead to increased flooding susceptibility in winter and spring with, increased flash drought potential in summer.**

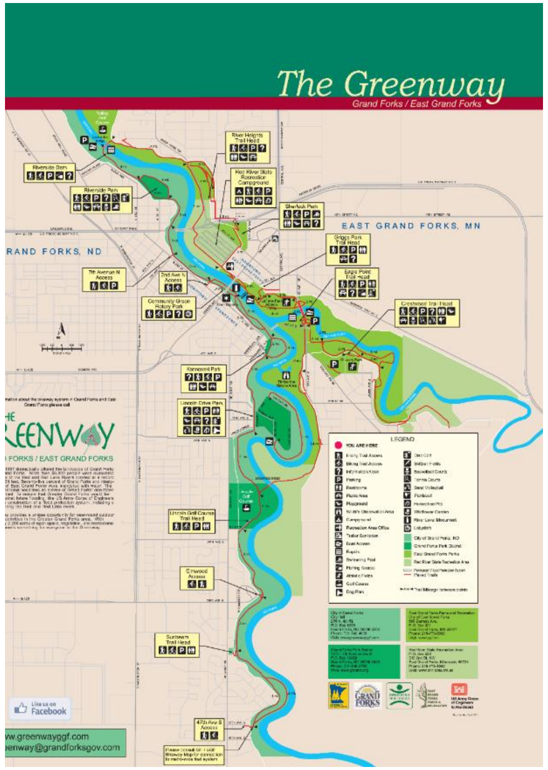



Midwest Chapter

# Societal Response

- Devils Lake Outlets
- Water Supply Projects
- Mouse River Flood Protection
- And others

# 1997 Flood & The Greenway



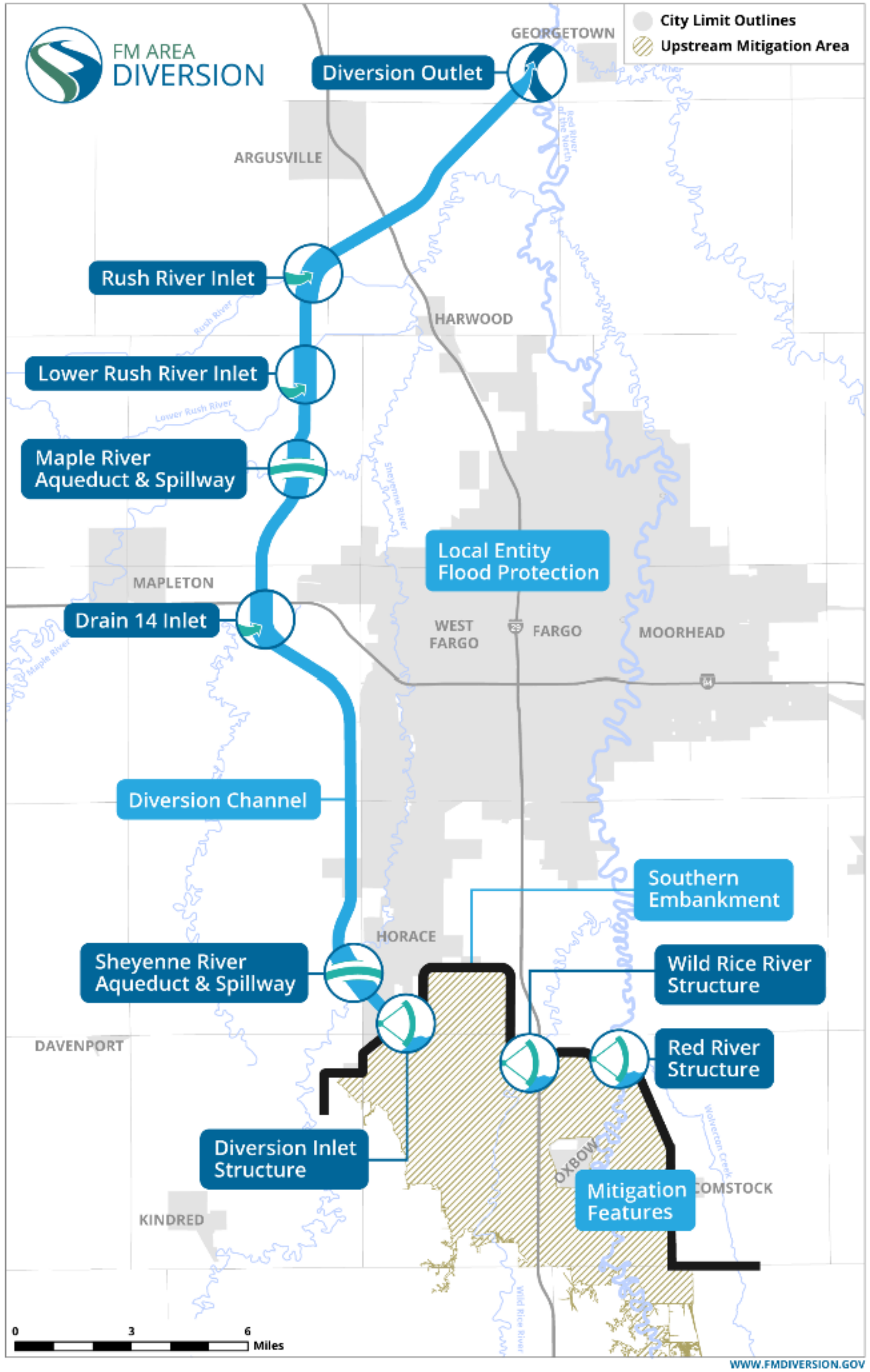


- Since 1997, more than 1 billion dollars has been spent on flood-control projects with an estimated 3-billion-dollar project to divert floodwater around Fargo, North Dakota, and Moorhead, Minnesota, underway (Gunderson, 2017; Gunderson, 2021).
- Buyout of destroyed properties in Grand Forks, ND, and East Grand Forks, MN, after the 1997 and the construction of a Greenway.
- The Greenway consists of 2,200 acres along the Red River and the Red Lake River (a tributary that joins the Red at Grand Forks).
  - Multi-use, all-season recreational trail system
  - Two golf courses
  - Nature preserve
  - Picnic sites
  - Camping area
  - Fishing access

(City of Grand Forks, ND, 2020)

# FM-Area Diversion

- The Fargo-Moorhead diversion entails building:
  - 30-mile-long diversion channel in North Dakota with an upstream staging area,
  - 14 drainage inlets,
  - 2 Interstate Highway crossings,
  - 3 railroad crossings,
  - 12 other road crossings, and
  - “southern embankment”.
- The Southern Embankment entails building:
  - 20-mile earthen embankment,
  - 3 gated control structures,
  - Interstate Highway bridge crossing and 4-mile grade raise, and
  - Other road crossings.
- Numerous other mitigation projects.
- City and county governments working on in-town protection measures.




(Metro Flood Diversion Authority, 2024)


Monitoring
and Analysis
Continues
USGS