HYDRAULIC CONCERNS 2021 AND 2022

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St. Paul District

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US Army Corps of Engineers®

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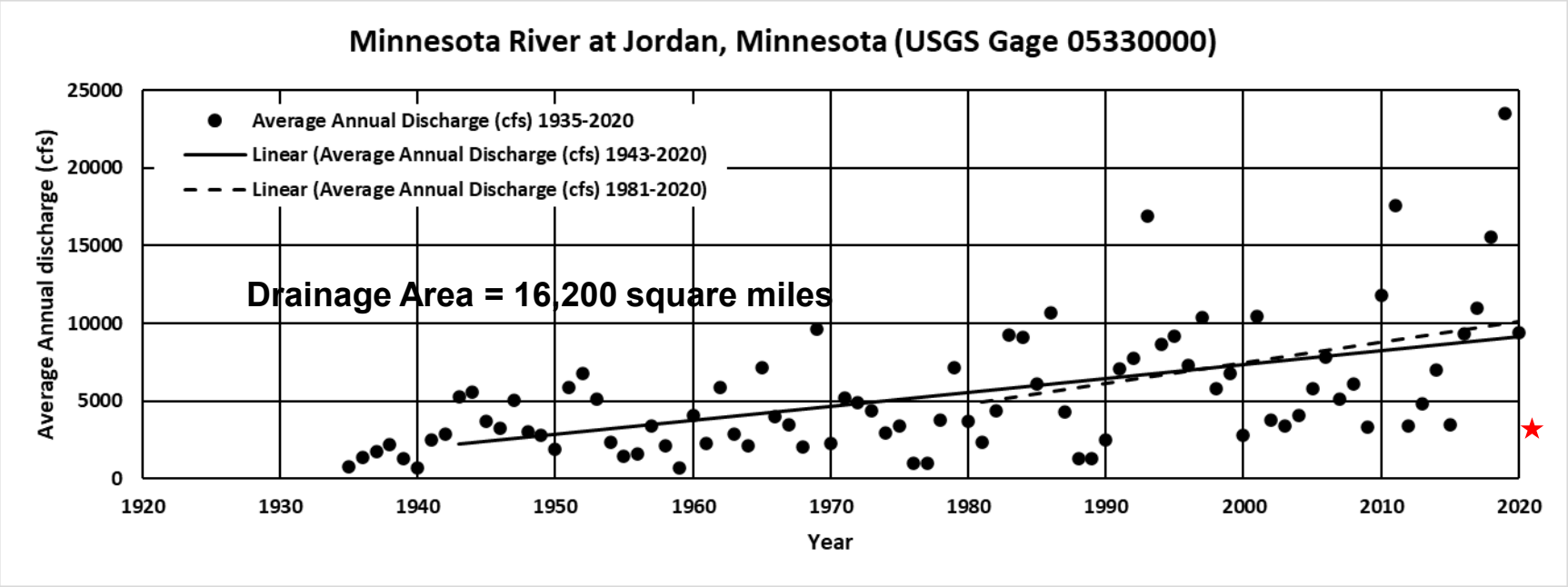
and Taking Care of People!

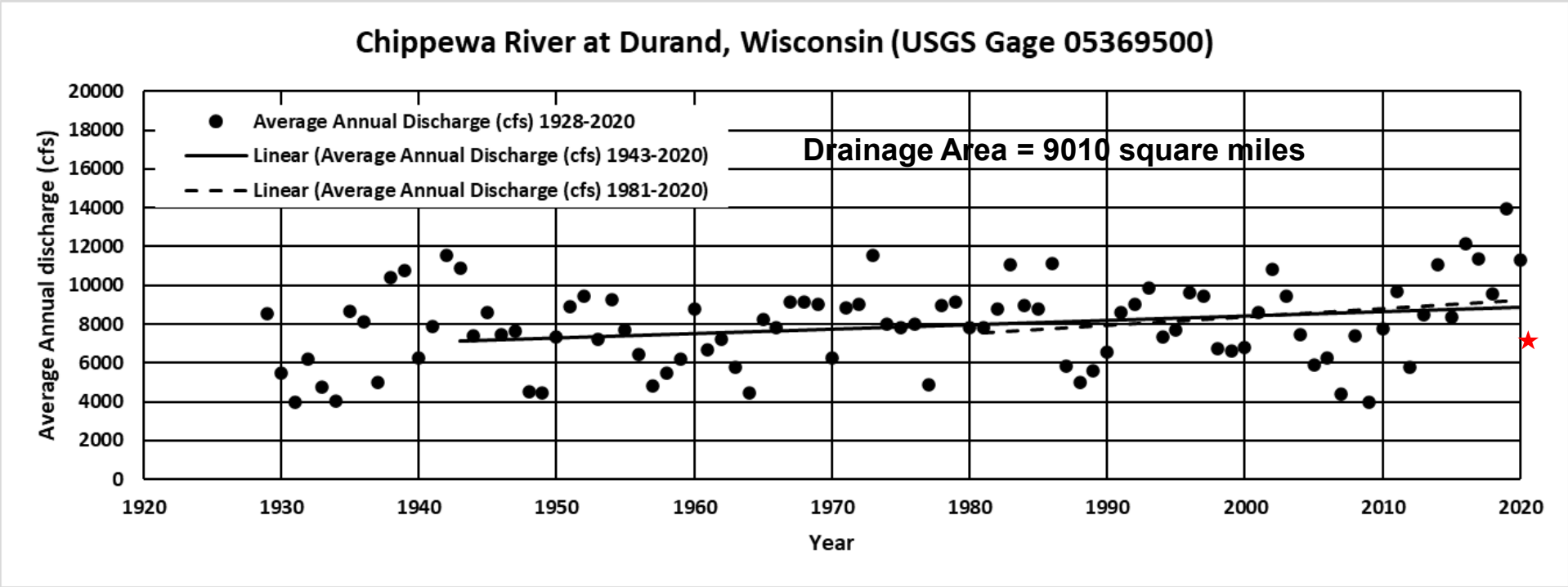
MINNESOTA RIVER



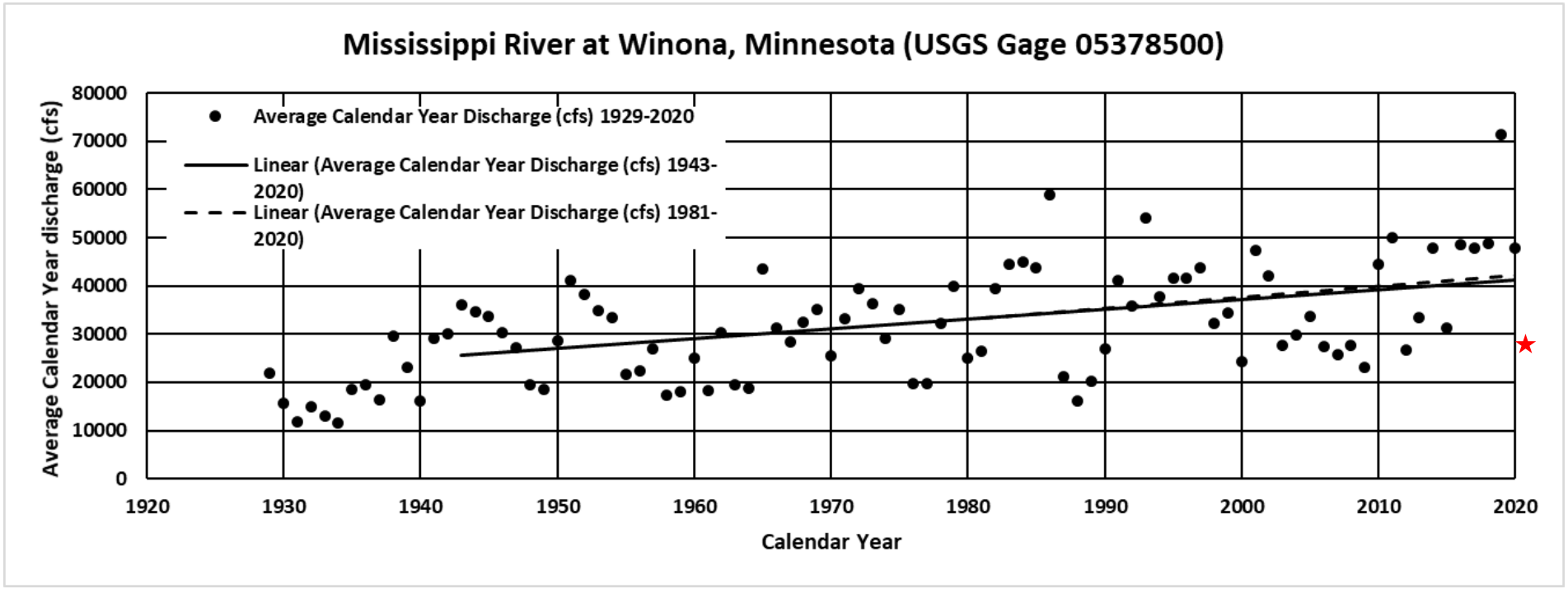
Decade	Bankful Flooding Events
1930-1939	0
1940-1949	1
1950-1959	3
1960-1969	5
1970-1979	2
1980-1989	5
1990-1999	9
2000-2009	6
2010-2019	18

- There is a statistically significant trend of increasing discharge from 1943 to 2020
- Average Discharge at Jordan
  - 1943 to 1980 = 3770 cfs
  - 1981 to 2020 = 7510 cfs (double the 1943 to 1980 ave.)
- Discharge in 2016, 2017, 2018, 2019, 2020 = 9360, 11,000,15520, 23550, 9370 cfs
- The number of bankfull flooding events (Q > 26,000 cfs) has increased in the 2010s (see table)
- 2011 to 2020 is wettest decade on record

CHIPPEWA RIVER



MISSISSIPPI RIVER



Average Calendar Year Discharge at Winona
1943 to 1980 = 28,950 cfs
1981 to 2020 = 37,820 cfs (30 % increase)

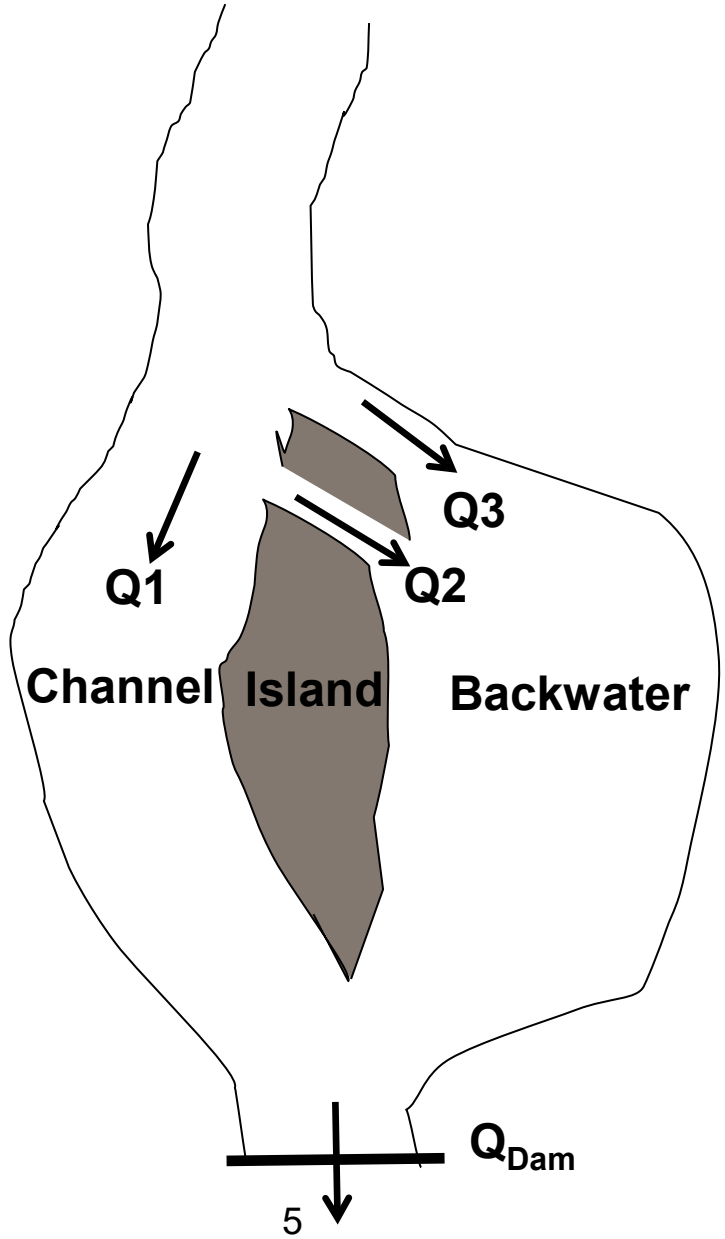
2016, 2017, 2018, 2019, 2020 = 48,700, 47,960, 48,900, 71,520, 47,850 cfs
2010 to 2020 is wettest decade on record

WATER EXCHANGE

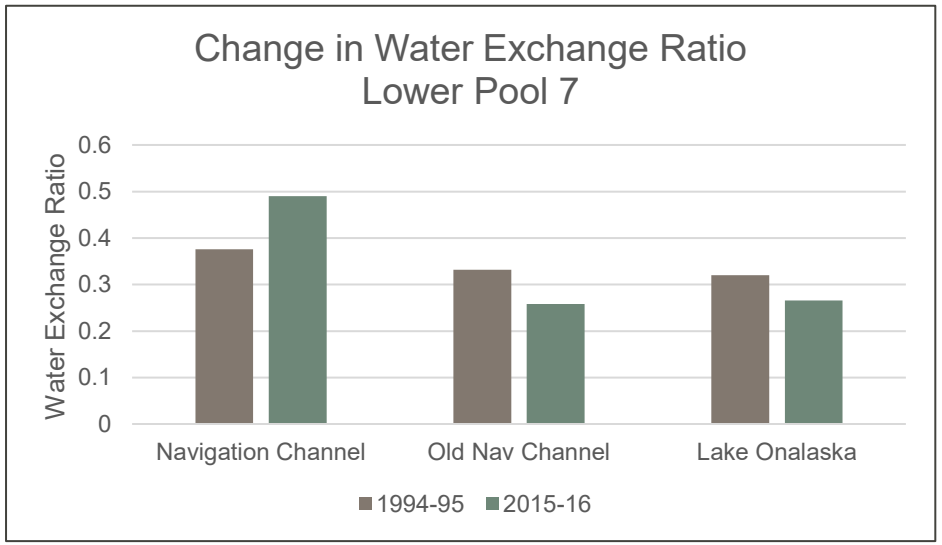
In this example, the water exchange ratio between the channel and the backwater is

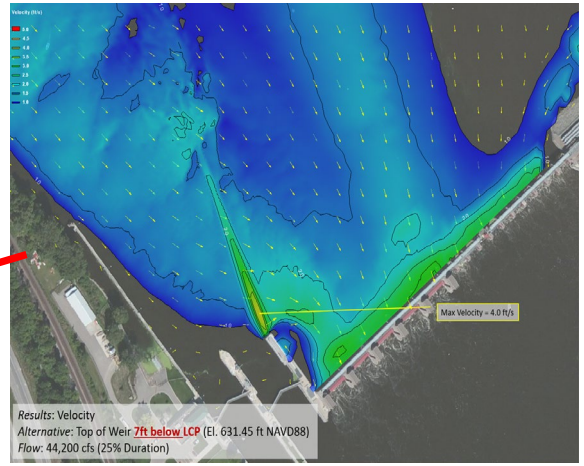
$(Q_2 + Q_3)/Q_{dam}$ where Q = river flow

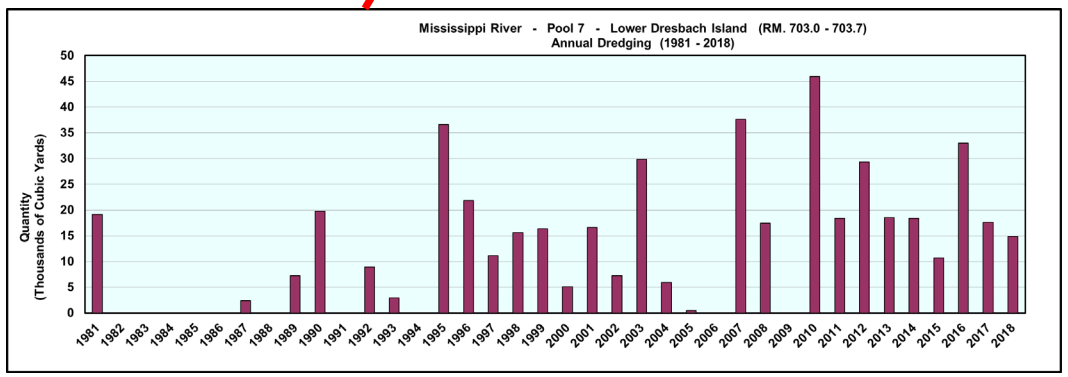
Expressed as a ratio or percentage



WATER EXCHANGE – A SURROGATE FOR GEOMORPHIC CHANGE

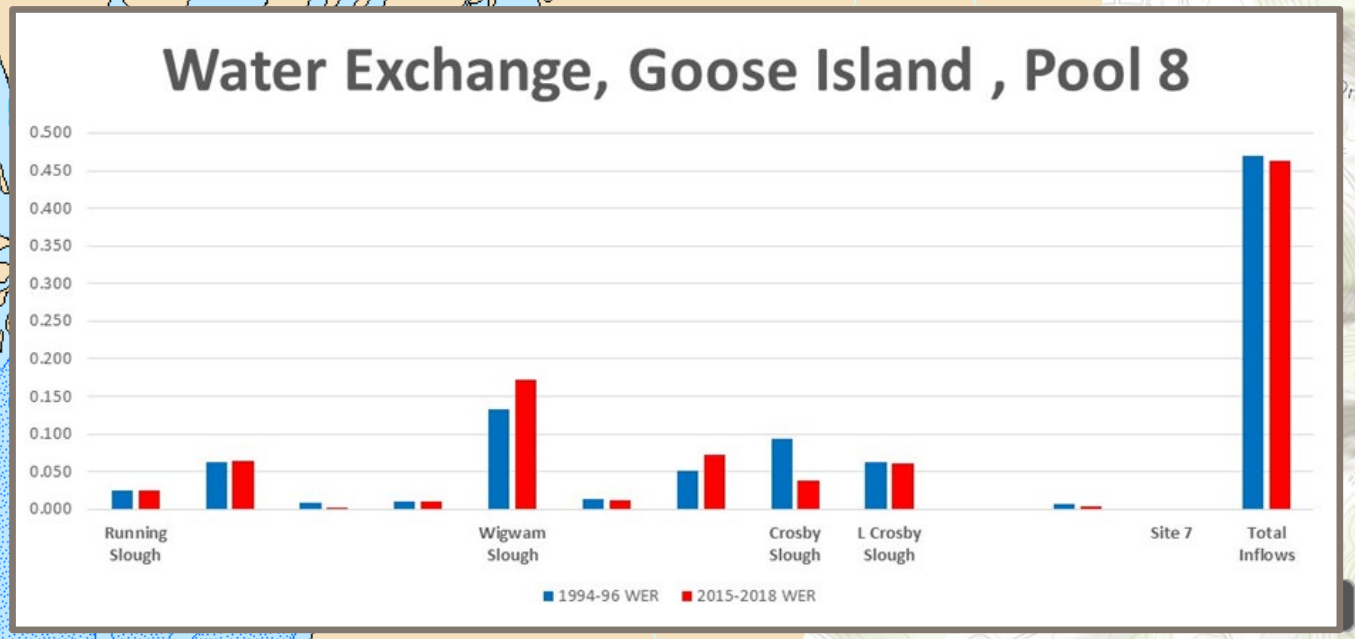




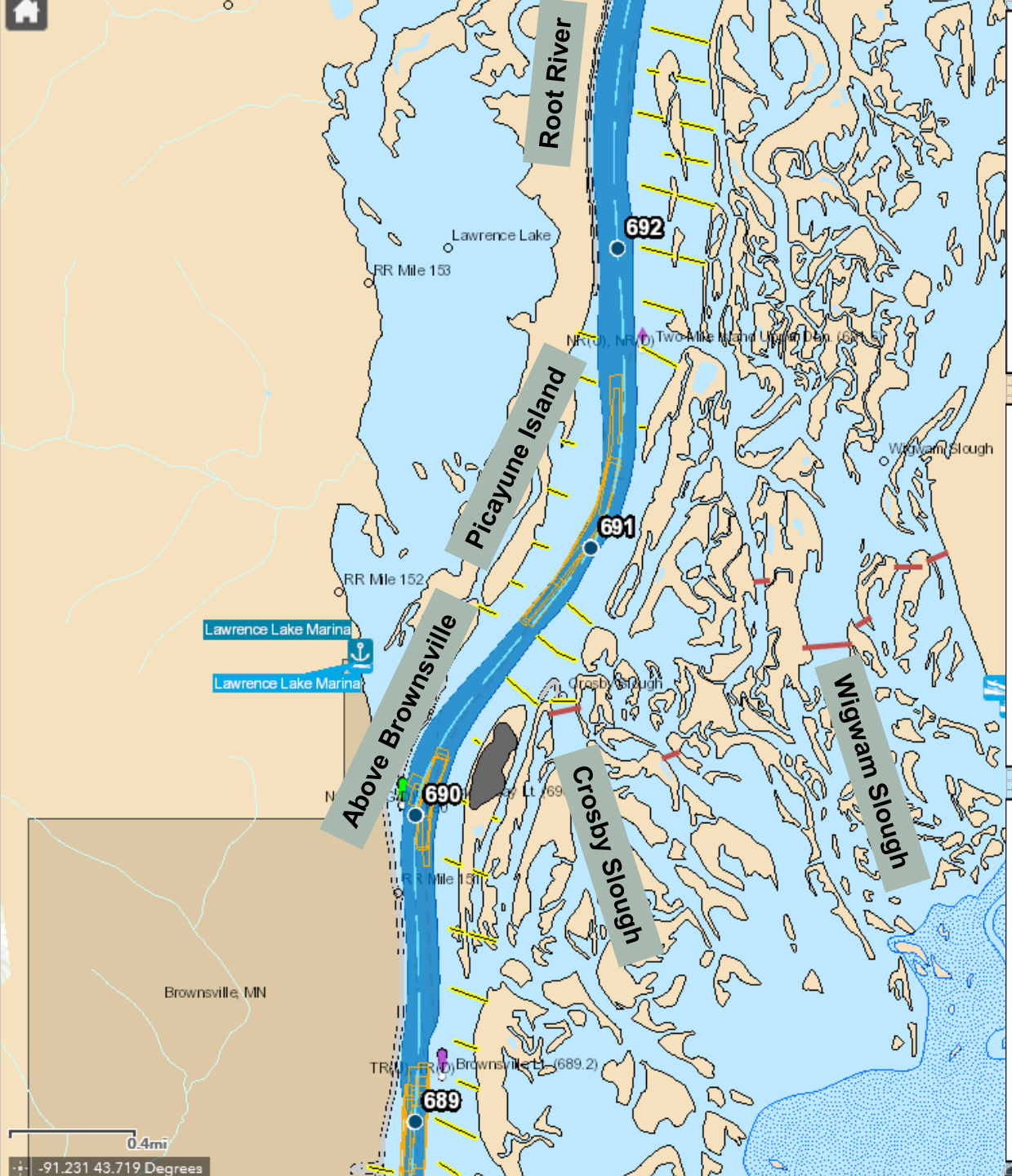


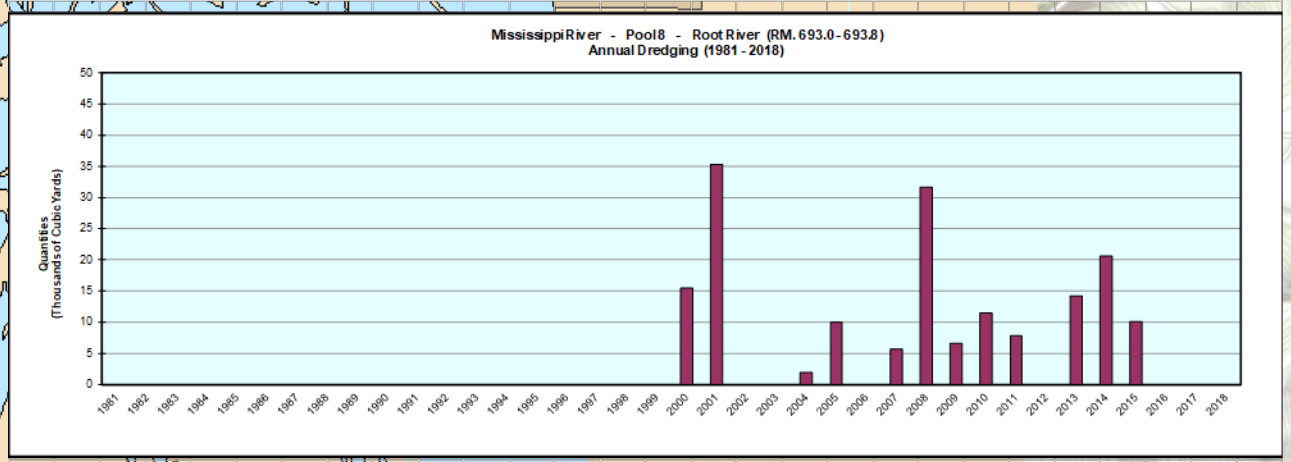
Change in Water Exchange Ratio:

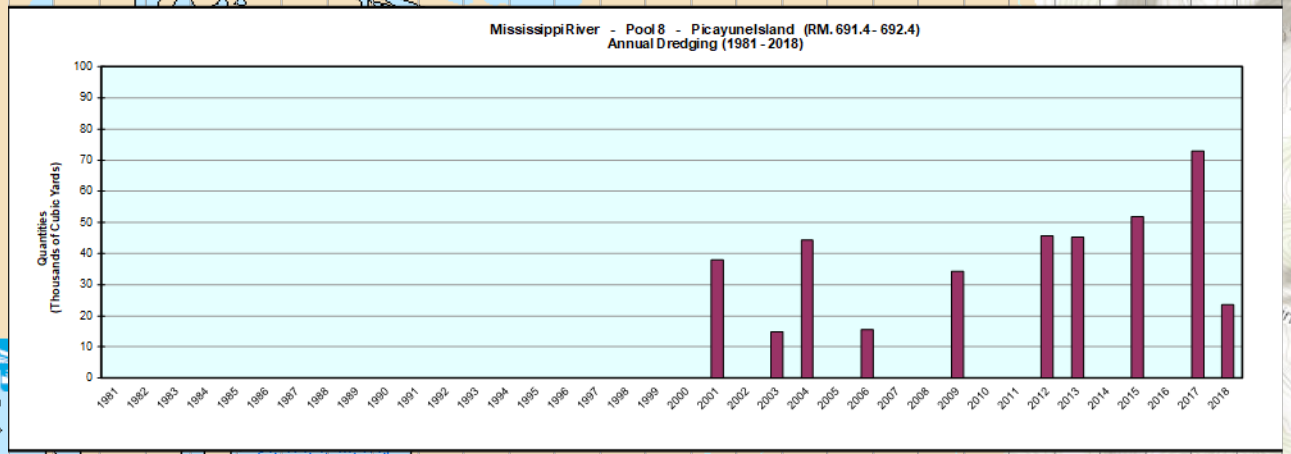
- Shifted dredging downstream
- Increased outdraft at LD 7

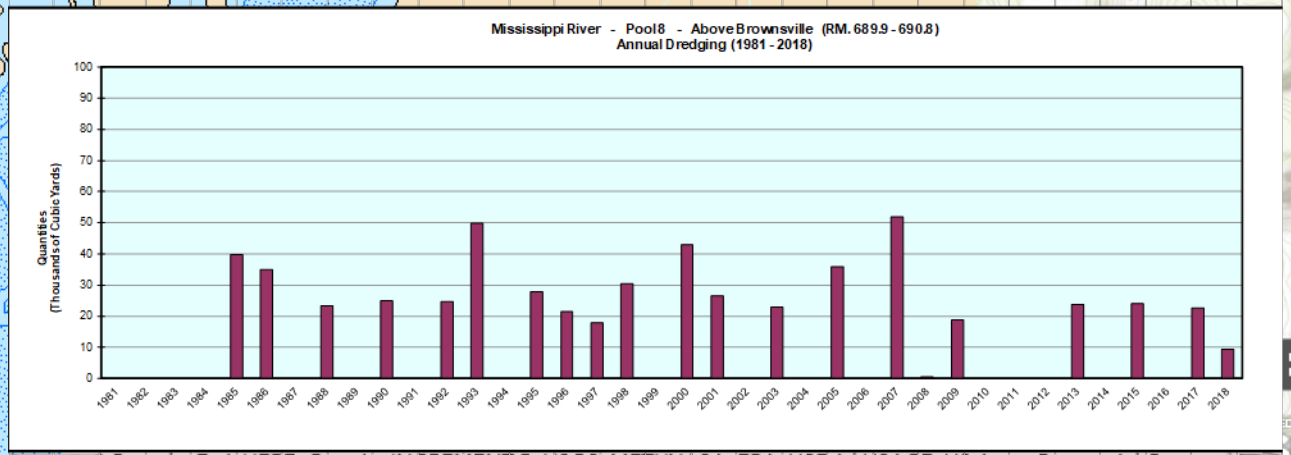


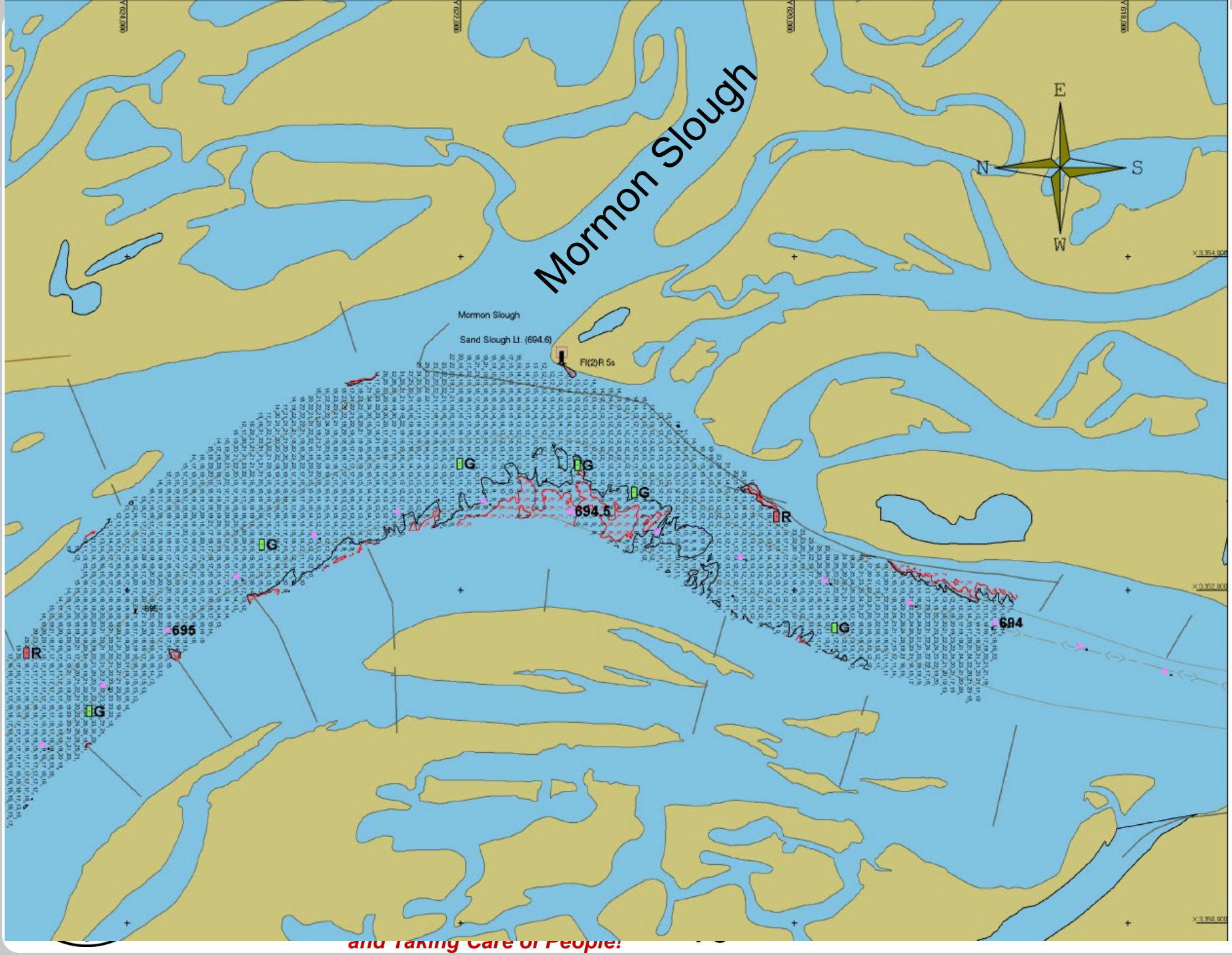
Goose Island
Goose Island Landing
Lawrence Lake
RR Mile 153
692
691
RR Mile 152
Lawrence Lake Marina
Lawrence Lake Marina
Wigwam Slough
Crosby Slough
690
689
Brownsville, MN
0.4mi
-91.231 43.719 Degrees
Esri Canada, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA | USACE, US Army Geospatial Cen...









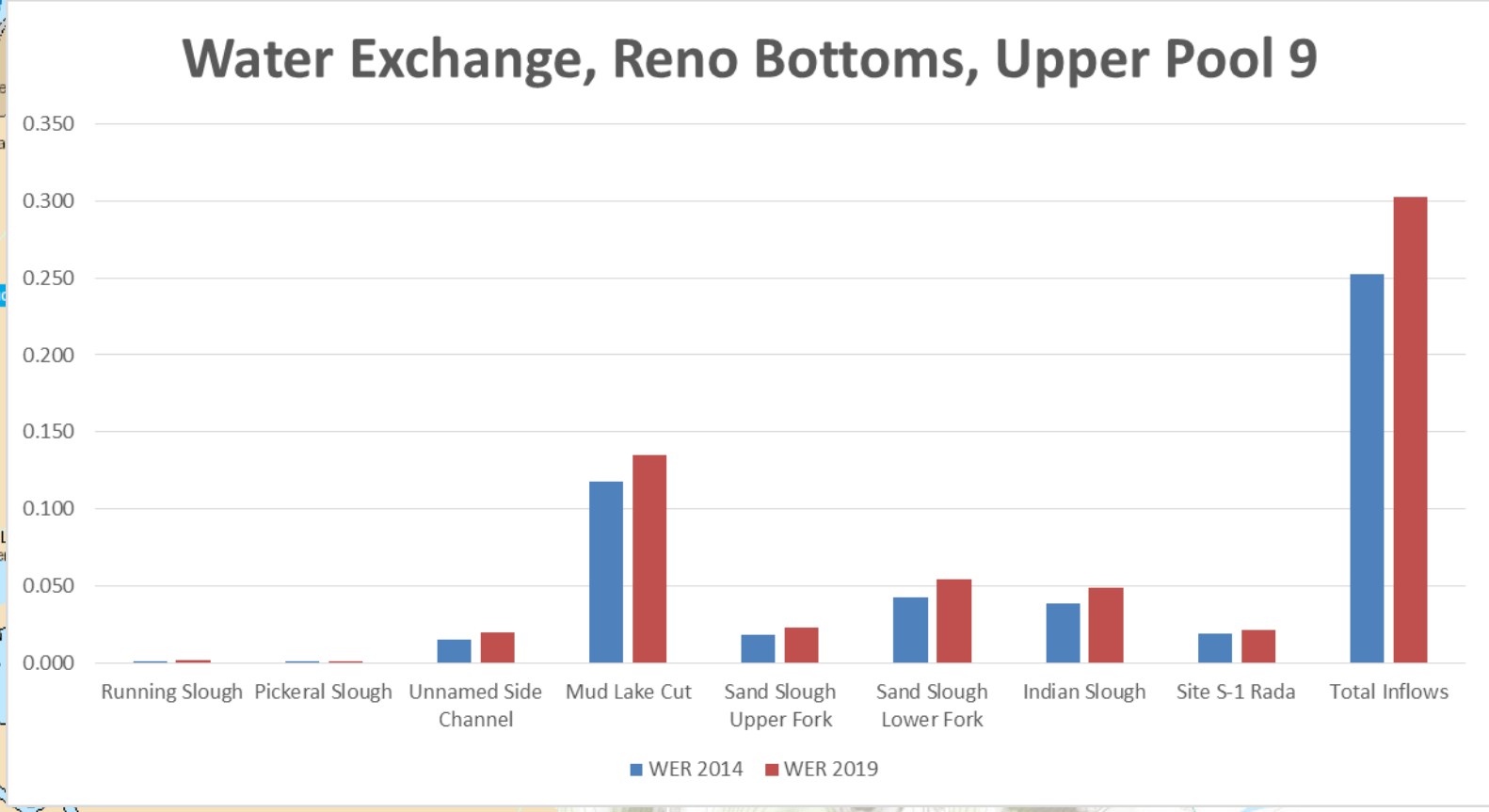


Water exchange at Mormon Slough is increasing.

Is this causing point bar to encroach further in the channel?

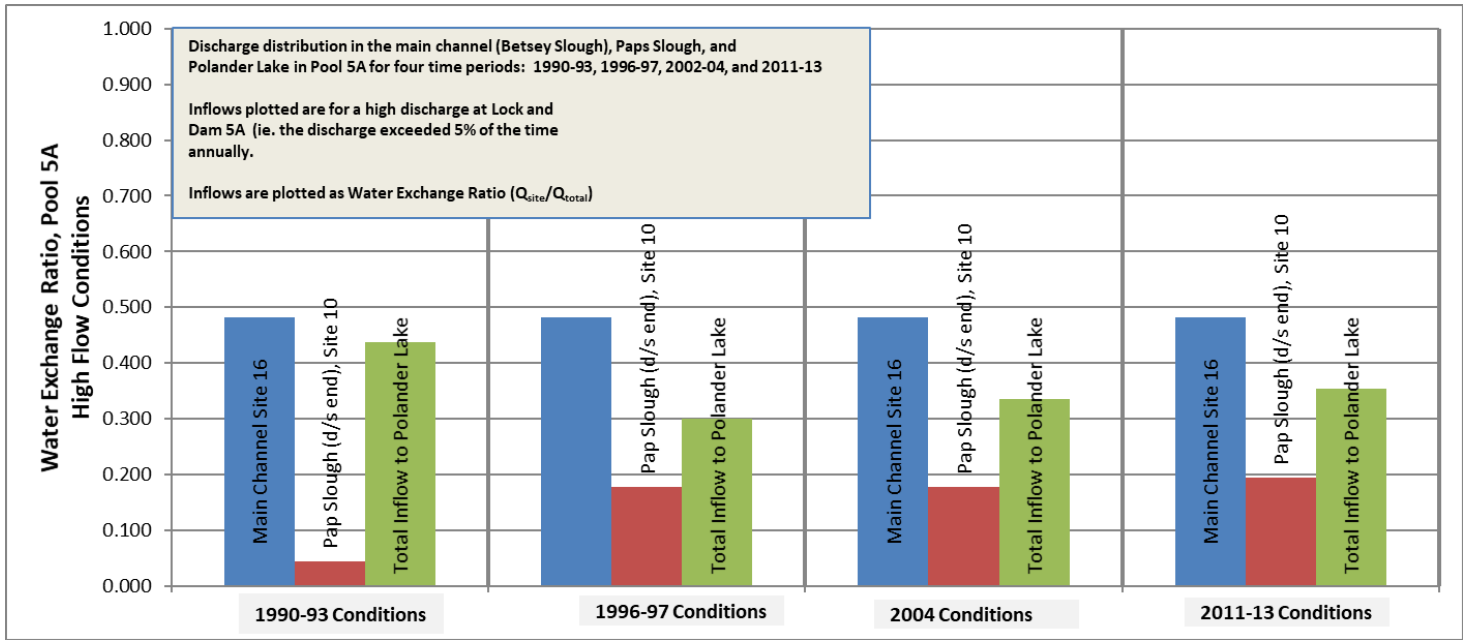
Solutions?


Find address or place
678
677
676
675
Dairyland Power Cooperative, Genoa
Thief Slough
Clark Slough
Island 126 Lower Lt. (677.4)
MILLSTONE LANDING
Mud Lake
Ice Haul Slough
Goose Lake
Minnesota Slough
Bad Axe Bend Dbn. (675.9)
Bad Axe River Lt. (676.0)
Bad Axe Upper Dbn. (674.9)
Bad Axe Island Lt. (674.7)
Indian Slough
RR Mile 277
BAD AXE LANDING
Bad Axe Landing

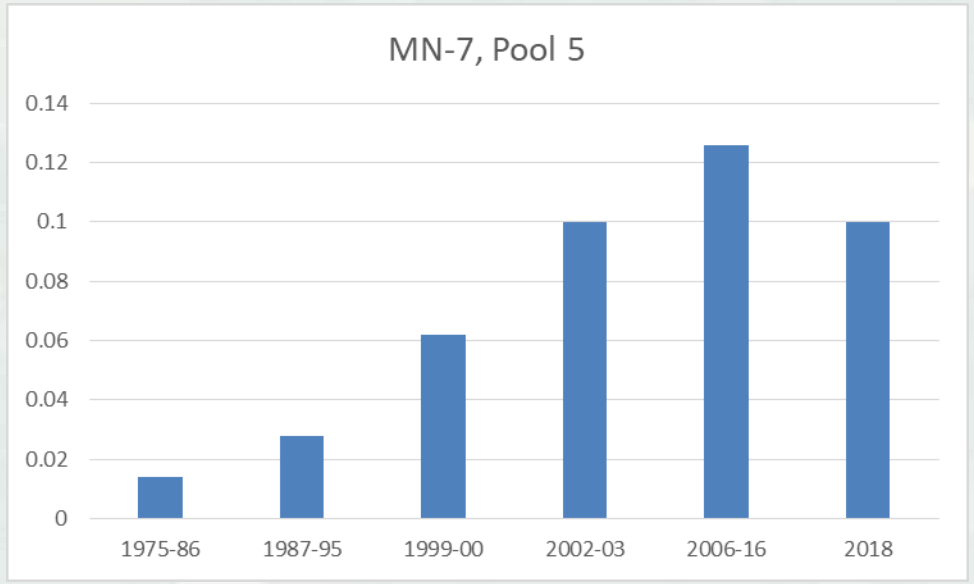

Water Exchange, Reno Bottoms, Upper Pool 9
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Running Slough
Pickeral Slough
Unnamed Side Channel
Mud Lake Cut
Sand Slough Upper Fork
Sand Slough Lower Fork
Indian Slough
Site S-1 Rada
Total Inflows
WER 2014
WER 2019

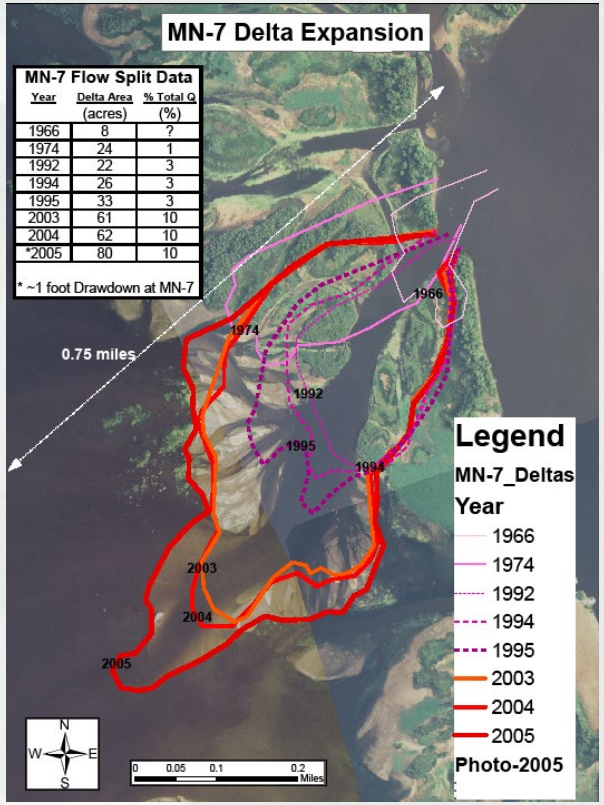

Mundsack Rd
S Bad Axe
S Bad Axe Rd
Malphy Ln

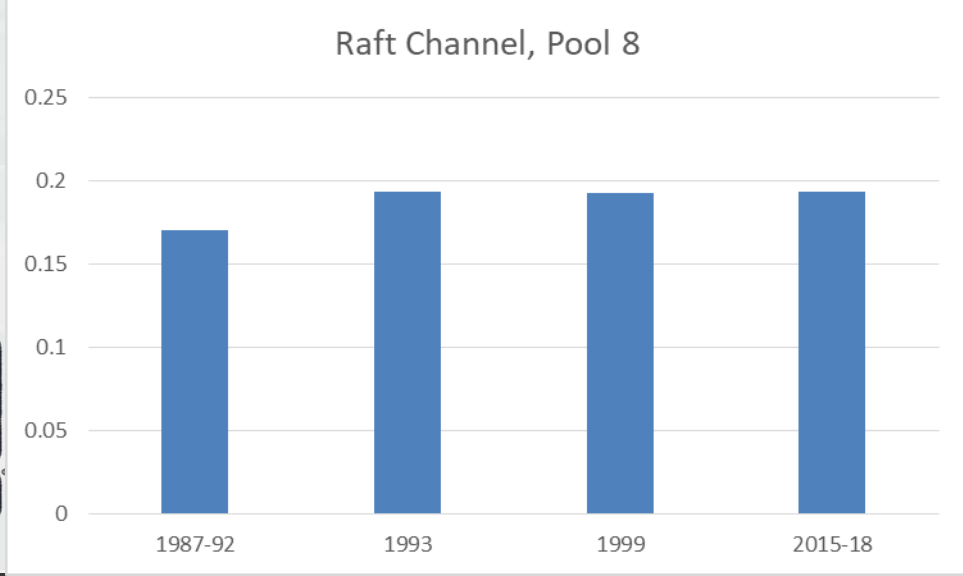

UMRR Discharge Viewer
U.S. Army Corps of Engineers St. Paul District (USACE MVP)
Find River Mile or Place
733
732
731
730
729
Pool 5a
Paps Slough
Main Channel
Site 9
Burleigh Slough
-91.742 44.110 Degrees
esri

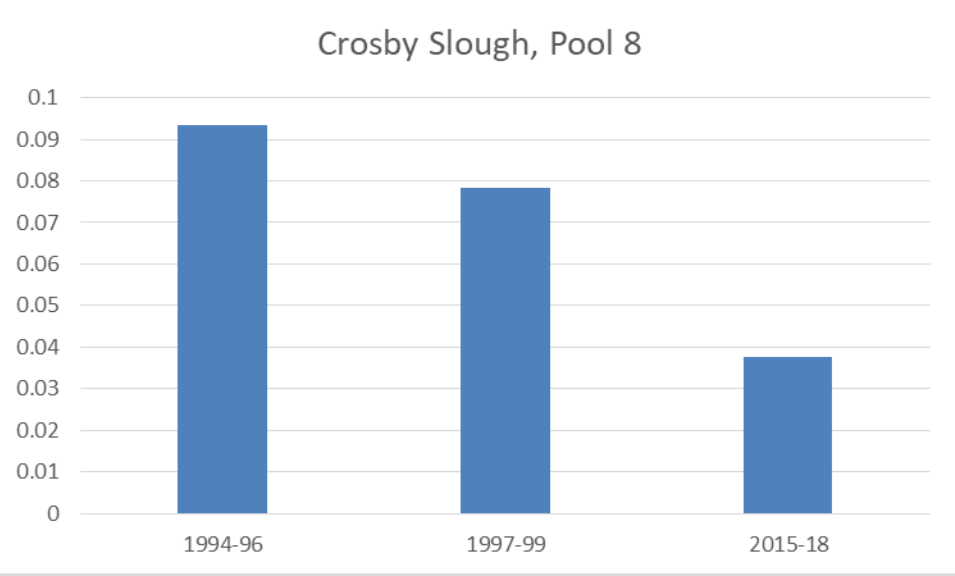

Discharge distribution in the main channel (Betsey Slough), Paps Slough, and Polander Lake in Pool 5A for four time periods: 1990-93, 1996-97, 2002-04, and 2011-13
Inflows plotted are for a high discharge at Lock and Dam 5A (ie. the discharge exceeded 5% of the time annually.
Inflows are plotted as Water Exchange Ratio (Q_{site}/Q_{total})
Water Exchange Ratio, Pool 5A High Flow Conditions
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Main Channel Site 16
Pap Slough (d/s end), Site 10
Total Inflow to Polander Lake
1990-93 Conditions
1996-97 Conditions
2004 Conditions
2011-13 Conditions

Water Exchange Rates Quantify Geomorphic Change And Response to Projects









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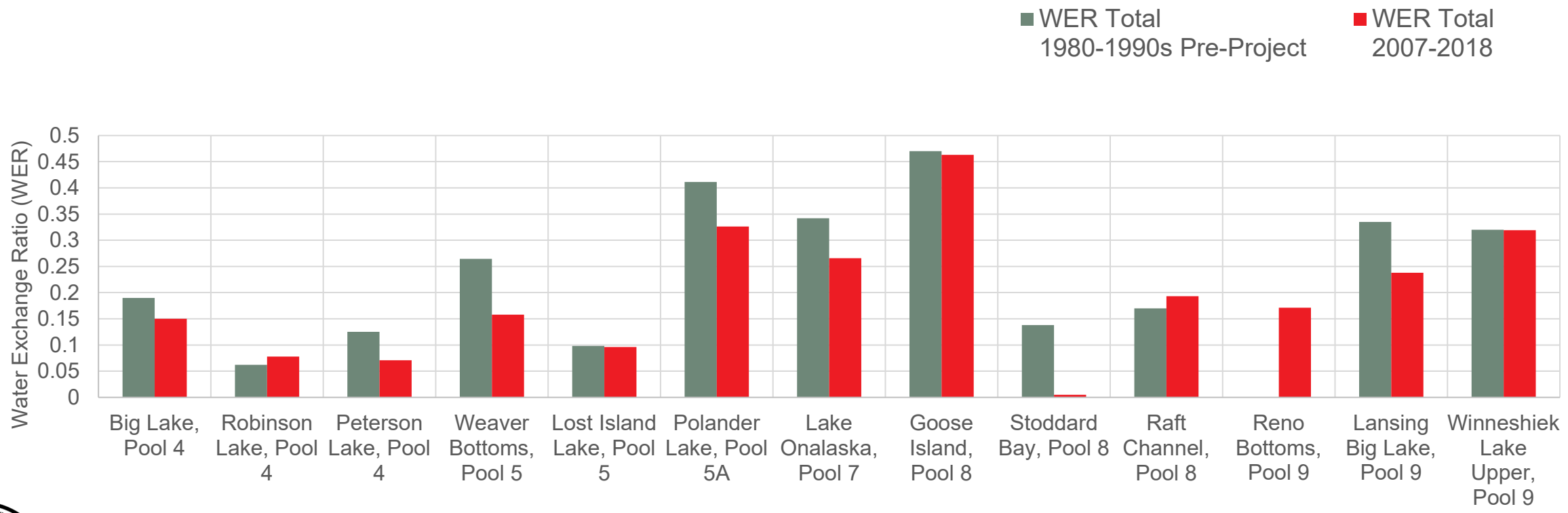
BACKWATER SEDIMENT SINKS ARE DECREASING

Change in Water Exchange Ratio (WER) Backwaters in Geomorphic Reach 3 for the Discharge Exceeded 25% of the Time Annually 1980-1990s time period to 2007-2018 time period

$$WER = (\sum Q_{side\ channel}/Q_{total})$$



Data processing funded by UMRR Science in Support of Management

SEDIMENT MEASUREMENTS CHIPPEWA RIVER AT DURAND AND PEPIN

District/Other USACE PDT Members

St. Paul – Bryan Peterson, Steve Tapp, Dan Cottrell, Jon Hendrickson, Alex Nelson

ERDC – David Abraham, William Butler

Leveraging/Collaborative Opportunities

1. 2017 – 2020 Collect data, calibrate methods & equipment
2. 2020 Scientific Investigations Report, USGS
3. 2021 continued monitoring
4. USACE Navigation and RSM funding

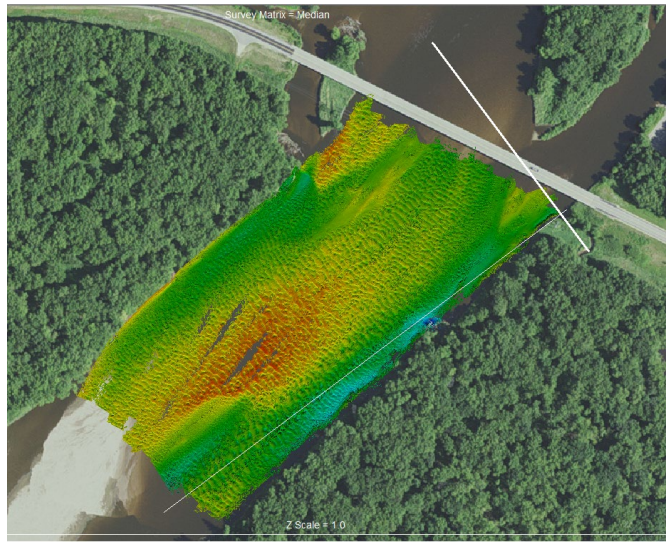
Stakeholders/Partners

Joel Groten, Jeff Ziegeweid, Will Lund, USGS Minn.

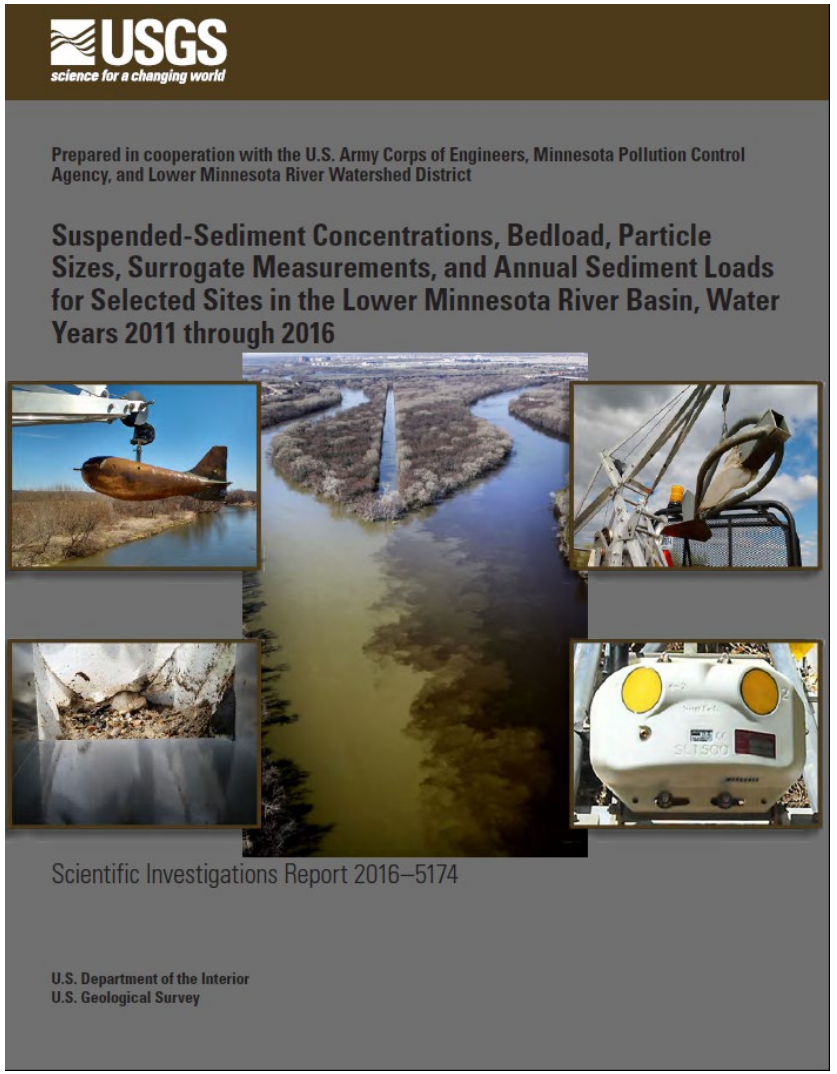
Dave Dean, USGS Grand Canyon Research Center

Dan Buscombe, Northern Arizona State University

Faith Fitzpatrick, Joe Shuler, USGS Wisc.



Minnesota River Surrogate Metric: Acoustic Backscatter



Groten, J.T., Ellison, C.A., and Hendrickson, J.S., Suspended-Sediment Concentrations, Bedload, Annual Sediment Loads, Particle-Sizes, and Surrogate Measurements for Selected Sites in the Lower Minnesota River, 2011 through 2014: U.S. Geological Survey Scientific Investigations Report 2016–5174, 29 p.

Data indicates:

- Minnesota River Sand Load is 250,000 yd3/yr.
- Minn. River dredging is 21,000 yd3/yr or 8.4% of total sand load.

2022 EFFORTS

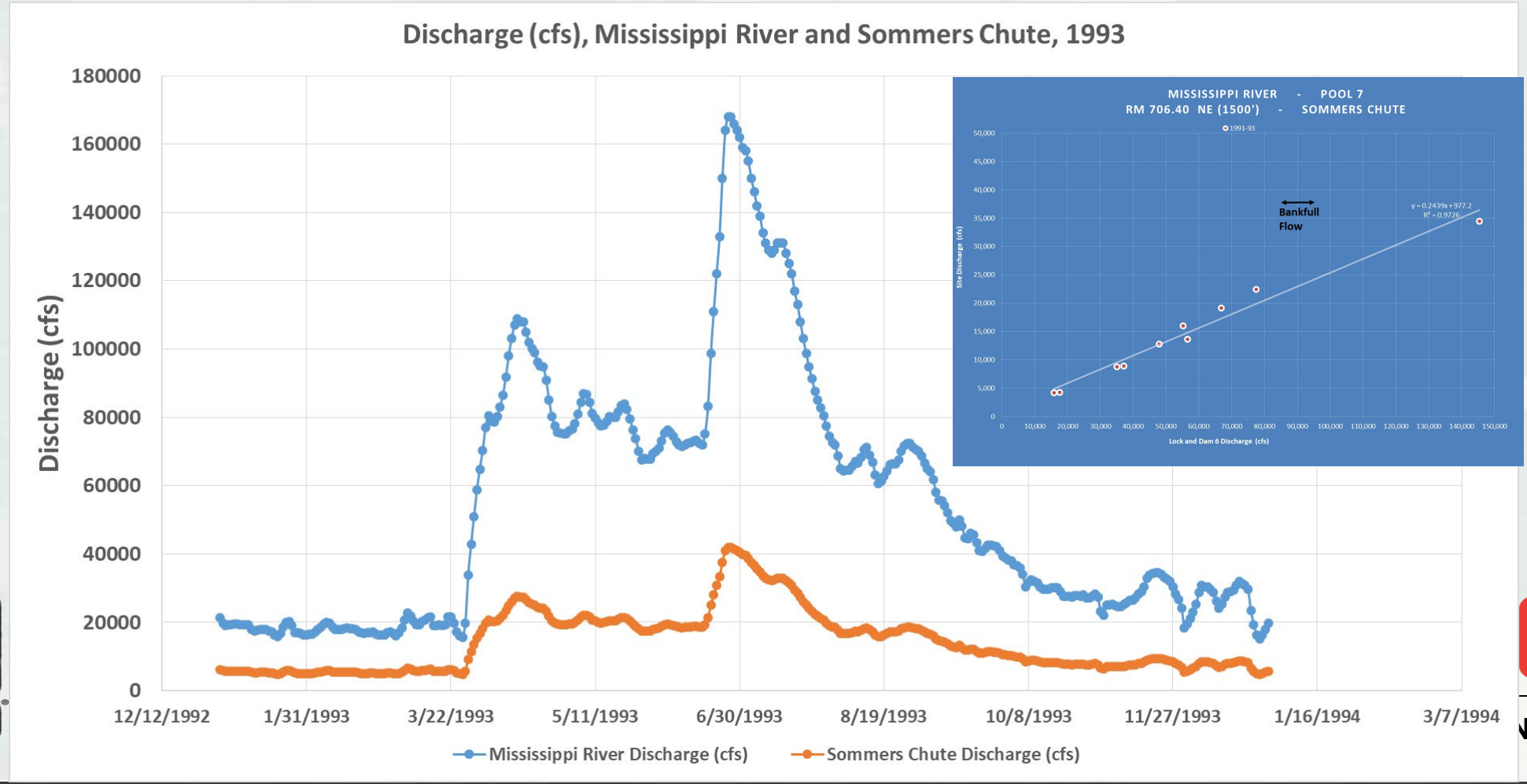
- Secondary channel measurements offer the best indicator of the complex geomorphic changes that are occurring.
- Chippewa River sediment monitoring will continue.
- Minnesota River sediment monitoring?? Gaging platform was destroyed in 2019 flood. Switch to Jordan, Minn. gage.
- Considering adding a Mississippi River sediment gaging station near St. Paul

DISCUSSION?

18

Questions?

Estimates of Daily Water Exchange



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UMRR Discharge Viewer
U.S. Army Corps of Engineers St. Paul District (USACE MVP)
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733
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Pool 5a
Paps Slough
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Site 9
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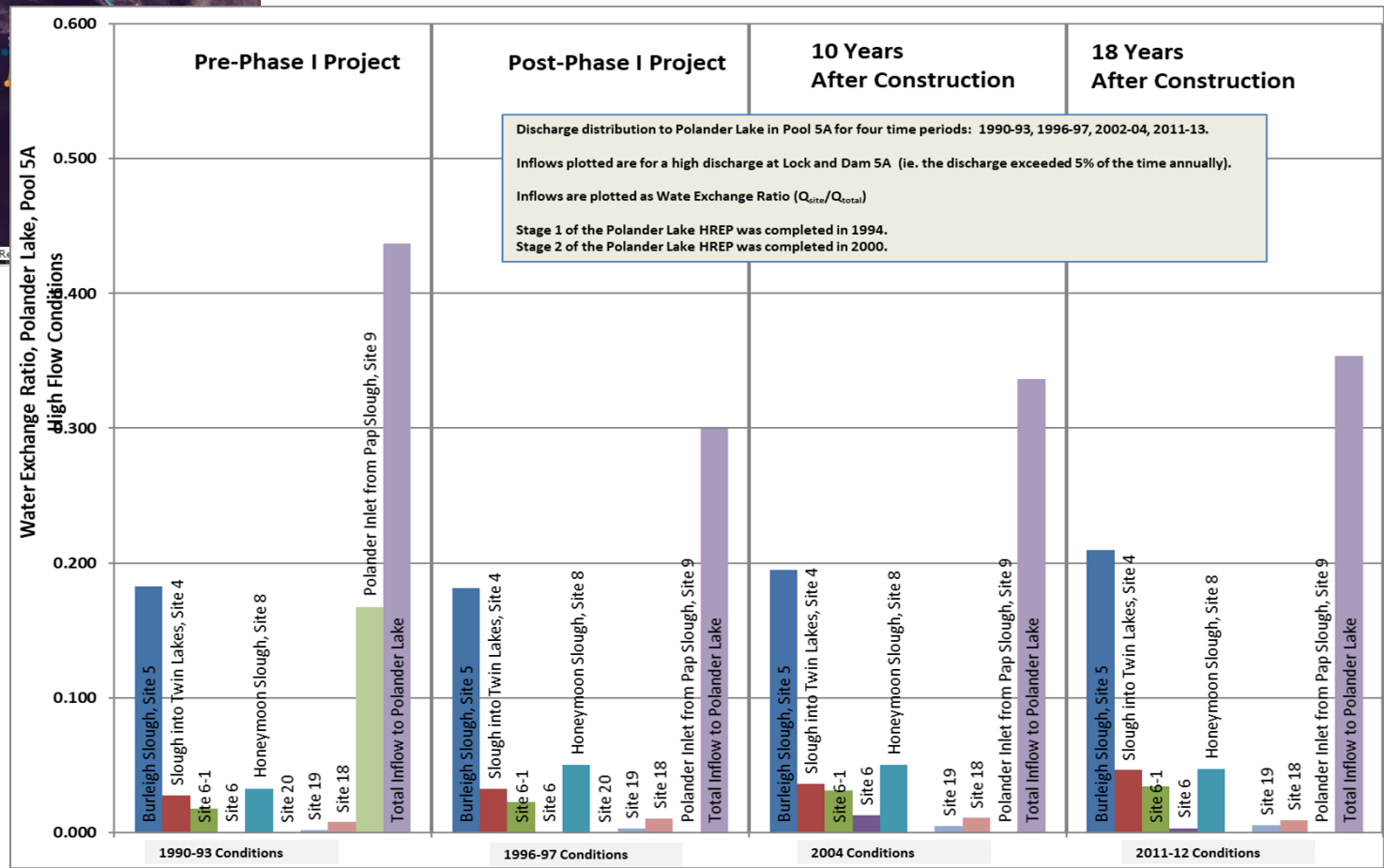
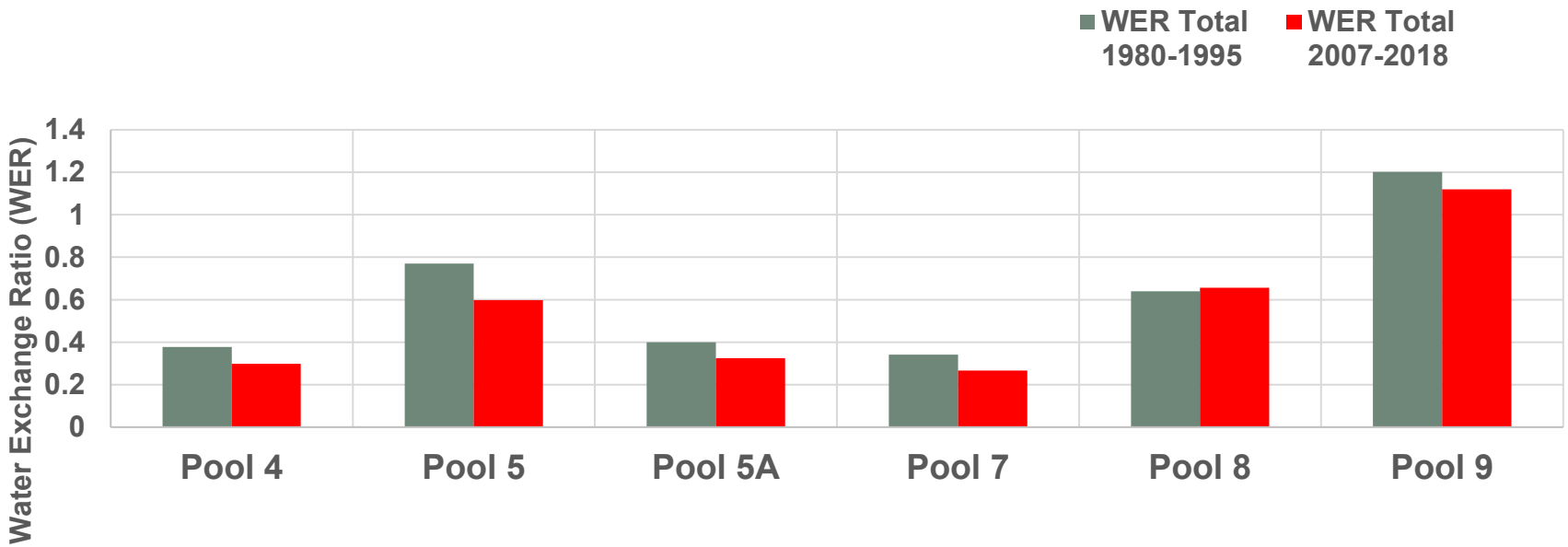

Pre-Phase I Project
Post-Phase I Project
10 Years After Construction
18 Years After Construction
Discharge distribution to Polander Lake in Pool 5A for four time periods: 1990-93, 1996-97, 2002-04, 2011-13.
Inflows plotted are for a high discharge at Lock and Dam 5A (ie. the discharge exceeded 5% of the time annually).
Inflows are plotted as Wate Exchange Ratio (Q_{site}/Q_{total})
Stage 1 of the Polander Lake HREP was completed in 1994.
Stage 2 of the Polander Lake HREP was completed in 2000.
Water Exchange Ratio, Polander Lake, Pool 5A
High Flow Conditions
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Burleigh Slough, Site 5
Slough into Twin Lakes, Site 4
Site 6-1
Site 6
Honeymoon Slough, Site 8
Site 20
Site 19
Site 18
Polander Inlet from Pap Slough, Site 9
Total Inflow to Polander Lake
1990-93 Conditions
1996-97 Conditions
2004 Conditions
2011-12 Conditions

WATER EXCHANGE RATIO, GEOMORPHIC REACH 3

Total Water Exchange Ratio (WER) for Navigation Pools in Geomorphic Reach 3
for the Discharge Exceeded 25% of the Time Annually

$$WER = (\sum Q_{backwater}/Q_{total})$$



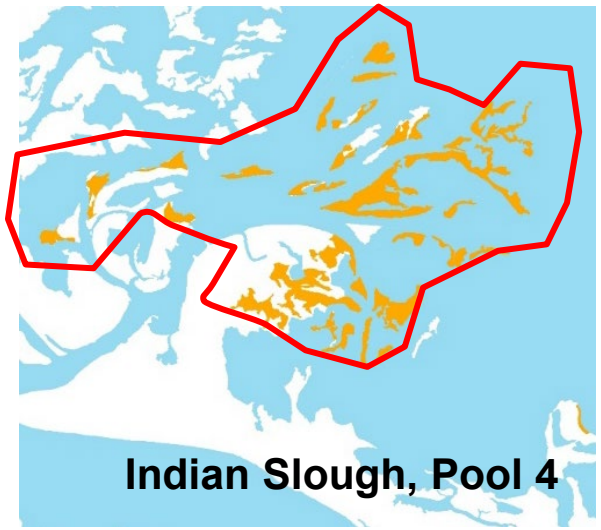
Data processing funded by UMRR Science in Support of Management

SEDIMENT SINKS

- Secondary channel measurements at several sites indicate that flow to backwaters decreases as sediment deltas expand.

- Pool 7 is Probably Most Significant Example to Date
  - Outdraft
  - Shift in Dredging
  - Greater sand loads to Pool 8??

- Delta expansion is occurring in many backwaters



Hydrogeomorphic units

Rogala, USGS