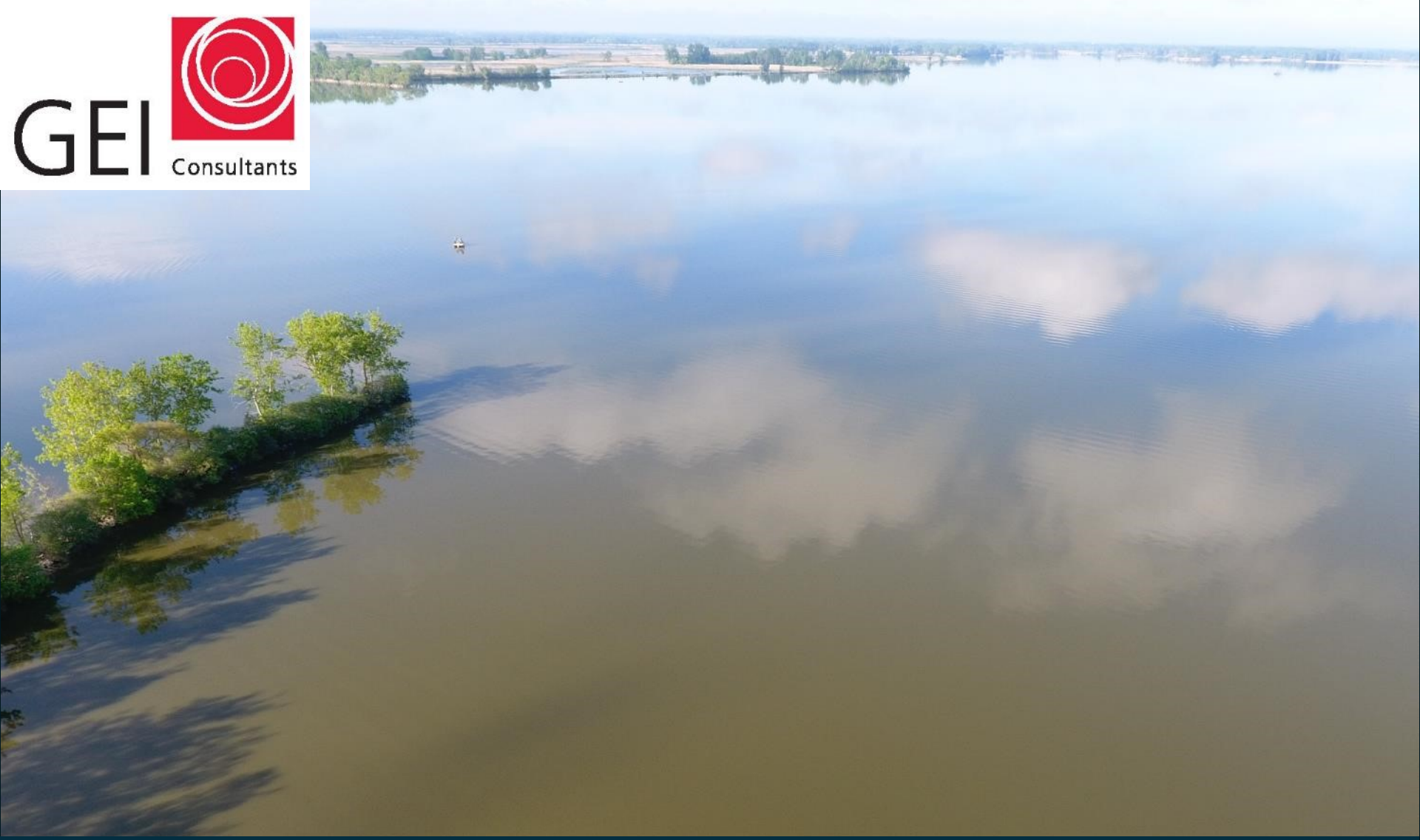


Muddy Creek Bay: Challenges Associated with Large Scale Great Lakes Coastal Wetland Restoration

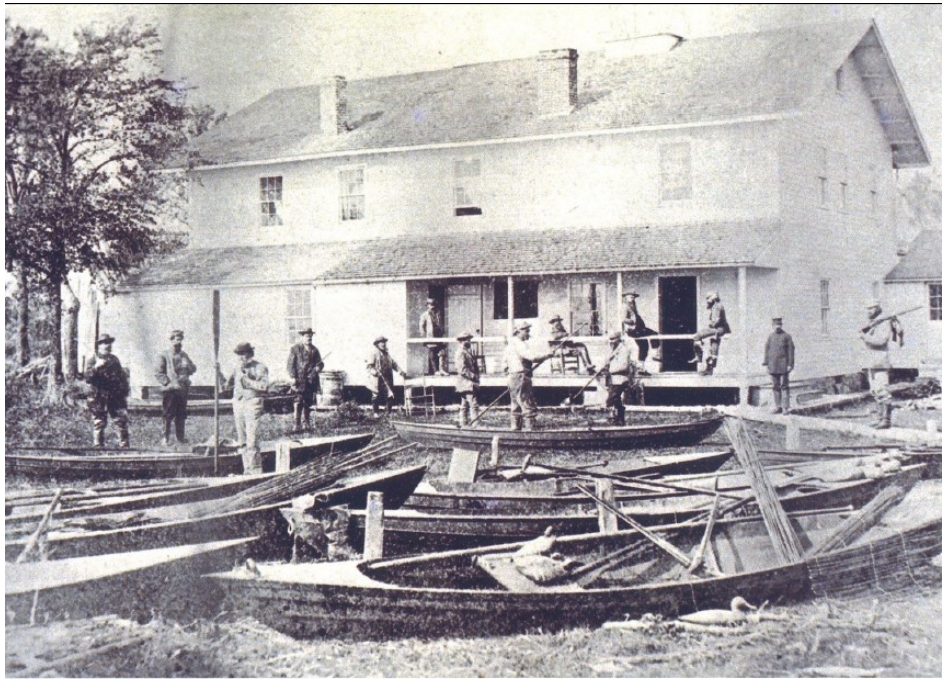
Brian Majka, Senior Restoration Ecologist, GEI

Acknowledgements

- The Nature Conservancy
- Winous Point Marsh Conservancy
- Ohio Department of Natural Resources
- Hull and Associates
- Affiliated Researchers

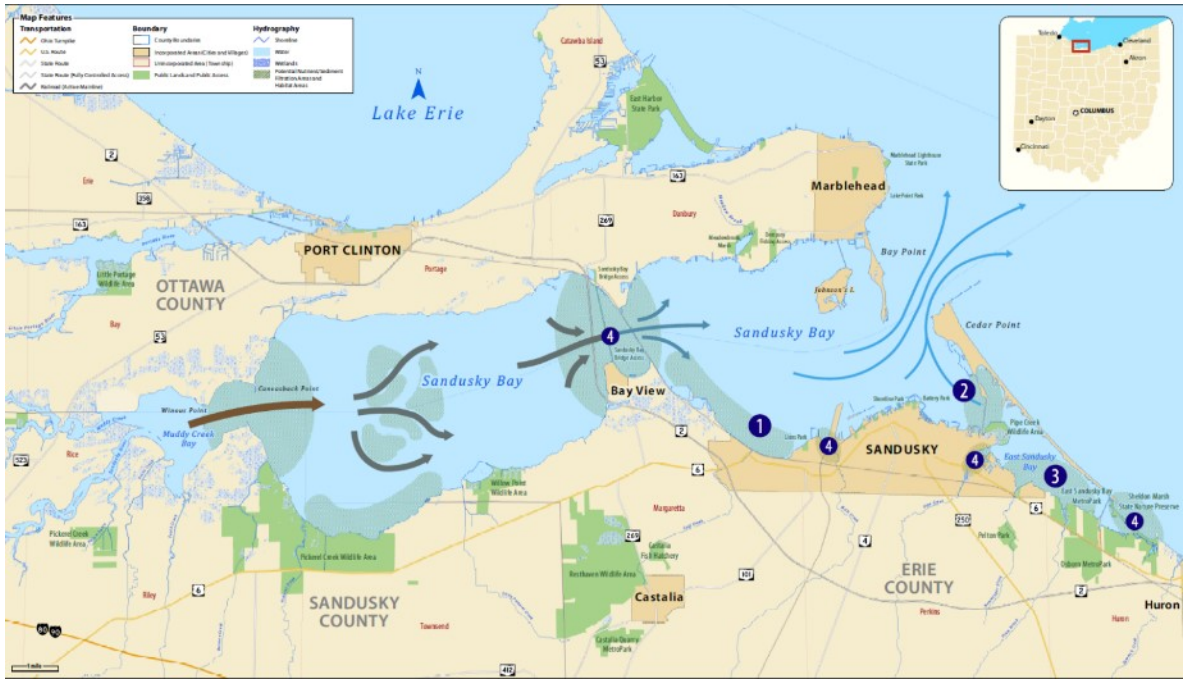
The Nature Conservancy

Protecting nature. Preserving life.™

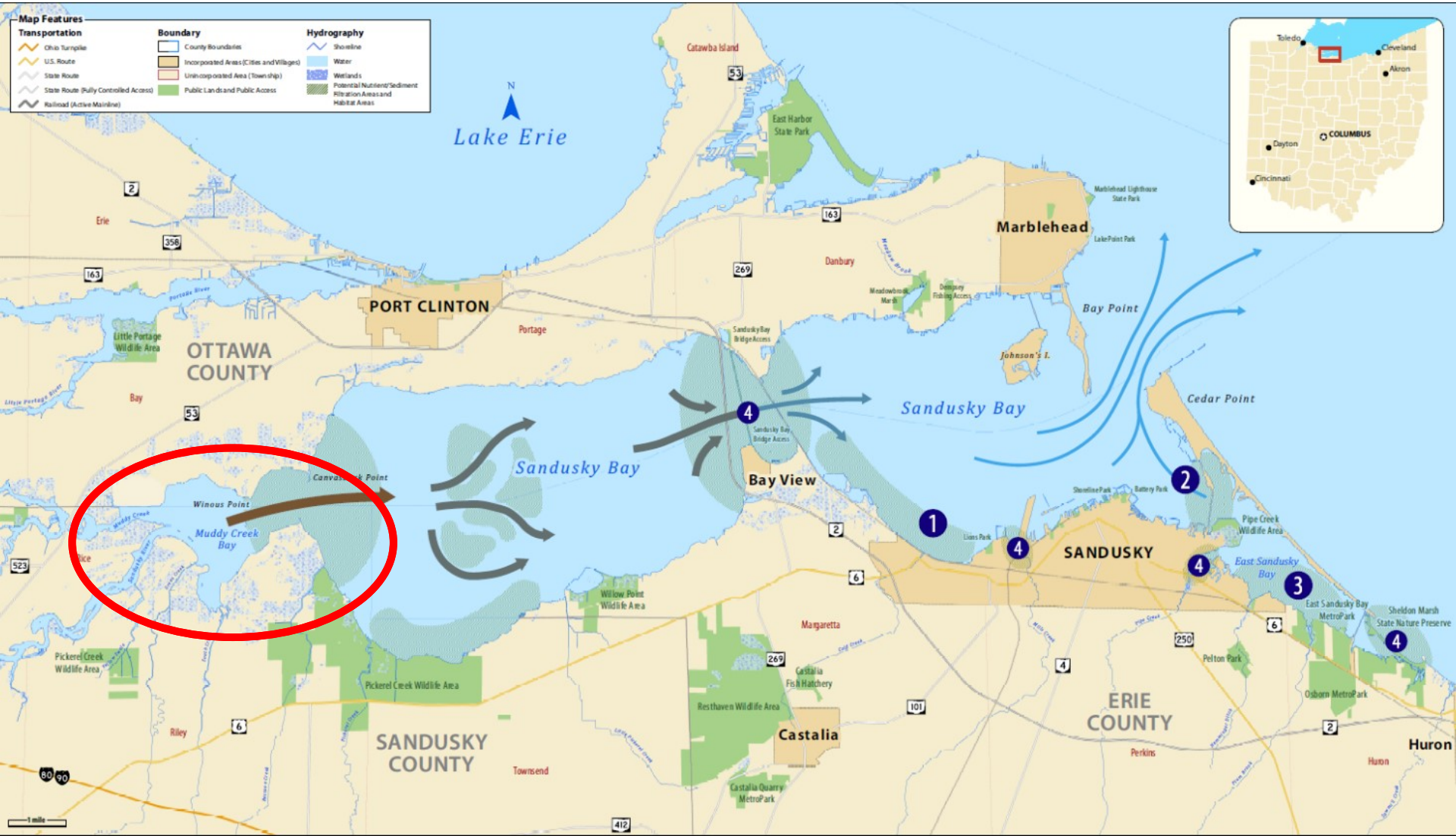


The Sandusky Bay Initiative (SBI)

- Effort led by Ohio DNR and Ohio EPA to restore the 64 square mile Sandusky Bay
- Historical impairments from nutrient loading, development
- Beneficially re-use dredge sediments to restore thousands of acres of wetlands
- Avoid “random acts of restoration” through planned restoration efforts (Scudder Mackey, ODNR)



Muddy Creek Bay

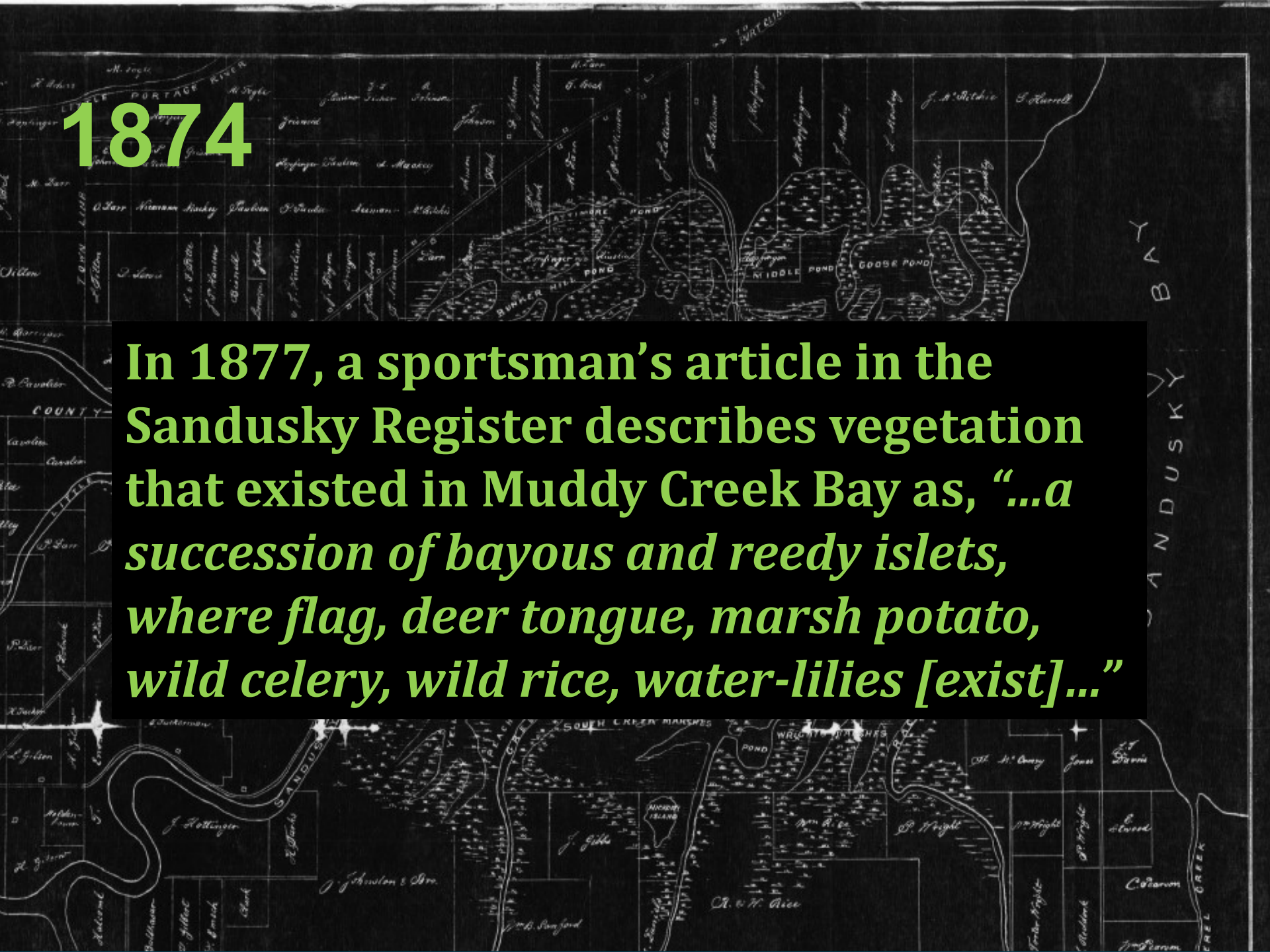


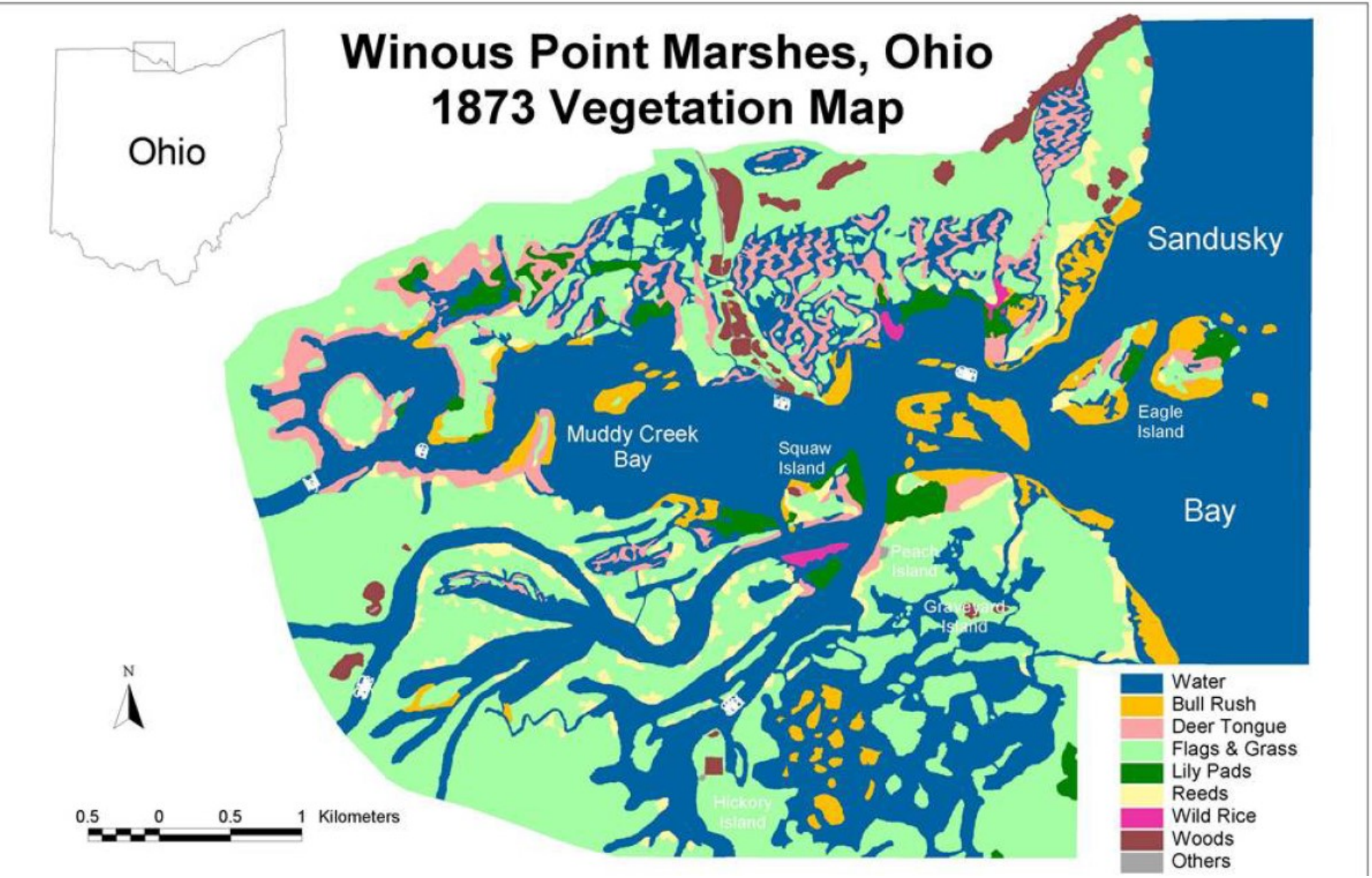
1874


LITTLE PORTAGE RIVER
COUNTY LINE
MUD CREEK
LITTLE MUD CREEK
MUD CREEK BAY
SANDUSKY BAY
EAGLE ISLAND
MIDDLE ISLAND
BEACH ISLAND
BITTER ISLAND
BUNKER HILL
MIDDLE POND
GOOSE POND
PEA PATCH
WINONS POINT
SANDUSKY RIVER
OTTOWA CREEK
HONES POINT CLUB HOUSE
GOOSE POND
CHANNEL
SOUTH CREEK MARSHES
WRIGHT MARSHES
PEACH ORCHARD CREEK
YELLOW SPRINGS
GRAVEYARD ISLAND
NICHOLS ISLAND
MUD HOLE
OUTER BAR
J. Hollinger
J. Gibbs
J. Houston & Son
A. & H. Rice
P. Wright
J. T. Farris
C. Hone
C. Garrison

1874

In 1877, a sportsman's article in the Sandusky Register describes vegetation that existed in Muddy Creek Bay as, *"...a succession of bayous and reedy islets, where flag, deer tongue, marsh potato, wild celery, wild rice, water-lilies [exist]..."*




Winous Point Marshes, Ohio
1873 Vegetation Map
Ohio
Sandusky
Bay
Eagle
Island
Muddy Creek
Bay
Squaw
Island
Peach
Island
Graveyard
Island
Hickory
Island
N
0.5
0
0.5
1
Kilometers
Water
Bull Rush
Deer Tongue
Flags & Grass
Lily Pads
Reeds
Wild Rice
Woods
Others


2018
Winous Point
Muddy Creek Bay
Muddy Creek
Sandusky River
Green Creek
Image © 2020 TerraMetrics

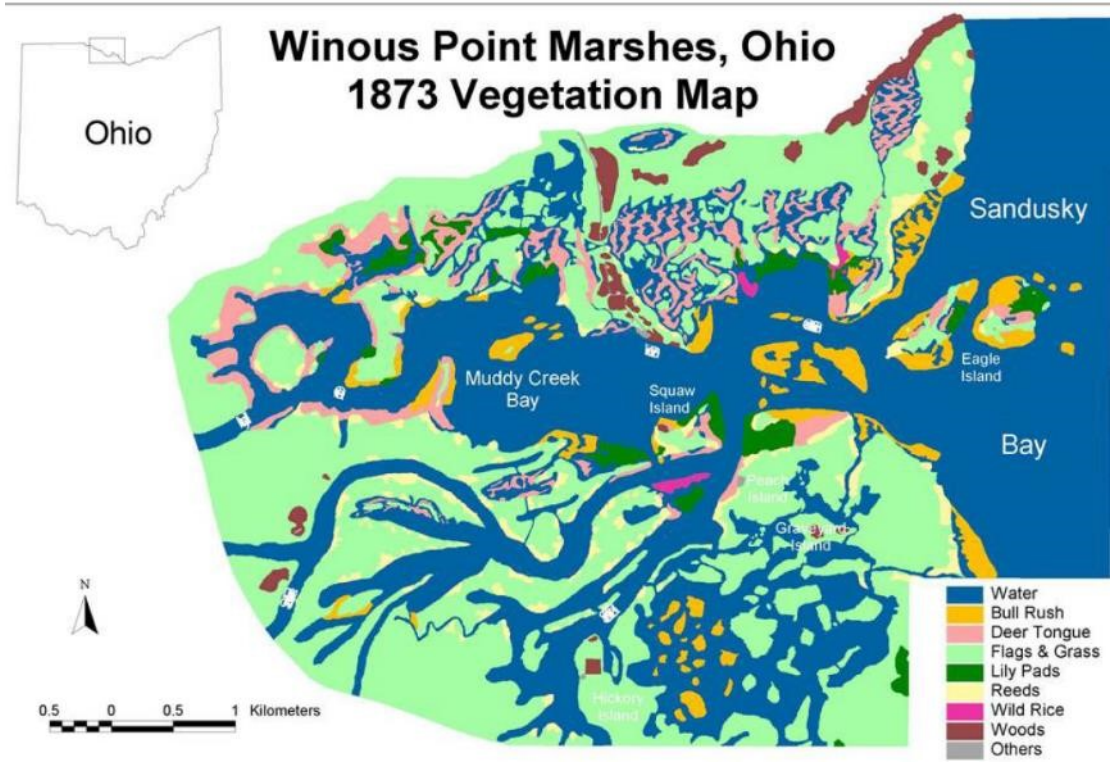
Muddy Creek Bay

- ~3 miles long x 2 miles wide
- Extremely turbid “muddy” waters
- Near total loss of wetlands within bay
- EXCEPT those protected with dikes by the Winous Marsh Conservancy
- How do we bring wetlands back to the bay?


Approximate Location of Historic Deltas in Muddy Creek Bay
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID
IGN, and the GIS User Community

When did Muddy Creek Bay lose its wetlands?

- Bay vegetation has been well studied
- Half of the wetlands were lost between 1894 and 1926 (Gottgens et. al)
- This was a period of average to low Lake Erie levels—so wetlands should have been expanding
- Wild rice was abundant in 1873, nearly absent in 1894



The Landward Advancement Paradigm (LAP)

- Gottgens et. al used GIS to analyze lost marshes in Lake Erie
- 3 main converging factors have contributed to loss of wetlands:
  - Sustained elevated water levels
  - Introduction/presence of carp (1879) in clay and silty sediments
  - Inability of wetlands to advance landward due to historic diking

So what are the physical, chemical, biological, or anthropogenic factors that affect the presence or absence of wetlands in Muddy Creek Bay?

1. Physical
    1. Waves
    2. Sediment
    3. Hydrology
    4. Turbidity
2. Chemical
    1. Nutrients
3. Biological
    1. Carp
4. Anthropogenic
    1. Dikes
    2. Ballville Dam
    3. Boats
    4. Farming

How do we know what matters and what doesn't?

1. We research
2. We model
3. We measure
4. We compare abiotic and biotic factors in areas of the bay that have wetlands, with areas that don't

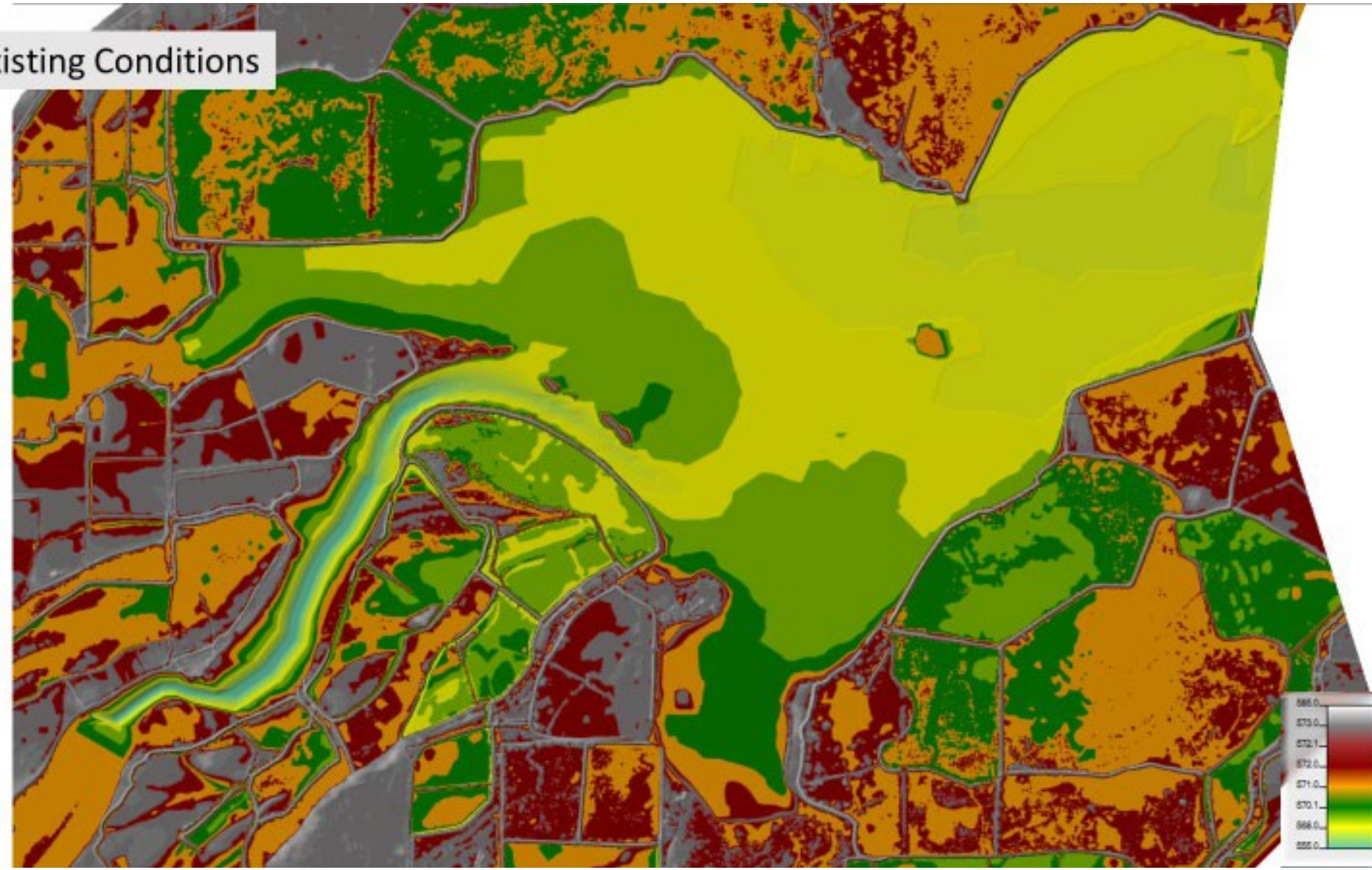
Where do we have (non-diked) wetlands left in the bay?

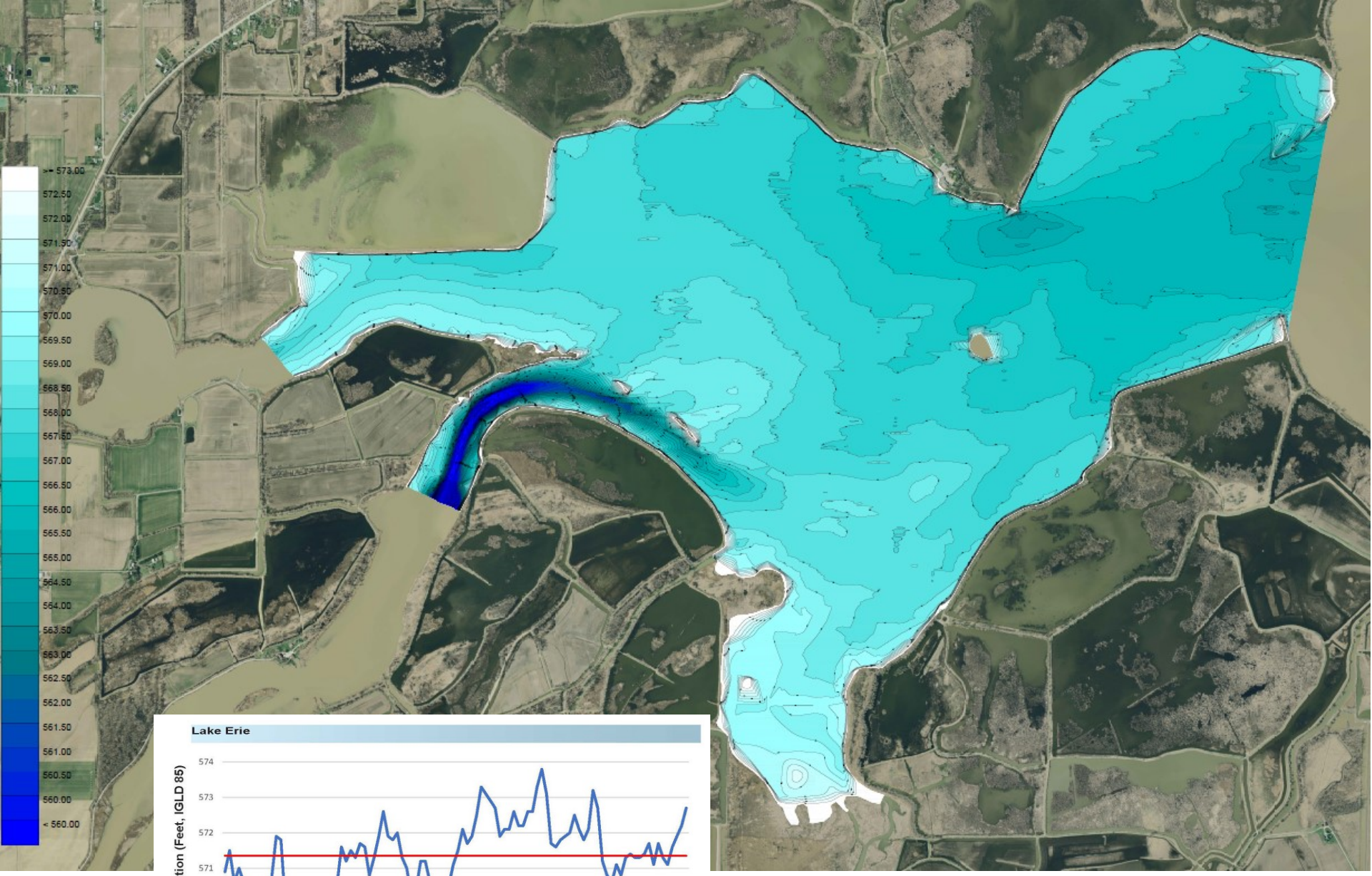
Winous Point
Diked Wetlands

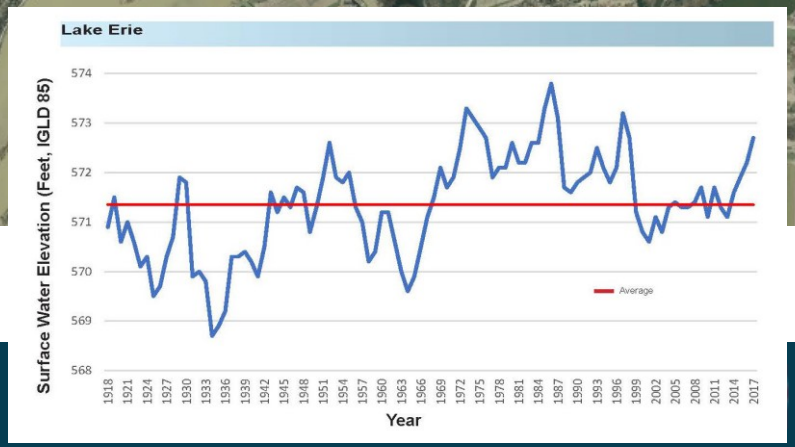
What are the abiotic conditions in the bay, especially where vegetation is present?

1. Physical
    1. Bathymetry
    2. Waves
    3. Sediment
    4. Hydrology
    5. Turbidity
2. Chemical
    1. Nutrients
3. Biological
    1. Carp
4. Anthropogenic
    1. Dikes
    2. Ballville Dam
    3. Boats
    4. Farming

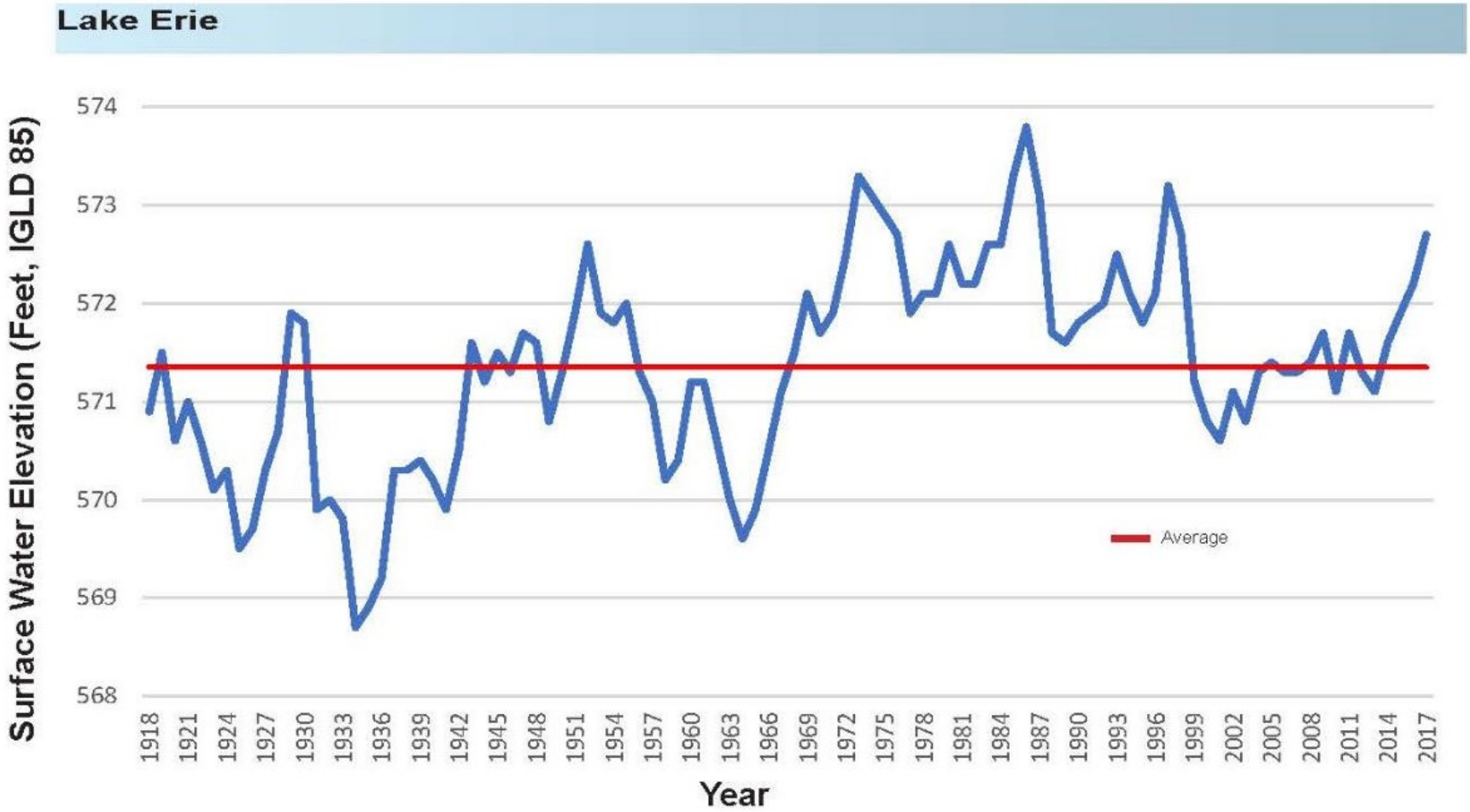
Existing Conditions



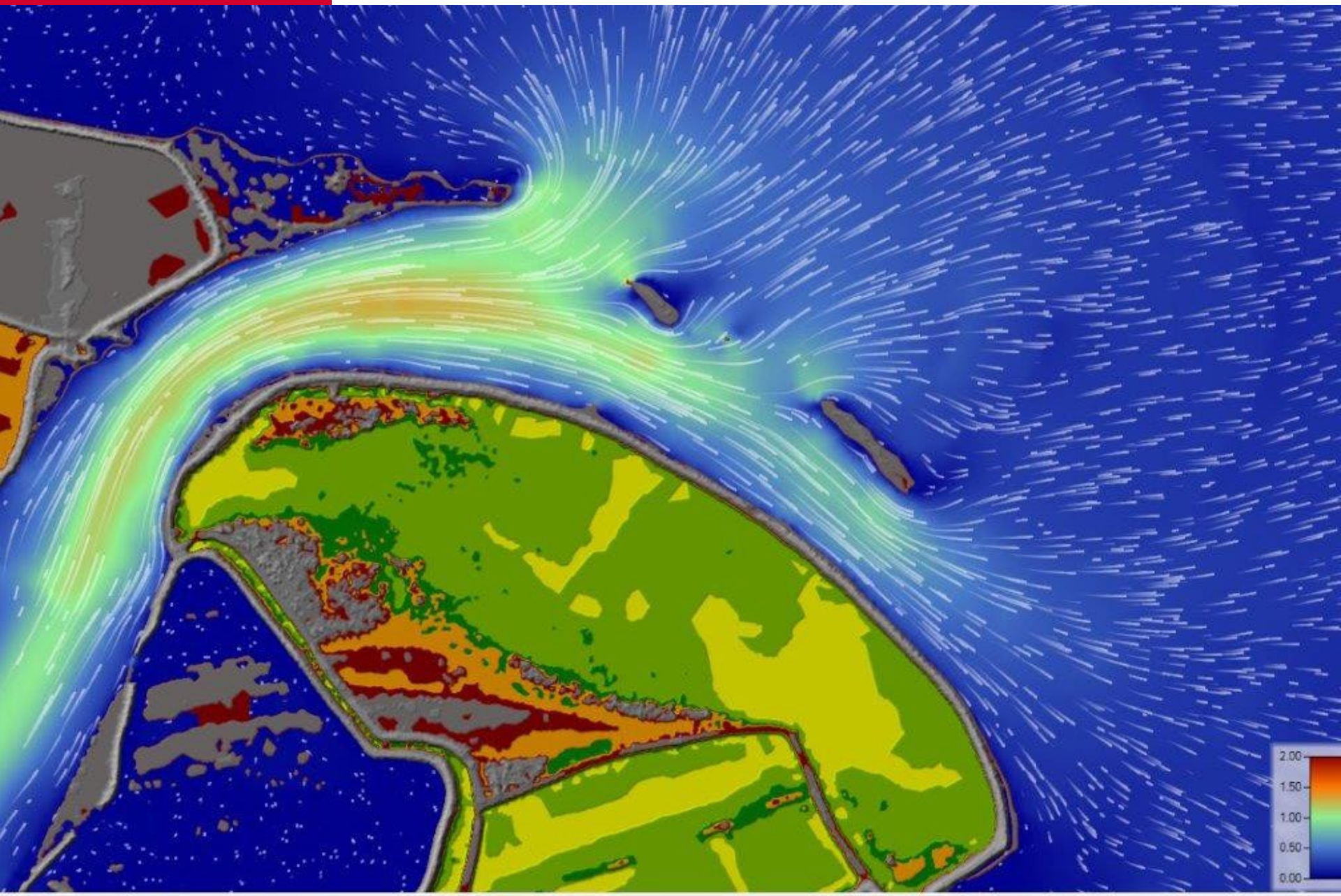

>= 573.00
572.50
572.00
571.50
571.00
570.50
570.00
569.50
569.00
568.50
568.00
567.50
567.00
566.50
566.00
565.50
565.00
564.50
564.00
563.50
563.00
562.50
562.00
561.50
561.00
560.50
560.00
< 560.00


Lake Erie
Surface Water Elevation (Feet, IGLD 85)
574
573
572
571
570
569
568
Average
1918
1921
1924
1927
1930
1933
1936
1939
1942
1945
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Year

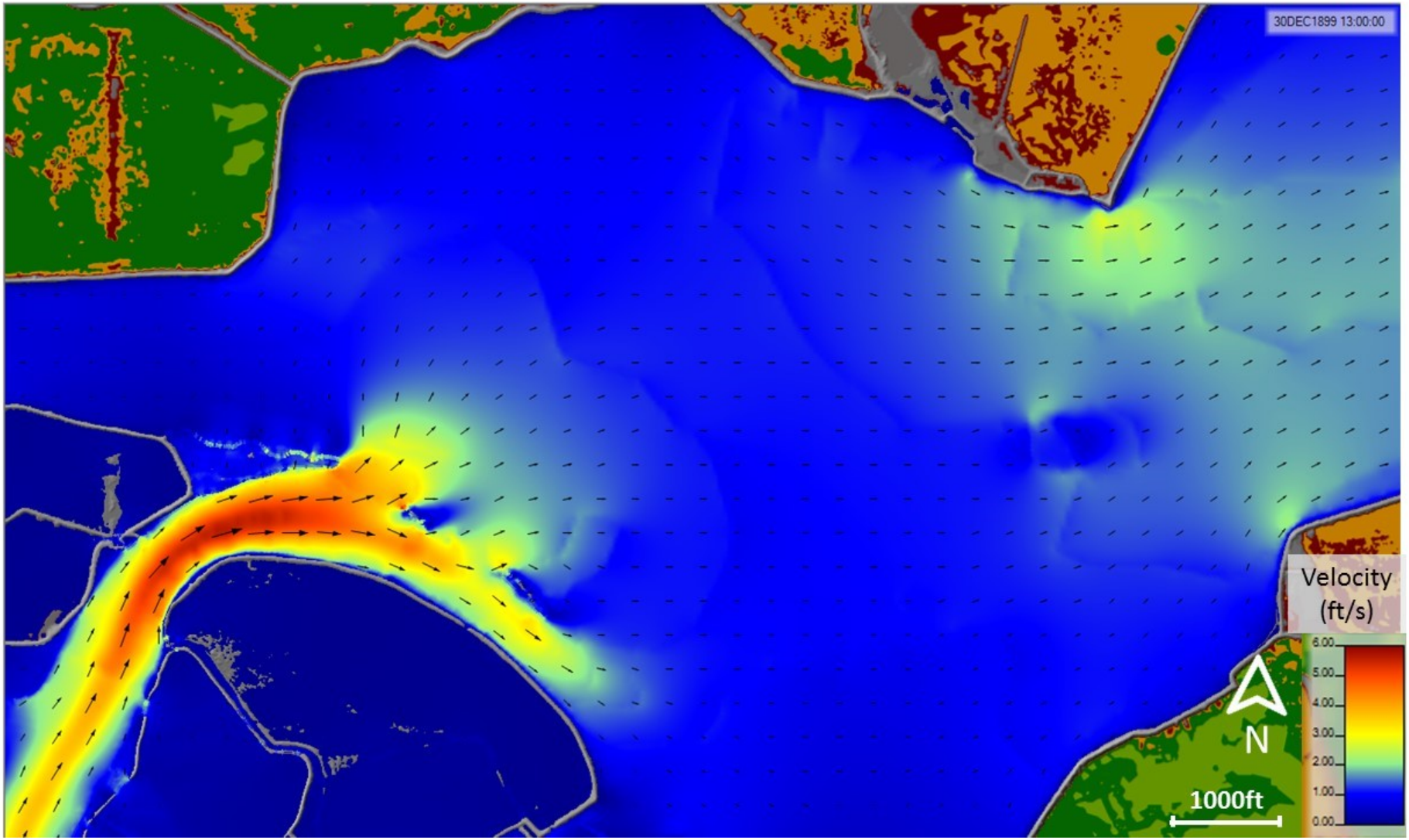
Water Levels



Flows



Flows


30DEC1899 13:00:00
Velocity
(ft/s)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
N
1000ft

Fetch


Heading: 80°
9.6 miles
Sandusky River Mouth
Muddy Creek Bay
Sandusky Bay
0
0.5
1
Miles

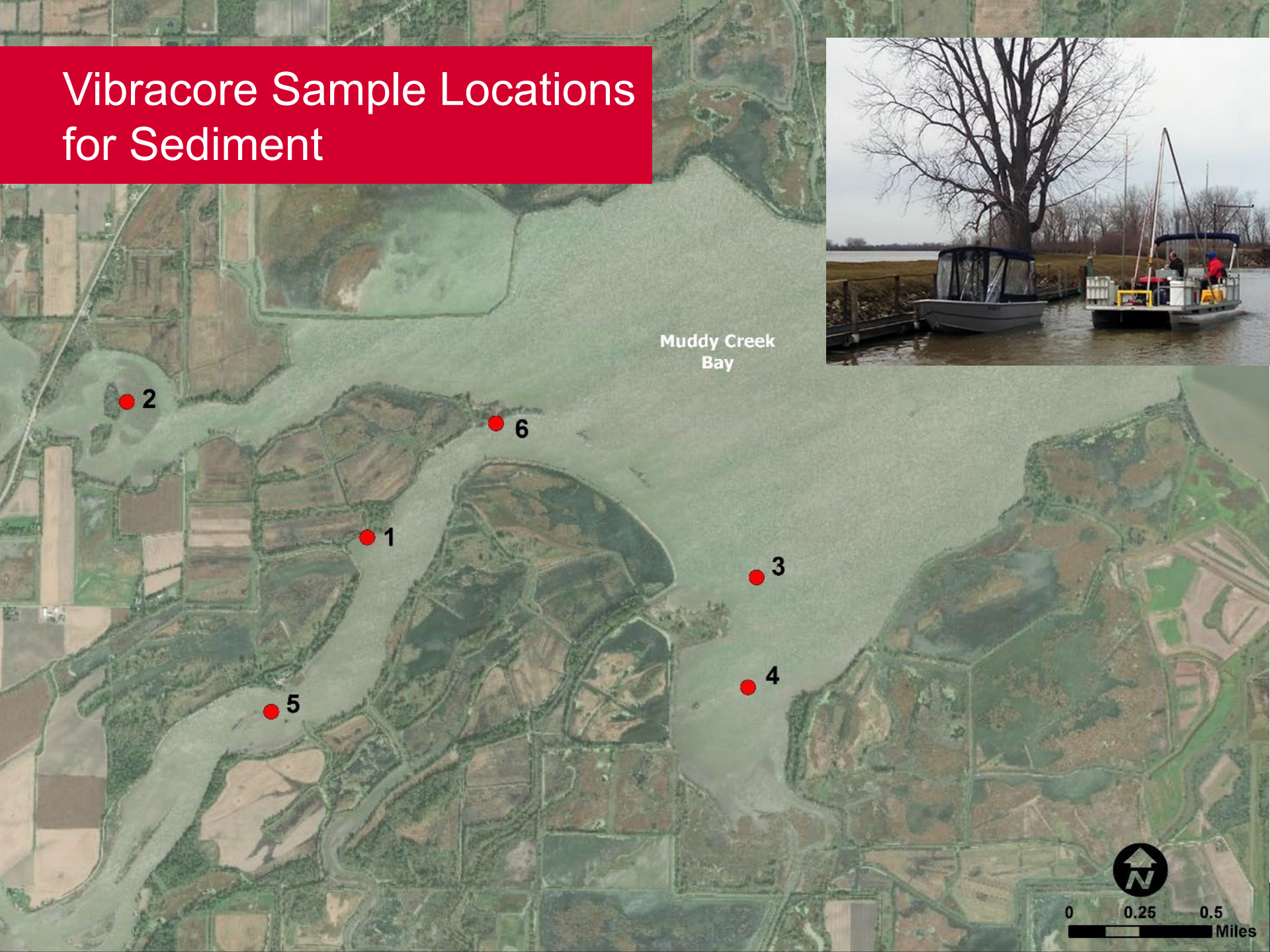
Waves

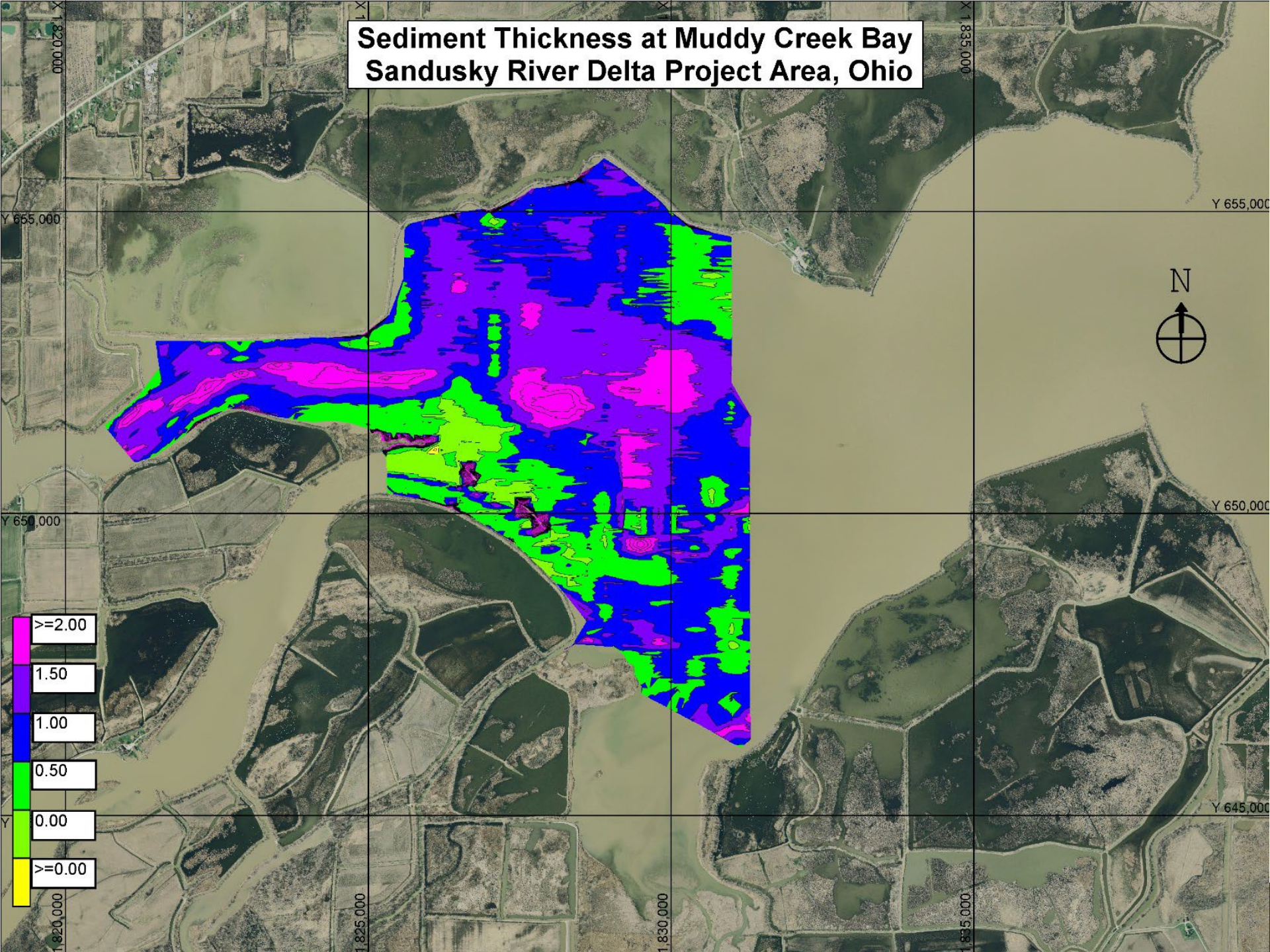
Location	Wind speed (kts/mph)	Significant wave height H_s (ft)	Wave period (s)	H_1 wave (ft)
Muddy Creek	**10/12**	0.89	2.1	1.49
	39/45	2.58	3.61	4.31
	61/70	3.43	4.25	5.73
Sandusky mouth	**10/12**	0.87	2.07	1.45
	39/45	2.57	3.56	4.28
	61/70	3.42	4.2	5.71
Winous Point	**10/12**	0.84	2.02	1.39
	39/45	2.55	3.48	4.26
	61/70	3.41	4.1	5.69

Sediment Sampling

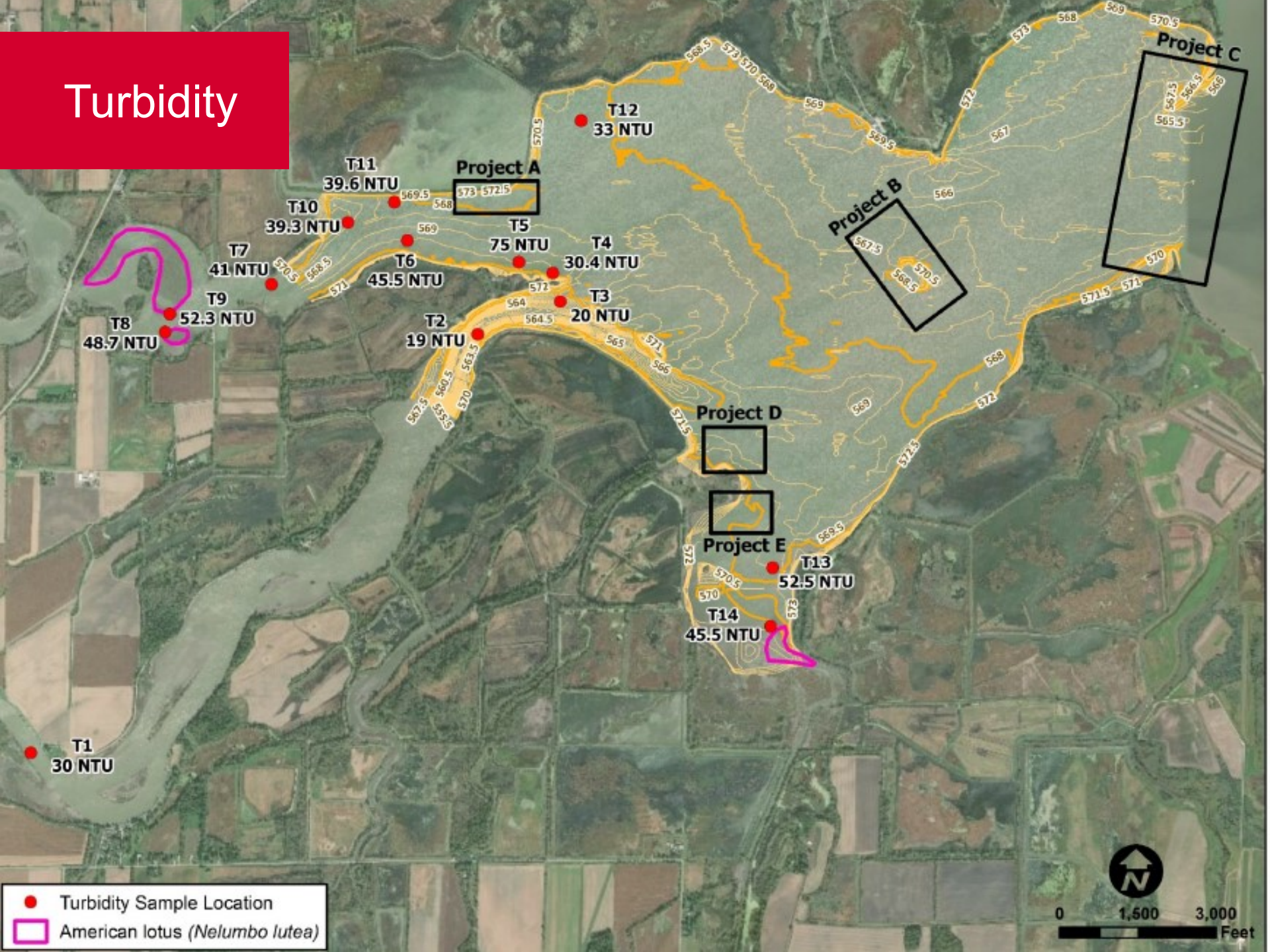
- Almost all silts and clays
- Virtually no coarse sediments (Sand)
- Indicative that the bay is no longer acting as a delta

Vibracore Sample Locations for Sediment




Sediment Thickness at Muddy Creek Bay
Sandusky River Delta Project Area, Ohio
X 1,820,000
X 1,825,000
X 1,830,000
X 1,835,000
Y 655,000
Y 650,000
Y 645,000
N
>=2.00
1.50
1.00
0.50
0.00
>=0.00

Turbidity


Project A
Project B
Project C
Project D
Project E
T1
30 NTU
T2
19 NTU
T3
20 NTU
T4
30.4 NTU
T5
75 NTU
T6
45.5 NTU
T7
41 NTU
T8
48.7 NTU
T9
52.3 NTU
T10
39.3 NTU
T11
39.6 NTU
T12
33 NTU
T13
52.5 NTU
T14
45.5 NTU
Turbidity Sample Location
American lotus (Nelumbo lutea)
0
1,500
3,000
Feet

Turbidity

- Less than 5 plant species typically found when turbidity exceeds 20 NTU (Loughheed et. al.)
- Readings in Muddy Creek Bay, including those where vegetation was present, were from 33-75 NTU
- Turbidity clearly a major factor

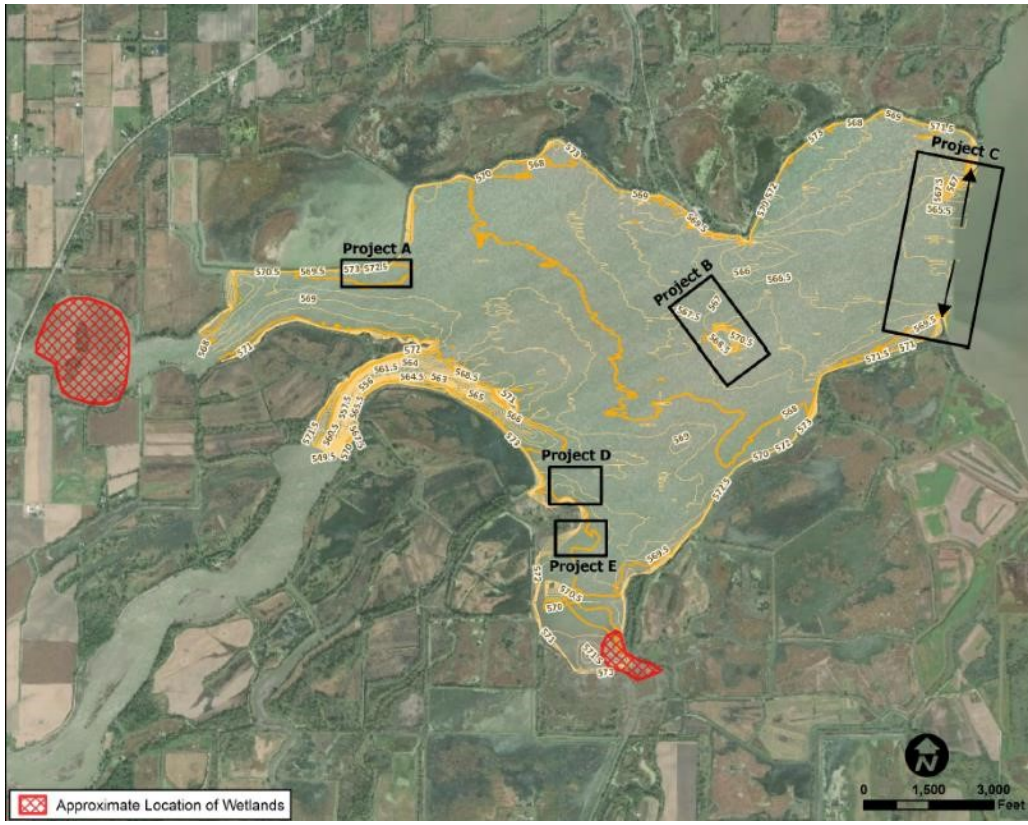
ID	Depth (ft)	Turbidity (NTU)	pH	DO (mg/L)	Water Depth (ft)	Notes
T1	1	29	7.9	7.5		
T1	2	30	7.8	7.5		
T2	1	19.4	8	6.5	10+	
T2	2	19	8	5.6		
T3	1	20.5	7.8	7		
T3	2	20	7.6	5.6		
T4	1	32	7.9	6		
T4	2	30.4	7.9	5.4	4	
T4	4	47	7.9	4.7	4	
T5	1	56	8	6	4	
T5	2	75	8	5.7	4	
T5	4	77	8.1	5.3	4	
T6	1	42.5	8.2	4.7	4	
T6	2	45.5	8	4.5	4	
T6	4	58	7.7	4.3	4	
T7	1	38.5	8.2	4.4	6	
T7	2	41	7.8	4.4	6	
T8	1	50.4	8	5.2	3.5	Lotus bed
T8	2	48.7	7.8	4.6	3.5	Lotus bed
T8	3	64	7.9	4.2	3.5	Lotus bed
T9	1	48.7	8.1	4.9	3.7	Lotus bed
T9	2	52.3	7.9	4.6	3.7	Lotus bed
T9	3	63.2	7.9	4.4	3.7	Lotus bed
T10	1	35.5	8.3	5.2	4.2	Lotus bed
T10	2	39.3	8.2	4.7	4.2	Lotus bed
T10	3	41	8.1	4.7	4.2	Lotus bed
T11	1	39.7	8	4.5	6	
T11	2	39.6	7.9	4.3	6	
T12	1	31	8.1	7	5.8	
T12	2	33	8	6	4.1	
T13	1	52.5	8.2	9.6	4.1	
T13	2	52.5	8.2	8.6	4.1	
T14	1	45.7	8.4	7.8	3	Lotus bed
T14	2	45.5	8.3	7.7	3	Lotus bed

What causes turbidity?

- Suspended fine sediments
  - Waves—Wind driven, reflected energy from dikes
  - Carp
  - Lack of rooted vegetation
- Phytoplankton
  - Nutrients
  - Lack of vegetation

What conditions favor wetlands?

- From local reference sites:
  - -Water depths less than 4’
  - -Wave protection
  - -Waves less than ~2’
- From research:
  - -Turbidity less than 20 NTU
  - -Need adequate substrate
  - -Need shallow areas to establish wetlands and allow them to advance landward



So what do we need to do?

- Reduce turbidity
  - -Carp control
  - -Wave breaks
  - -Control nutrients coming from watershed
- Increase coarse sediment
  - -Dam removal
  - -Beneficial re-use of dredge sediments
- Establish rooted vegetation
  - -Transplant mature vegetation into "safe spots"

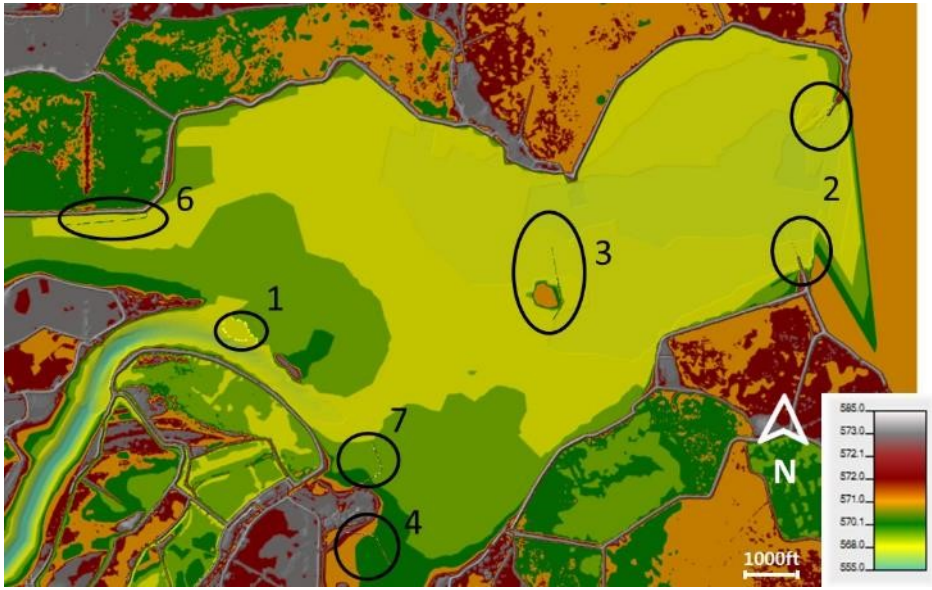

Easy, right?

Design Questions

1. Can we reduce wave height and energy?
2. Can we reduce catastrophic event impacts?
3. In some areas, can we reduce most of the energy most of the time, so the area becomes depositional or more depositional?
4. Can we, in localized areas during sustained periods, reduce turbidity?
5. Can we create areas that will either vegetate on their own or plant and sustain newly vegetated systems?
6. Can we establish wetlands that are dynamic yet stable over short and long-term periods?

Design Concepts

- Start with concepts
- Run models to determine impacts of structures
- 2-dimensional modeling to determine:
  - Flows
  - Wave Reduction
  - Upstream Impacts
- No single project can accomplish the goals—individual projects must work in aggregate



But…

- Bay is at the convergence of 3 streams
- Structures in the bay have the capacity to increase upstream water surface elevations
- Structure location, configuration, and composition had to be altered to reduce upstream impacts
- Iterative process

Scenario	Sandusky River WSE (ft)	Muddy Creek WSE (ft)	Structure type	Structure length (ft)	Description
Existing conditions	576.56	573.8			
Area1-Alt1	577.38	573.71	dike	2600	Connect all islands at mouth of Sandusky with solid dike
Area1-Alt2	576.64	573.79	dike	1800	Connect 2 islands at mouth of Sandusky
Area1-Alt3	576.61	573.87	dike	3000	"C" shaped dike at eastern island
Area1-Alt4	576.58	573.85	dike	2200	
Area1-Alt7	576.57	573.83	dike	2000	
Area1-Alt10	576.6	573.81	dike	1600	Between islands but not connected
Area1-Alt12	576.59	573.85	dike	2800	Between islands, set back from mouth
Area1-Alt15	576.56	573.81	dike	2100	Extend dike west of Sandusky mouth
Area1-Alt16	576.56	573.82	dike	2600	
Area1-Alt20	576.53	573.79	NA		Remove middle island

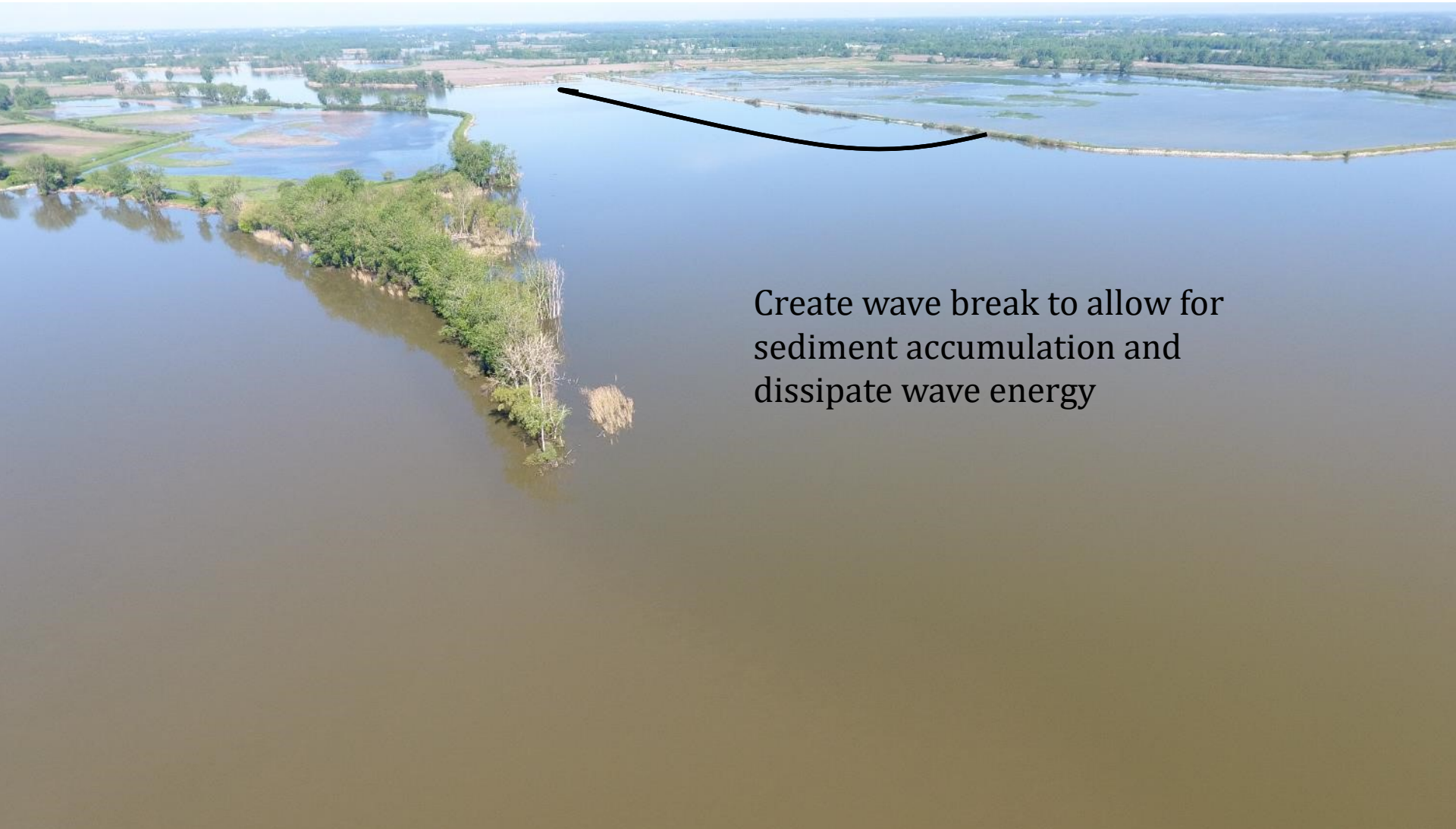
		100-yr water surface (ft)		Dike design		WADs design		
Scenario	Scenario components	Sandusky River	Muddy Creek	Length (ft)	Top elevation (ft)	Length (ft)	Top elev. (ft)	Single or double row
Existing conditions		576.56	573.8					
Combined1	Area2-Alt8+Area3-Alt6	576.57	573.83	1500	576-578	2250	574-577	single
Combined2	Area1-Alt20_Area2-Alt8_Area3-Alt6	576.54	573.82	1500	576-578	2250	574-577	single
Combined3	Area1-Alt20_Area2-Alt9_Area3-Alt7	576.55	573.86	1500	576-578	2250	574-577	double
Combined4	Area1-Alt20_Area2-Alt10_Area3-Alt8	576.55	573.87	1500	576-578	2250	574-577	single
Combined5	1Alt20_2Alt14_3Alt11_4Alt1_6Alt4_7Alt1	576.55	573.87	600	576	7100	576+	single
Combined6	1Alt20_2Alt15_3Alt12_4Alt1_6Alt4_7Alt1	576.54	573.85	600	576	6250	576+	single
Combined7	1Alt20_2Alt17_3Alt16_4Alt2_6Alt5_7Alt2	576.55	573.88	600	576	6250	576+	double
Combined8	1Alt20_2Alt18_3Alt18_4Alt3_6Alt4_7Alt1	576.56	573.92	1500	577	5350	576-578	single/double
Combined9	2Alt18_3Alt18_4Alt3_6Alt4_7Alt1	576.59	573.92	1500	577	5350	576-578	single/double


2N West
2N East
6 East
6 West
3 North
3 West
3 East
3 South
2S West
2S East
7 West
7 East
4 West
4 East
N
2000ft
585.0
573.0
572.1
572.0
571.0
570.1
568.0
555.0

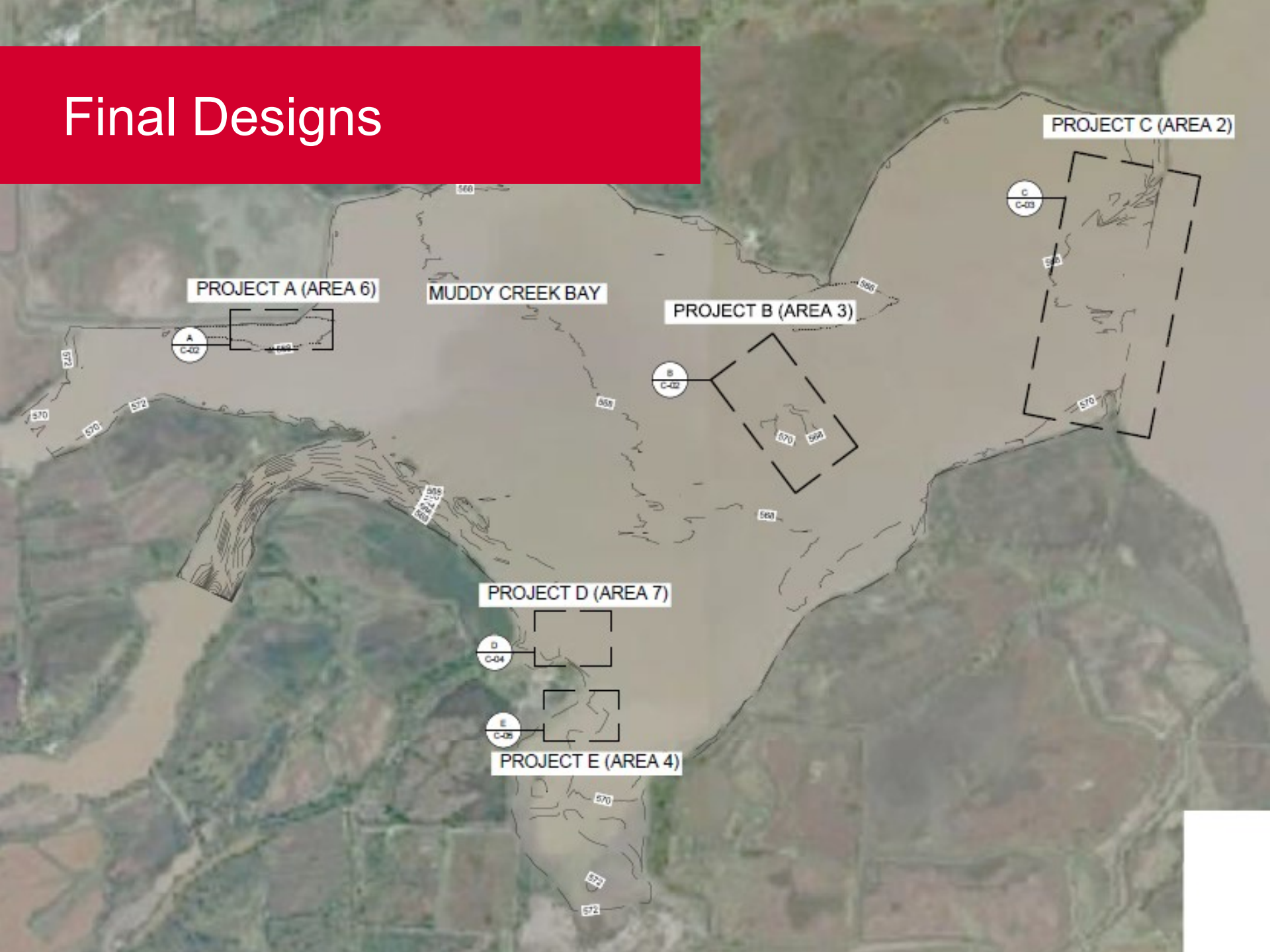
Area 2 (Bay Mouth)

Area 4 and 7

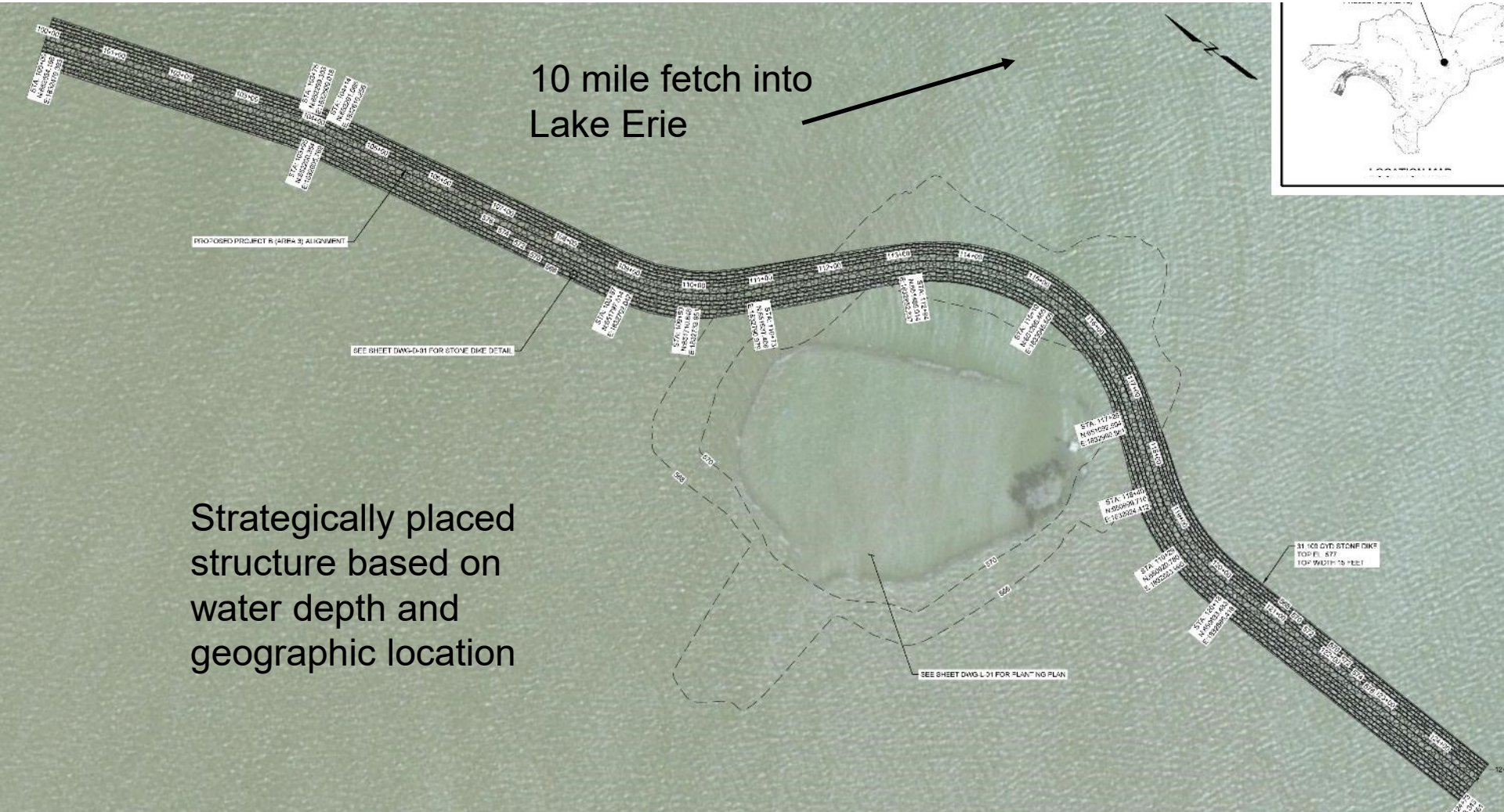
Area 1 and 6


Create wave break to allow for sediment accumulation and dissipate wave energy

Final Designs

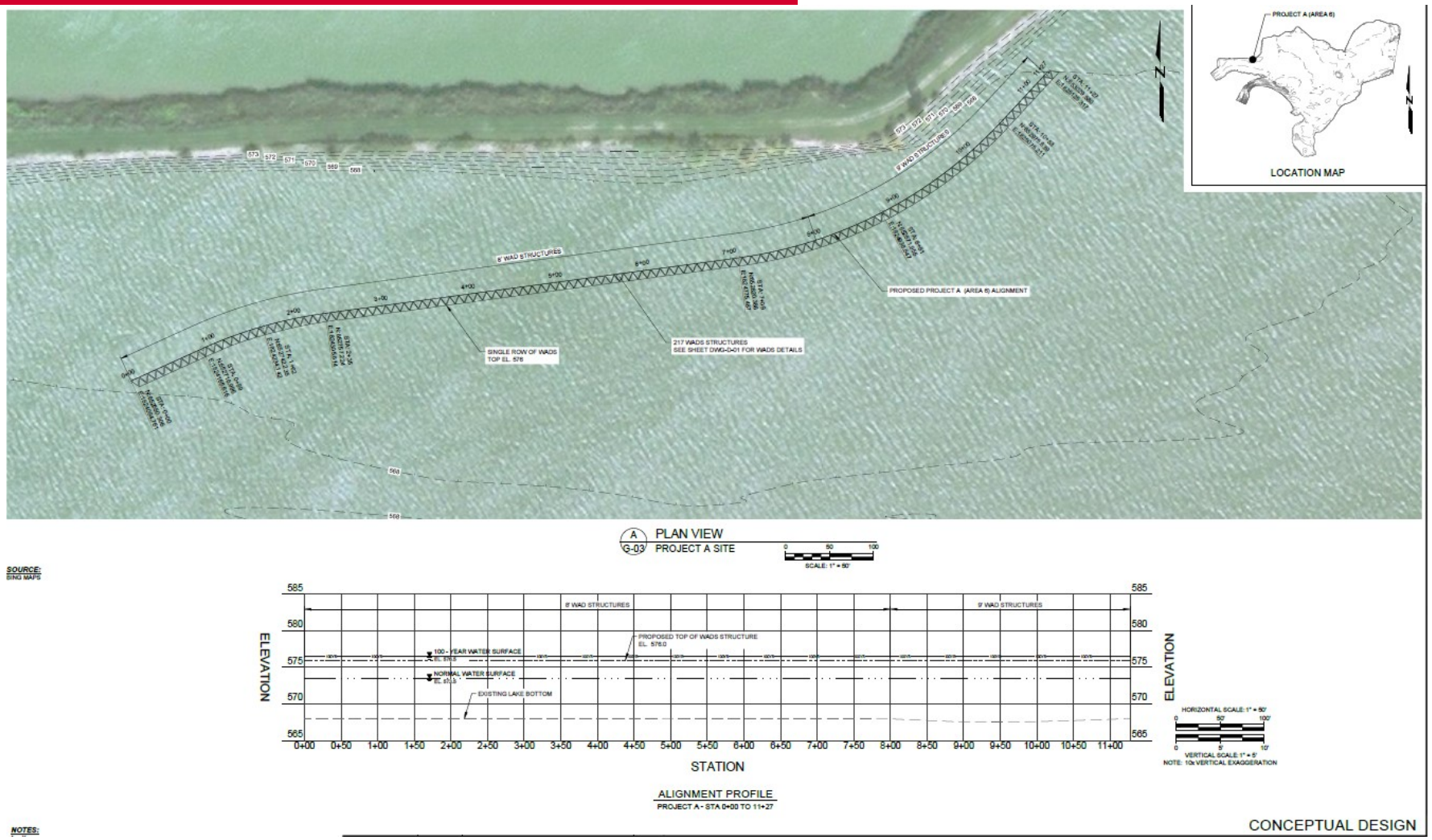


Final Designs

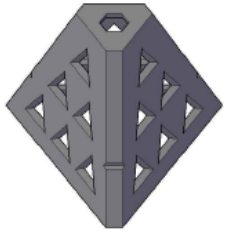


Strategically placed structure based on water depth and geographic location

Final Designs

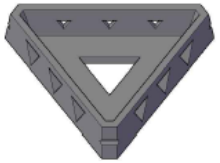


Wave Attenuation Devices (WADS)



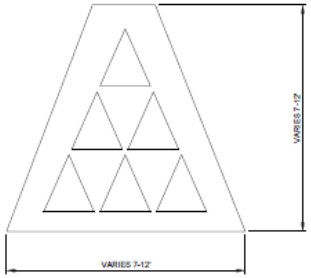
ISOMETRIC VIEW - TOP PIECE OF WADS

SCALE: N.T.S.



ISOMETRIC VIEW - BOTTOM PIECE OF WADS

SCALE: N.T.S.

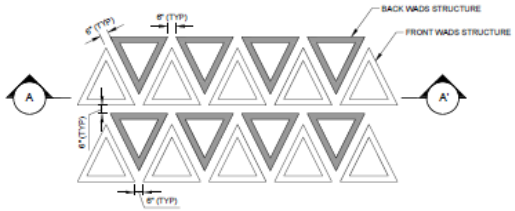


1 - DETAIL - SIDE VIEW
WADS STRUCTURE

SCALE: N.T.S.

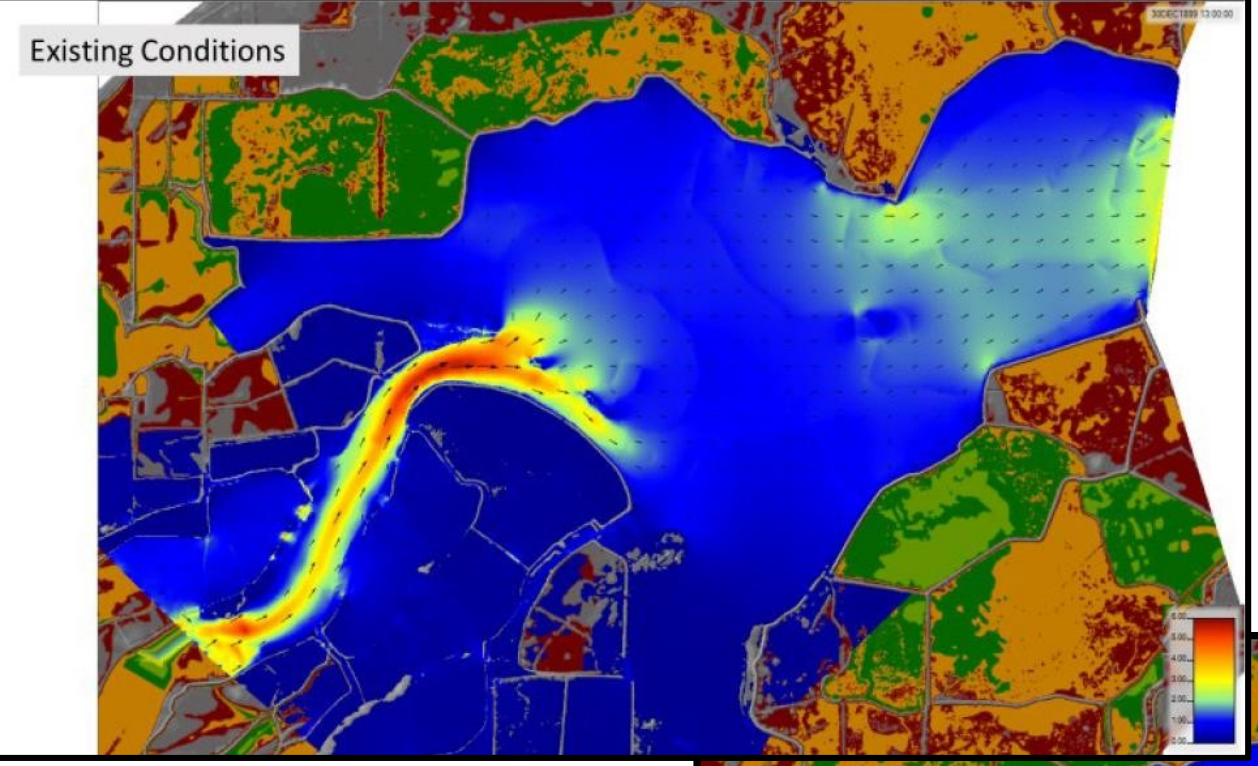
2 - DETAIL
SINGLE ROW OF WADS LAYOUT

SCALE: N.T.S.

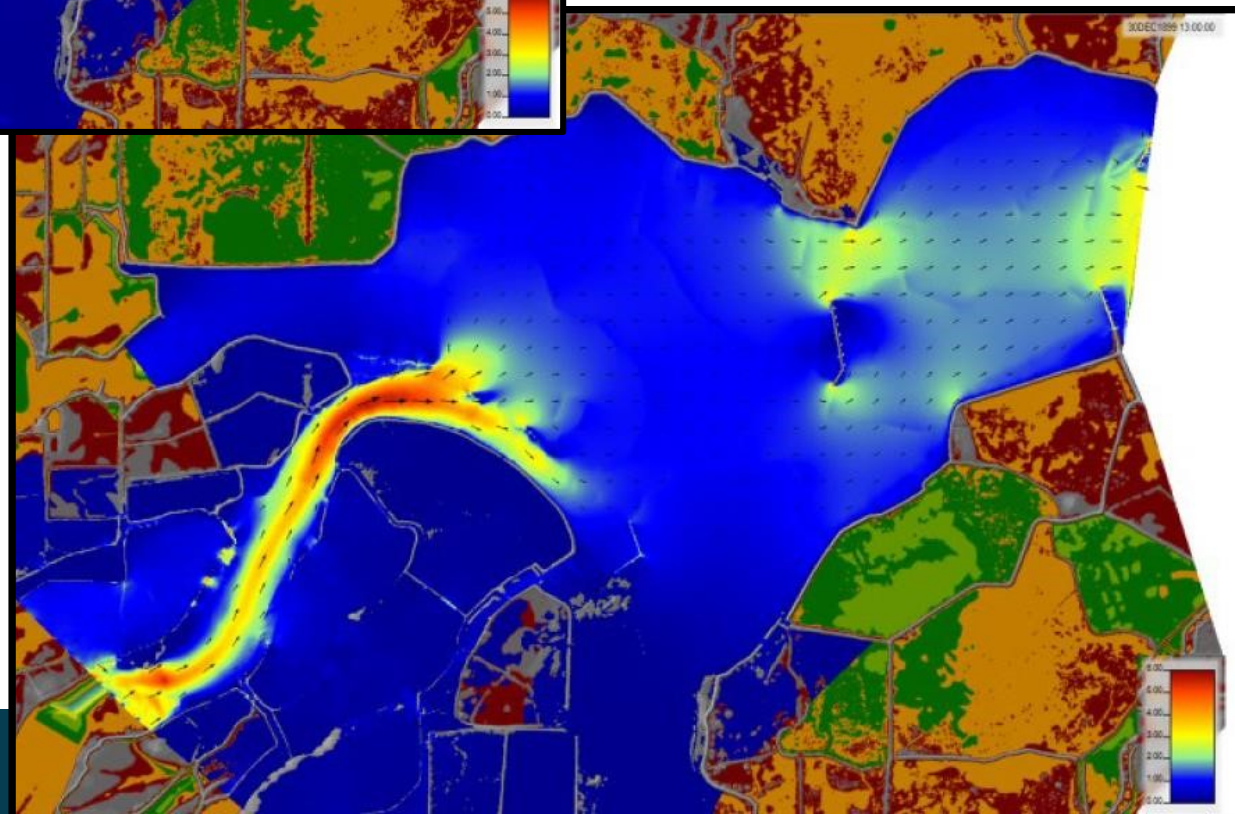


3 - DETAIL
DOUBLE ROW OF WADS LAYOUT

SCALE: N.T.S.



Proposed Conditions



Wave Reduction

Wind speed	Target location	Scenario	Wave height H_s (ft)
39kts/45mph	Muddy Creek	Existing	2.6
		Area2	2.2
		Area3	2.1
	Sandusky mouth	Existing	2.6
		Area2	2.0
		Area3	1.7
	Winous Point	Existing	2.6
		Area2	1.6
61kts/70mph	Muddy Creek	Existing	3.4
		Area2	3.2
		Area3	3.0
	Sandusky mouth	Existing	3.4
		Area2	3.0
		Area3	2.6
	Winous Point	Existing	3.4
		Area2	2.5

0.5-1' wave reduction

Design Conclusions

- Area 6—1,127 LF WADS
- Area 3—2,473 LF riprap dike
- Area 2—1,500 LF WADS
- Area 7—900 LF WADS
- Area 4—1,127 LF Wads
- Total estimated cost=~$10M

Design Conclusions

- We can reduce waves in the bay and import coarse sediment to mimic conditions conducive to wetland formation
- Little control over upstream sediments or nutrients
- Little control over carp
- It will take this effort—plus many more—to bring back Muddy Creek Bay

Next Steps

- Ohio DNR is working with TNC to go to final design, permitting, and construction
- Permitting—agencies have no idea how they're going to permit something at this scale
- FEMA, ODNR, OEPA, USACE engaged in permitting discussions

Summary

- Whole bay restoration requires understanding all of the biotic and abiotic factors that affect the establishment of wetlands
- We need to understand the big picture and project goals
- It will take years, partnerships, and a lot of funding to bring back the bay

Thank you!

Brian Majka
GEI Consultants
bmajka@geiconsultants.com

GEI Consultants