Smart Watersheds for Smart Lake Management

February 28th, 1:30 p.m. EST

Webinar Logistics

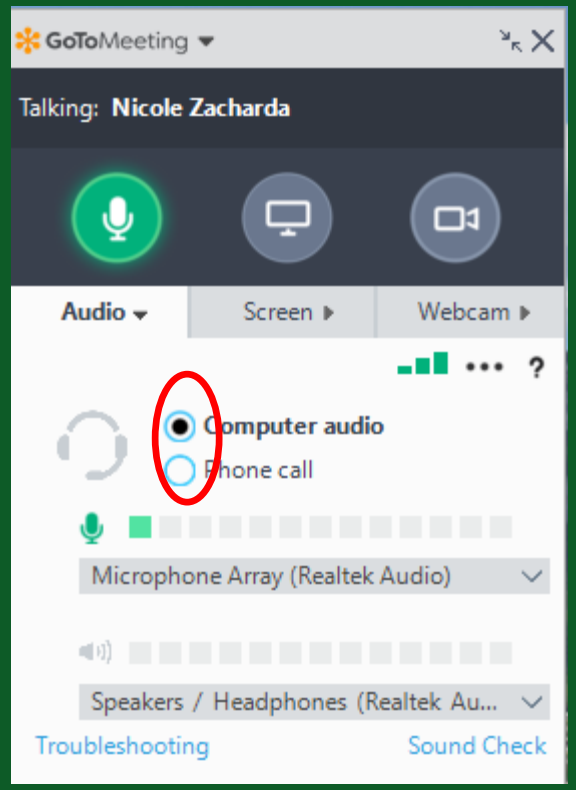
All participants will be automatically muted...

Audio can be streamed through your computer or phone..

Here's how:

- Click either "Computer Audio" or "Phone call" to switch

  (You may have to click on the "Audio" tab, first.)



Webinar Logistics

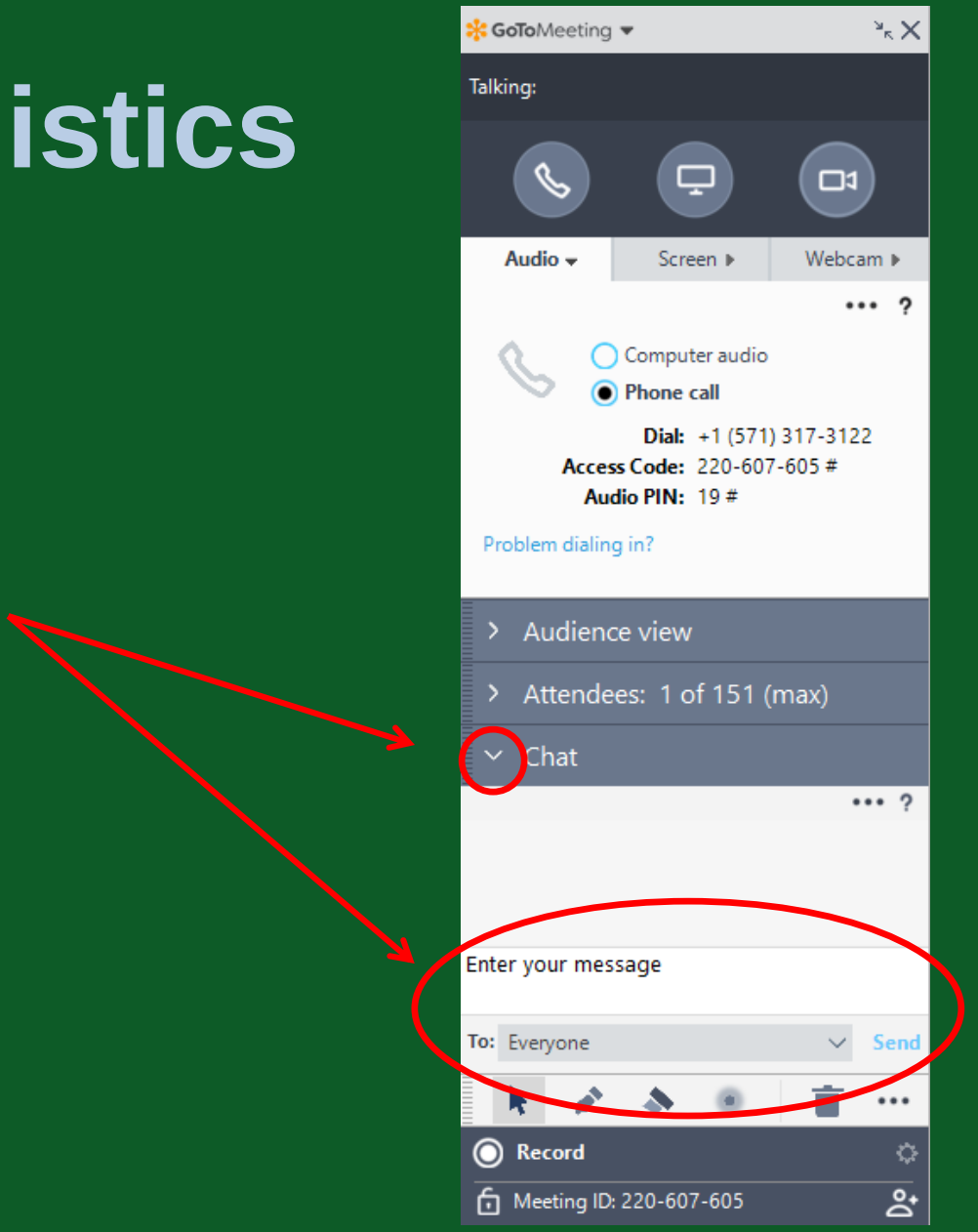
Questions will be saved until the end

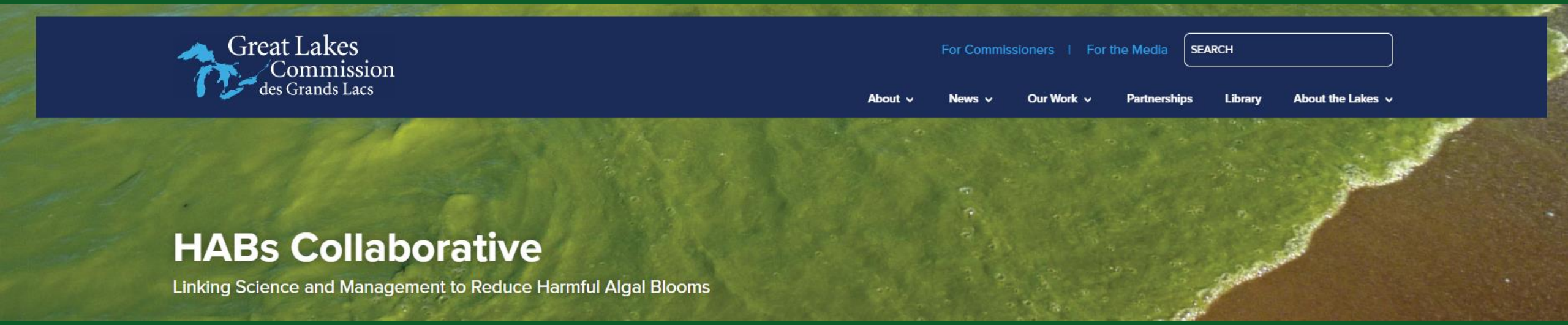
Ask a question :

- Submit questions / comments **in writing** using the GotoWebinar chat box.

Technical Issues?

- Send us a Question
- If all else fails, log-out and rejoin the webinar / audio





Website: https://www.glc.org/work/habs

To send an email to the List-serv (which has ~300 members!)

- Format the email exactly as you would like the members to receive it.
- Send it to: habscollaboratory@great-lakes.net

Upcoming Activities:

- HARRNESS webinar, March 5th 2:00 p.m.
  - **https://tinyurl.com/qslya5j**

- Lakewide Action and Management Plan webinar, March 26th 2:00 p.m.
  - Register at **http://bit.ly/LAMPwebinar**

Speakers

- Bryan Stubbs, Cleveland Water Alliance
- Dr. Branko Kerkez, University of Michigan
- Myles Downhour and Angela Crain, USGS

Smart Lake Initiative

Bryan Stubbs
Executive Director
Cleveland Water Alliance

cleveland water alliance

cleveland water alliance

Regional Challenge:

- $1.5 billion over 30yrs
- Goal: 40% by 2025
- Insufficient Data

Progress

Efficiency

ROI

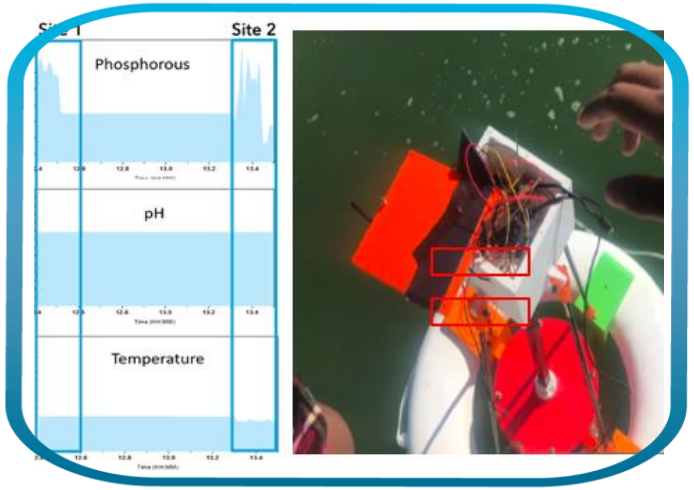
cleveland water alliance

The Opportunity:

SMART LAKE

A new breed of Smart & Connected Infrastructure that enables intelligent regional water management by a cross-sector collaborative of institutions and communities.

What is a “Smart” Lake?



Data

- Deployed Sensors & Data Sondes
- Remote Sensing & Satellite Imaging
- Grab Samples & Citizen Science

Information

- Analytics and Visualizations
- Notifications and Dashboards
- What else?

Action

- Serving solution providers
- Engaging the public

SMARTLAKE

cleveland water alliance
Invest, Innovate and Accelerate

SMART LAKE

cleveland water alliance

Competitions

erie hack

INTERNET of H2O

Research

BGSU

OHIO STATE

CASE WESTERN RESERVE UNIVERSITY EST. 1826

Projects

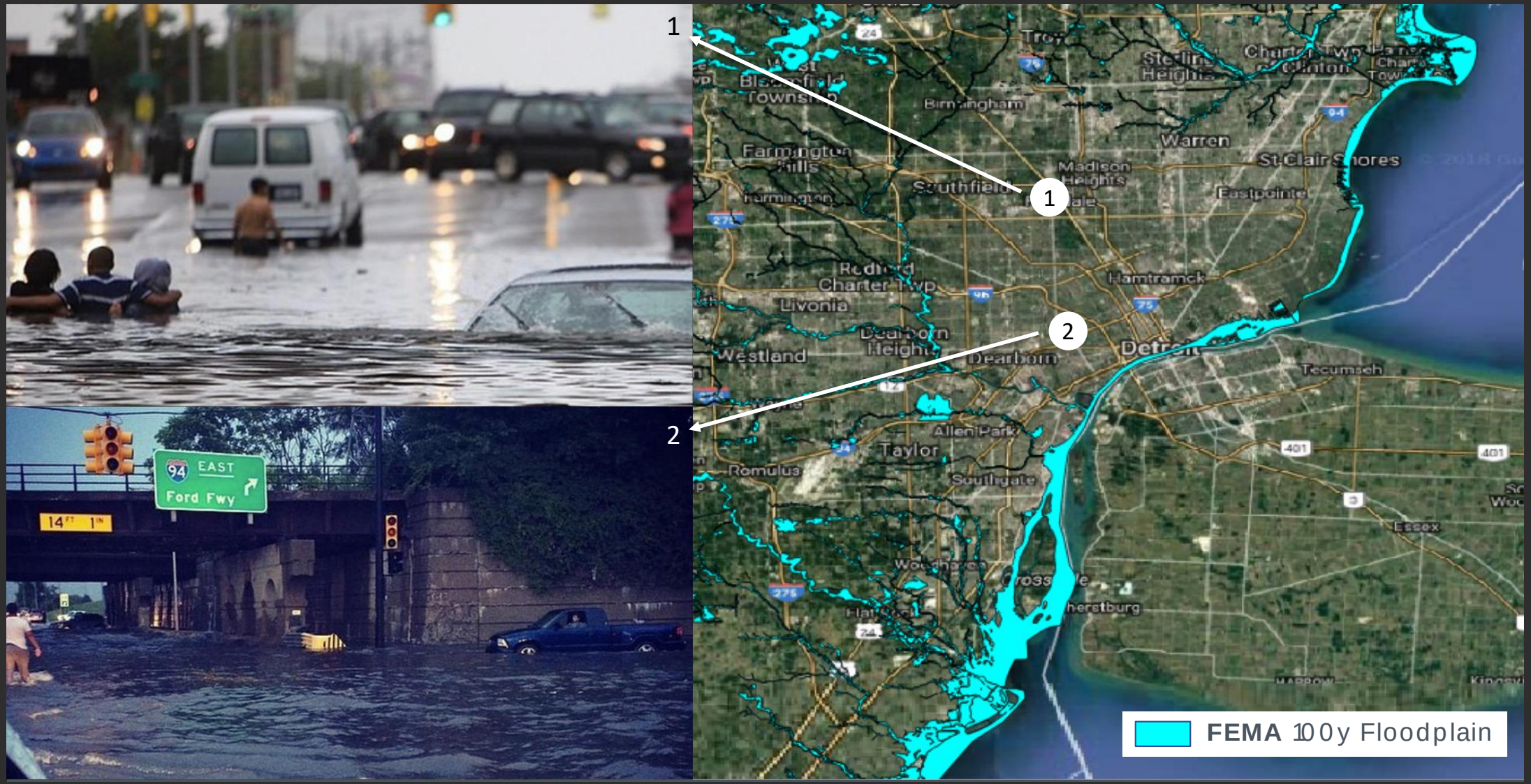
great lakes observing system

LimnoTech

Where we (mostly) work


SOUTH
39
MILE
3
.8


94
EAST
Ford Fwy
14 FT 1 IN


1
2
94 EAST
Ford Fwy
14 FT 1 IN
Detroit
Dearborn
Warren
Livonia
Westland
Taylor
Southfield
Hamtramck
Eastpointe
Tecumseh
Essex
FEMA 100y Floodplain

have

have

want

have

do

want

have

do

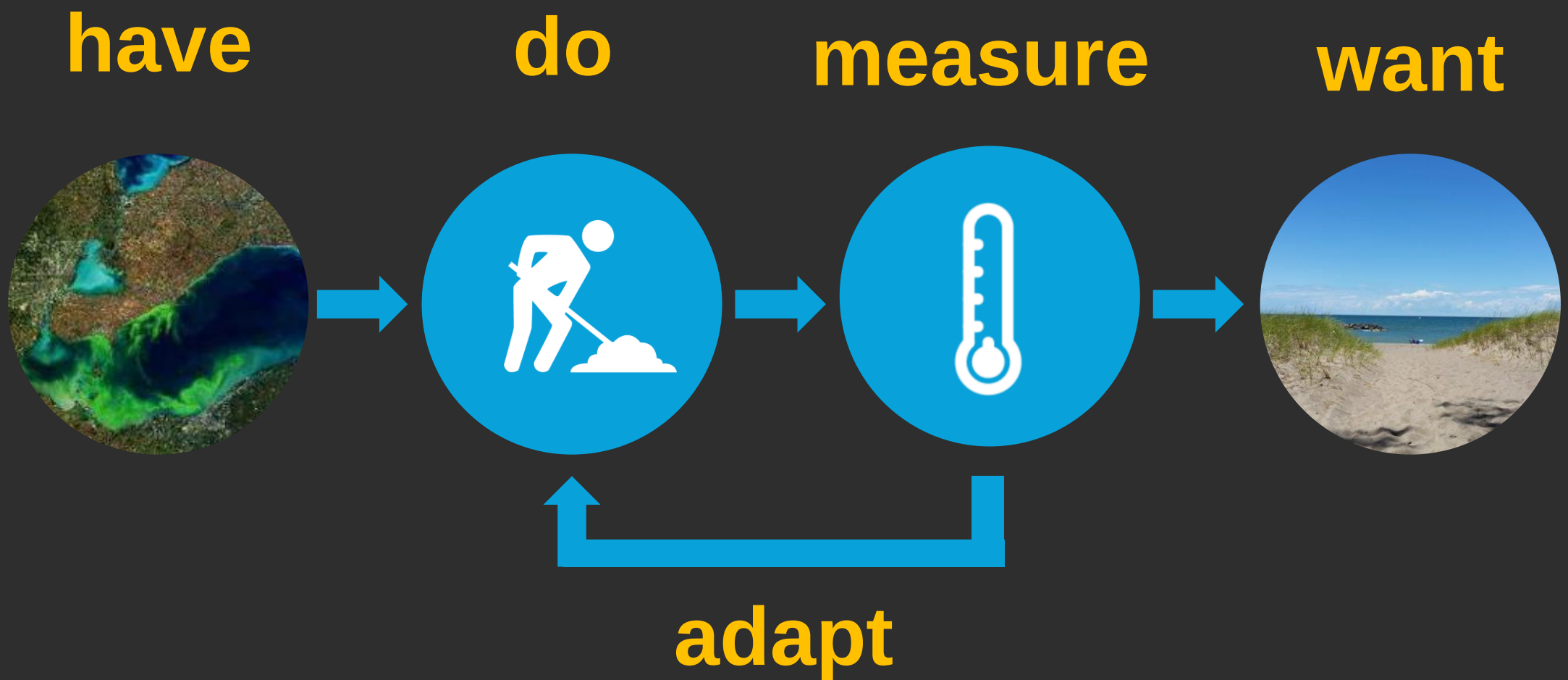
want

have

do

measure

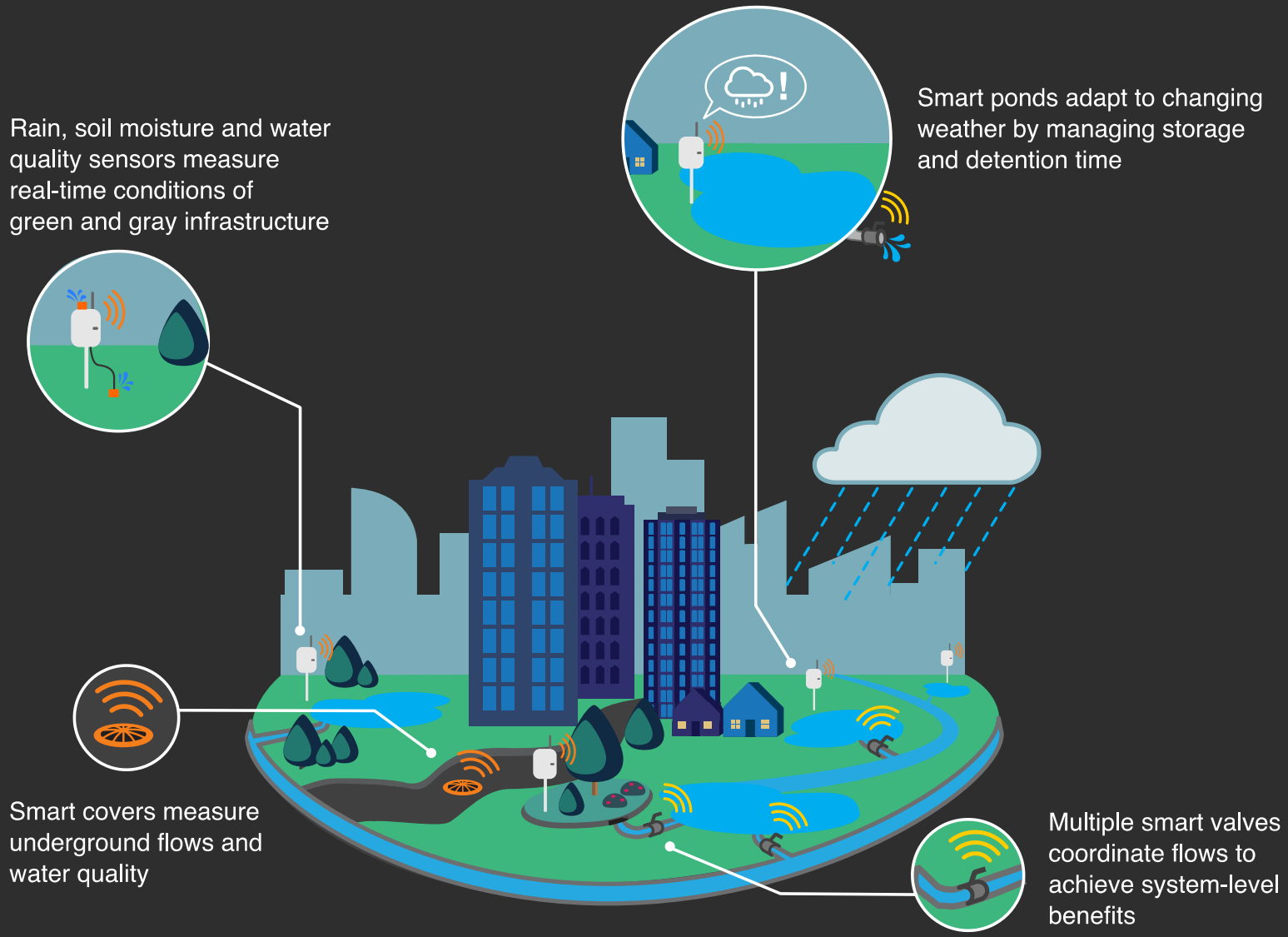
want

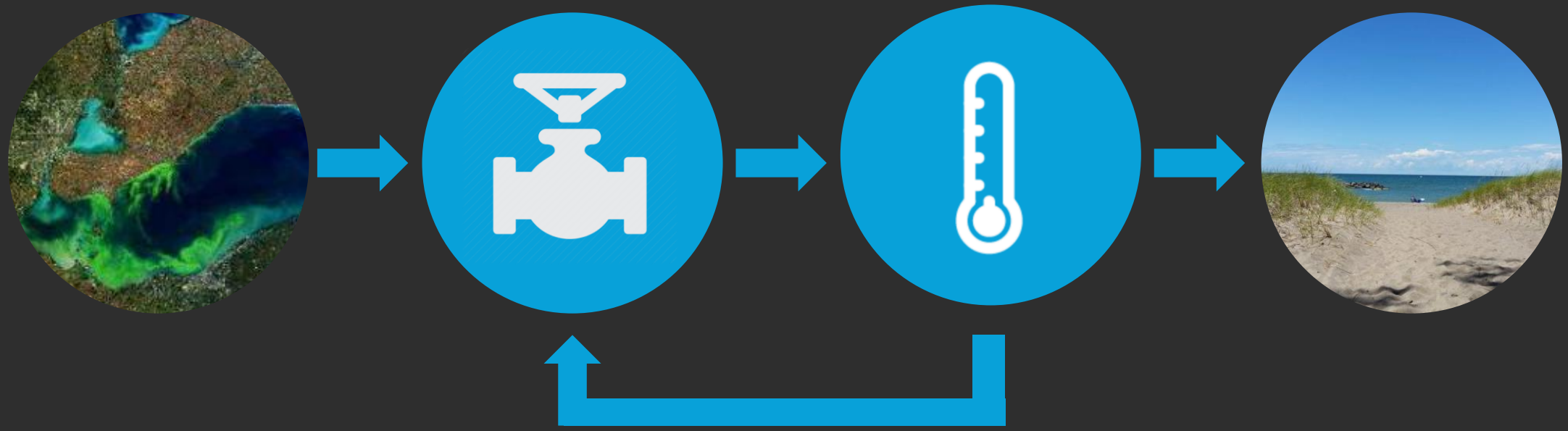

have
do
measure
want
adapt

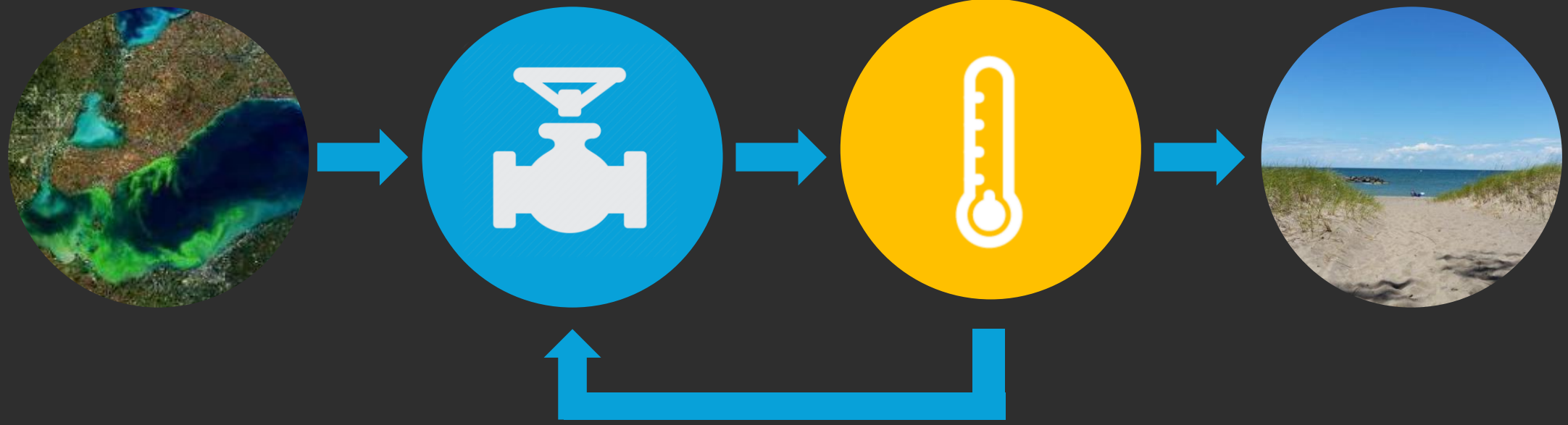

nest
AIRWAVE
74


72
68
ecobee

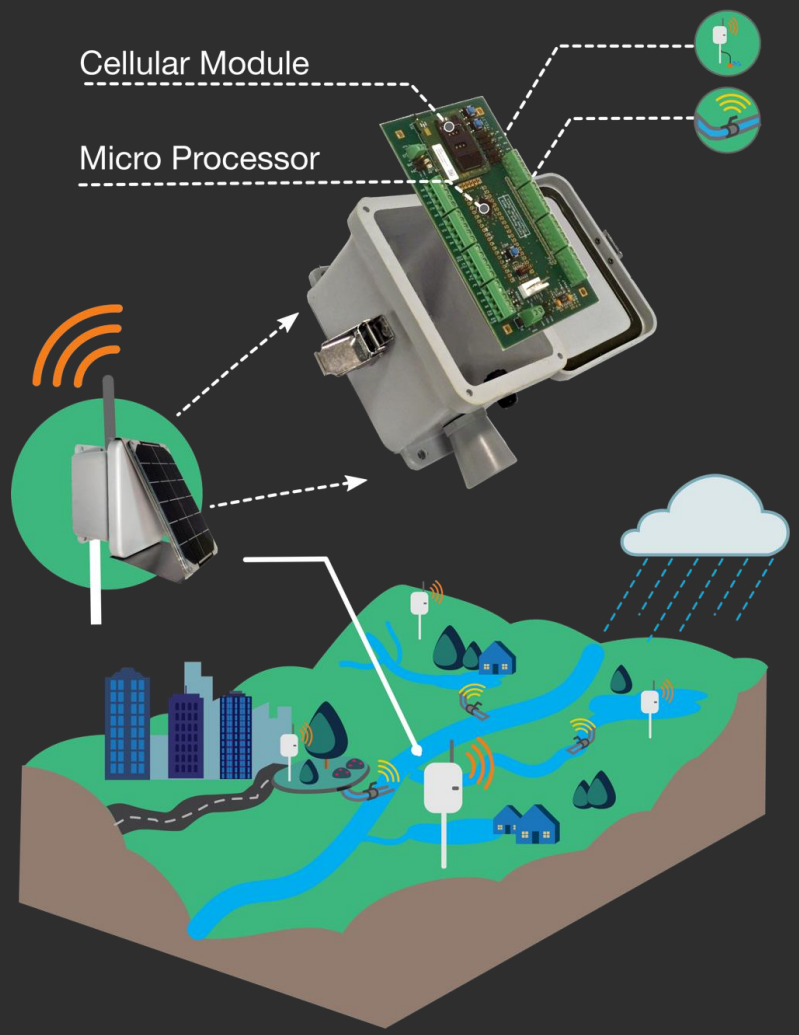

SMART
HOME


Rain, soil moisture and water quality sensors measure real-time conditions of green and gray infrastructure
Smart ponds adapt to changing weather by managing storage and detention time
Smart covers measure underground flows and water quality
Multiple smart valves coordinate flows to achieve system-level benefits



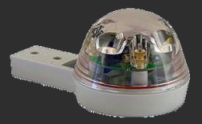


OPEN-STORM.ORG



Measure

Control



Rain

Valves

Depth

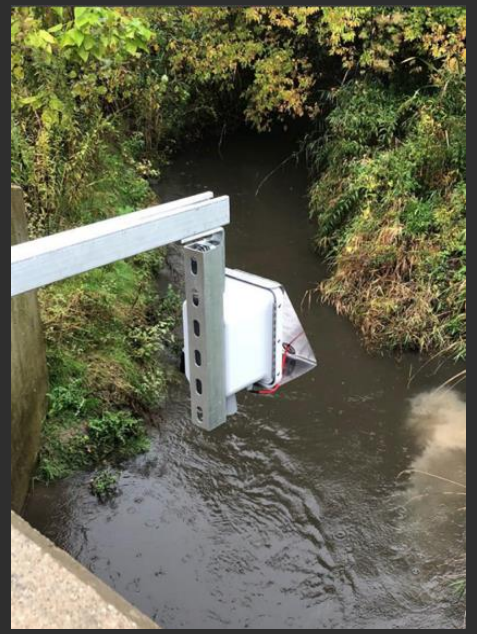
Gates

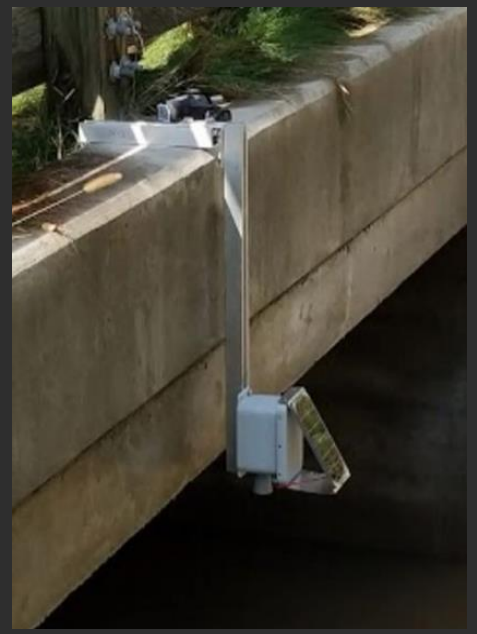
Soil Moisture

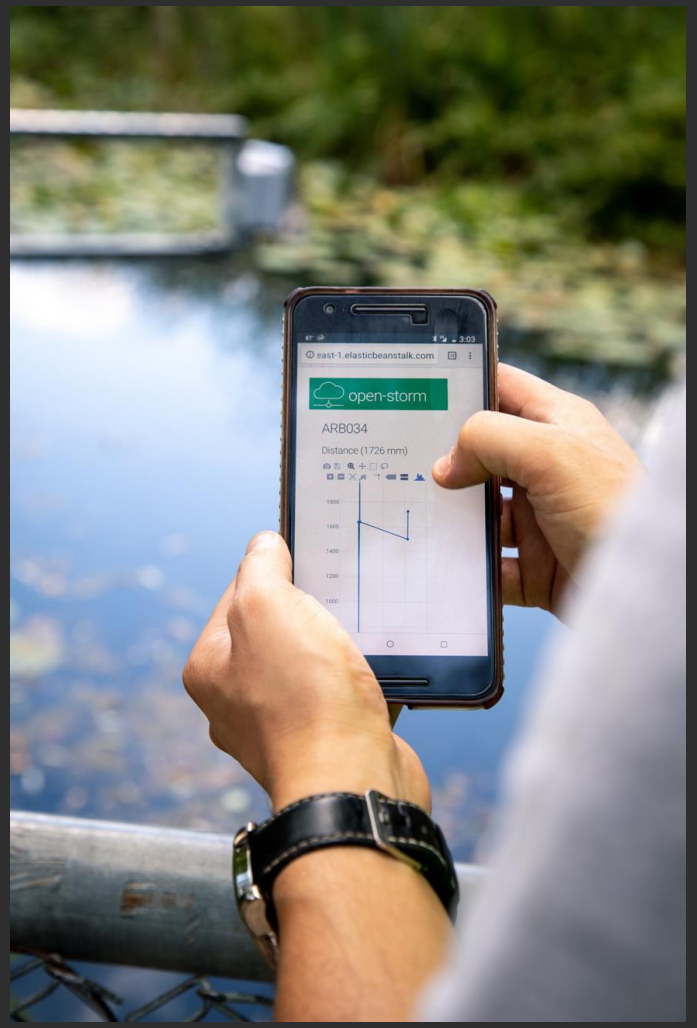
Water Quality

Automated Samplers


Telit DE910-DUAL
MEID: A1000048ABD1A3
Model: DE910-DUAL
FCC ID: RI7DE910-DUAL
IC: 5131A-DE910DUAL
Designed in Korea, Made in China
ANT
GPS
ON/OFF
RESET
TELIT

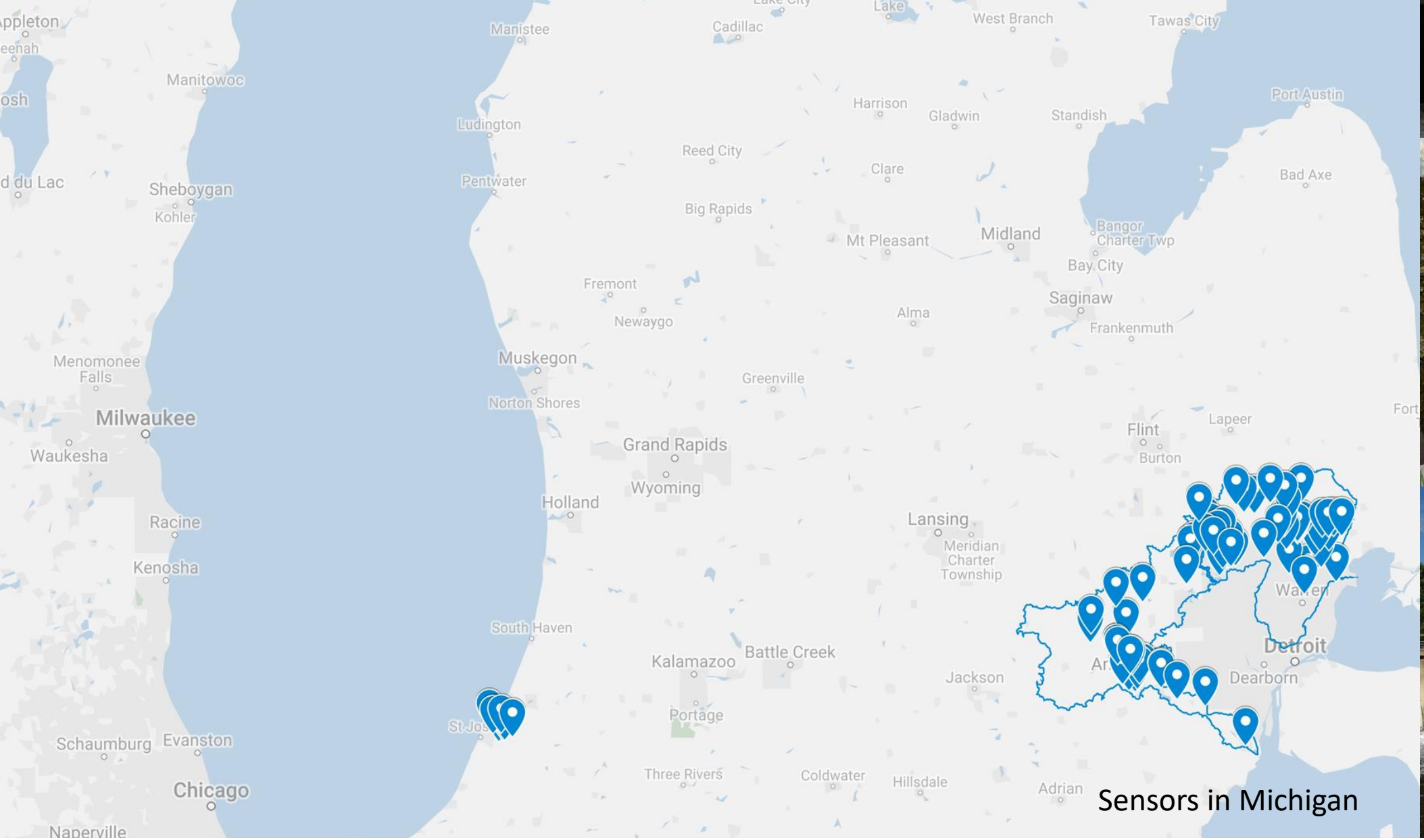




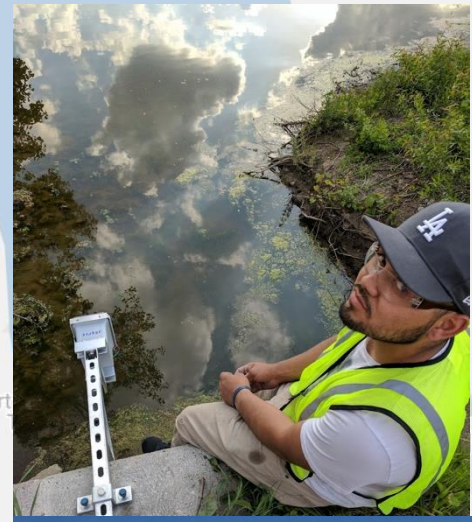

east-1.elasticbeanstalk.com
open-storm
ARB034
Distance (1726 mm)

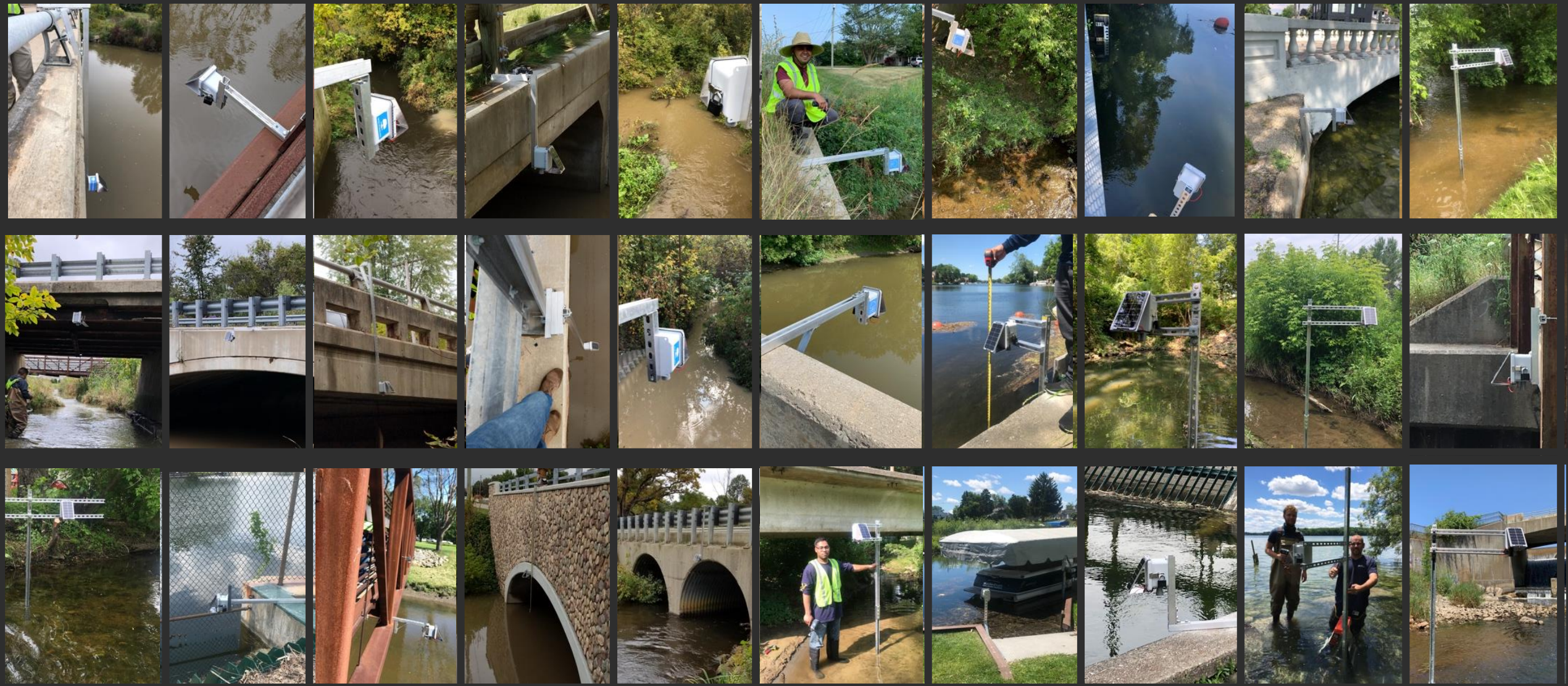

Grafana - Clinton River Waters
Apps
S_NOW
L_NOW
AU
QAQC
Map
DFW
MLibrary
Mendeley
M-Reports
Canvas
iCorps
Analytics
CR
Guitar Physics
Other Bookm
Clinton River Watershed
Zoom Out
Jun 4, 2019 17:08:56 to Jun 7, 2019 09:08:57
Clinton Battery
4.40
4.30
4.20
4.10
4.00
3.90
6/4 20:00
6/5 00:00
6/5 04:00
6/5 08:00
6/5 12:00
6/5 16:00
6/5 20:00
6/6 00:00
6/6 04:00
6/6 08:00
6/6 12:00
6/6 16:00
6/6 20:00
6/7 00:00
6/7 04:00
6/7 08:00
DET001 DET003 DET004 DET008 DET012 DET015 DET016 DET022 DET023 DET024 DET020
Clinton Depth
4.0 K
3.0 K
2.0 K
1.0 K
0
-1.0 K
DET001 Voltage Status
4.01 V
DET003 Voltage Status
4.05 V
DET004 Voltage Status
4.02 V
DET008 Voltage Status
4.00 V
DET012 Voltage Status
3.95 V
DET015 Voltage Status
4.02 V
Click to go back, hold to se


open-storm
ARB030
Depth (0.005 Feet)
1.2
1
0.8
0.6
0.4
0.2
0

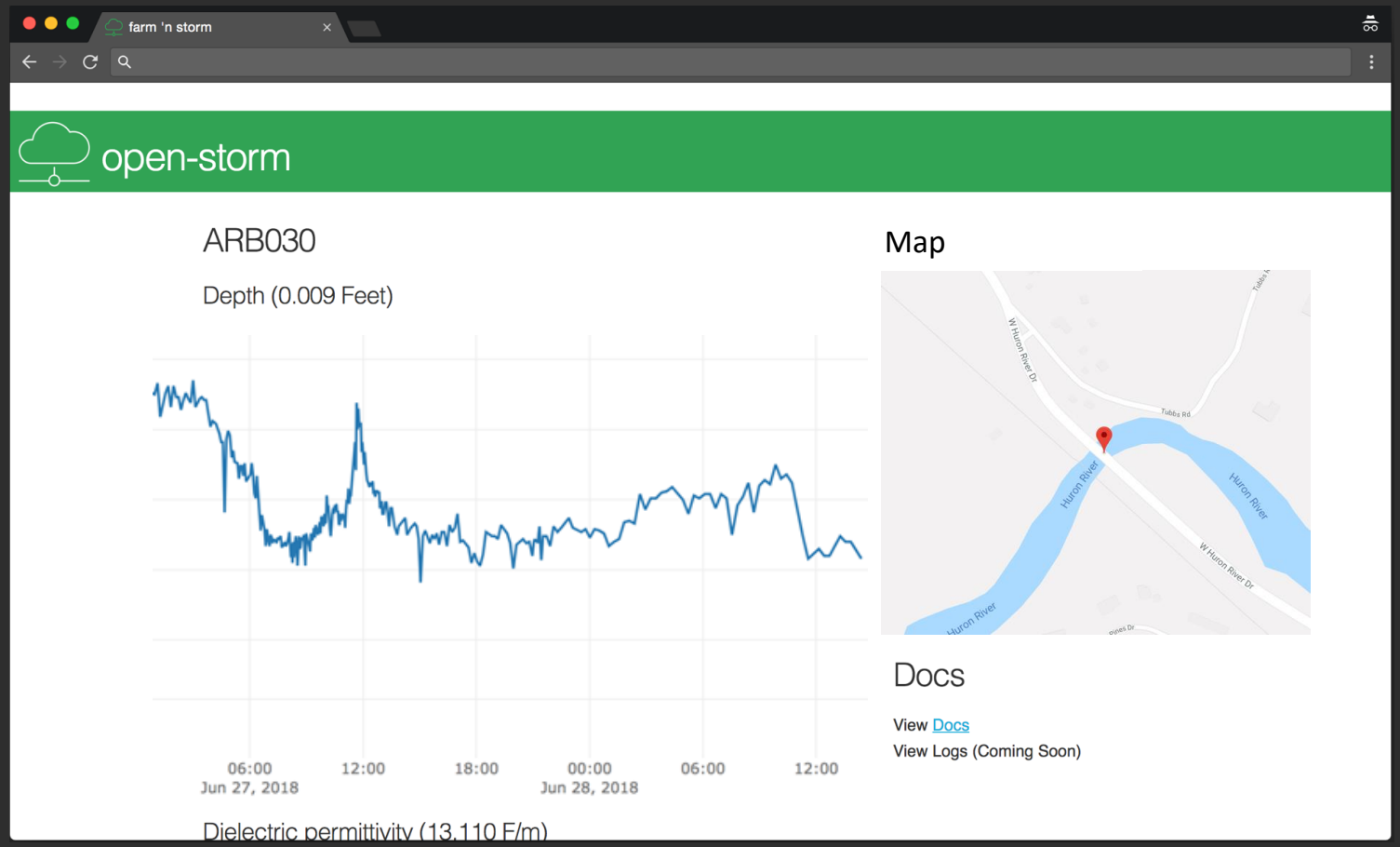


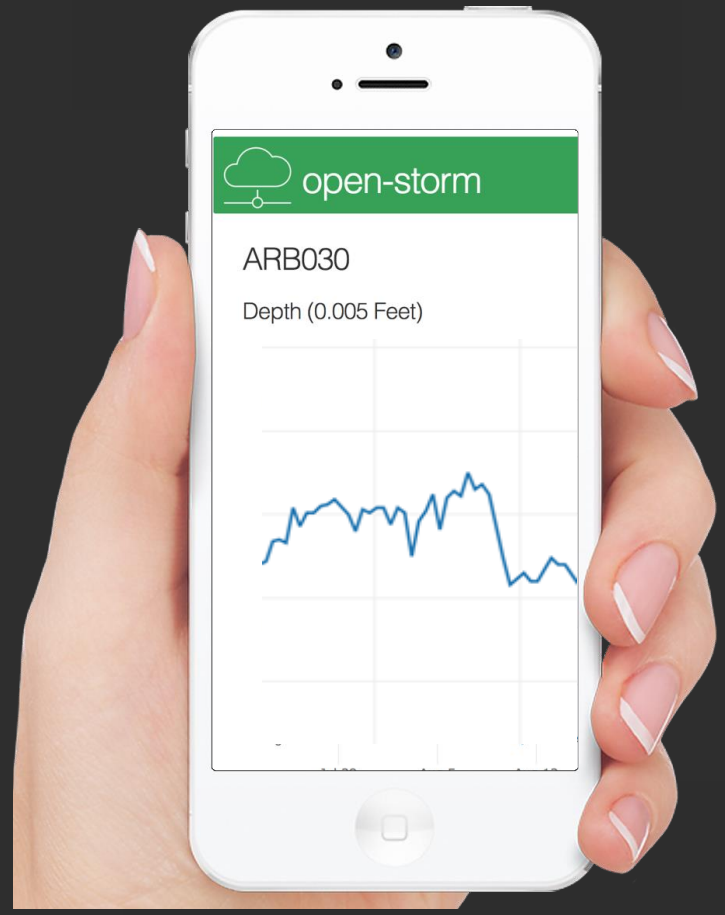
Sensors in Michigan



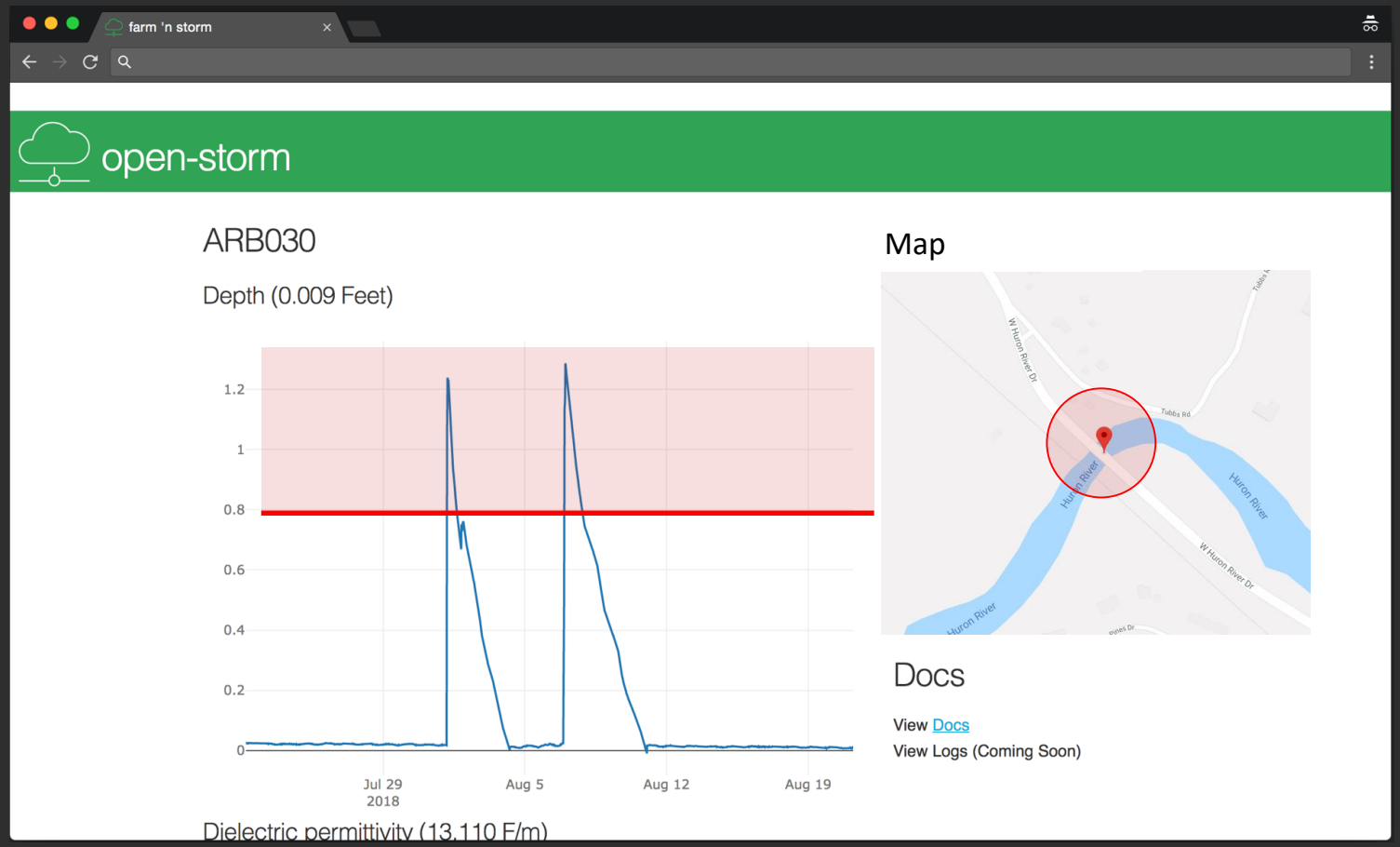


Meridian Charter Township
Williamston
Webberville
Fowlerville
Oak Grove
Parshallville
Village of Clarkston
Waterford Twp
Hartland
Highland Charter Twp
Howell
Mason
Dansville
Commerce Charter Twp
West Bloomfield Township
Milford Charter Twp
Brighton
Wixom
Warren
Farmington Hills
Novi
Madison Heights
Southfield
Ferndale
Eastpointe
Township of Hamburg
Pinckney
South Lyon
Whitmore Lake
Unadilla
Hell
Hudson Mills
Worden
Redford Charter Twp
Hamtramck
Plymouth
Livonia
Dexter
Ann Arbor Charter Twp
Dearborn Heights
Dearborn
Detroit
Chelsea
Westland
Canton
Superior Charter Twp
Lima Center
Wayne
Allen Park
Taylor
Ypsilanti
Van Buren Charter Township
Romulus
Pittsfield Charter Twp
Ypsilanti Charter Twp
Southgate
Hollow
Bridgewater
Saline
Manchester
Township of Sumpter
Woodhaven
Benton
York Charter Township
Flat Rock
Amherstburg
Milan

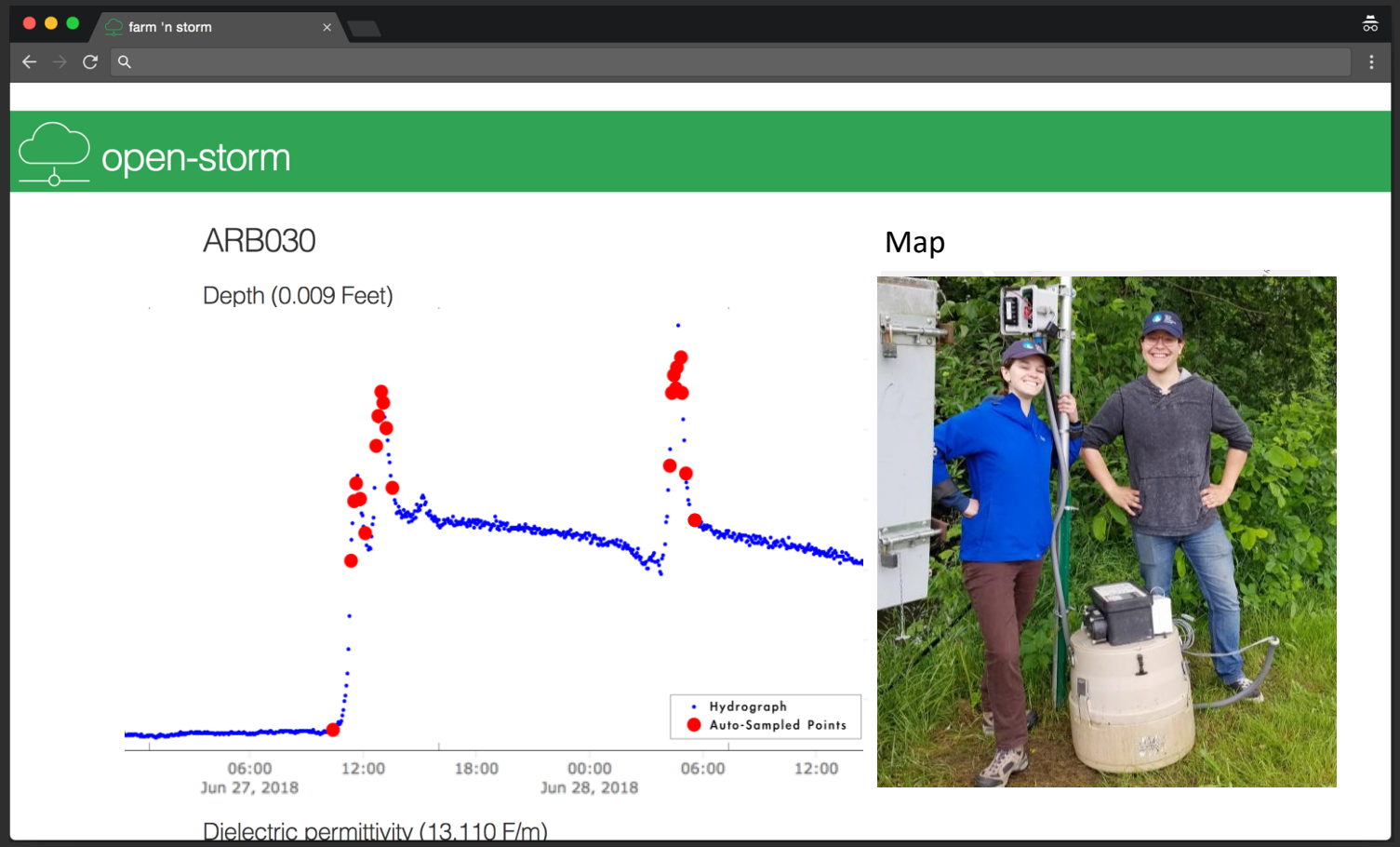




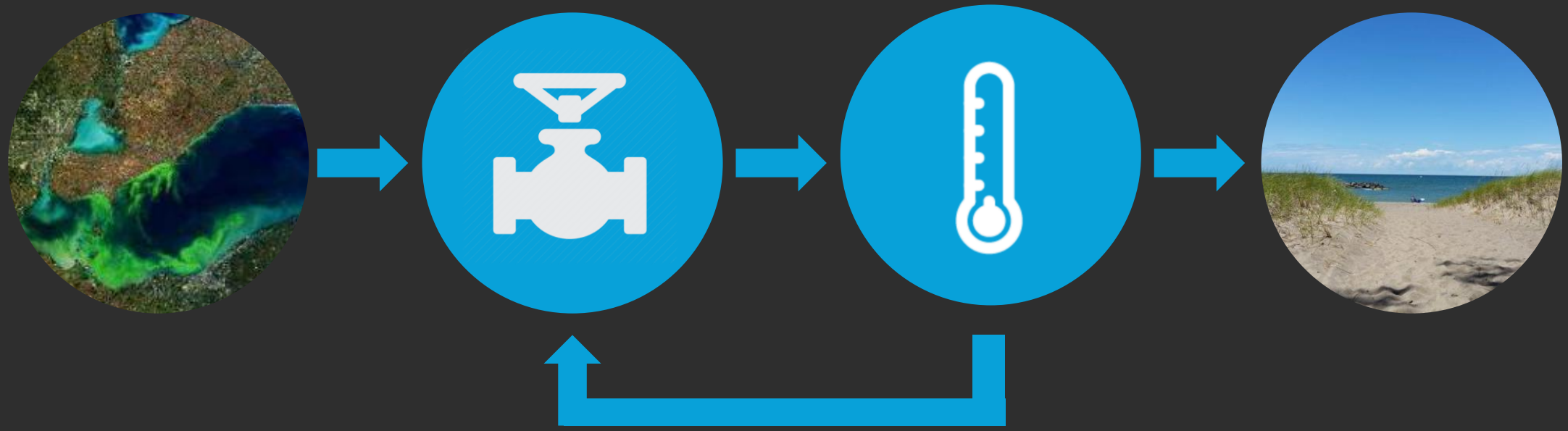
Sensors **instantly** report the water level at streams and road crossings.

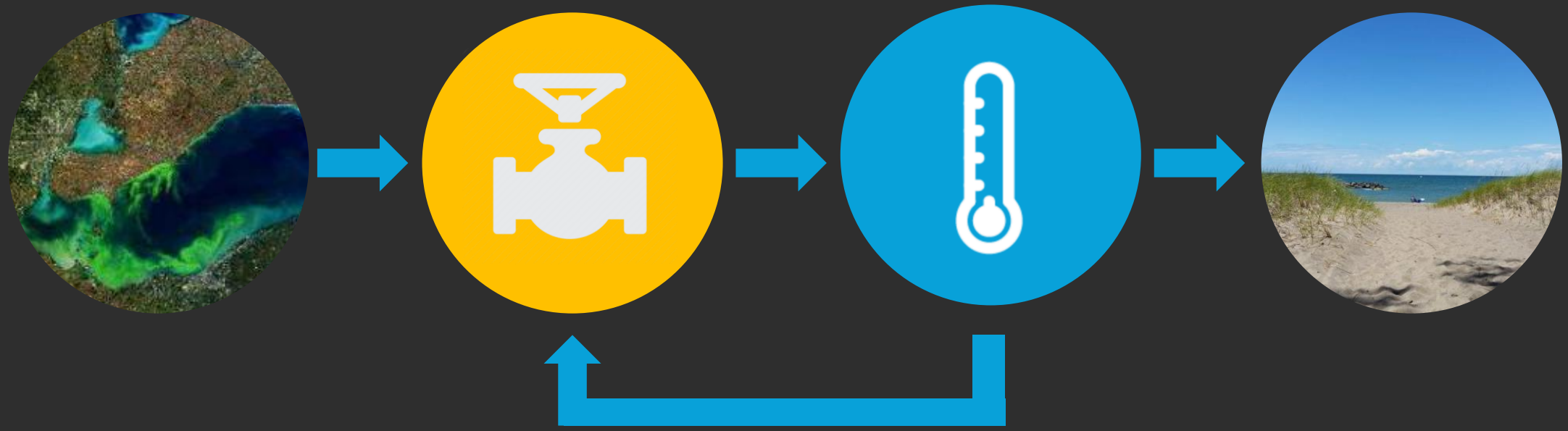


If flooding is detected, an **automatic alert** is sent immediately.



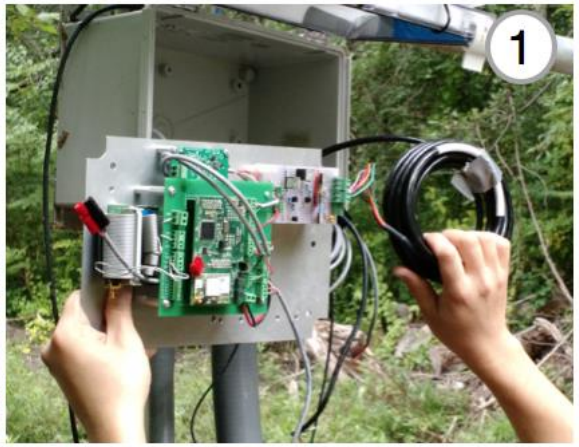
Automatically trigger remote samplers as water levels change.






2

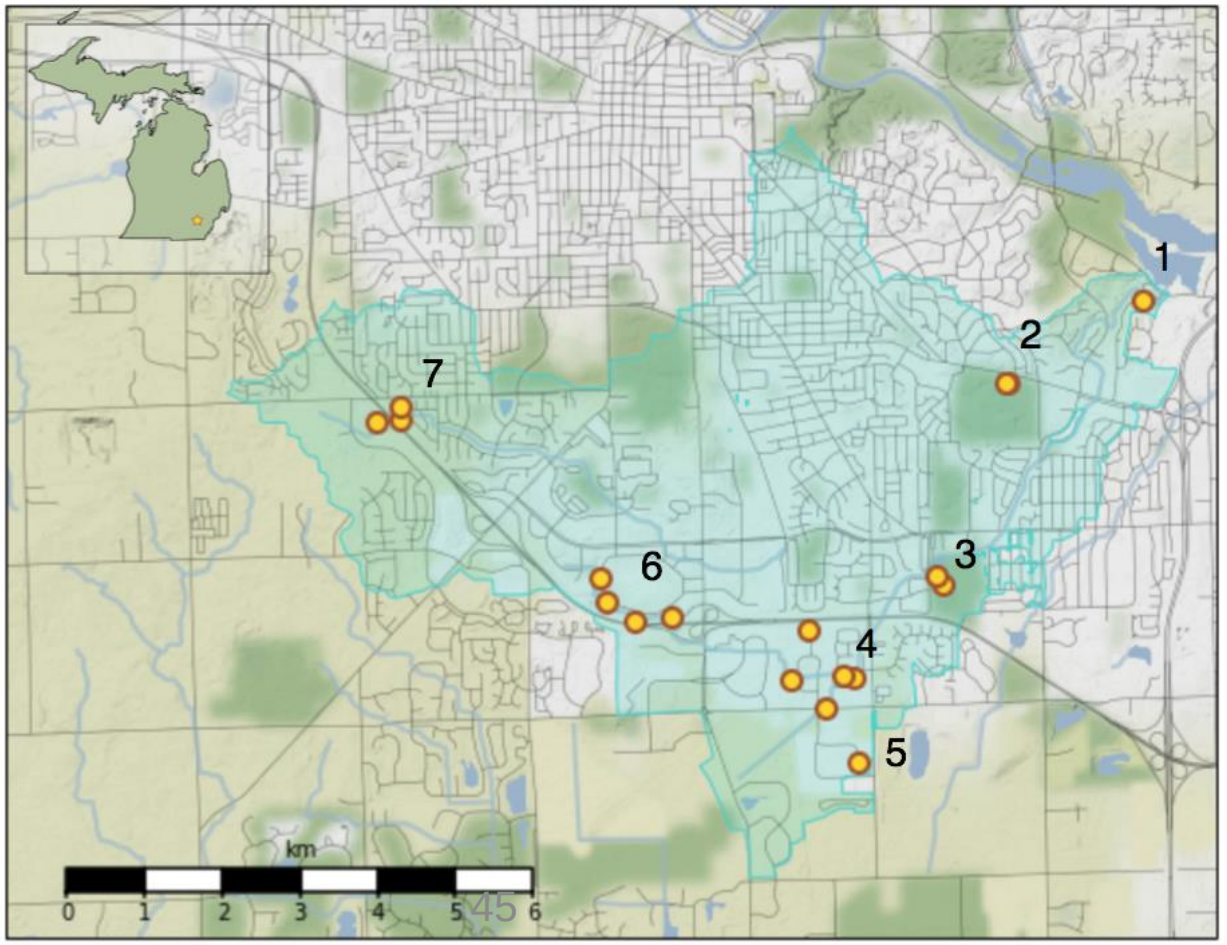

1


1


6


2


2


1
2
7
6
3
4
5
km
0
1
2
3
4
5
6


1


7


3

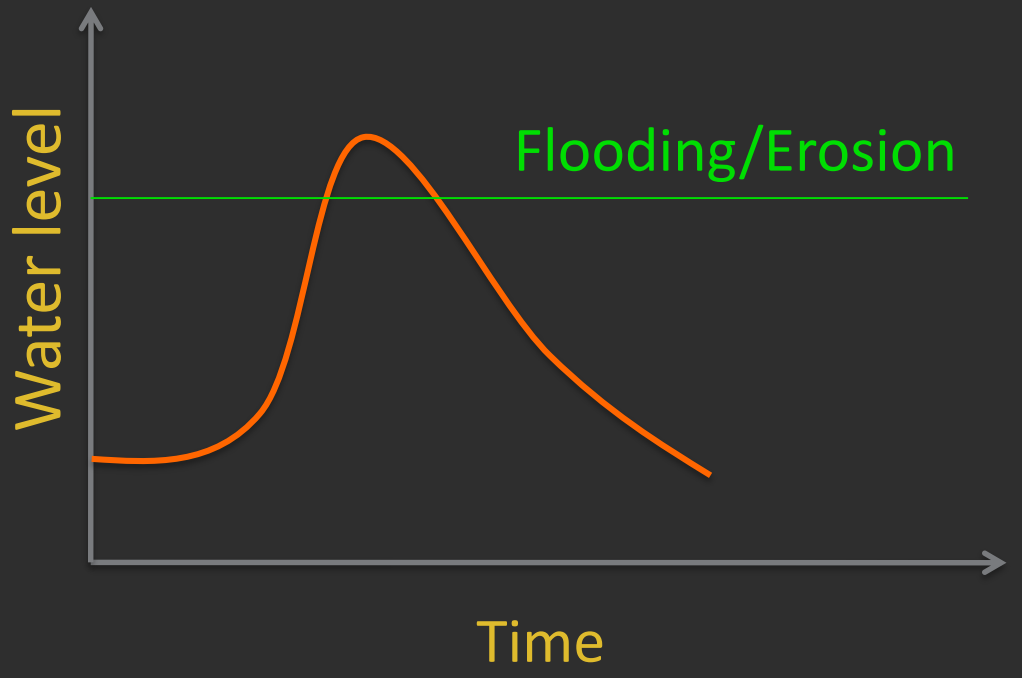

5

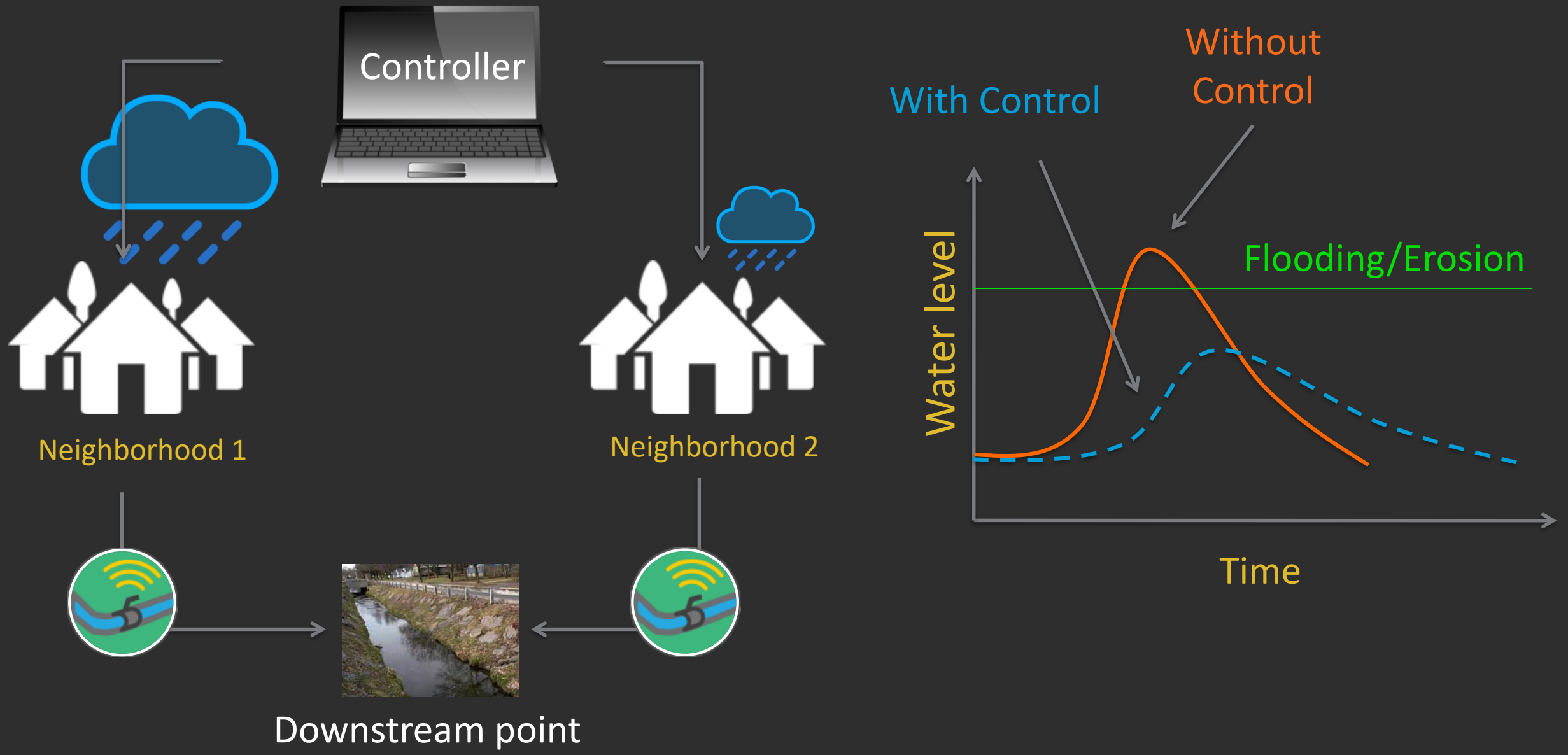

3

Neighborhood 1

Neighborhood 2

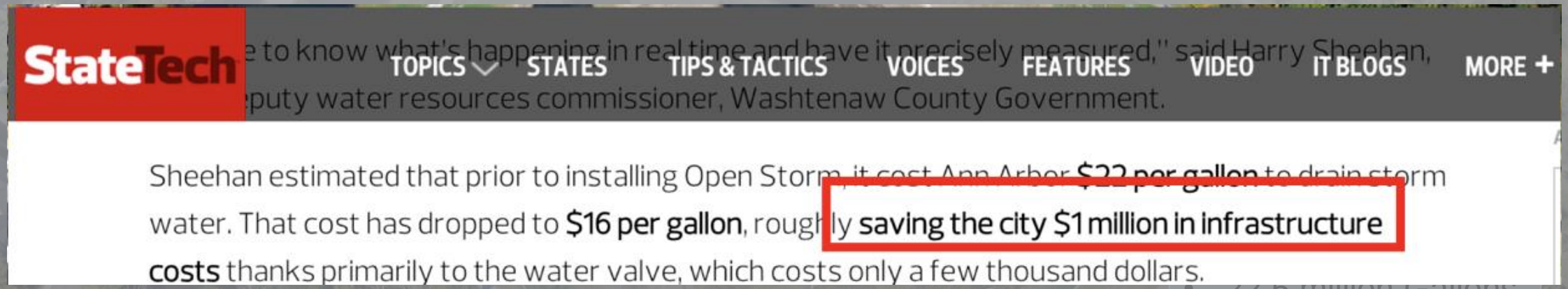
Downstream point




Controller
Neighborhood 1
Neighborhood 2
Downstream point
With Control
Without Control
Water level
Flooding/Erosion
Time


50% Increase
in Capacity

- Before
- 15 Million Gallons Storage
- $22/gal
- 600 lb/yr Total P



StateTech

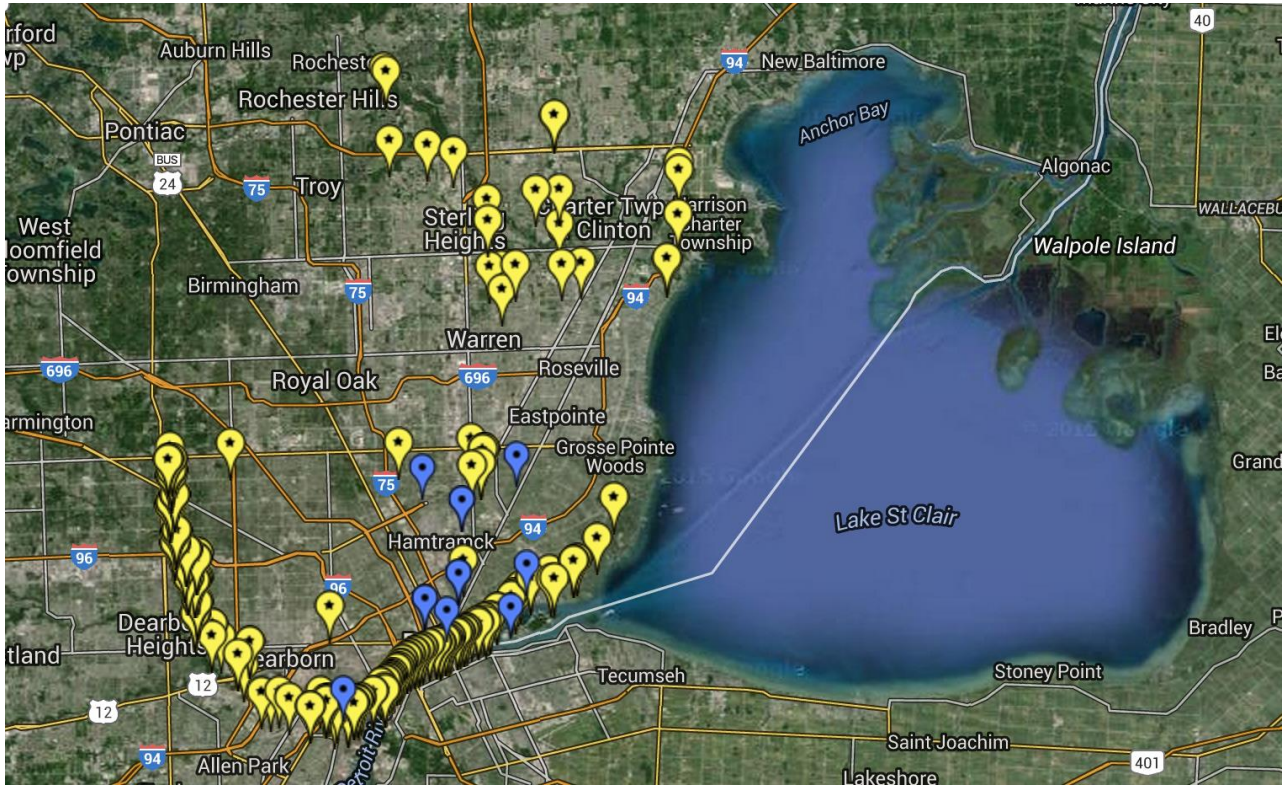
TOPICS STATES TIPS & TACTICS VOICES FEATURES VIDEO IT BLOGS MORE +

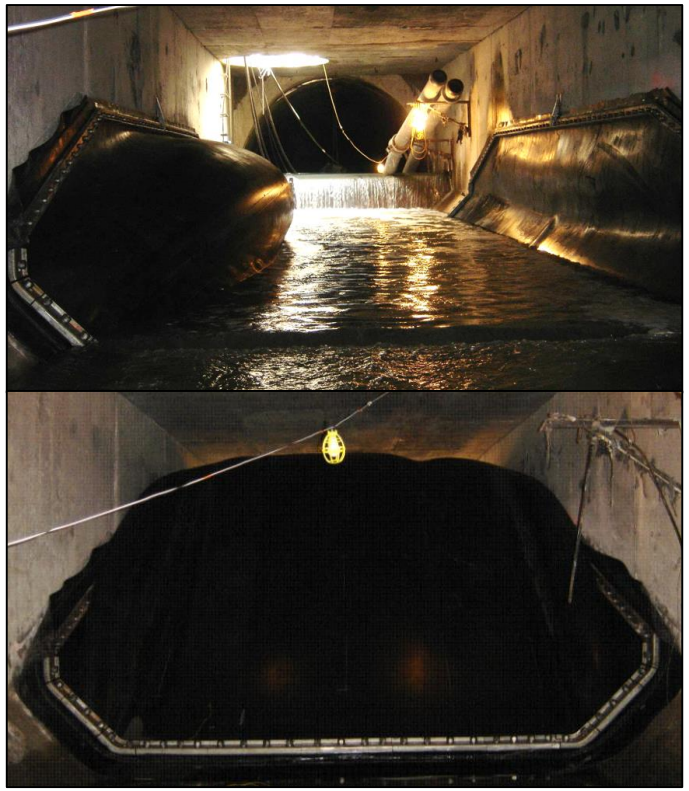
e to know what's happening in real time and have it precisely measured," said Harry Sheehan, puty water resources commissioner, Washtenaw County Government.

Sheehan estimated that prior to installing Open Storm, it cost Ann Arbor **$22 per gallon** to drain storm water. That cost has dropped to **$16 per gallon**, roughly **saving the city $1 million in infrastructure costs** thanks primarily to the water valve, which costs only a few thousand dollars.

- 22.5 million Gallons
- $16/gal
- 800 lb/yr Total P

The Opportunity



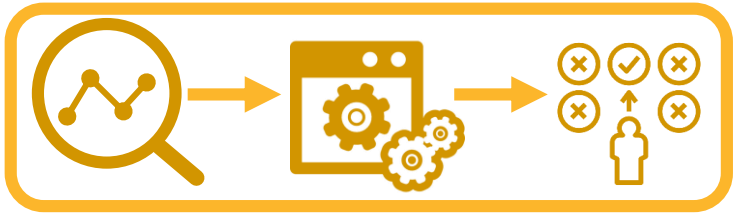


100+
Sensors

20+ Control
Points


Asset
Flow Rec
State Rec
ISD 001
ISD 002 57 1.00
ISD 003 0 0.00
ISD 004 0 0.00
ISD 005 0 1.00
ISD 006 0 0.00
ISD 007 0 0.00
ISD 008 0 0.00
ISD 009 0 0.00
ISD 010 0 1.00
ISD 011 0 0.00
ISD 012 38 0.00
ISD 013 32 0.00
ISD 013
ISD 009
ISD 012
ISD 008
ISD 007
ISD 011
ISD 003
ISD 004
ISD 001
ISD 002
ISD 006
ISD 005
Wyoming
Livernois
Wyoming Relief
Conant - Mt. Elliott
First - Hamilton
Clark
Livernois Relief
Baby Creek
NIEA
Meldrum
VR-16
VR-15
VR-13
VR-10
VR-11
VR-4
VR-6
VR-5
Lieb SDF
St. Aubin SDF
DR2
DRI
WRRF
Detroit River
Fairview PS
Detroit River
Conner Creek RTB
Conner Storm
Freud PS
In-System Gates
Asset
Flow Rec
State Rec
CC Forebay Gates 0.0 0.00
Fr. PS 0.0 0.00
CC to RTB 0.0 0.00
CC to DRI 150.0 1.00
CC Dewatering 4.8 1.00
CC Forebay to DRI 0.0 0.00
FV PS to DRI 167.6 1.00
CC CSO Complex - Storage Depths
CC Complex -- Actions At Control Points

Reprogram the System



100 MG sewer

Overflow Reduction

VS

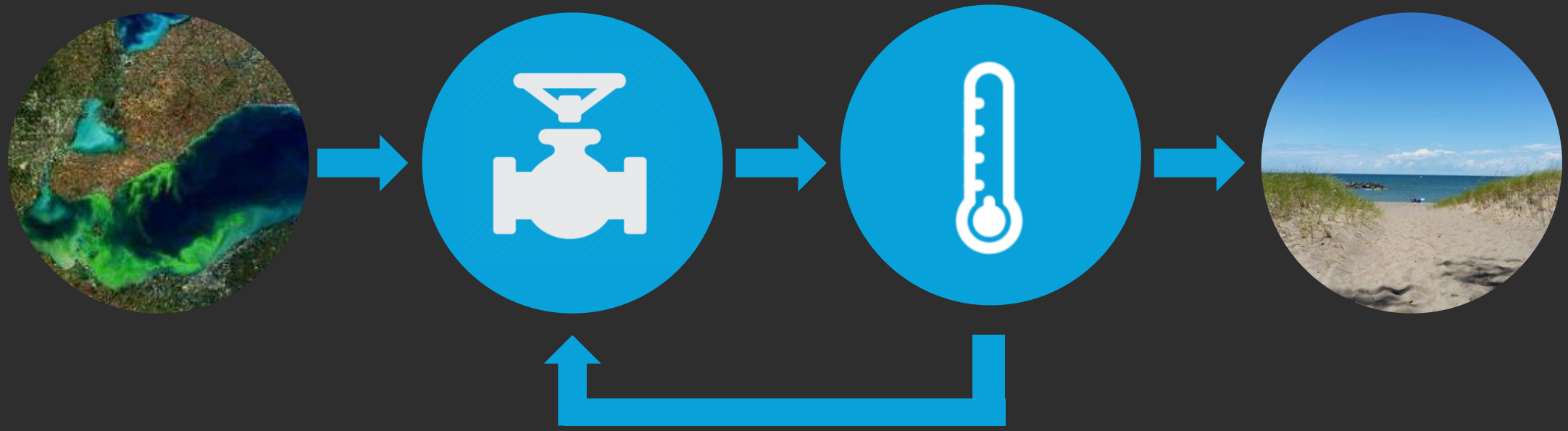
Build More

100 MG storage

have

do

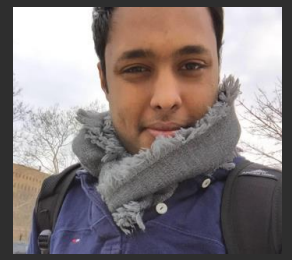
want



www.open-storm.org bkerkez@umich.edu





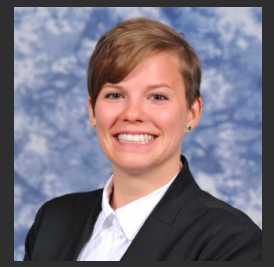

EGLE
GLPF






NSF



USGS
science for a changing world

Ohio-Kentucky-Indiana Water Science Center
Serving the Nation and providing high-quality science for over 100 years

Use of various real-time nutrient monitors for modeling and load estimation

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

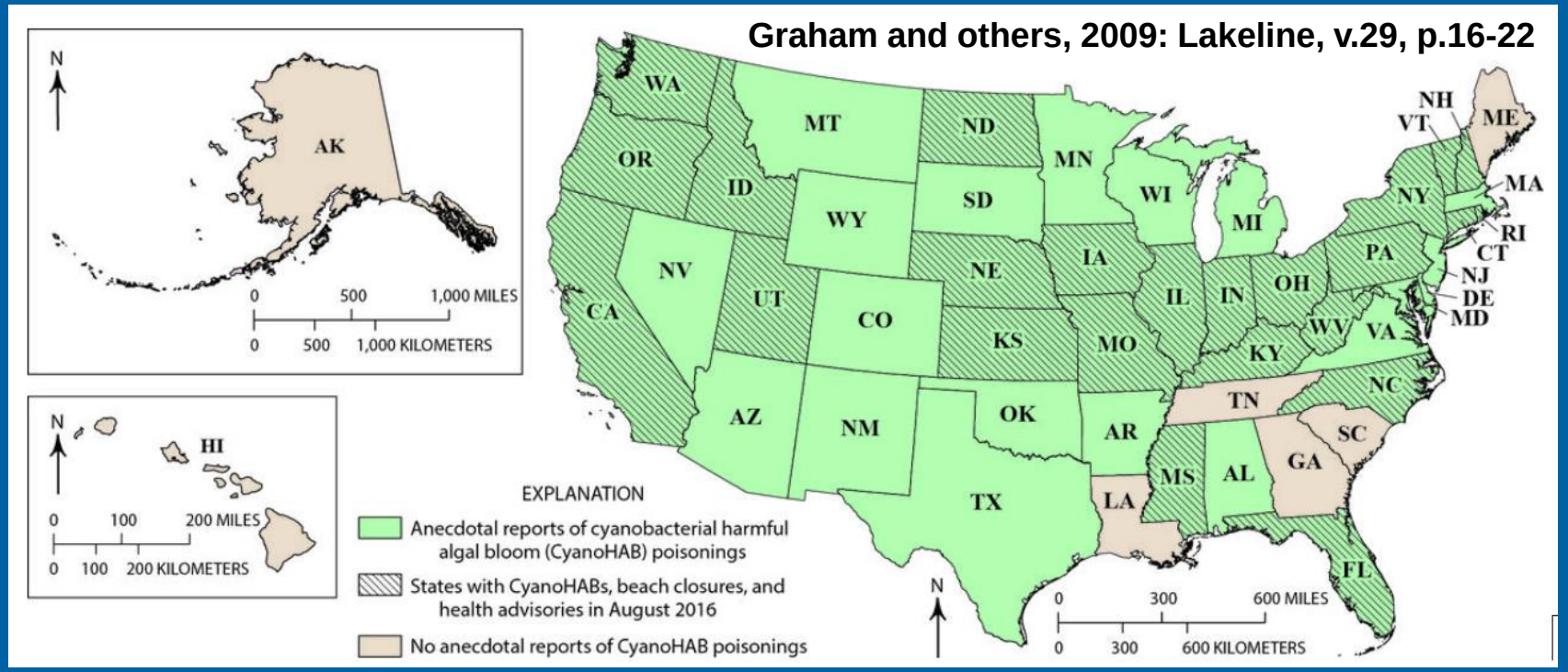
Talk Outline

- Nutrient enrichment is a key factor in cyanoHABs occurrence
  - Importance of continuous nutrient monitoring
  - Nutrient sensor technology
- Developing continuous nutrient surrogate models
- Identifying nutrient “hotspots”
  - Assessing nutrient loads

USGS

CyanoHABs are increasingly a national concern

- Threaten human and aquatic ecosystem health
- Cause major economic damage

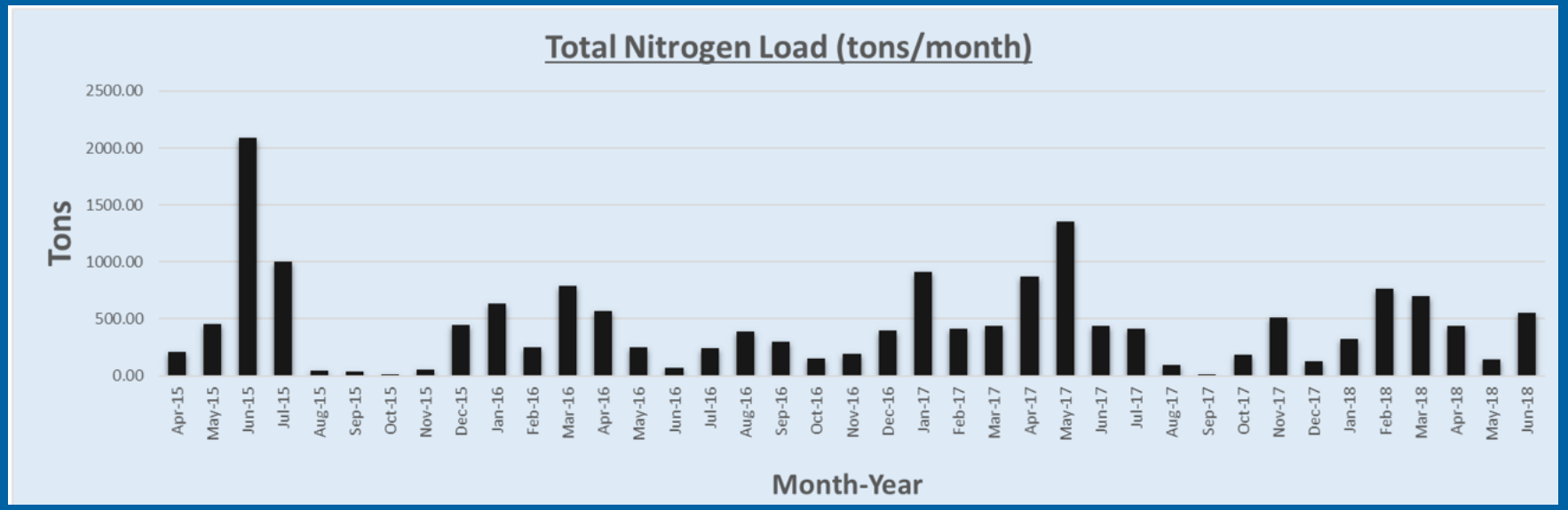


USGS

Expanding our knowledge

Challenges to understanding cyanoHABs

- Changes in climate
  - Warmer temperatures
- Changes in nutrient loads (nitrogen and phosphorus)



USGS

Why monitor nutrients continuously?

- 24/7 data collection
- Wide range of constituents with direct or surrogate measurements
- Captures all events
- Optimizes the collection of discrete samples

USGS

Applications

- Early warning for drinking water and wastewater
- Load assessment
- Source identification
- Event detection
- Real-time decision support
- …

USGS

Ohio River at Ironton, OH

Relating continuous sensor data to nutrients

Directly measured	Computed or estimated
Nitrate plus nitrite	Total nitrogen
Orthophosphate	Total phosphorus
Turbidity	Total nitrogen Total phosphorus Suspended sediment
Specific conductance	Nitrate plus nitrite

USGS

There are multiple types of nutrient sensors

Nitrate plus nitrite *(optical)*

Ion-selective electrode

Orthophosphate *(wet chemistry)*

USGS

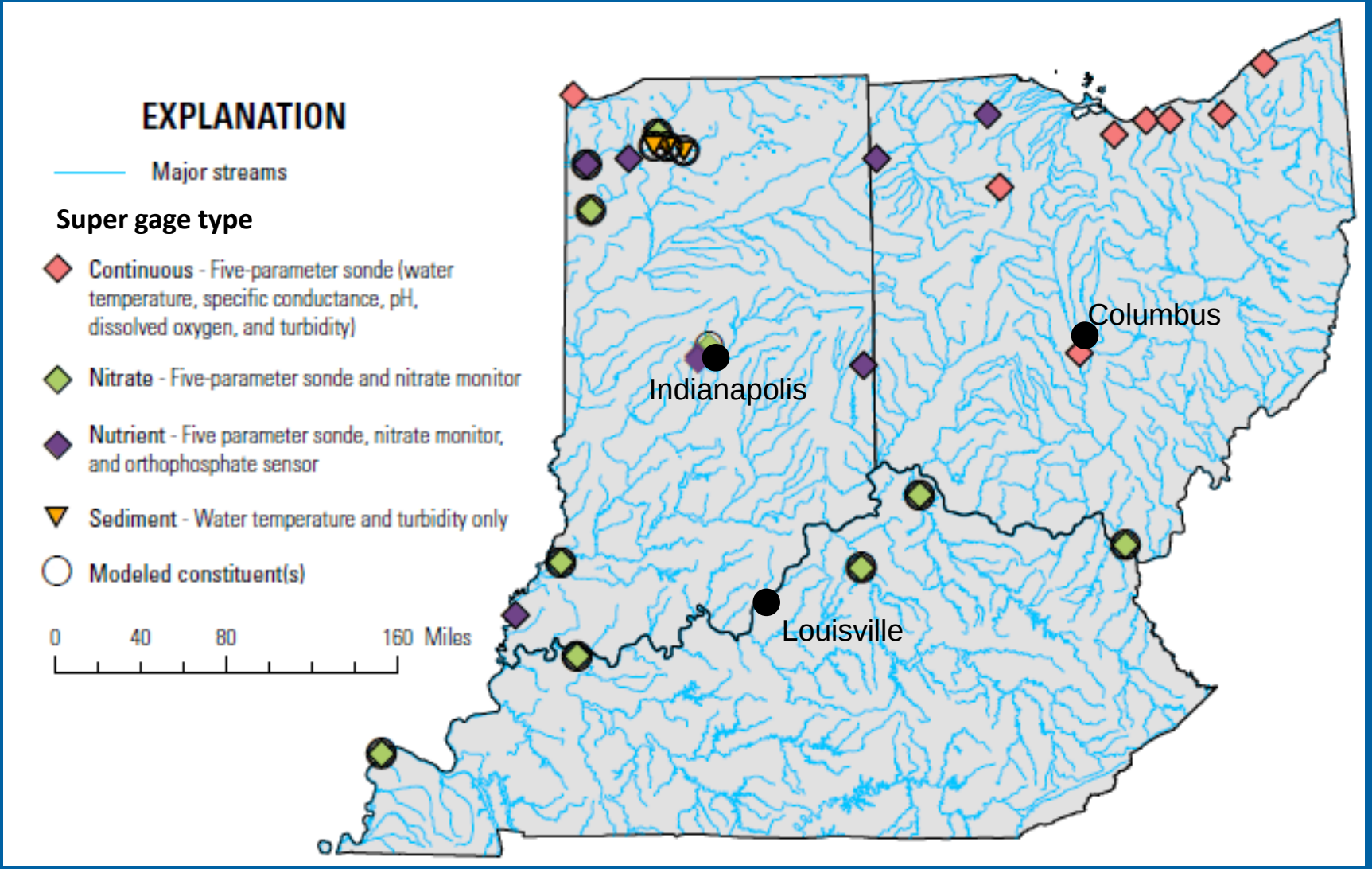
Advantages and Disadvantages

Type	Principle	Advantages	Disadvantages
Optical (UV) sensors	**Spectral absorption by a photometer**	***High resolution, accuracy, precision** ***Chemical free** ***Fast response time**	***Expensive (>$20,000)** ***High power requirement** ***Only available for nitrate**
Wet-chemical sensors	**Wet chemical colorimetric reaction with detection by photometry**	***High resolution, accuracy, precision** ***Relatively fast response time** ***Available for NH4, NO3, and phosphate**	***Expensive (>$20,000)** ***High power requirement** ***Requires reagents** (generates waste) ***Freezing lines in cold temperatures**
Ion-selective electrodes (ISE)	**Direct potentiometry between sensing electrode and reference electrode**	***Inexpensive (<$1,500)** ***Easy to use** ***Fast response time** ***Not influenced by color or turbidity**	***Low resolution, accuracy, and precision** ***High instrument drift** ***Limited shelf life** ***Technique sensitive calibration**

USGS

Pellerin and others, 2016
JAWRA v.52, issue 4

OKI super gage sites (fixed position)



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Successful Operation of a Super Gage

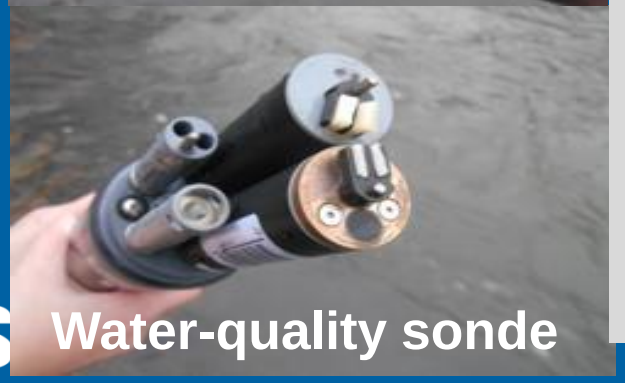
4 Components

- **Streamflow**
- **Continuous monitoring:** multiparameter water-quality sonde; nitrate monitor; orthophosphate analyzer
- **Discrete sampling: e.g. nutrients, sediment, microcystin**
- **Surrogate regression modeling**

Ohio River at Ironton, OH
(cyanoHAB bloom)

USGS

Super Gages monitor continuously



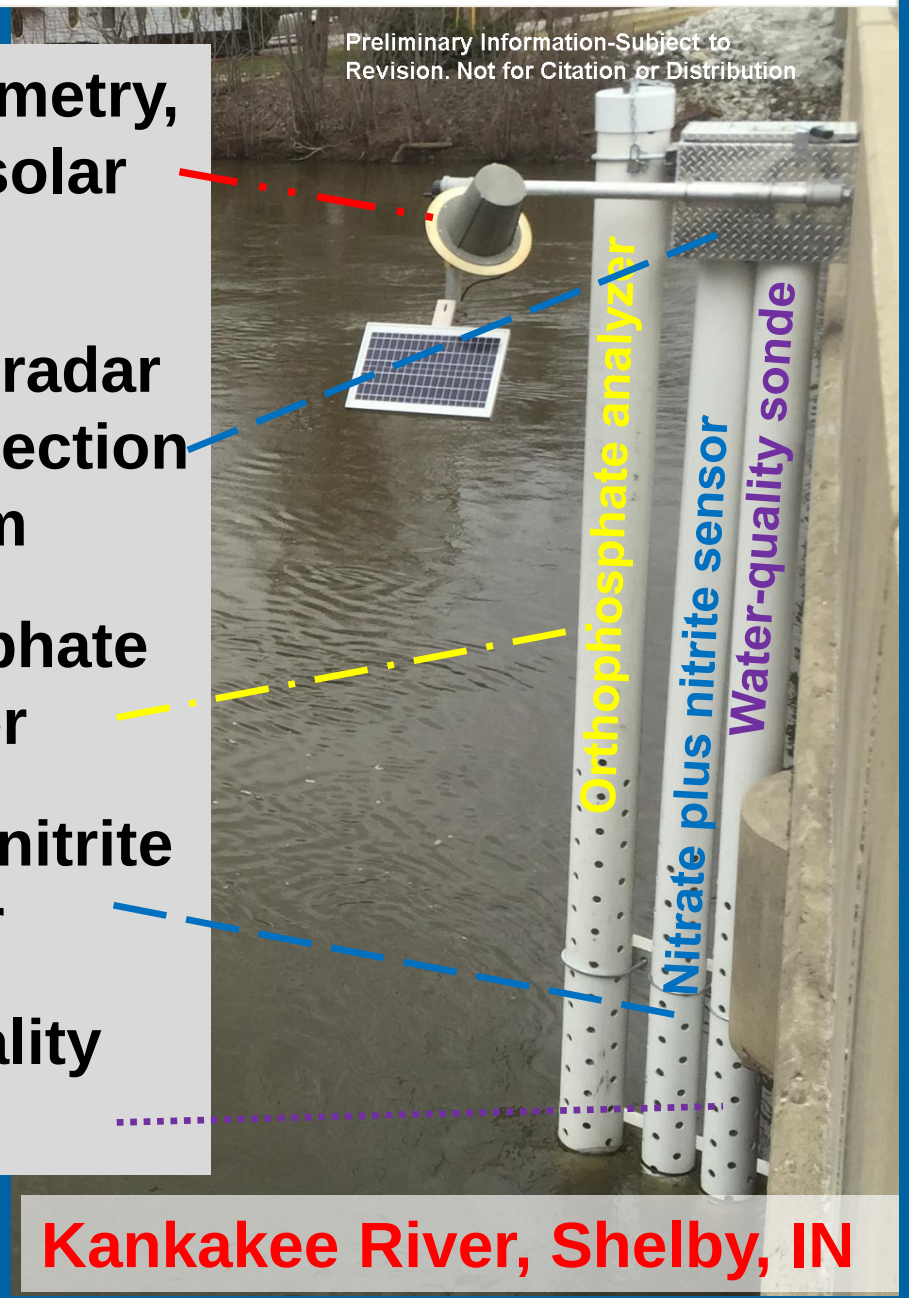
Satellite telemetry, GPS, and solar panel

Streamflow radar and data collection platform

Orthophosphate analyzer

Nitrate plus nitrite sensor

Water-quality sonde



Kankakee River, Shelby, IN

Data are publicly available at www.USGS.gov

Super Gages are adapted to the site


Maumee River at Antwerp, OH


East Fork Whitewater River at Richmond, IN


School Branch at Maloney Road near Brownsburg, IN


Ohio River at Ironton, OH

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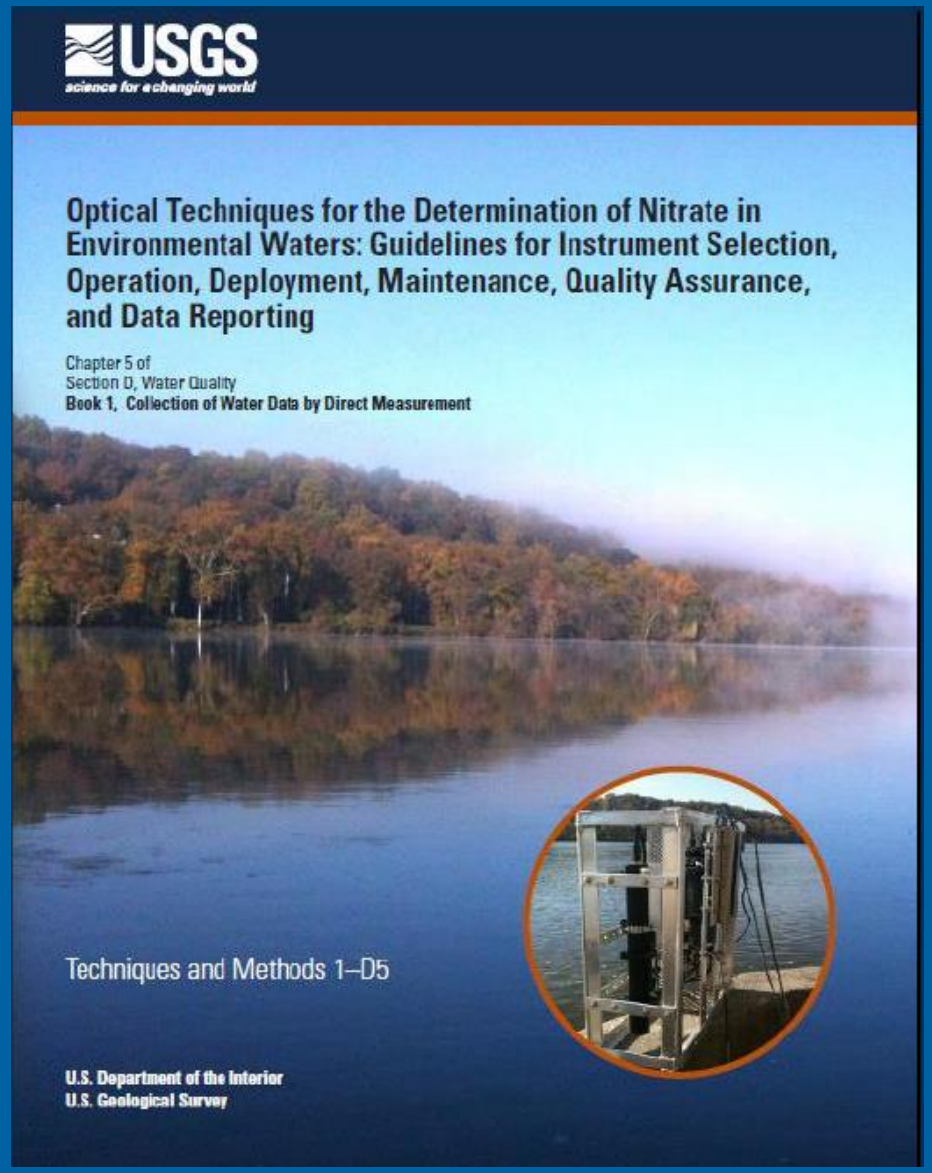
Approved Guidelines and Protocols

- Guidelines for use in a variety of environments



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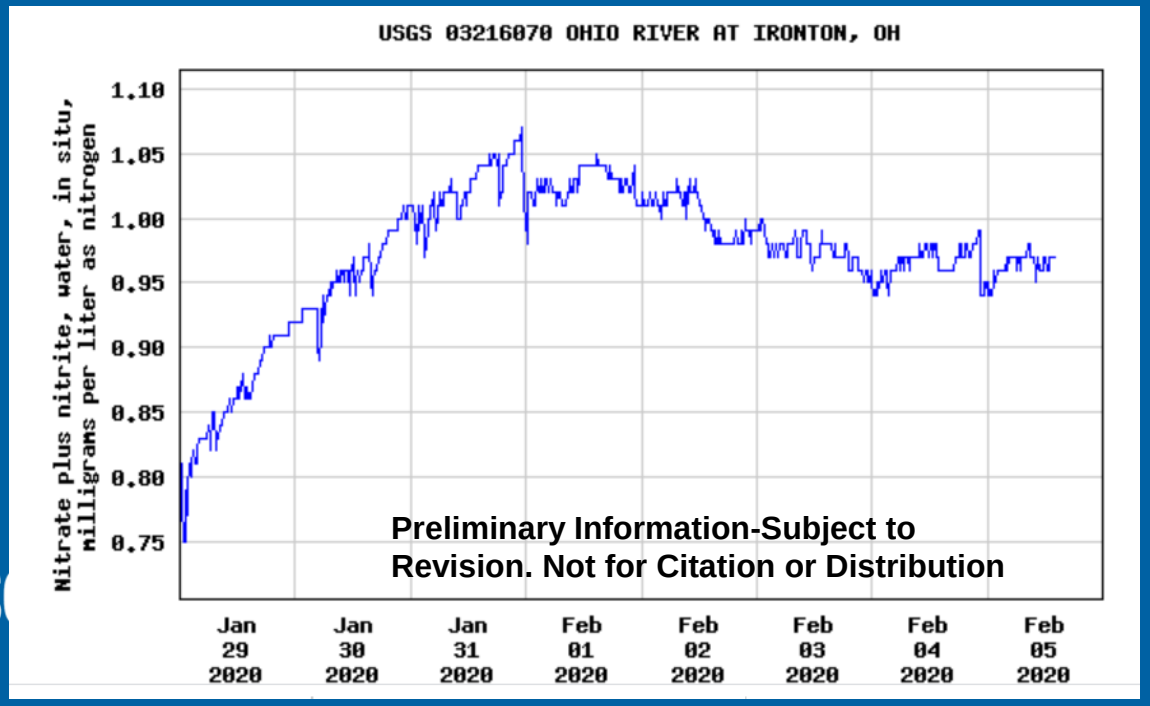
Site Operation and Maintenance Visits

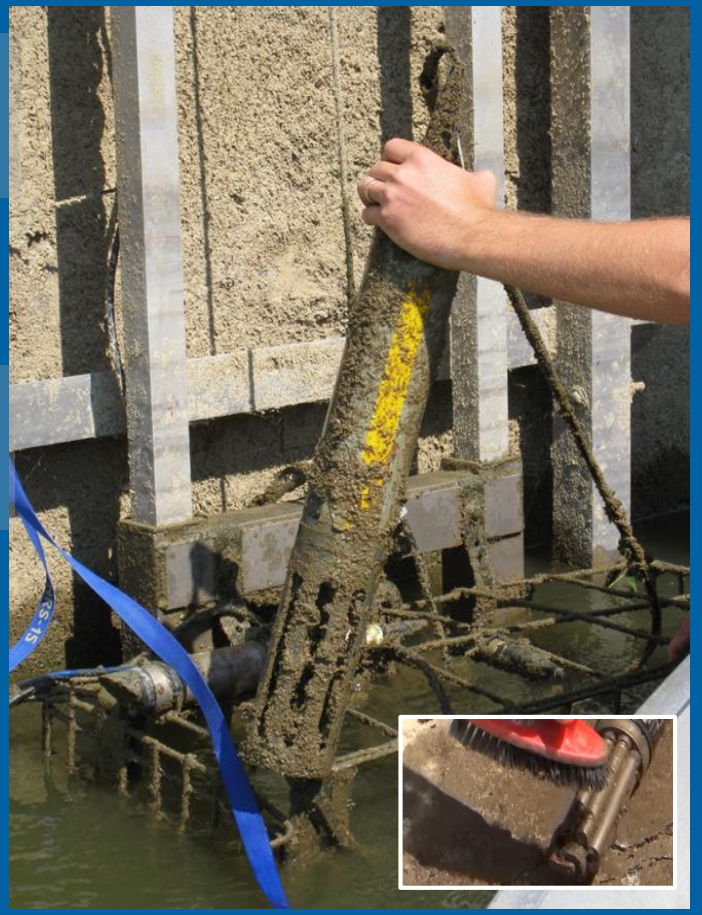
Clean and recalibrate the monitor (20+ visits/yr)

- Once every 2-4 weeks

Daily online data checks of the monitor, troubleshoot as necessary

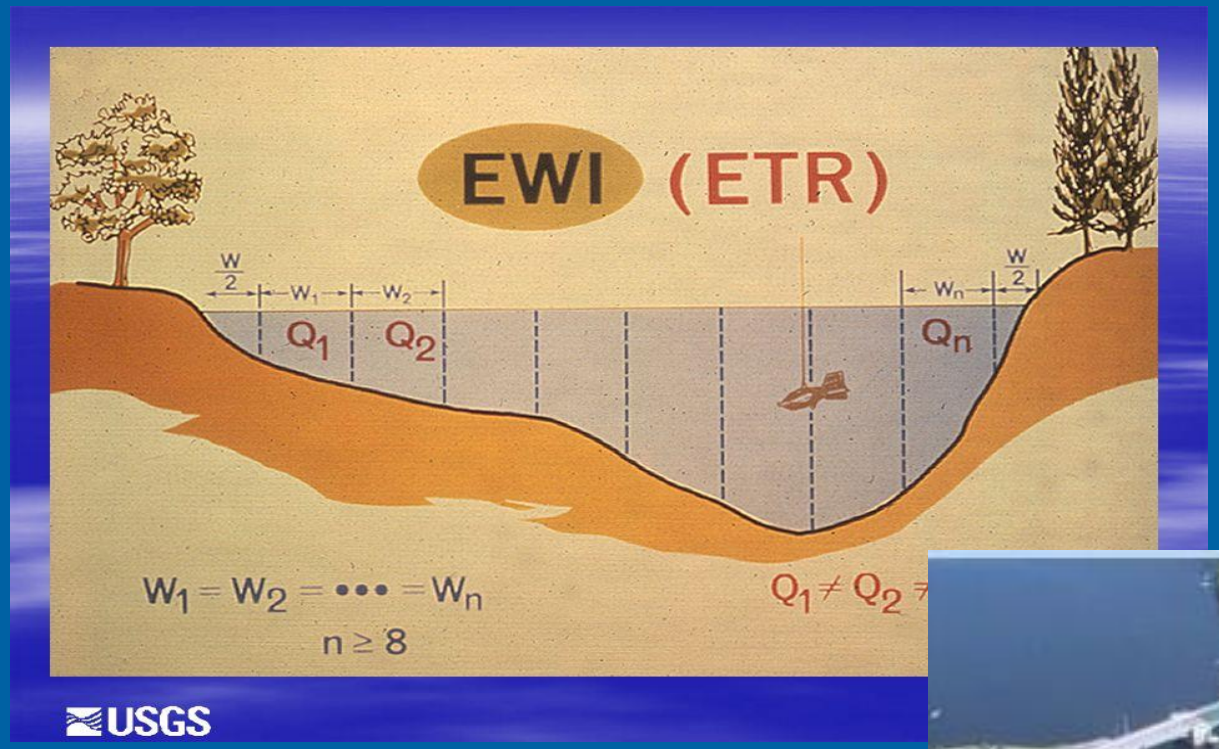
Internal review and approval of all data prior to publication





Wagner and others, 2006, **Guidelines and standard procedures for continuous water-quality monitors**; U.S. Geological Survey Techniques and Methods 1-D3

Collecting Representative Water Samples



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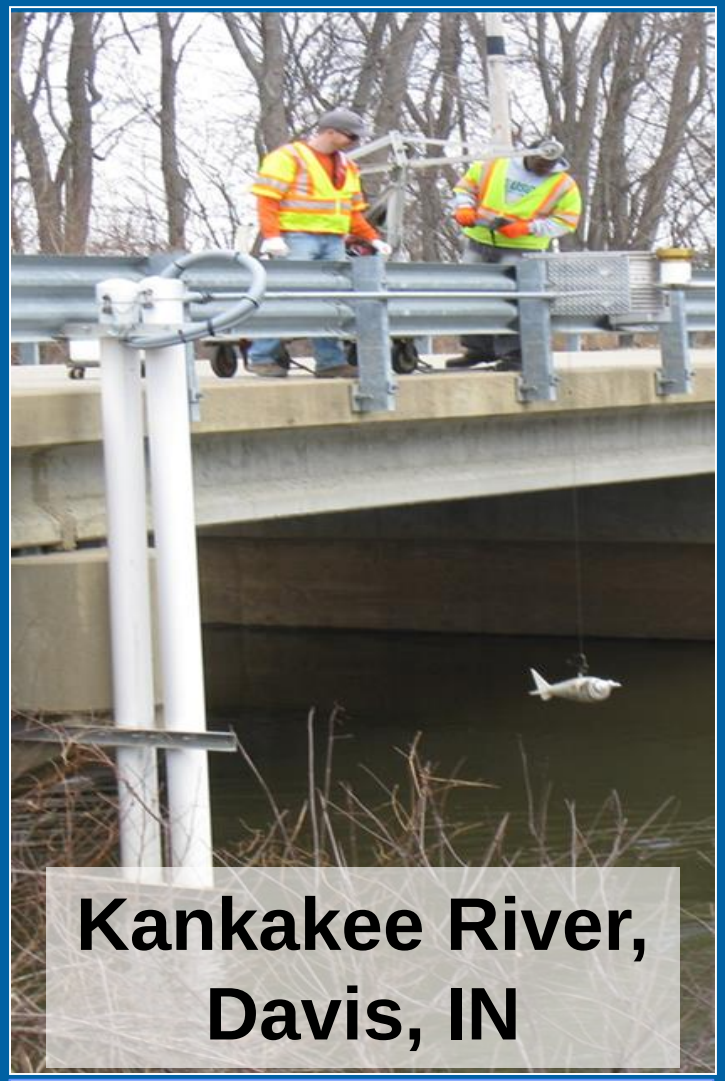
Collecting Representative Water Samples



Kankakee River, Davis, IN

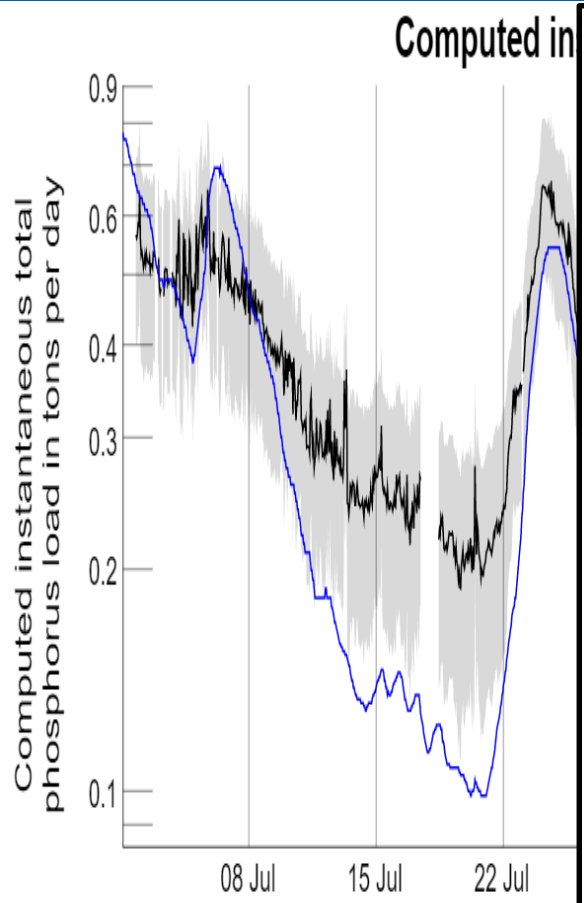
St. Mary's River, Ft. Wayne, IN

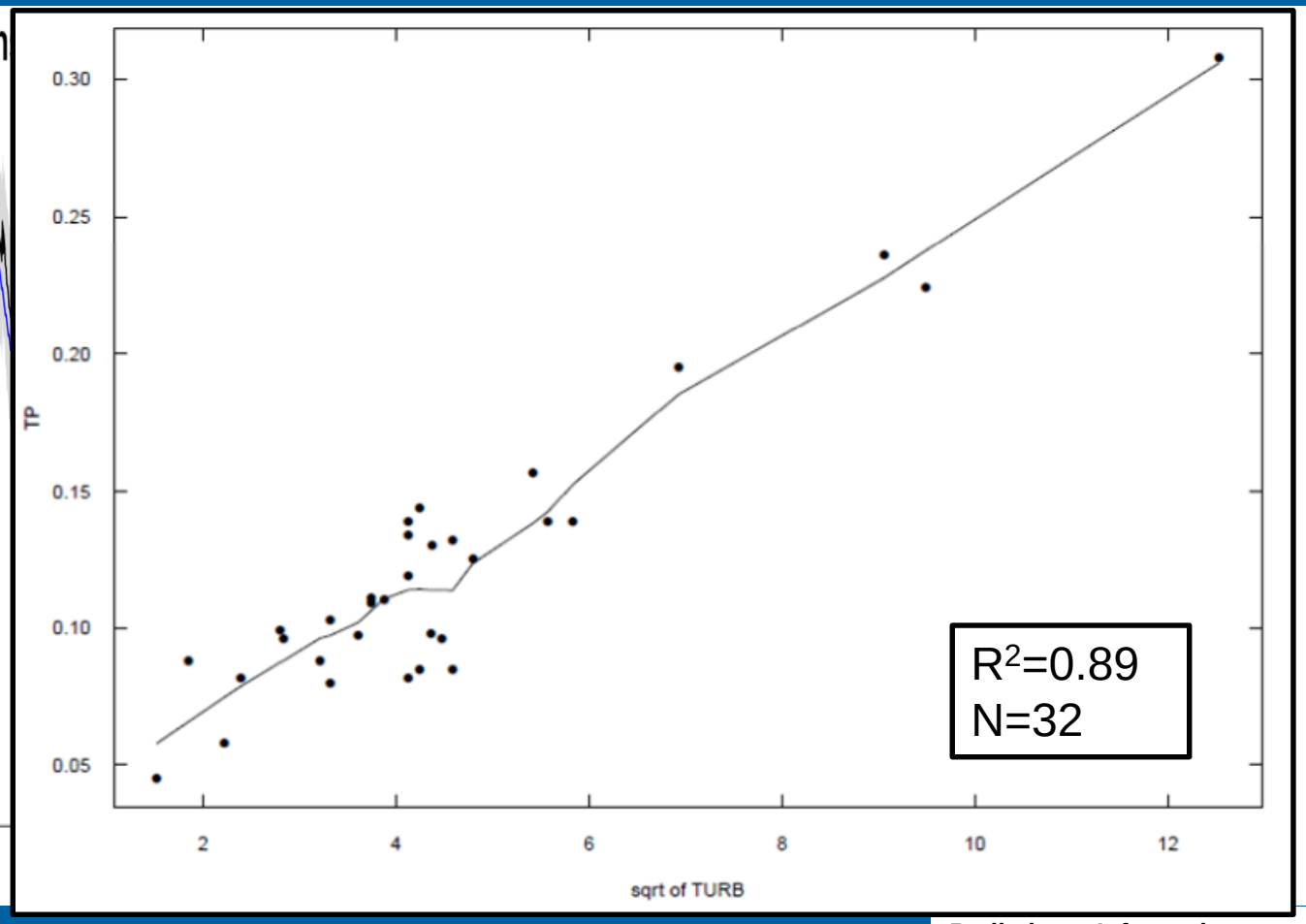
Wabash River New Harmony, IN

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: USGS Techniques of Water-Resources, book 9

Developing Continuous Surrogate Models

Total Phosphorus – Kankakee River at Shelby, Indiana





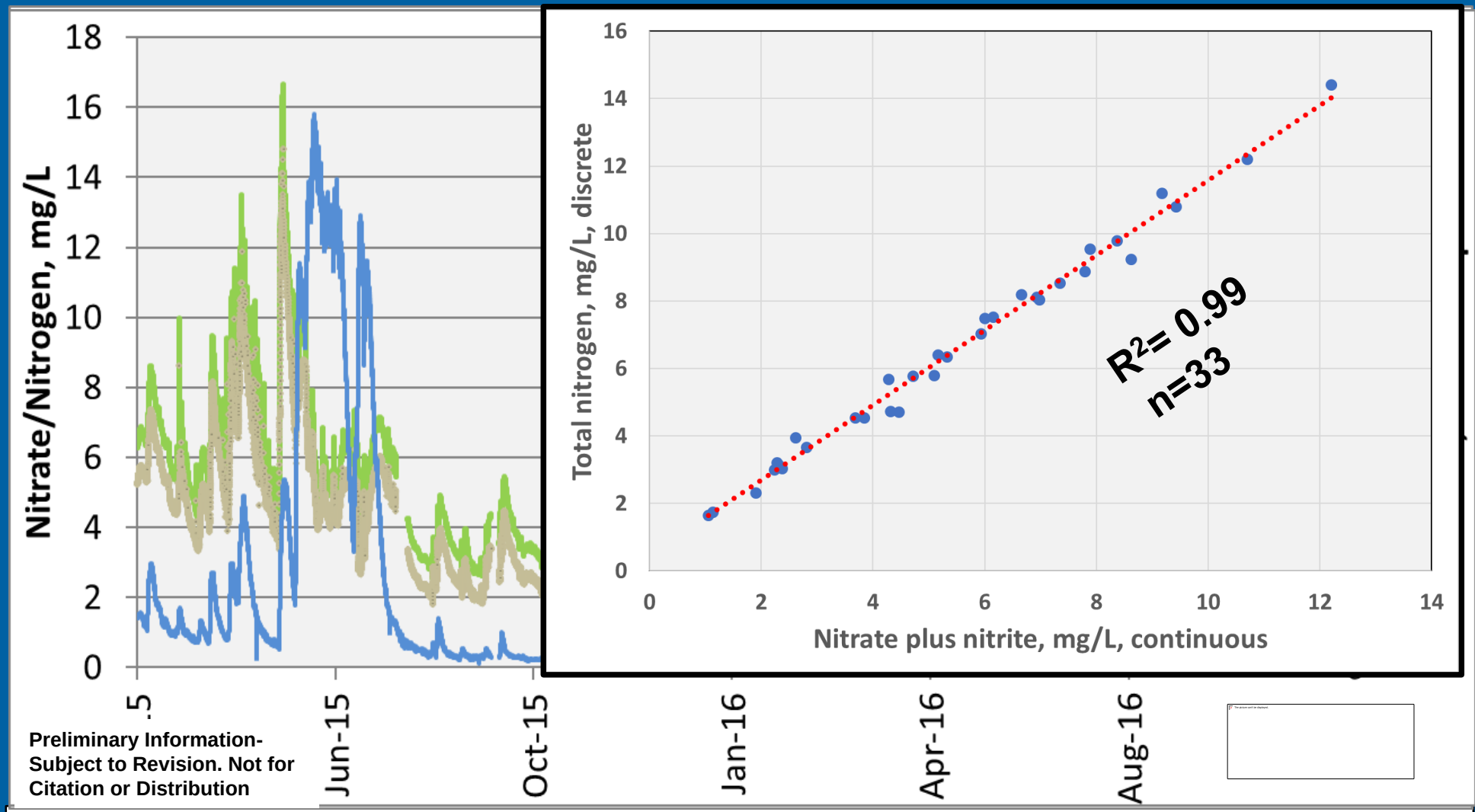
Preliminary Information-Subject to Revision. Not for Citation or Distribution

TP concentration = (0.02255 x sqrtTURB) + 0.02047

Load TP = TP * streamflow(site) * constant for conversion of units

Developing Continuous Surrogate Models

Total Nitrogen - Iroquois River near Foresman, IN



Preliminary Information-Subject to Revision. Not for Citation or Distribution

$$Log_{10}TN = (0.83 \times log_{10}NOx) + (0.03 \times log_{10}Q) + 0.09$$

*Load TN = TN * streamflow(site) * constant for conversion of units*

Why do surrogates work?

- There is a physical relation between the measured sensor value and the constituent of interest
  - Nitrate plus nitrate relates directly with total nitrogen
  - Orthophosphate relates directly with total phosphorus
  - Sediment directly causes turbidity
- In other cases, there is an association between the constituent or interest and the in-situ measurement
  - Phosphorus is associated with sediment (turbidity)
- Cost-effective tool

USGS

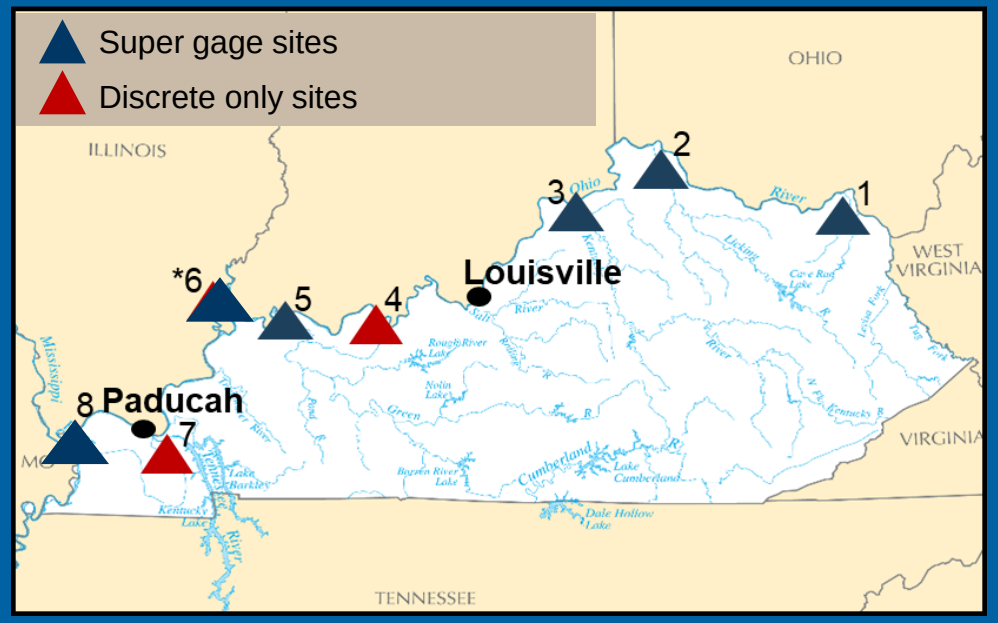
Assessing loads using continuous nutrient monitoring

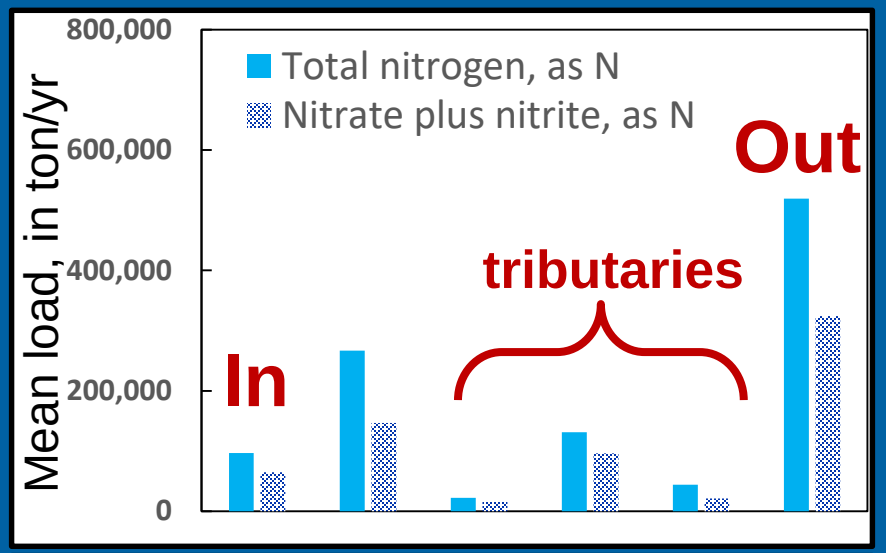
- May prove important for assessing and managing nutrient loads delivered to rivers and across land-water interface (e.g. edge-of-field)
- Continuous monitoring data can improve accuracy and reduces uncertainty of load estimates
- May help guide implementation and evaluation of BMPs (edge-of-field to watershed scale)

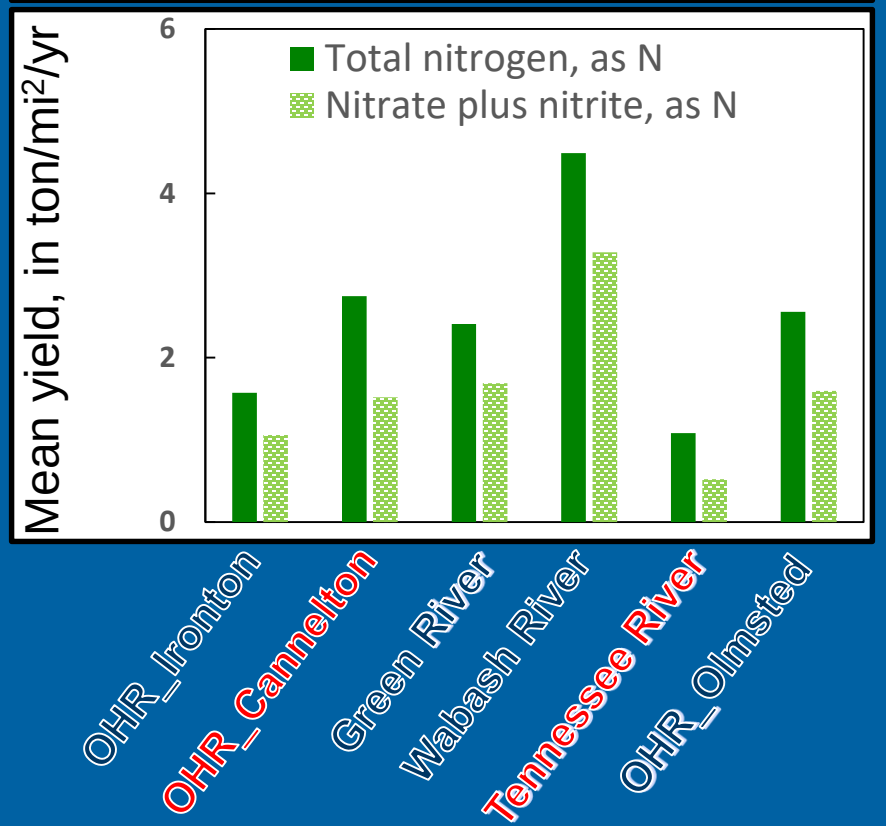
USGS

Super gage network:

Total nitrogen in the Ohio River and tribs, 2014-17







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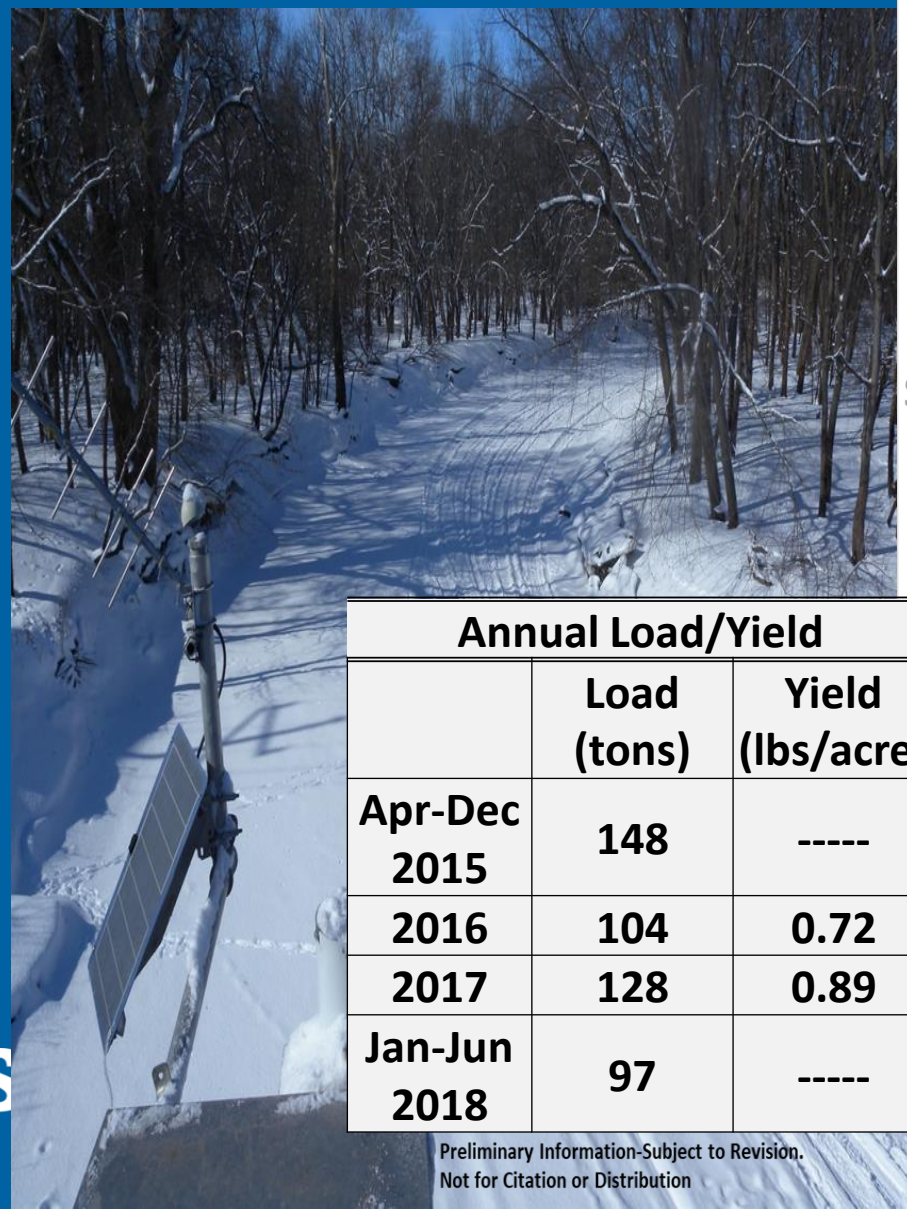
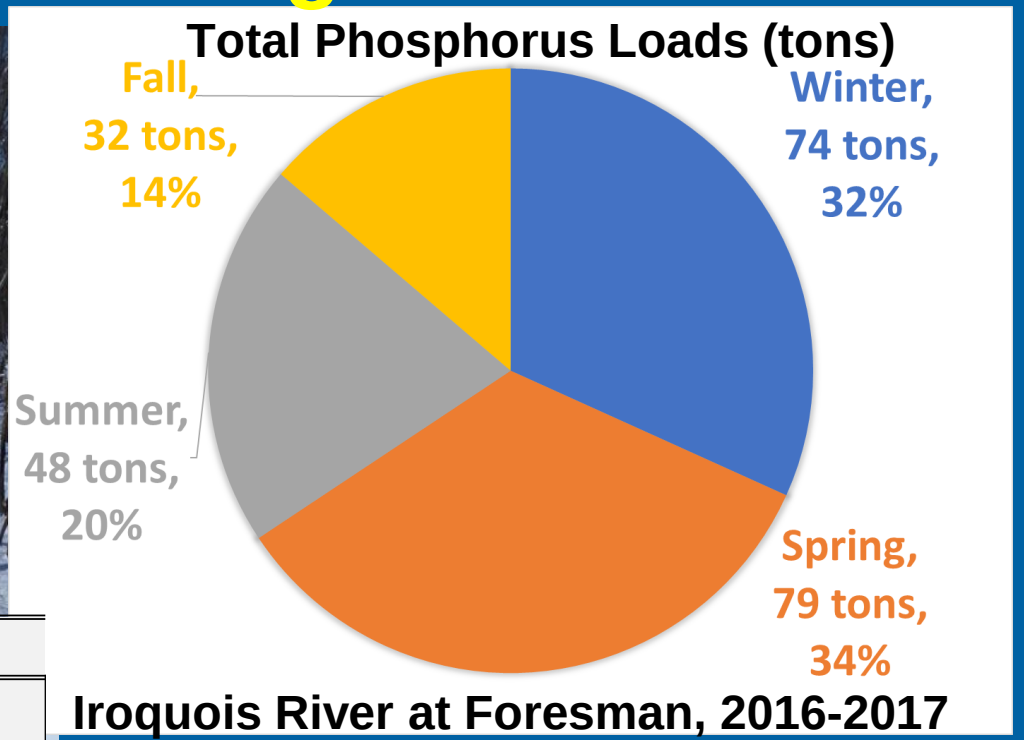
Continuous monitoring allows us to show seasonal loading differences





Iroquois River at Foresman, 2016-2017

Annual Load/Yield		
	Load (tons)	Yield (lbs/acre)
Apr-Dec 2015	148	-----
2016	104	0.72
2017	128	0.89
Jan-Jun 2018	97	-----

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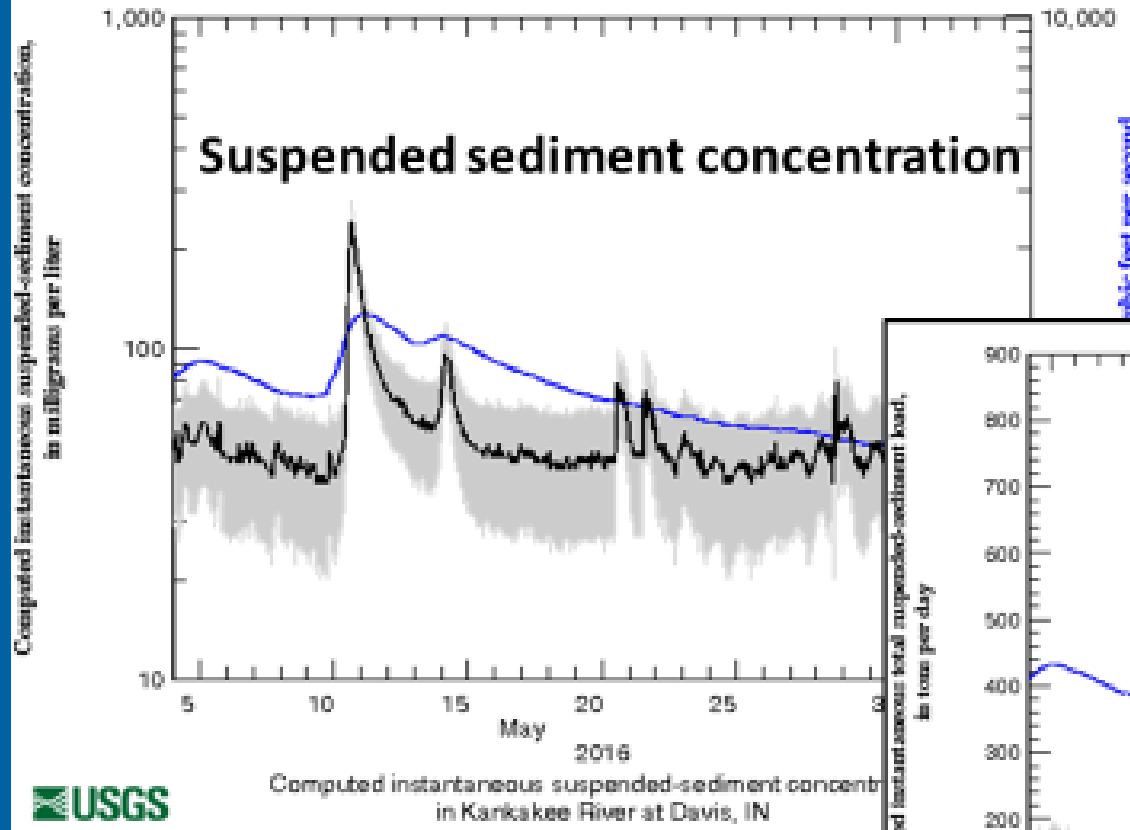
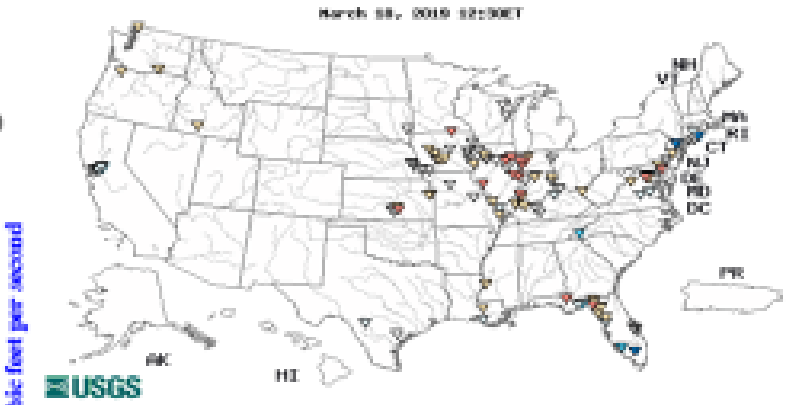
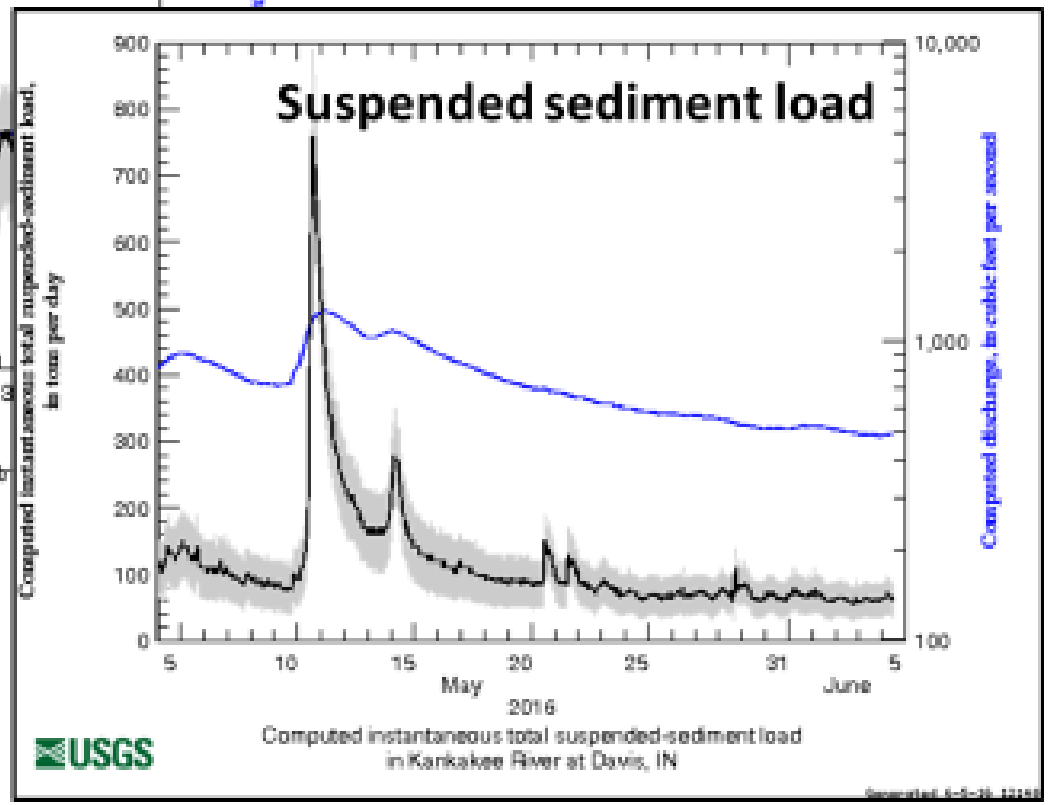
Access to National Real-Time Water Quality

nrtwq.usgs.gov







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Future efforts for Super Gages

- Improving surrogate capabilities
  - cyanoHABs
- Creating additional continuous monitoring opportunities
- Working across borders/ agencies/land uses
- Public awareness


Kentucky River

USGS

Acknowledgements

Richmond Sanitary District

Kankakee River Basin Commission

ZIONSVILLE

citizens energy group

Ohio Environmental Protection Agency

Indiana Department of Environmental Management

The Nature Conservancy

The Walton Family Foundation

USDA Natural Resources Conservation Service
United States Department of Agriculture

KADF Kentucky Agricultural Development Fund

Great Lakes Restoration

Kentucky River Authority

Indiana State Department of Agriculture

The City of Columbus

Purina

Managing Northern Kentucky's Wastewater and Storm Water

Division of Water

US Army Corps of Engineers

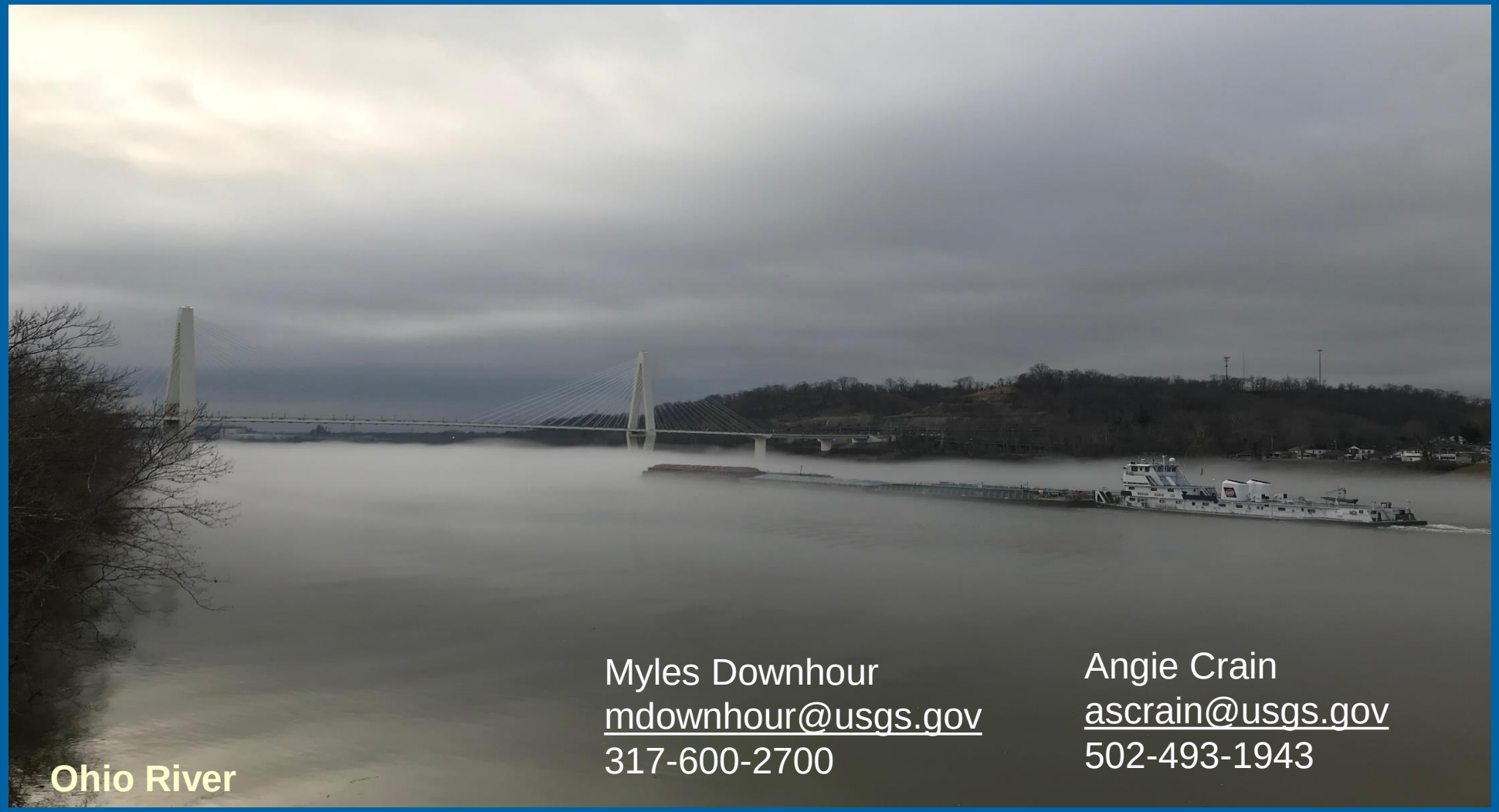
USGS

Iroquois River Conservancy District

USGS National Water Quality Program

Ohio Water Development Authority

Thank you



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Questions?

Thank you!