Field and lab method comparisons and remote sensing of HABs/cyanoHABs

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Milford Reservoir, Kansas 7/14/16

Photo: Christopher Churchill, USGS

Outline

- Method Comparison Study
  - Objectives
  - Study design/methods
  - Salient results
  - Discussion
  - Deliverables
- Satellite Remote Sensing Study
  - Objectives
  - Study design/methods

Acknowledgements

- Funding cooperators
  - Method Comparison Study
    - Texas Commission on Environmental Quality
  - Satellite Remote Sensing Study
    - USGS Water Mission Area
    - North Texas Municipal Water district
    - Dallas Water Utilities
    - Others?
- Partners
  - USGS MD/DE/DC and ID Water Science Centers
  - NASA

Method Comparison Study

Objectives

- Baseline conditions
- Method comparison
  - Data sondes
  - Photopigments
  - Cyanotoxins
- Explanatory variables
  - HABs
  - HAB potential

Study design FY 18-19 (Phase 2)

- Task 1: QAPP
- Task 2: Methods assessment/comparison for Phase 1 data
- Task 3
  - Field work (July 25, 2018 – September 27, 2018)
  - Sixteen reservoirs
  - Spring 2019 In-Situ Aqua Troll 600, 25 surveys
- Task 4: Data management and reporting

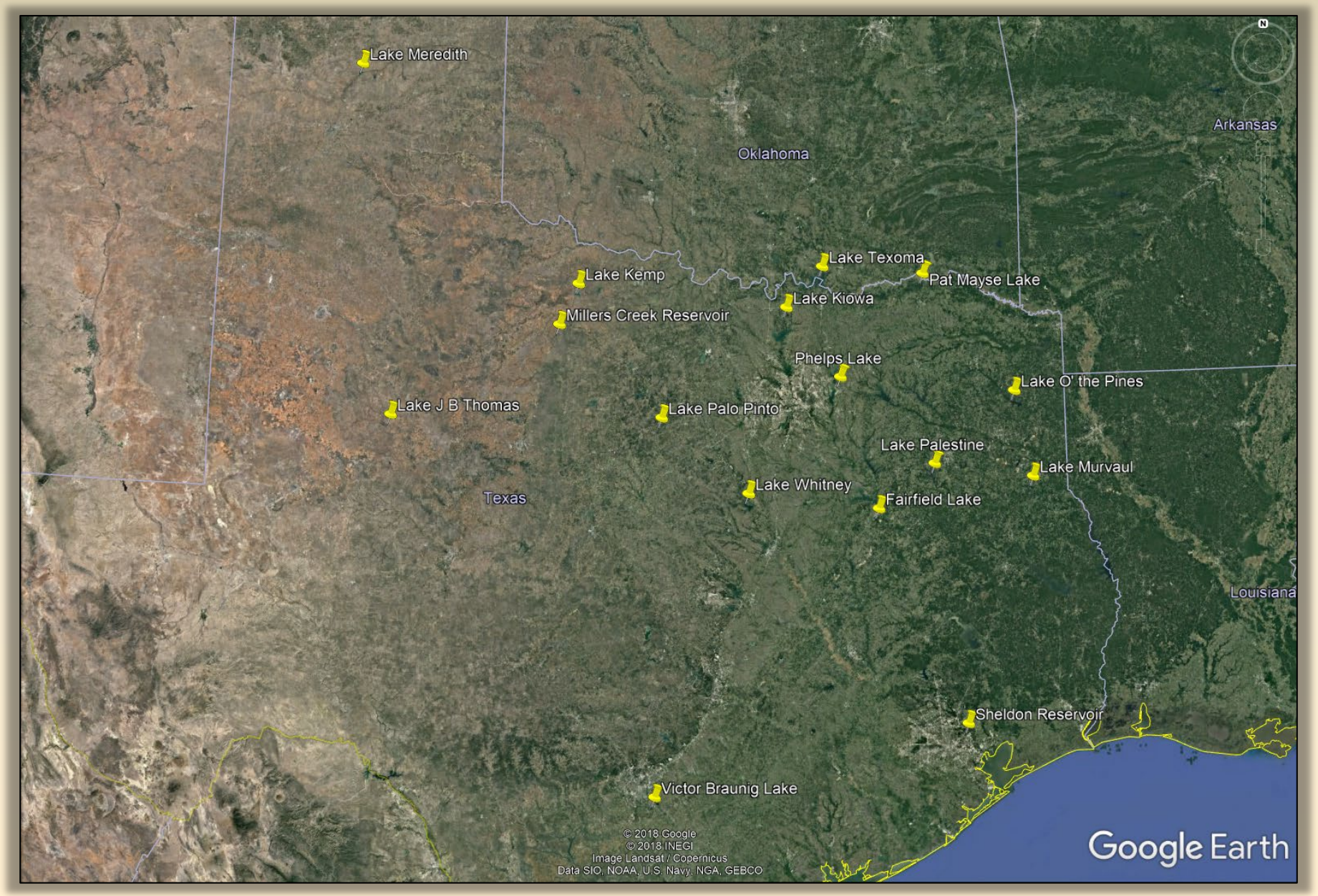
Target compounds

- Field measures
  - Big 5, PAR, photopigments(2), Secchi, atmospheric(4)
- Water chemistry
  - Ions, DOC, TOC, TDS, nutrients, photopigments(2)
- Cyanobacterial/cyanotoxin genetics (started Phase 2)
  - Cyanobacteria, MCN, SXN, ANA, and CYN
- Cyanotoxins
  - Dipstick kits(3), ELISA(5), LC/MS/MS(15)
- T&O compounds
  - Geosmin, MIB
- Phytoplankton taxonomy (to species)
- Derived variables

Site selection (Phases 2 and 3)

- YSI EXO total algae sensor (TAS)
  - Chlorophyll, phycocyanin
  - Readings at multiple sites
  - Target high concentrations of photopigments

Phase 2 study areas – all samples



Salient results

- Green algae and cyanobacteria detected in all sampled reservoirs in Phases 1 and 2
  - Green algae: 41 and 37 different genera
  - Cyanobacteria: 27 and 43 different species
- Golden algae detected in up to 69% of reservoirs
- T&O compounds detected in most reservoirs
- One cyanoHAB observed during Phase 1

Phase 1 – salient correlations

Variable 1	Variable 2	Spearman's rank correlation coefficient (r_s)	*p* value
Sensor-measured chlorophyll	Laboratory chlorophyll-*a*	0.61	0.008
Sensor-measured chlorophyll	Laboratory pheophytin-*a*	0.60	0.008
Sensor-measured chlorophyll	Total phytoplankton biovolume	0.77	< 0.001
Sensor-measured chlorophyll	Total phytoplankton abundance	0.92	< 0.001
Sensor-measured chlorophyll	Total Cyanophyta biovolume	0.69	0.001
Sensor-measured chlorophyll	Total Cyanophyta abundance	0.90	< 0.001
Sensor-measured phycocyanin	Laboratory chlorophyll-*a*	0.84	< 0.001
Sensor-measured phycocyanin	Total phytoplankton abundance	0.57	0.014
Sensor-measured phycocyanin	Total Cyanophyta biovolume	0.52	0.028
Sensor-measured phycocyanin	Total Cyanophyta abundance	0.56	0.015
Turbidity	*Pseudanabaena* biovolume	- 0.64	0.004
Turbidity	*Pseudanabaena* abundance	- 0.73	< 0.001

n = 18

Salient results

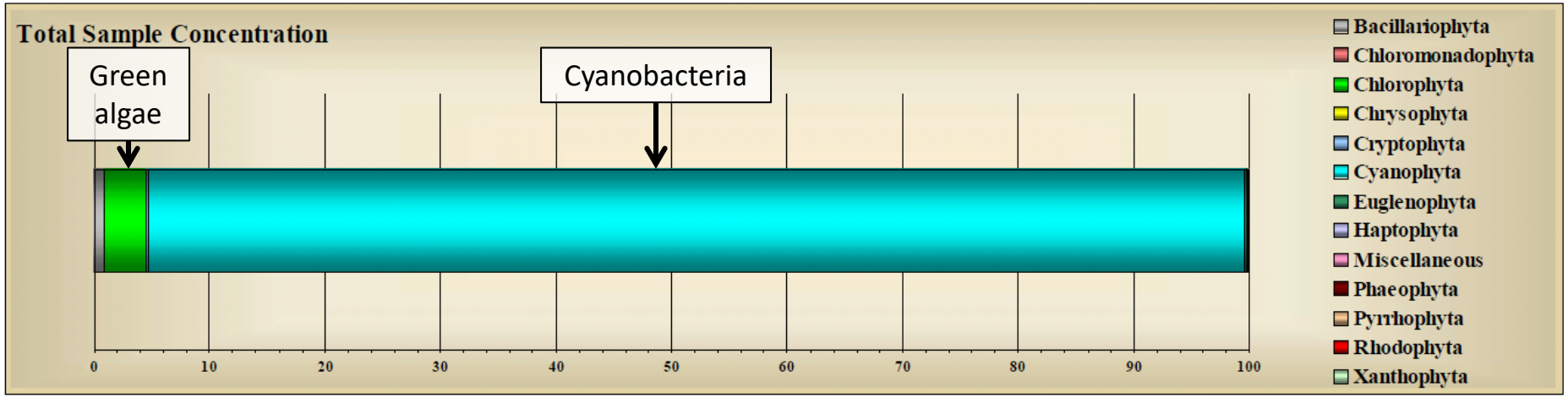
- *Microcystis aeruginosa*
  - Colonial
  - Can produce microcystin and anatoxins
  - Detected in 17% of reservoirs in Phase 1
  - Detected in 31% reservoirs in Phase 2

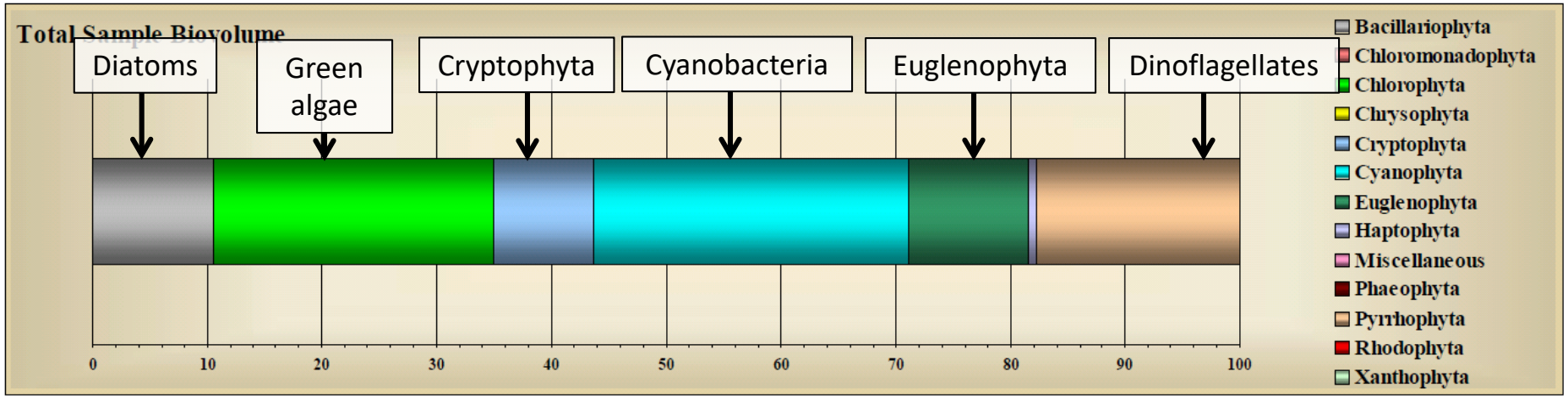
Salient results

- *Cylindrospermopsis raciborskii*
  - Filamentous
  - Can produce cylindrospermopsin, anatoxin-*a*, and saxitoxin
  - Detected in 72% of reservoirs in Phase 1
  - Detected in 100% of reservoirs in Phase 2

Grapevine – 10/05/2016
Phytoplankton data summary

Total Sample Concentration	Total Sample Biovolume
380,744.671	2,552,595.057
NU/ml	µm^3 /ml

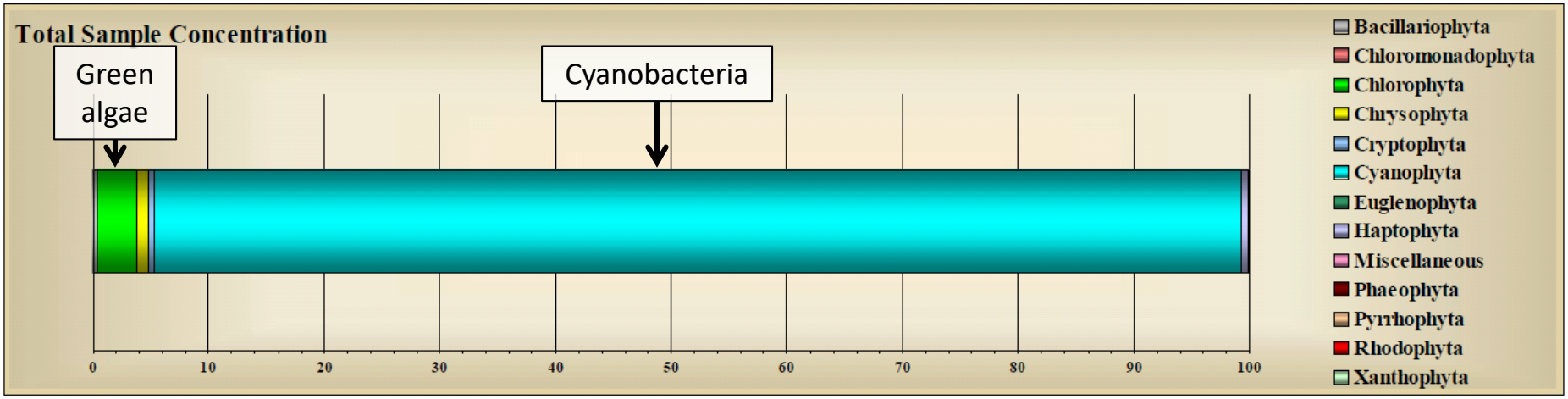


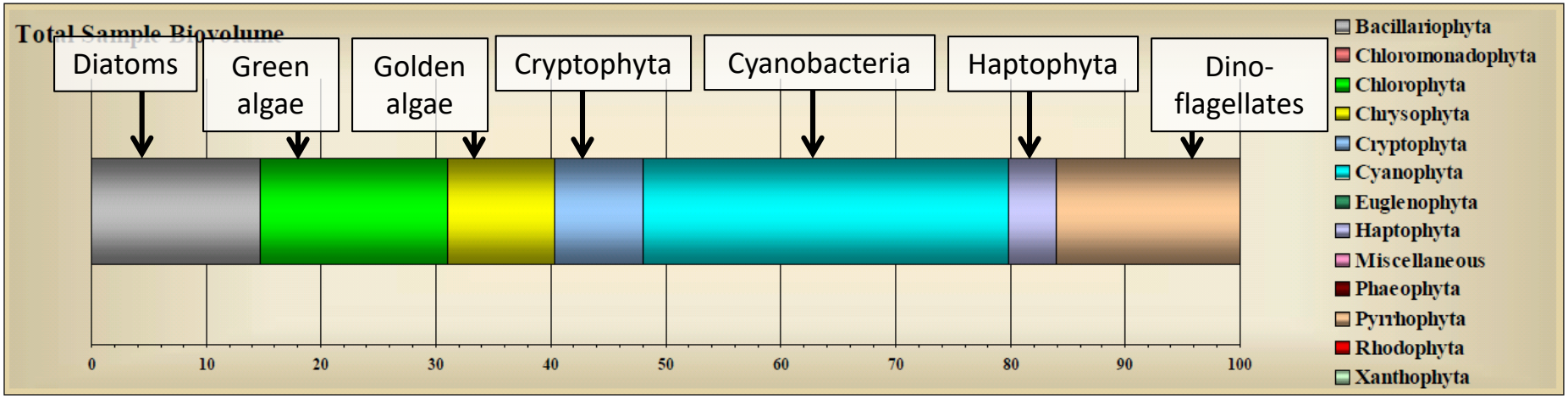


Percent of sample

Kemp – 09/14/2016
Phytoplankton data summary

Total Sample Concentration	Total Sample Biovolume
165,075.459	1,139,929.196
NU/ml	µm^3 /ml

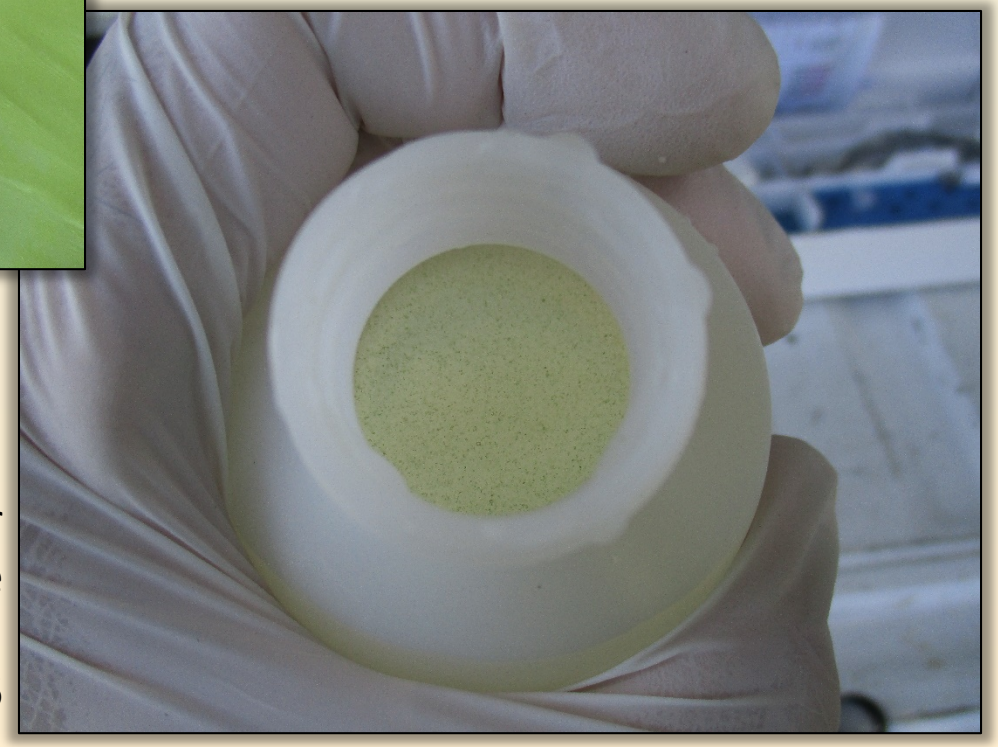




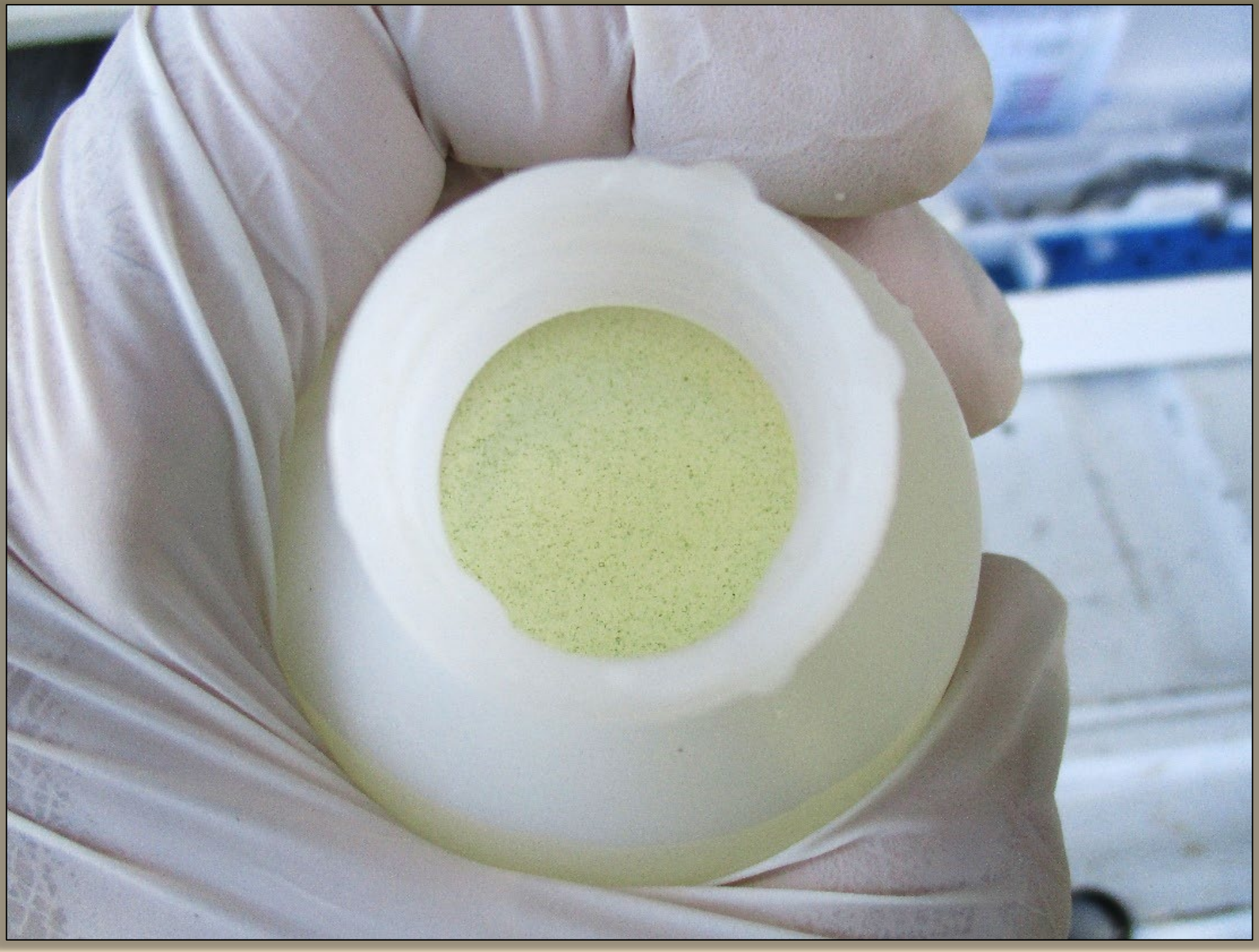
Percent of sample

USGS
science for a changing world

Harmful cyanobacterial bloom (*Microcystis*) at NRCS Upper Bosque River Site No. 4 near Stephenville, TX on 9/7/2016

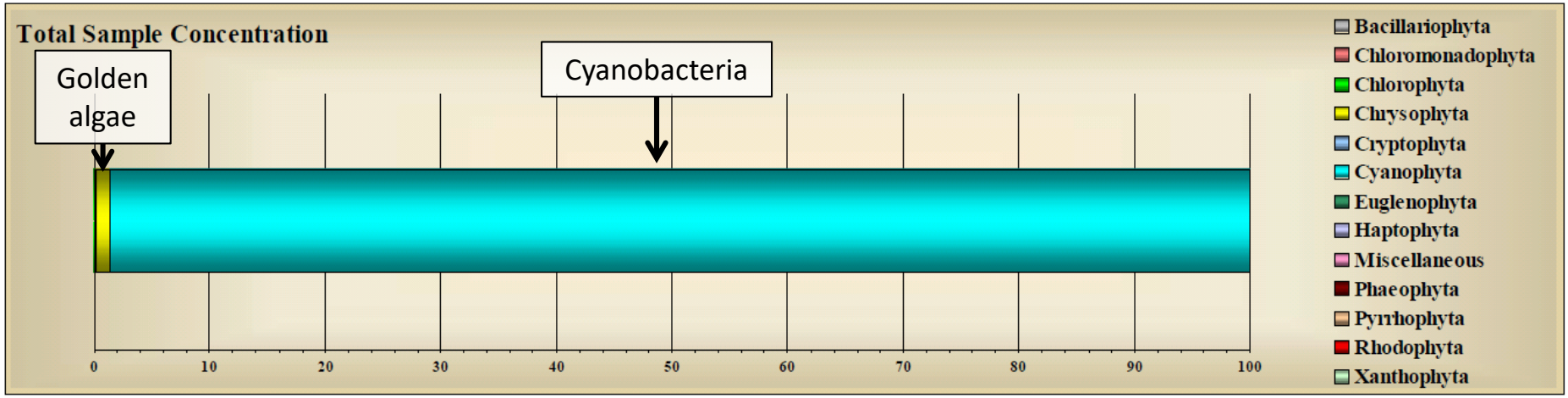


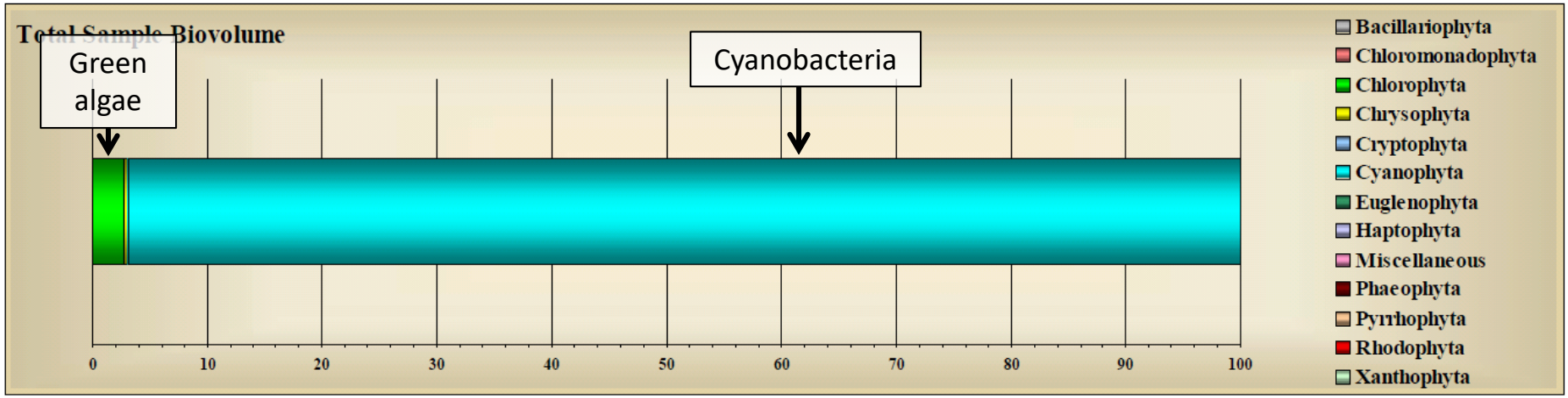
Visible *Microcystis* colonies in a surface-water grab sample collected at NRCS Upper Bosque River Site No. 4 near Stephenville, TX on 9/7/2016



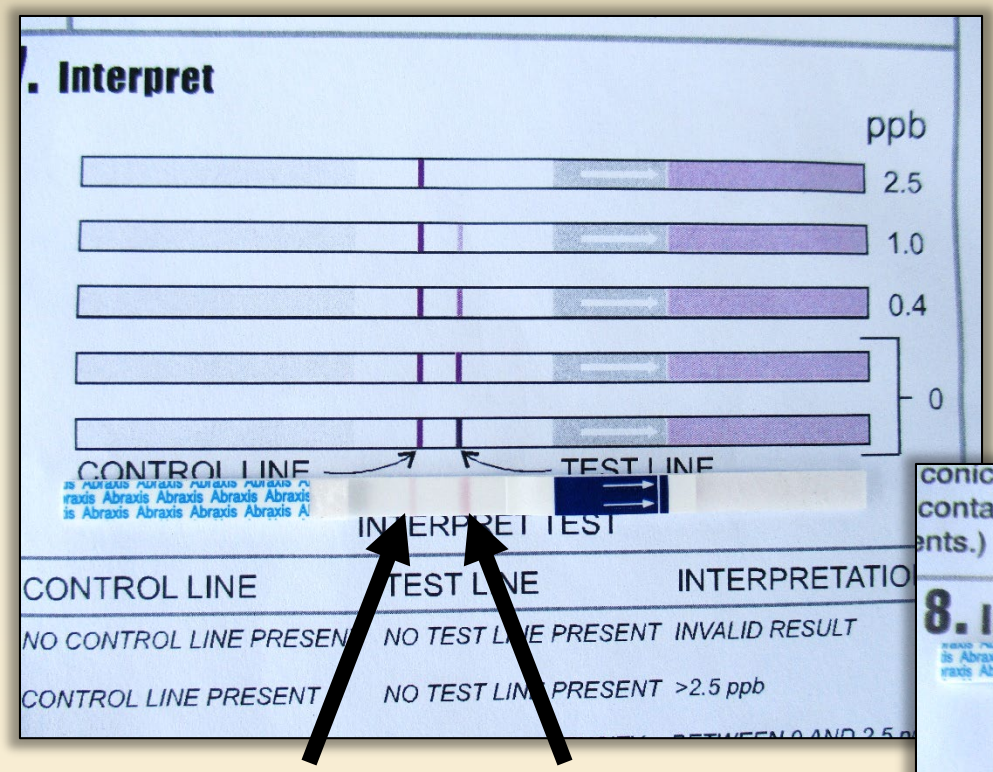
NRCS Upper Bosque River Site – 09/07/2016 Phytoplankton data summary

Total Sample Concentration	Total Sample Biovolume
1,231.054	9,054.356
NU/ml	µm^3 /ml

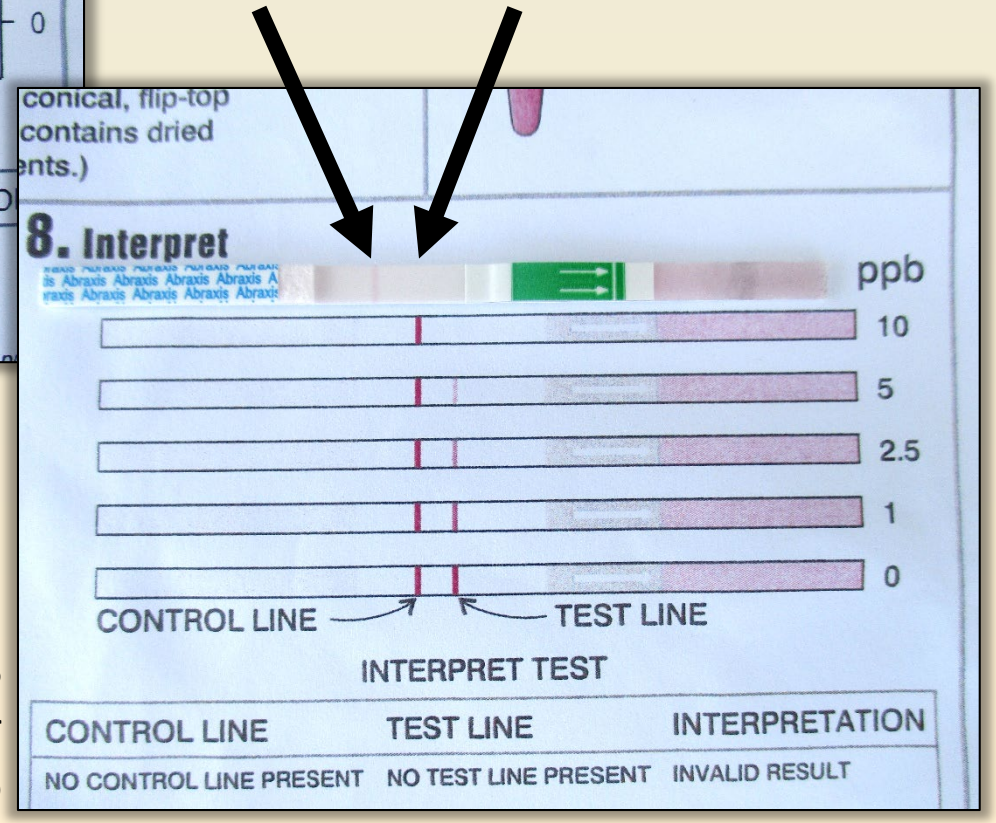




Percent of sample



Negative dipstick kit test result for anatoxin-*a* samples collected at NRCS Upper Bosque River Site No. 4 near Stephenville, TX on 9/7/2016



Positive dipstick kit test result for microcystin (> 10 µg/L) for samples collected at NRCS Upper Bosque River Site No. 4 near Stephenville, TX on 9/7/2016

Phase 1 – total cyanotoxins ELISA

Study area	Microcystin [1]	Saxitoxin [1]	Cylindrospermopsin [1]
NRCS Upper Bosque Reservoir [2]	**21.5**	<0.02	<0.05
Lake Kemp	<0.10	**0.03**	**0.84**
Braunig Lake	**0.19**	<0.02	<0.05
Lake Buchanan	<0.10	<0.02	**0.27**
Millers Creek Reservoir	**0.22**	<0.02	<0.05
Fort Phantom Hill Reservoir	**0.11**	<0.02	<0.05

[1] concentrations in µg/L
[2] mean of two replicates
detections greater than reporting level are in **bold**

Phase 2 – total cyanotoxins ELISA

Study area	Microcystin [1]	Saxitoxin [1]	Cylindrospermopsin [1]
Lake Whitney	<0.10	<0.02	**0.13**
Lake Palestine	**0.18**	<0.02	<0.05
Lake Kemp	<0.10	**0.04**	**0.80**
Lake J. B. Thomas [2]	**0.11**	<0.02	<0.05
Phelps Lake	**0.19**	<0.02	<0.05
Lake Kiowa	**0.17**	<0.02	<0.05
Lake Palo Pinto	**0.10**	<0.02	<0.05
Sheldon Reservoir	**0.11**	<0.02	**0.08**
Braunig Lake [2]	**0.14**	<0.02	<0.05

[1] concentrations in µg/L
[2] mean of two replicates
detections greater than reporting level are in **bold**

Phase 1 – cyanotoxins ELISA vs. LC/MS

Study area	Total microcystin	Total cylindrospermopsin
NRCS Upper Bosque Reservoir	E L	-----
Lake Kemp	-----	E L
Braunig Lake	E	-----
Lake Buchanan	-----	E
Millers Creek Reservoir	E	-----
Fort Phantom Hill Reservoir	E	-----

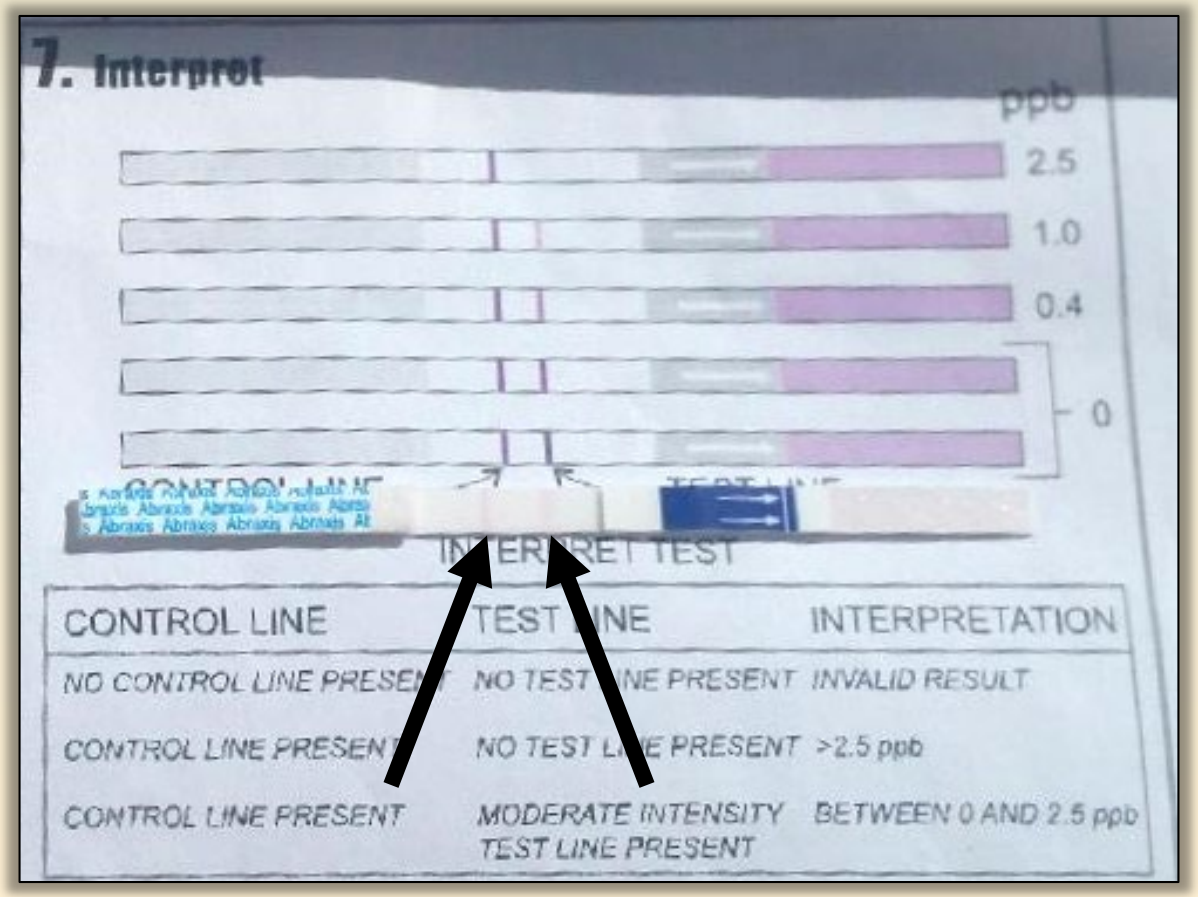
E detection by ELISA
L detection by LC/MS/MS
----- no toxin detected

Phase 2 – cyanotoxins ELISA vs. LC/MS

Study area	Total microcystin	Total saxitoxin	Total cylindrospermopsin
Lake Whitney			E L [1]
Lake Palestine	E		
Lake Kemp		E	E L
Lake J. B. Thomas	E		
Phelps Lake	E L		
Lake Kiowa	E		
Lake Palo Pinto	E		
Sheldon Reservoir	E		E
Braunig Lake	E		

E detection by ELISA
L detection by LC/MS/MS
[1] greater than detection level but less than reporting level
----- no toxin detected

Phase 2 – dipstick kit results



Weak positive result for anatoxin-*a* by rapid assessment dipstick kit for a sample collected at Pay Mayse Lake on August 29, 2018

Phase 2 – genetics

Study area	Anatoxin	Microcystin	Saxitoxin	Cylindrospermopsin
Lake Whitney		4,900		**16,000**
Lake Palestine	2,400	**23,000**		
Lake Kemp				**390,000**
Millers Creek Res			21,000	
Lake J. B. Thomas [2]			40,500	
Phelps Lake		**140,000**		
Lake Texoma		25,000		1,500
Pat Mayse Lake	7,100			
Sheldon Reservoir			2,400	
Braunig Lake [2]		**150,000**		

[1] values in copies/100 mL
[2] mean of two replicates
only detections greater than reporting level are listed
toxins detected also by ELISA or LC/MS are in **bold**

Phase 3 – deliverables

- QAPP
- Method Comparison document for Phase 2 data
- Data set: All non-taxonomy data in NWIS
- Data Release through ScienceBase: All data
- Summary of Findings document
- Journal article?

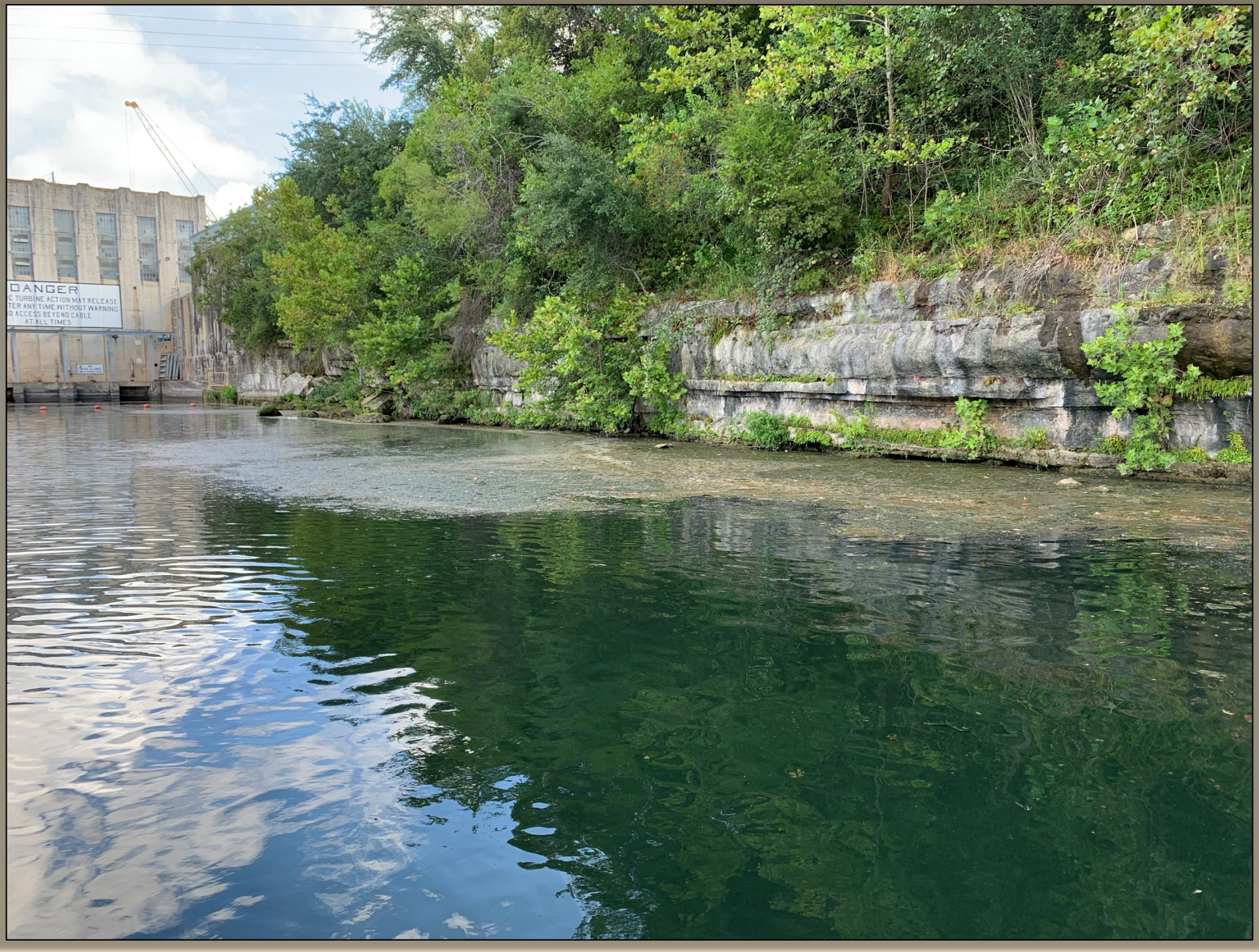
Satellite Remote Sensing Study

Objectives

- Develop regional/statewide HABs and cyanoHABs detection algorithms
  - Field data
  - Satellite imagery
- Create web-mapping app depicting near-real time chlorophyll and cyanobacterial conditions

Methods

- Field work
  - Coincides with satellite passovers
  - Collect spectroradiometric, WQ, and phyto data
- Remote sensing
  - Satellite image retrieval and processing
    - Google Earth Engine and Python
    - Atmospheric corrections
  - Remote sensing algorithms
- Link field data with remotely sensed data


DANGER
C TURBINE ACTION MAY RELEASE
TER ANY TIME WITHOUT WARNING
O ACCESS BEYOND CABLE
AT ALL TIMES

*** WE NEED YOUR HELP ***

- If you observe a potential HAB or cyanoHAB, please notify
  - Christopher Churchill or
  - Robin Cypher
- We ask that you provide (as soon as possible)
  - Location (GPS is best)
  - Date
  - Pictures/samples if you can get them

Questions?

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