An aerial photograph of a lake with a white boat on the left and a shoreline with trees and buildings on the right. The water is a deep green color. The boat is a large, white, curved structure, possibly a ferry or a large motorboat, with several windows and a door. The shoreline is lined with green trees and some buildings, including what appears to be a parking lot and a road. The overall scene is a natural, outdoor setting.

A Study of the Proliferation of Golden Brown Algae in Torch Lake

Becky Norris
For the Three Lakes
Association Team

THANKS

Consultants

Rex Lowe, Professor Emeritus, University of Wisconsin and UMBS

Jan Stevenson, Professor, Michigan State University

Pat Kociolek, Professor, University of Colorado at Boulder and UMBS

Tim Veverica, Analytica Chemist, UMBS

Property Owners

Bill and Claudia Penoza

Hayo-Went-Ha

Tom and Deborah Southworth

Duane and Pat Drake

Gary and Lyn Petty

Ed and Sandy Gourley

Hoadley Family

Core TLA Volunteers

Trish Narwold, Dean Branson, Fred Sittel, Art Hoadley, Paul Roush, Becky Norris

And numerous others who have helped through volunteer time, advice, and financial support

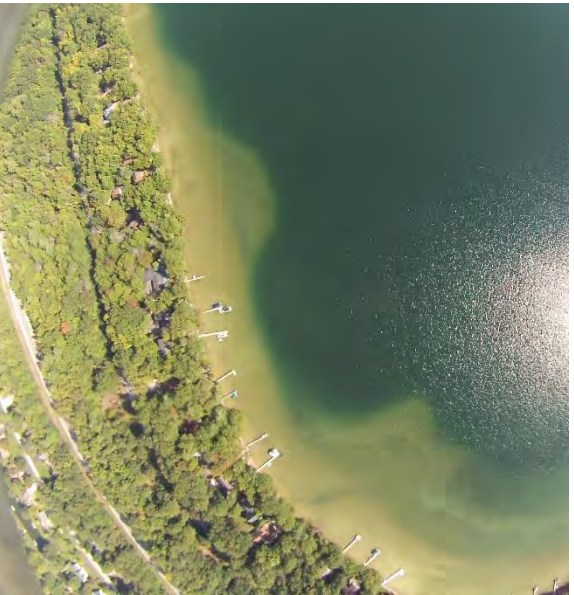




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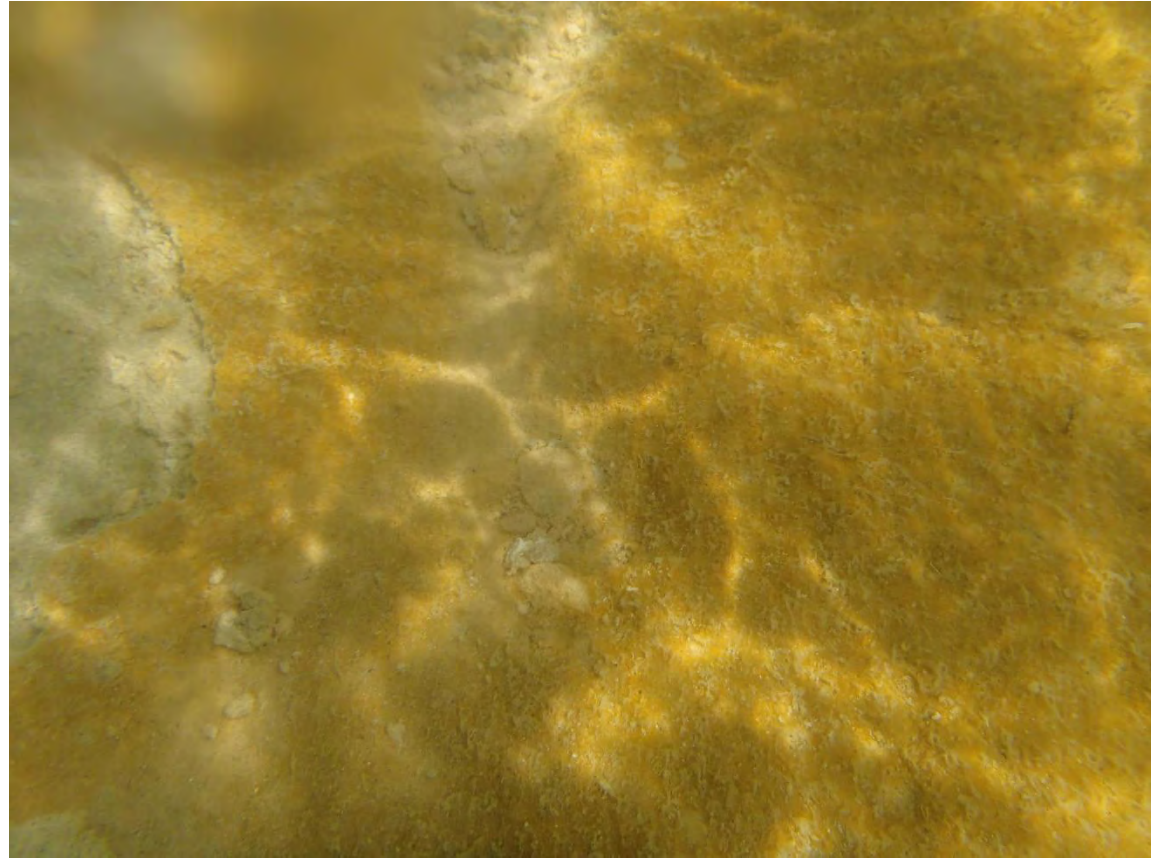
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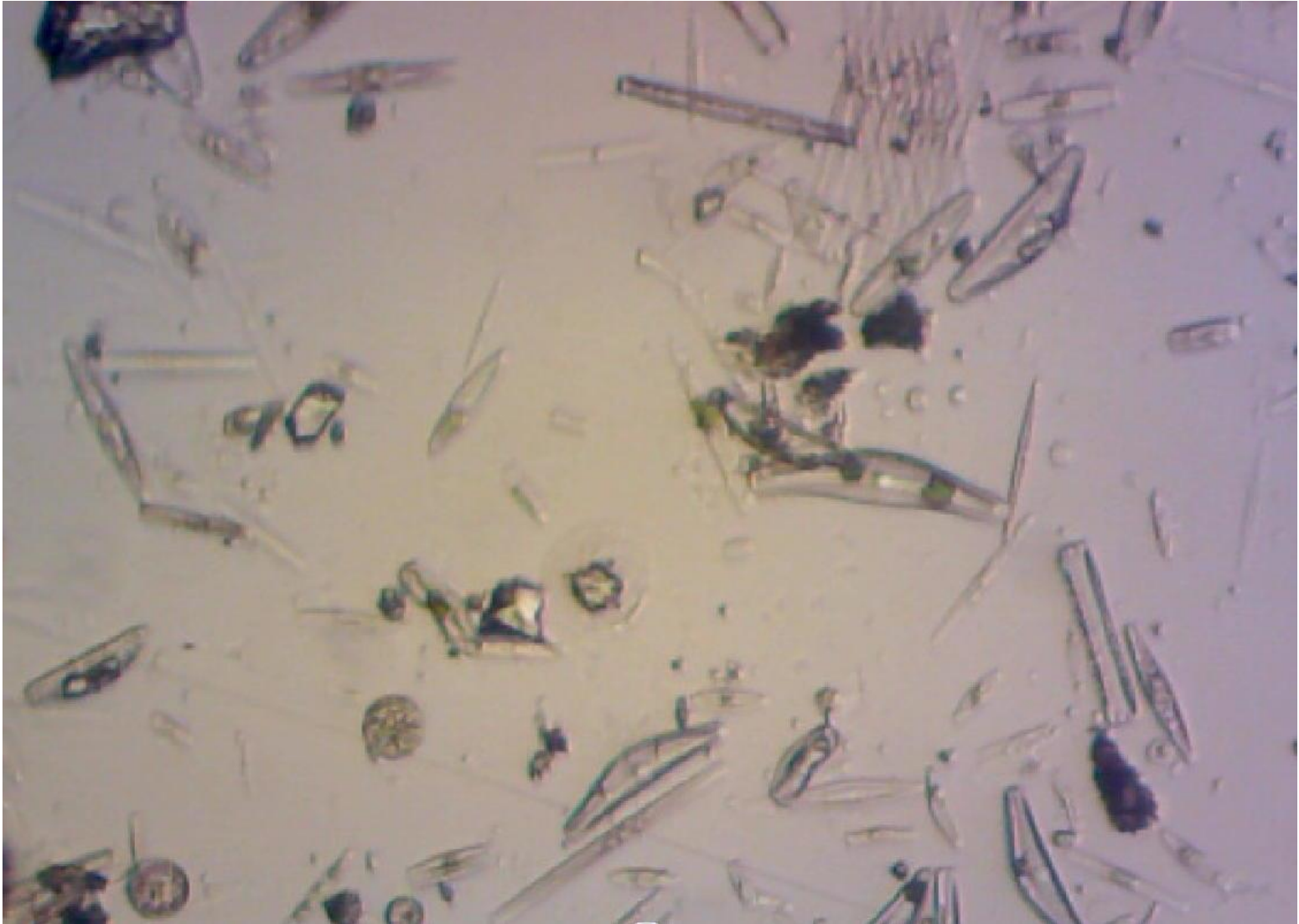
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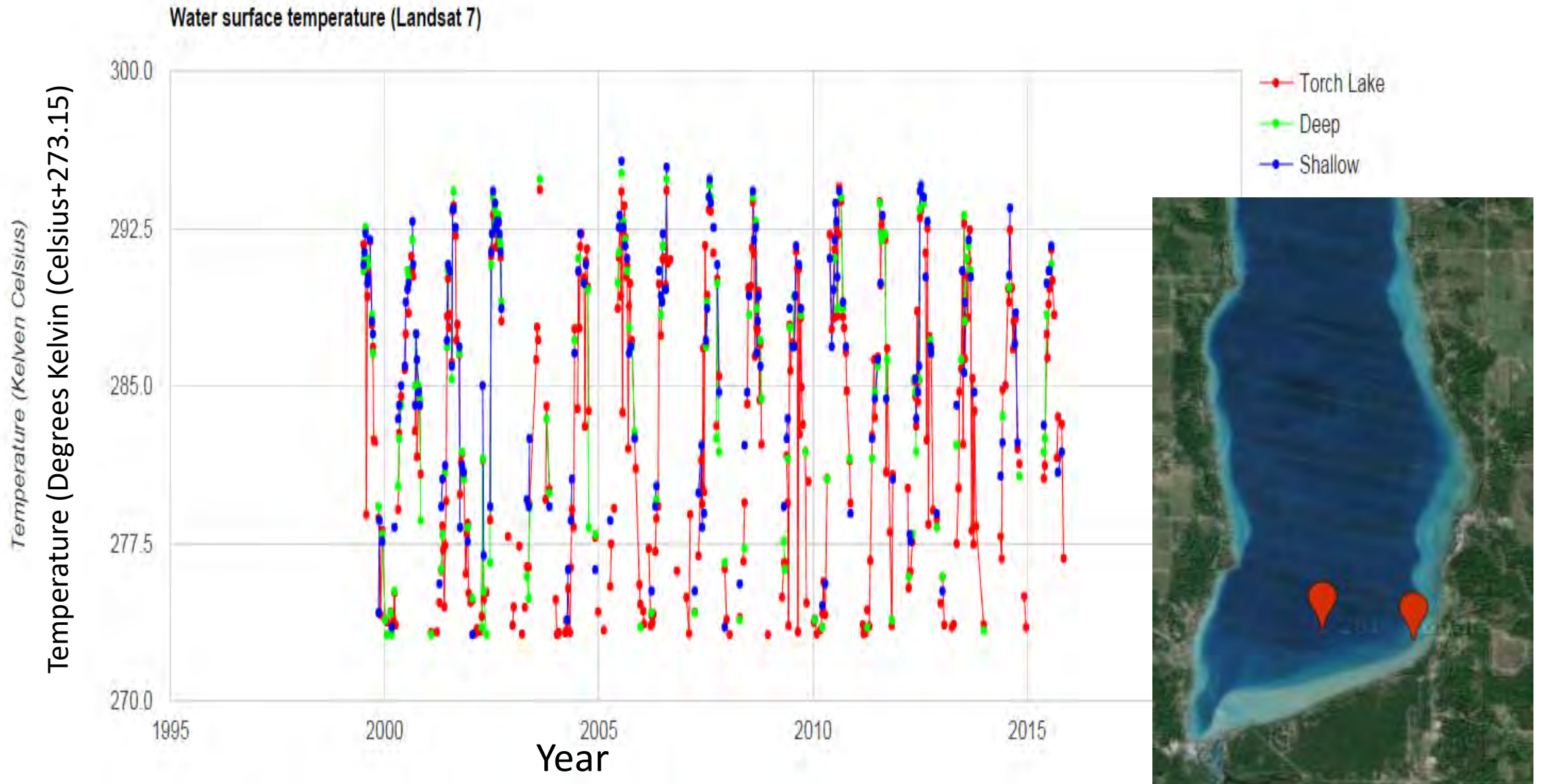
UNDER THE MICROSCOPE



Hypotheses Suggested to Explain the Algae Proliferation

- Zebra Mussels
 - Nutrients from plankton diverted to benthic sediment
- Reduced Population of Grazers
- Increased Nutrient Delivery from Surface Runoff
- Climate Change
 - Warmer water, longer growing season
- Increased Nutrient Delivery through Groundwater

Surface Water Temperature Unchanged



AND THAT BRINGS US TO GROUNDWATER POLLUTION

Having satisfied ourselves that the other most likely candidates to explain the GBA outbreak contribute little at best, we have focused our attention on groundwater.

Study Design

- Nutrient Diffusing Substrate to assess the most likely rate-limiting nutrients
- Benthic Algae Identification to learn what the orange crud is made of
- Comparison of nutrient levels (principally nitrogen and phosphorus) in groundwater and lake water

Study Sites 2015

HWH (Hayo-Went-Ha)

Petty

Gourley

Study Sites 2016

Spencer (HOBO site)

HWH

Petty

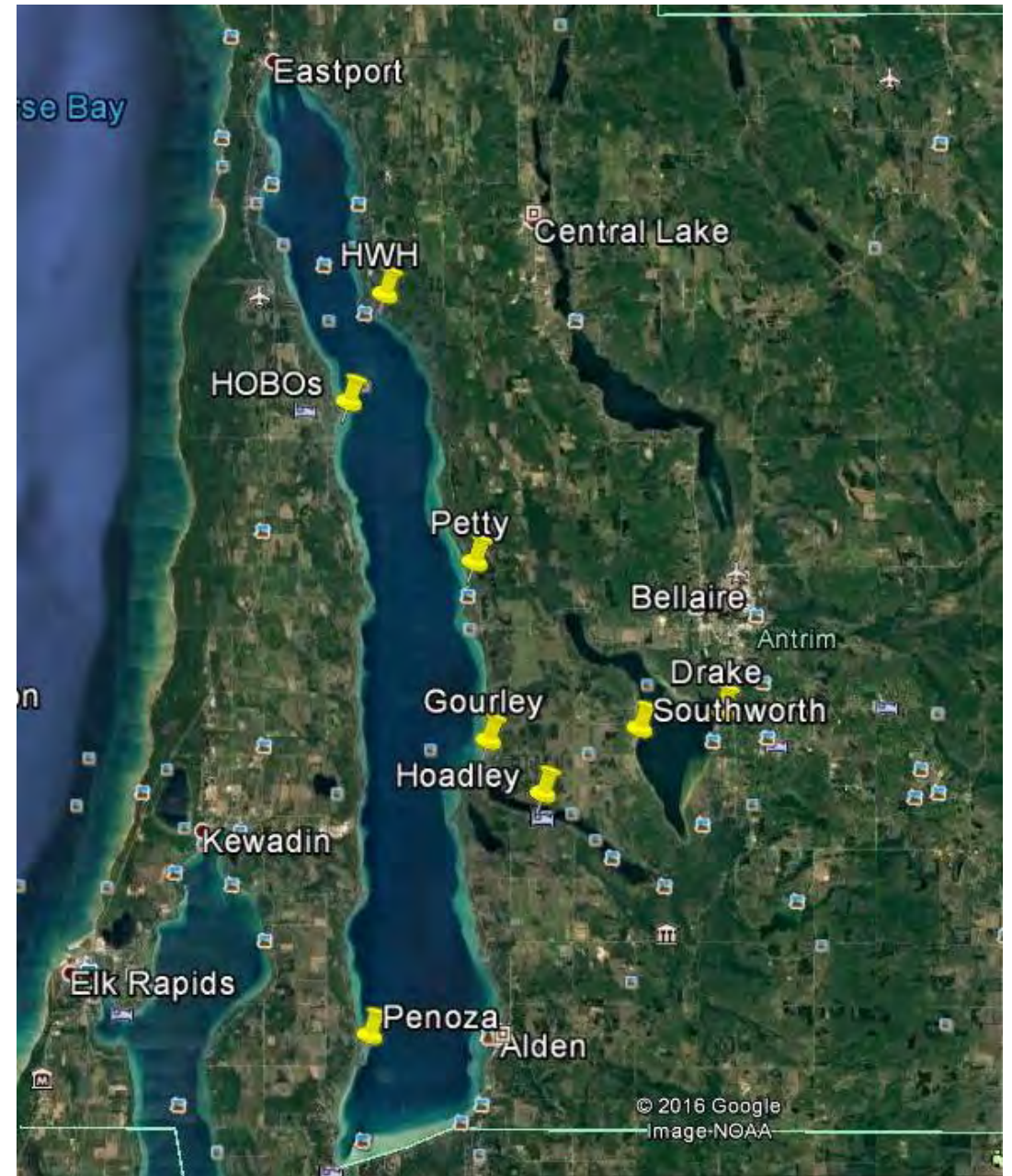
Gourley

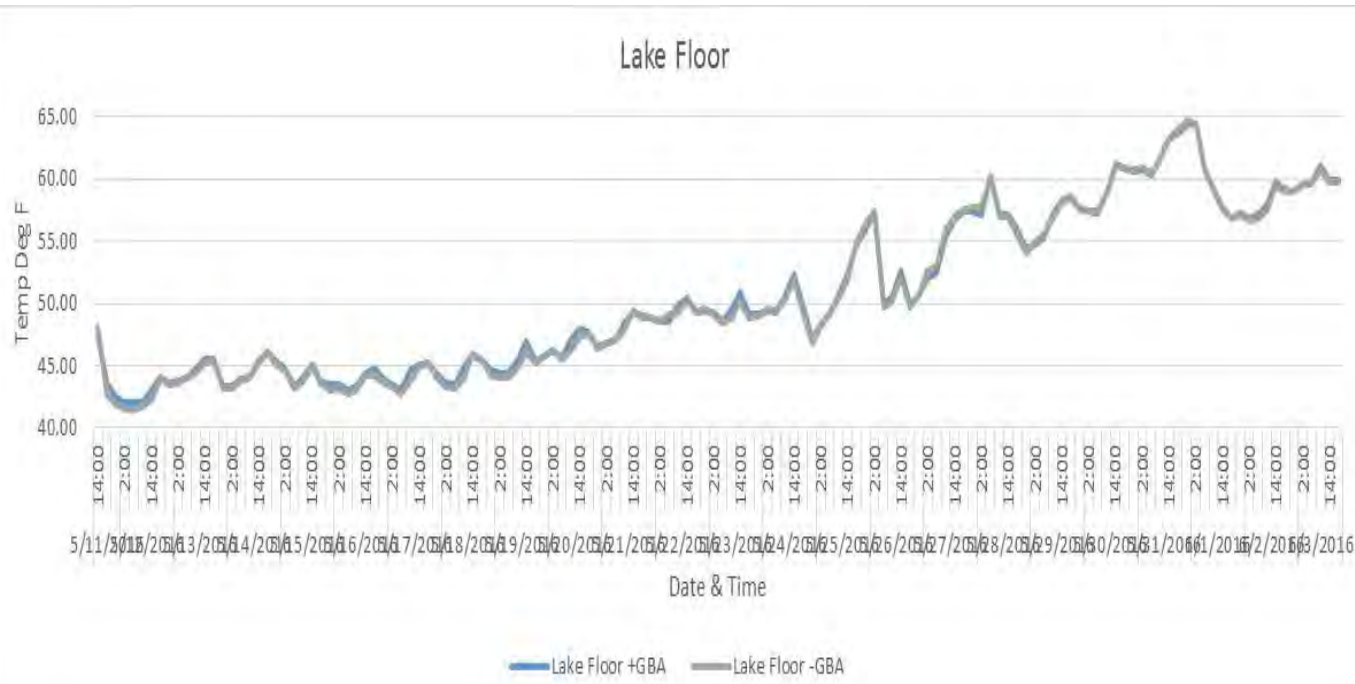
Penoza

Hoadley

Southworth

Drake

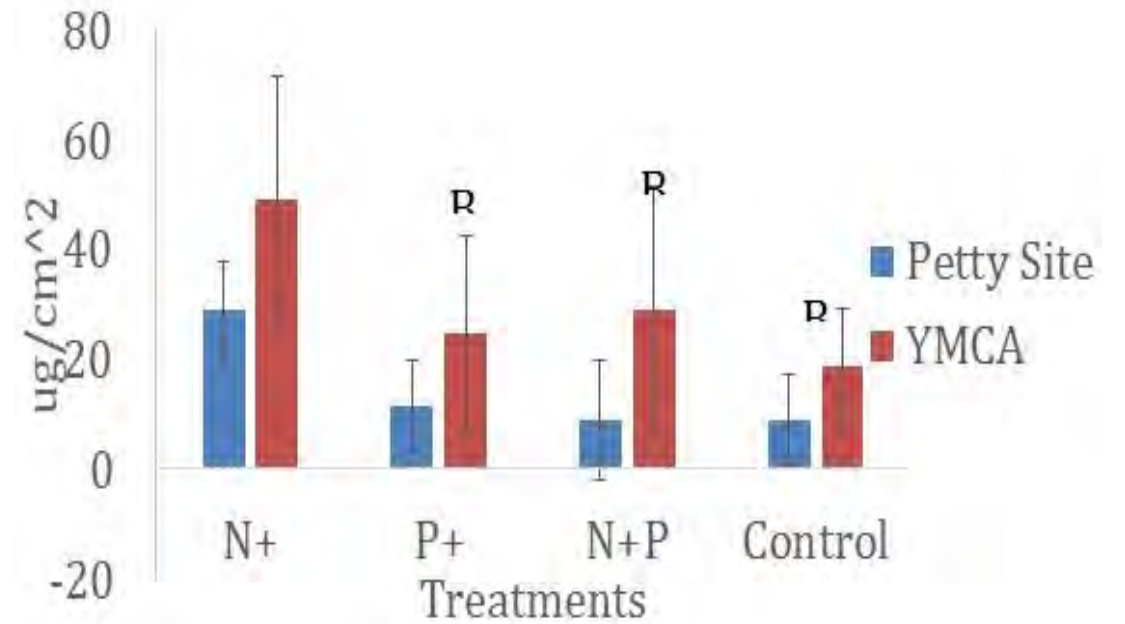




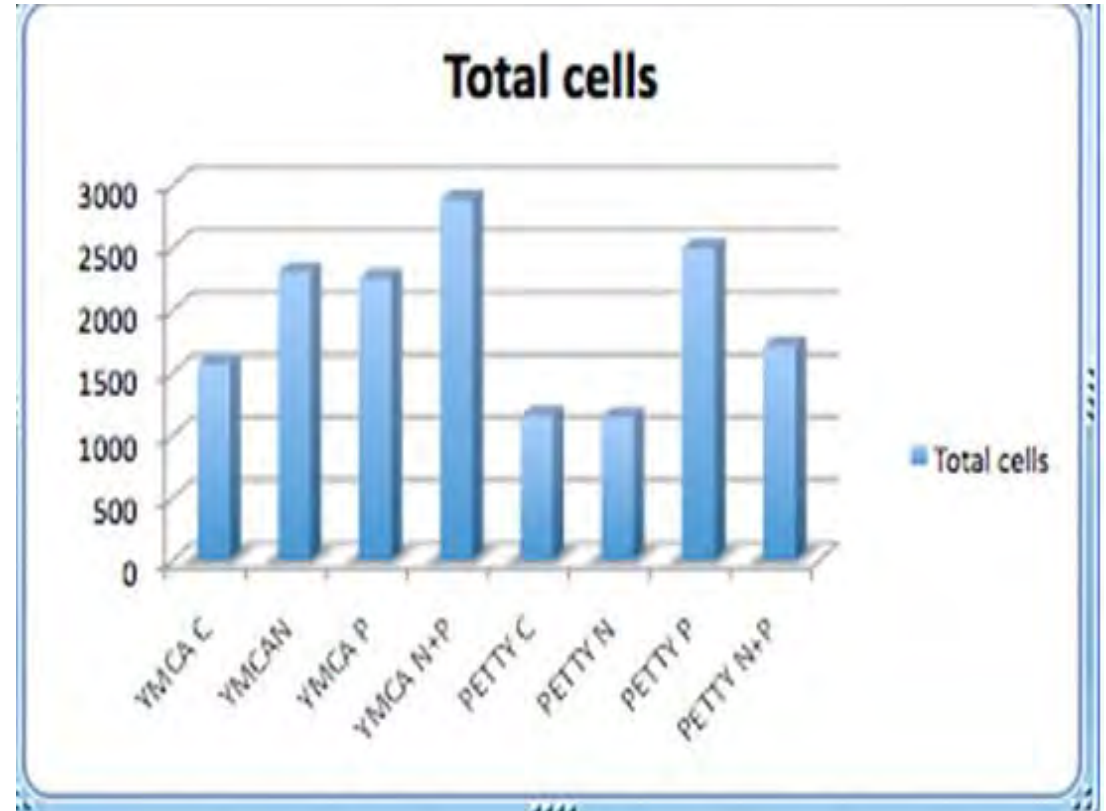
GBA Co-located with higher Groundwater influence

- Lake and subsurface temps increase in late spring.
- Subsurface slightly colder than Lake Floor temps indicating Groundwater influence.
- Subsurface with GBA slightly colder than Subsurface minus GBA.

NUTRIENT DIFFUSING SUBSTRATE 2015 EXPERIMENT

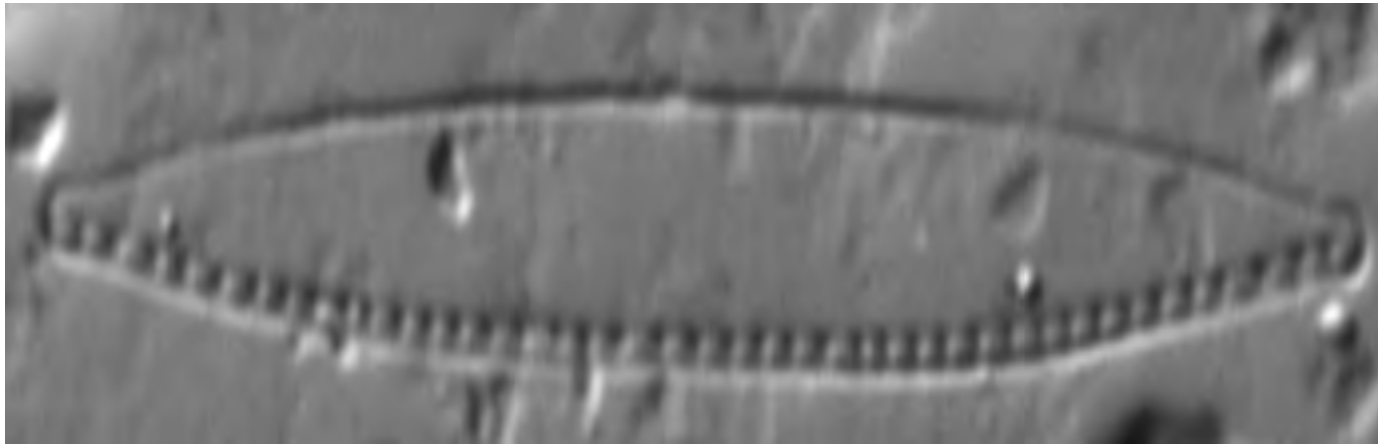


NUTRIENT DIFFUSING SUBSTRATE 2016 EXPERIMENT



NDS FINDING BY DR. LOWE

The genus *Nitzschia* responded strongly to phosphorus addition. This diatom genus is a strong indicator of point-source phosphorus loading and can be used as a strong indicator of areas of phosphorus loading in Torch Lake.



PREPARING SHALLOW GROUNDWATER WELLS

Assembly



Small Piezometer Point and Screen

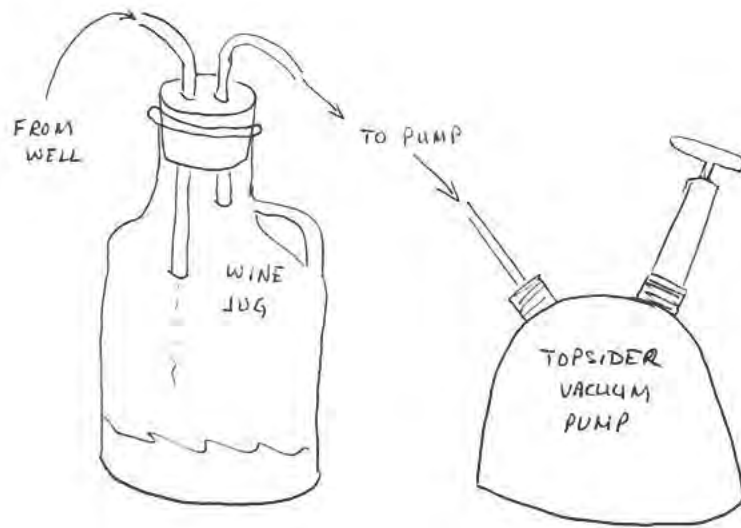


INSTALLING SHALLOW GROUNDWATER WELLS

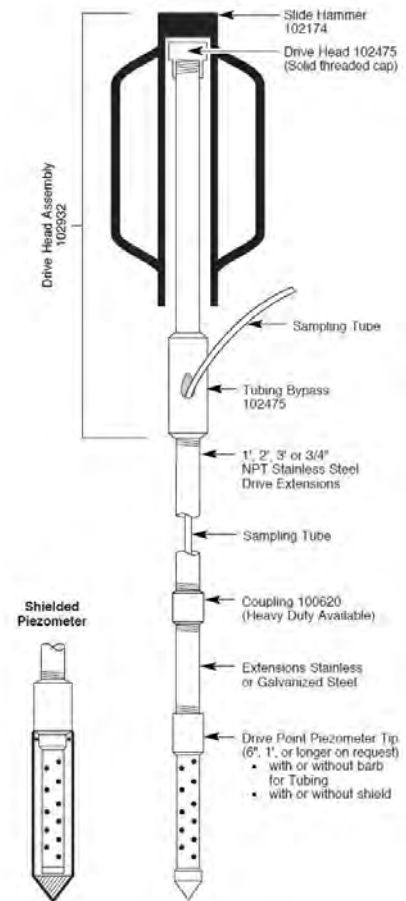


- Dean and Trish hold the piezometer insertion pipe
- Paul on the ladder pounds the rig into the lake floor.

COLLECTING GROUNDWATER



MORE EQUIPMENT



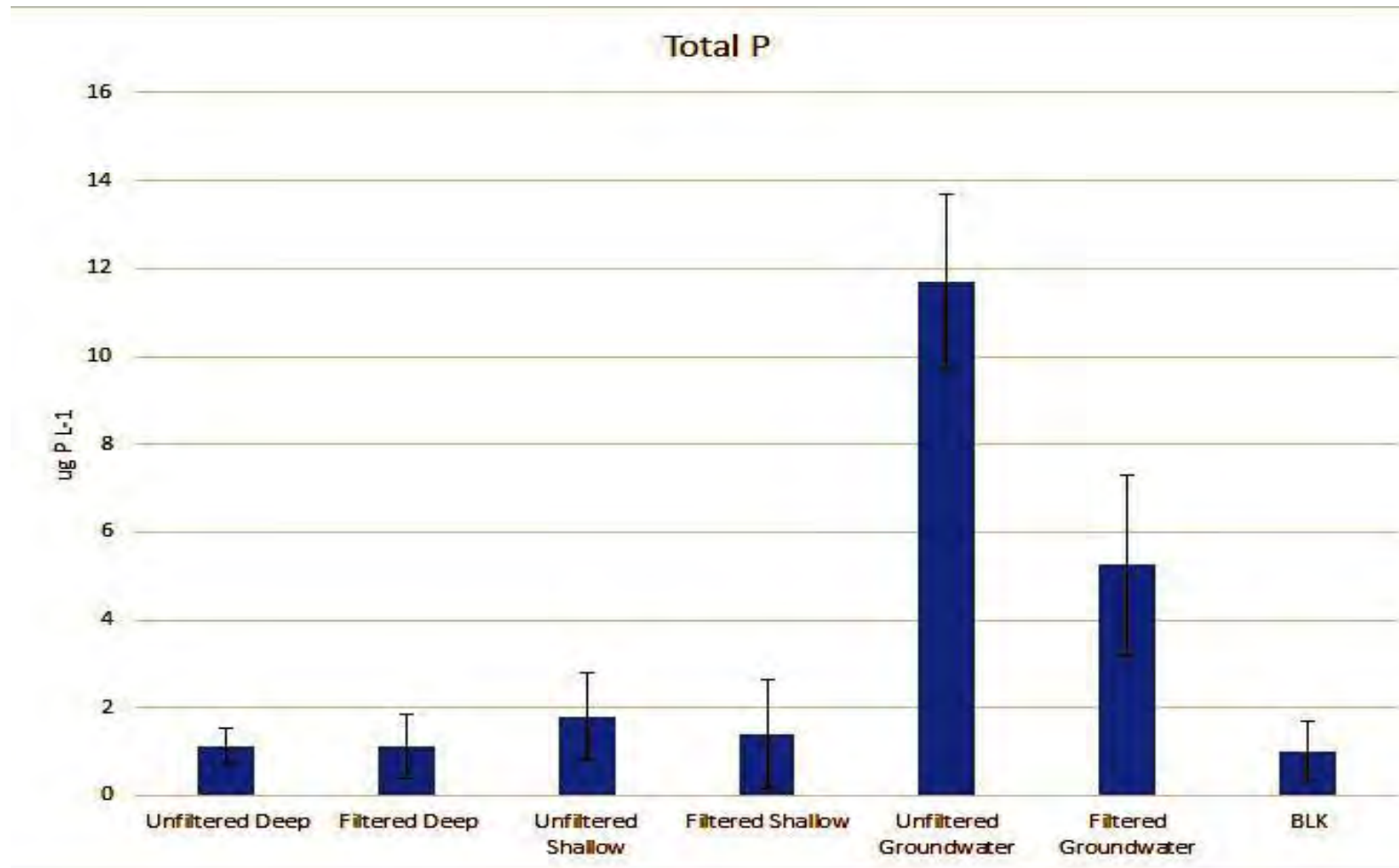
USING THE SOLINST PIEZOMETER



GROUNDWATER PHOSPHORUS

- From a 2005 TLA study of Torch Lake: 21.6 ppb (range 1.6 – 72).
- In 2015 study: 33.8 ppb (range 2.5 – 209.9).
- These samples were unfiltered and could have contained non-bioavailable phosphorus.
- Study in 2016 included filtering the main study samples and a small study to assess the impact of filtering on the phosphorus levels detected.

EFFECTS OF SAMPLE SOURCE AND FILTRATION



2016 STUDY ELEMENTS

Four monthly sampling events at 7 sites:

- Algae samples from the benthic floor and 3-4 inches below grade
- Nitrogen and phosphorus levels from
 - Household well water (deep groundwater)
 - Lake floor piezometers (shallow groundwater)
 - Lake water
 - Benthic sediment moisture
- Human-associated elements (caffeine, boron) in shallow groundwater
- Aerial and ground level photography to document GBA appearance over time

PROGRESSION OF VISIBLE GBA



June



July

PROGRESSION OF VISIBLE GBA



August



September

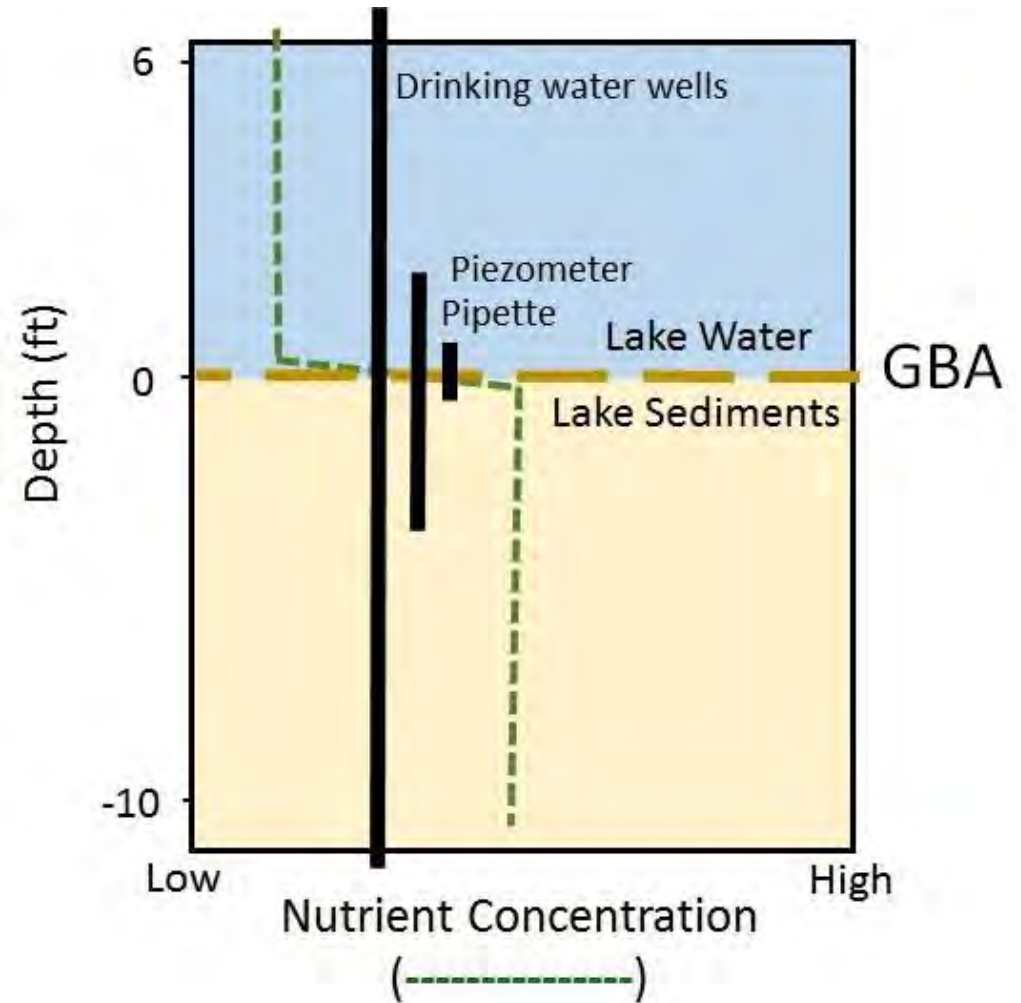
2016 DATA

- Algae: in analysis, no results currently available
- Human-source:
 - Boron levels unremarkable
 - Caffeine in analysis, no results currently available

2016 EXPECTATION

Water samples for nutrient analysis were collected monthly:

- Deep groundwater (household wells)
- Shallow groundwater (piezometers)
- Lake water
- Benthic sediment



2016 PHOSPHORUS DATA (MEDIAN VALUES)

	ppb
• Lake Water	4.2
• Household well water	7.5
• Piezometer water	5.5
• Benthic sediment	7.4

These results are somewhat surprising as we expected shallow groundwater to contain higher levels than the deeper drinking wells.

2016 NITROGEN (NO₂, NO₃, NH₄) DATA (MEDIAN VALUES)

	ppm
• Lake Water	0.268
• Household well water	0.079
• Piezometer water	0.149
• Benthic sediment	10.026

These results demonstrate that there is plenty of nitrogen to support algal growth.

CONCLUSIONS (1)

- Phosphorus is the rate-limiting nutrient in Torch Lake
- Groundwater and benthic sediment have more phosphorus than lake water
- Benthic sediment contains much more nitrogen than the water samples and is composed largely of ammonia
- Results thus far have not demonstrated a definite link between GBA growth and an identified source of phosphorus

CONCLUSIONS (2)

- Cultural eutrophication (acceleration of natural eutrophication due to human influence) is highly likely to be contributing to the GBA proliferation we are observing
- The one thing I believe we can be sure of is that the increasing GBA proliferation is an early warning sign that, one way or another, too much nutrient is getting into the lake and this will, ultimately, reduce water quality