Photoautotrophic-Periphyton Composition in Reaches with Differing Nutrient Concentrations in the Harpeth River of Middle Tennessee

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  - Lebkuecher et al. 2018. *Castanea* 83(2):288-299.
  - Google: “Harpeth River periphyton.”

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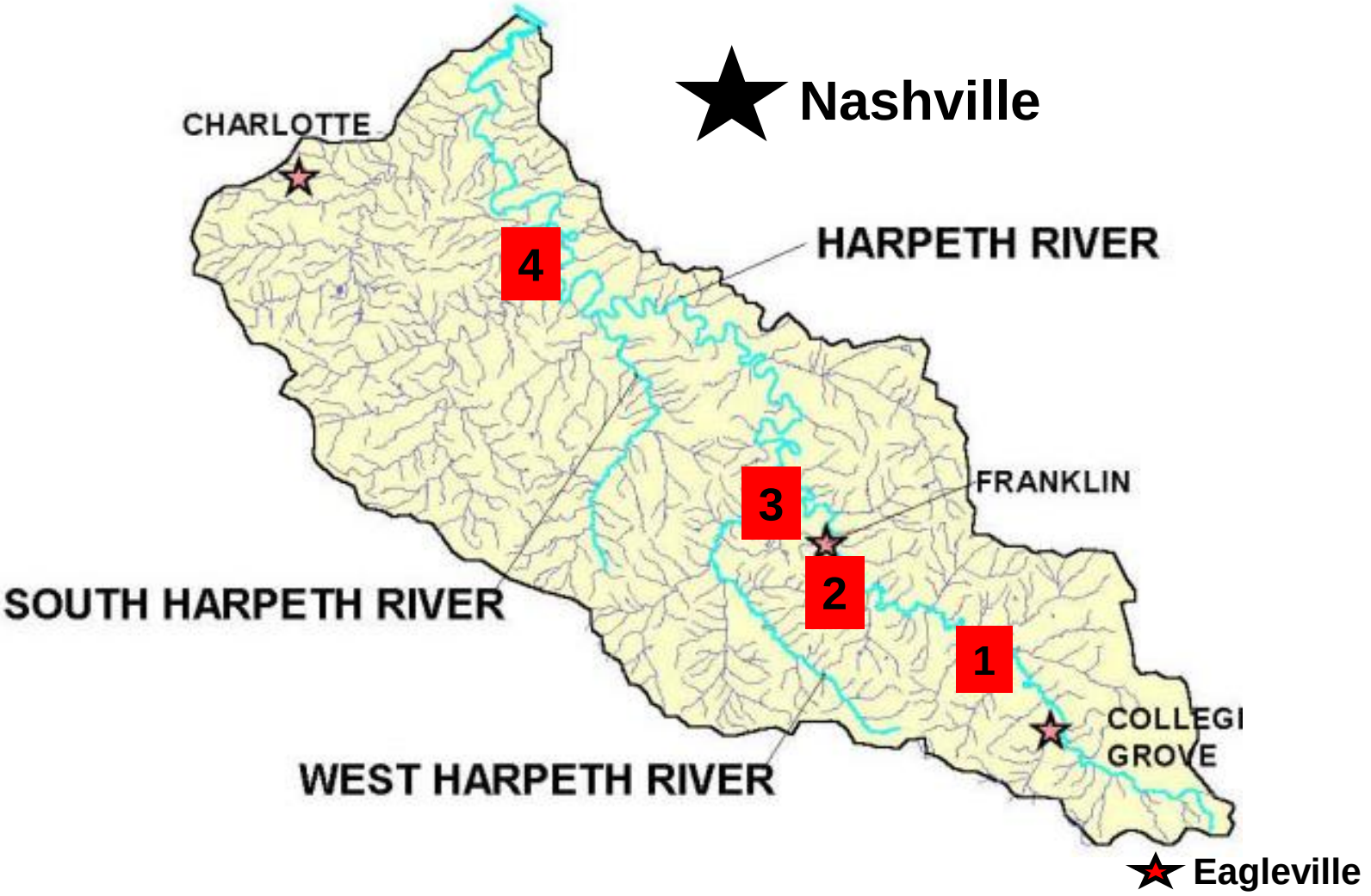
Biology Department, Austin Peay State University, Clarksville, Tennessee 37044

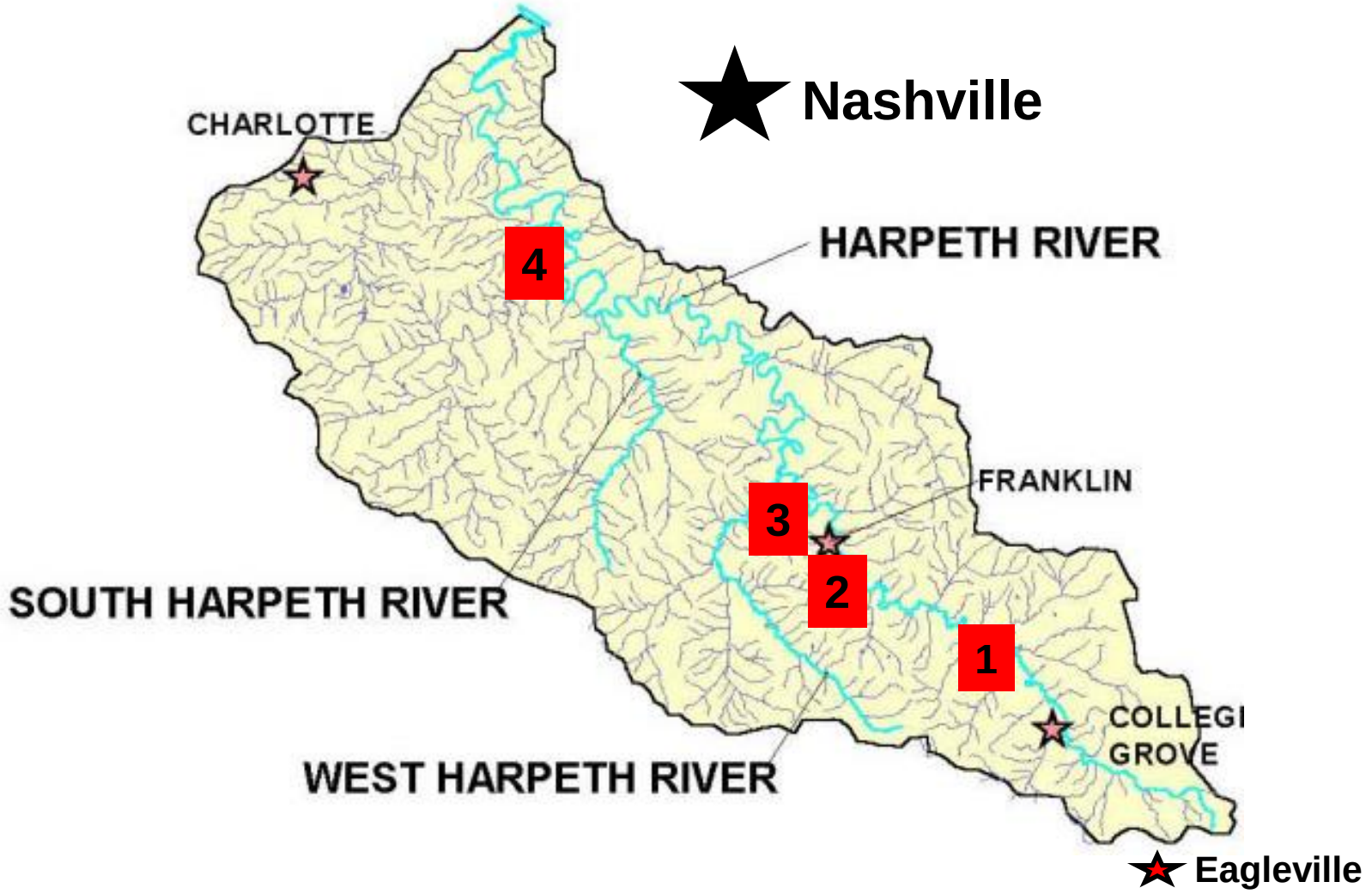
ABSTRACT Four sites of the Harpeth River, two upstream and two downstream of the Franklin Wastewater Treatment Facility in Franklin, Tennessee, were sampled to assess the impact of nutrient enrichment on the integrity of photoautotrophic periphyton. Concentrations of total phosphorus of water samples ranged from 310 $\mu g \cdot L^{-1}$ at the uppermost site to 1035 $\mu g \cdot L^{-1}$ at the site immediately downstream of the wastewater treatment facility. Concentrations of total nitrogen of water samples ranged from 687 $\mu g \cdot L^{-1}$ at the uppermost site to 1,434 $\mu g \cdot L^{-1}$ at the site immediately downstream of the wastewater treatment facility. Concentrations of benthic chlorophyll *a* did not differ significantly among the sites and ranged from 103 ± 11 $mg \cdot m^{-2}$ at the site immediately upstream of the wastewater treatment facility to 151 ± 13 $mg \cdot m^{-2}$ at the site immediately downstream. Percent composition of 186 algae taxa were documented: 92 taxa of soft-bodied algae and 94 taxa of diatoms. Values for the algae trophic index for soft-bodied algal assemblages increased from 71 at the site immediately upstream of the wastewater treatment facility to 107 at the site immediately downstream. Values for the pollution tolerance index for diatom assemblages decreased from 2.55 at the site immediately upstream of the wastewater treatment facility to 2.20 at the site immediately downstream. These index values demonstrate that the assemblages of soft-bodied algae and diatoms immediately downstream the wastewater treatment facility had a greater relative abundance of taxa tolerant of eutrophic conditions compared to the assemblages at the site immediately upstream.
Key words: Algae, chlorophyll *a*, diatoms, Harpeth River, soft-bodied algae, trophic state.

- sampled 4 river sites in on Oct 30, 2017.

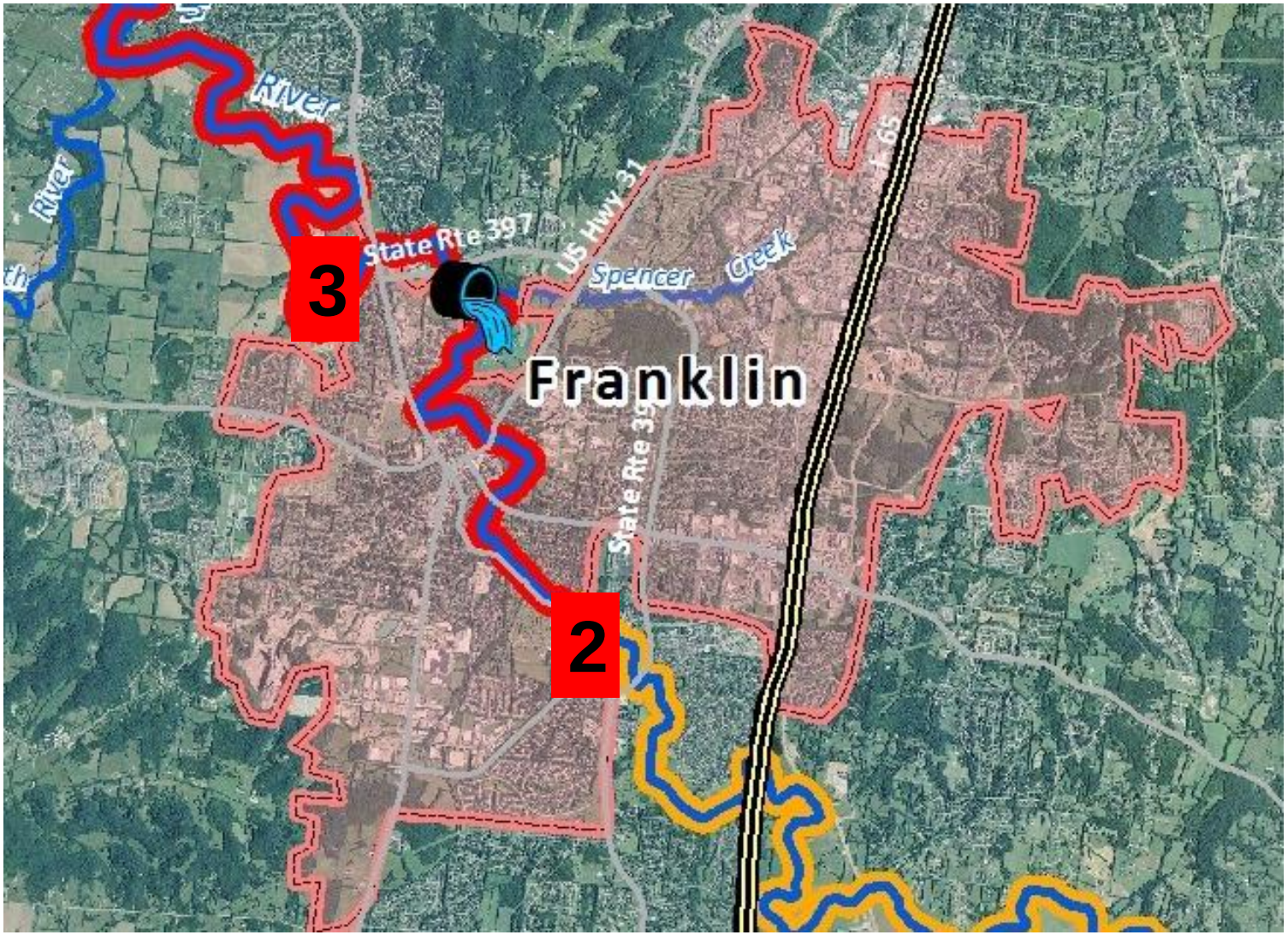


- site 1 is located 12 km east-southeast of Franklin, TN.

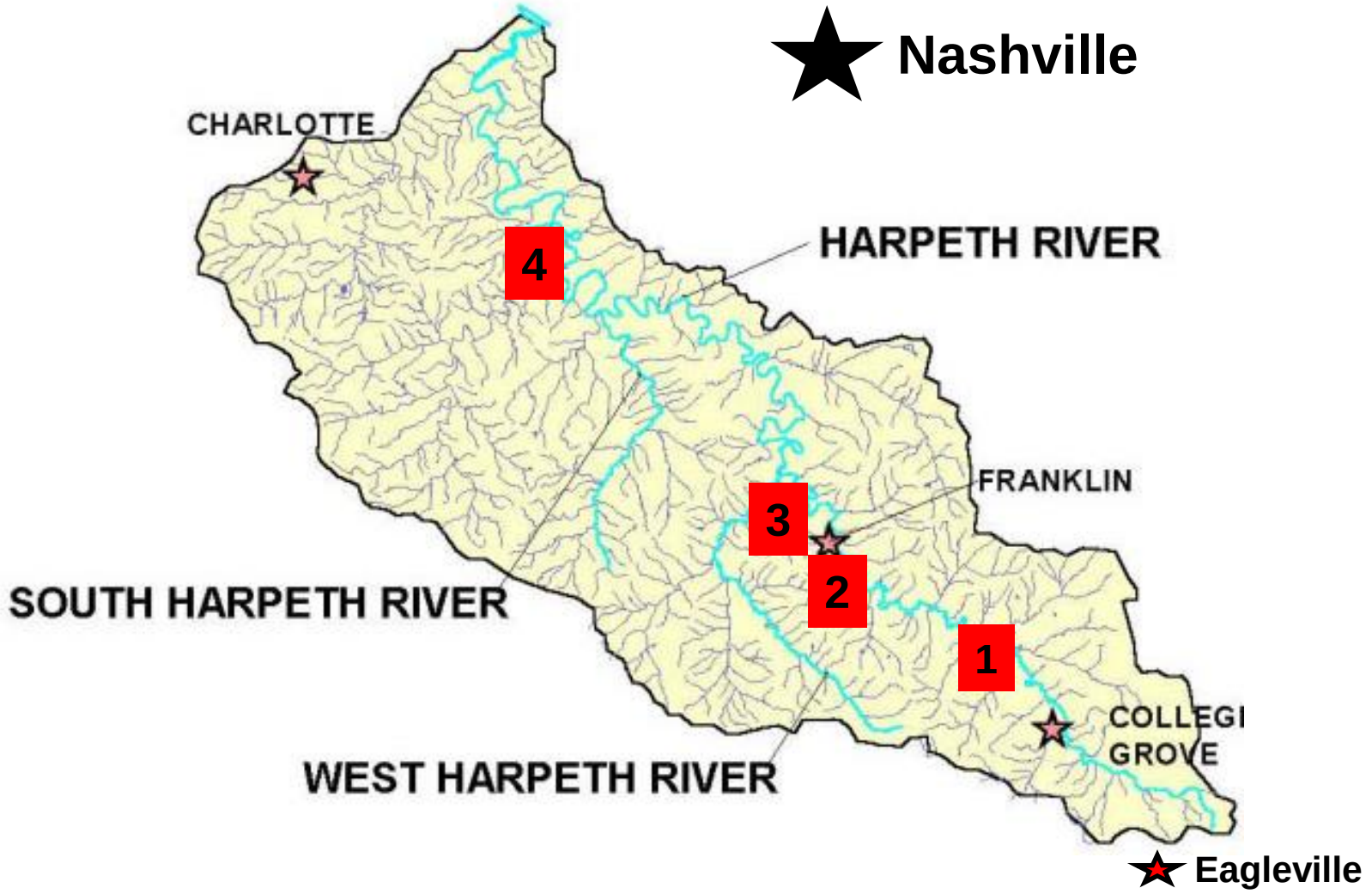
- site 2 is located in southeast Franklin.



- site 3 is located in west Franklin.
    - 5 km downstream the Franklin Wastewater Treatment Facility.



- site 4 is located:
    - 15 km north-northwest of Franklin.



- site 4 is located:
    - 15 km north-northwest of Franklin.
    - 100 m downstream of Hwy 100 bridge at the Harpeth River State Park canoe access point.

[Total phosphorus and total nitrogen]

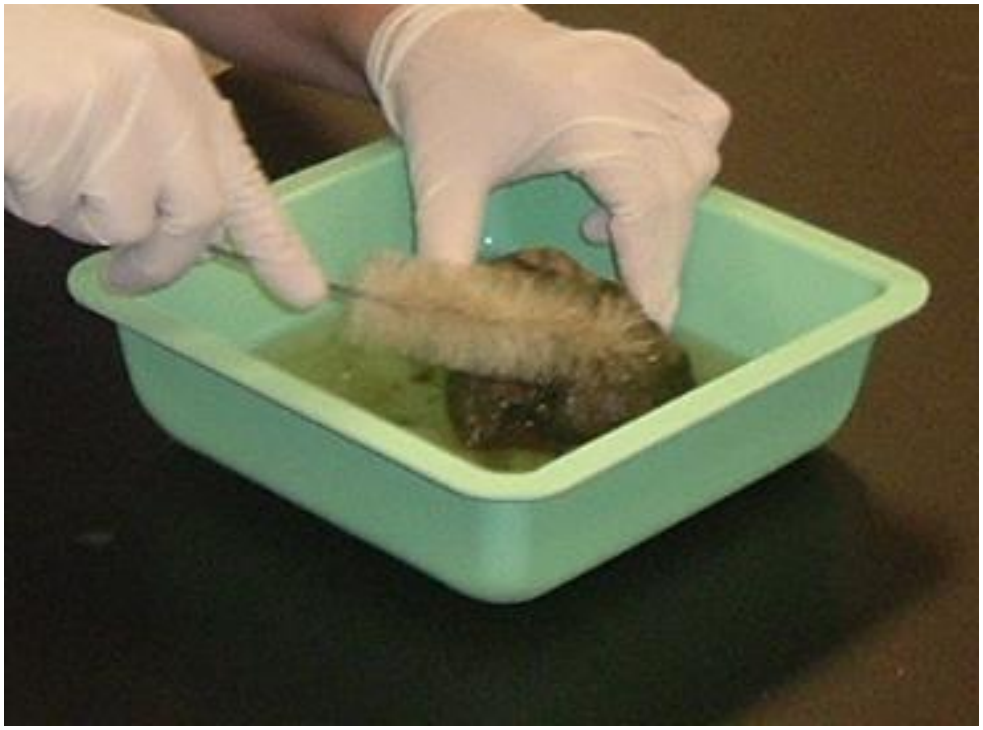
- were determined from water samples collected 5 cm below the surface.
- following standard methods using a LaChat QuickChem 8000 Flow Injection Analyzer (Hancock Biological Station).

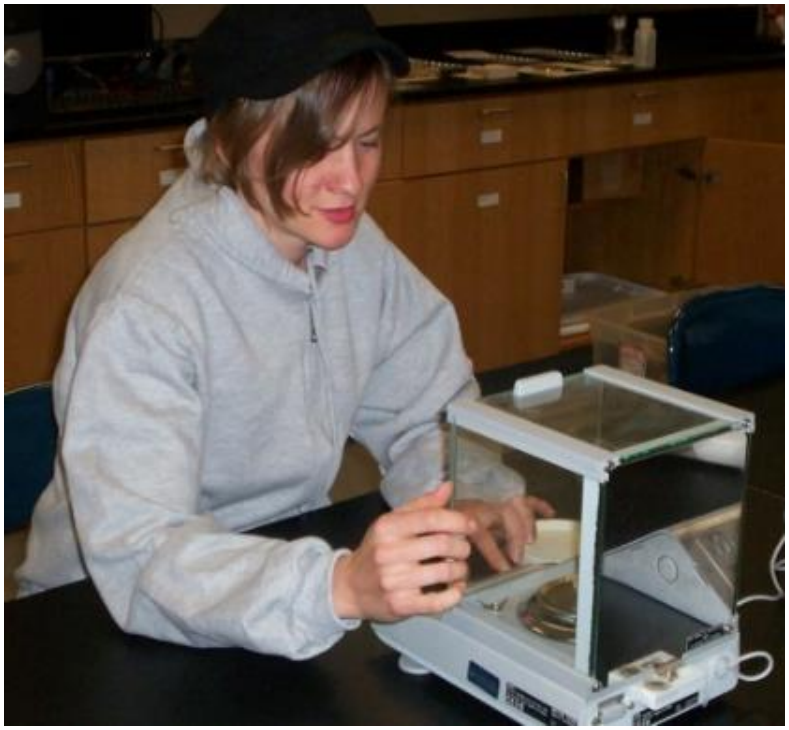
Site 2

Periphyton characteristics

- were determined from cobbles removed from 4 replicate plots (0.25 m^2) established with wire frames placed 1.25 m apart at each site.
- included:

1. AFDM of benthic organic matter.
    - from scraped cobbles (1 cobble/plot).
    - dried at 40^{O} C for 24 hrs and weighed.





1. AFDM of benthic organic matter.
   - from scraped cobbles (1 cobble/plot).
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   - ash wt. subtracted from dry wt. to get AFDW.

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   - ashed at 550^{O} C for 2 hrs.
   - ash wt. subtracted from dry wt. to get AFDW.
   - cobble surface area determined by the wt. of foil covering the cobble relative to known wt. of 1 m^2 of foil.
   - AFDW/m^2 calculated.

2. [chl *a*].
   - periphyton scraped from cobbles (1/ plot) into 90 % acetone and ground with mortar and pestle for 3 min to extract pigments.

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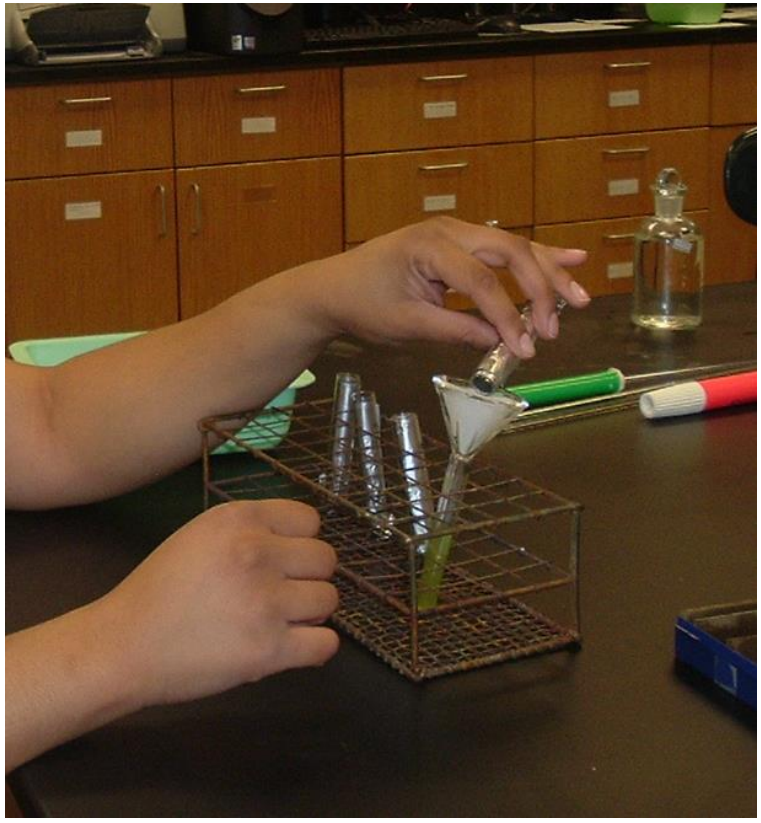
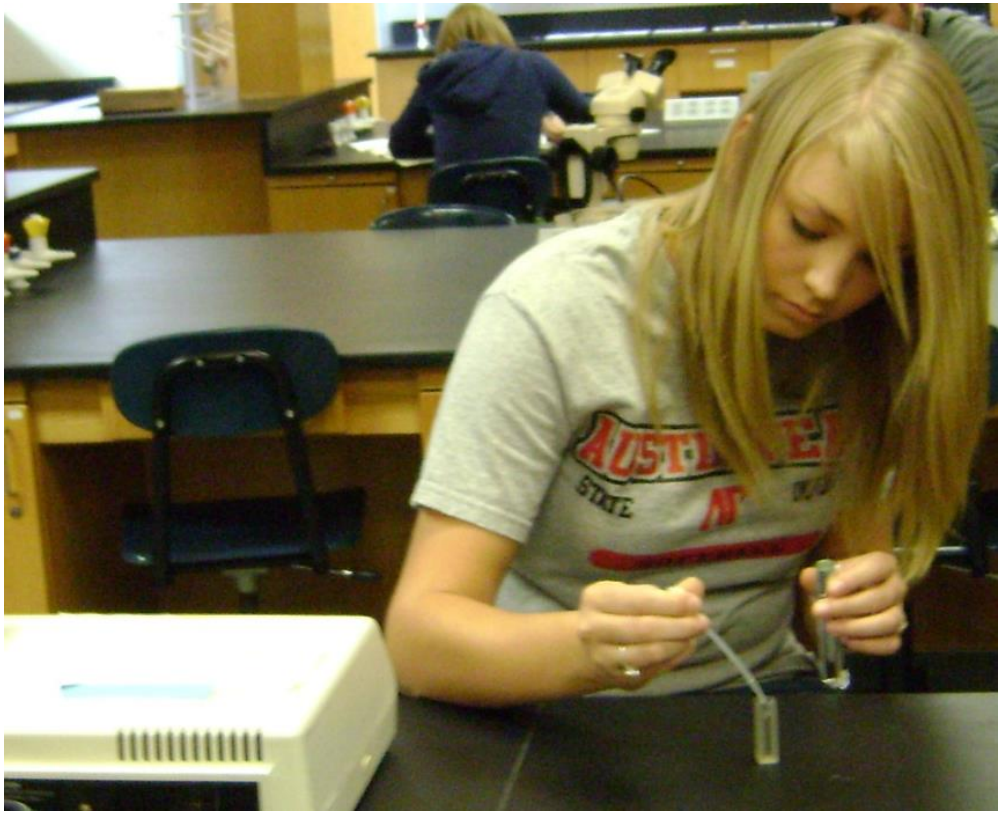
- periphyton scraped from cobbles (1/ plot) into 90 % acetone and ground with mortar and pestle for 3 min to extract pigments.
- extract filtered, [chl *a*] corrected for [pheophytin *a*], determined using a spectrophotometer.





Algae composition

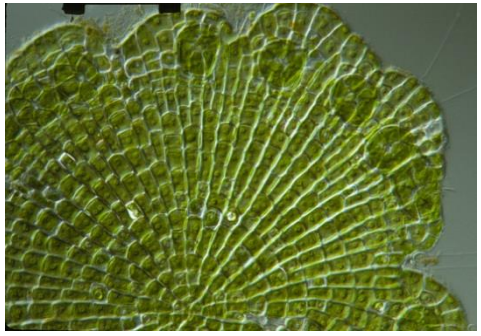
- determined from algae scraped from cobbles (1/plot) and preserved in 1 % glutaraldehyde.

Site 4

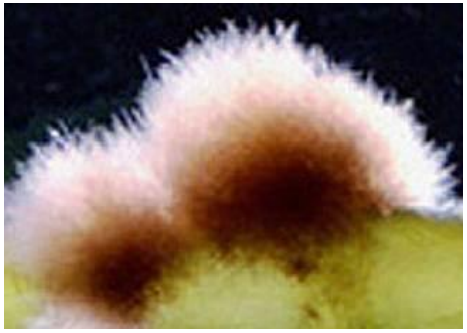
Soft algae

- were identified and units tallied using a gridded microscope slide.
    - 1 unit = 1 unicell; 1 colony; 10 µm of length of a filament.

Cryptomonas erosa

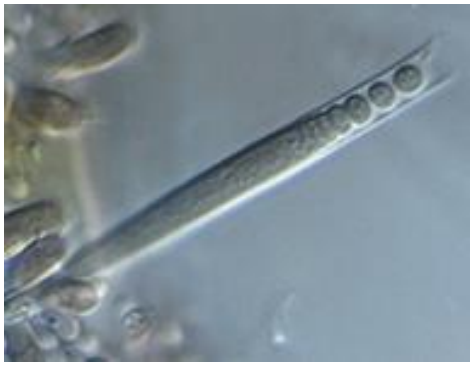


Coleochaetae orbicularis



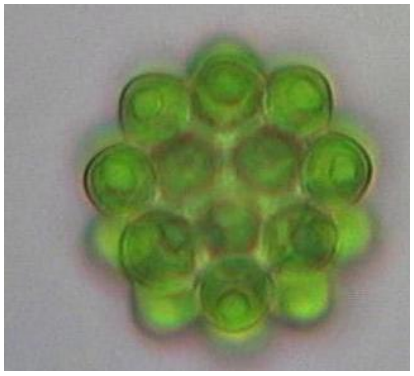
Audouinella violacea

Oocystis lacustris



Chamaesiphon confervicola

S. quadriculata

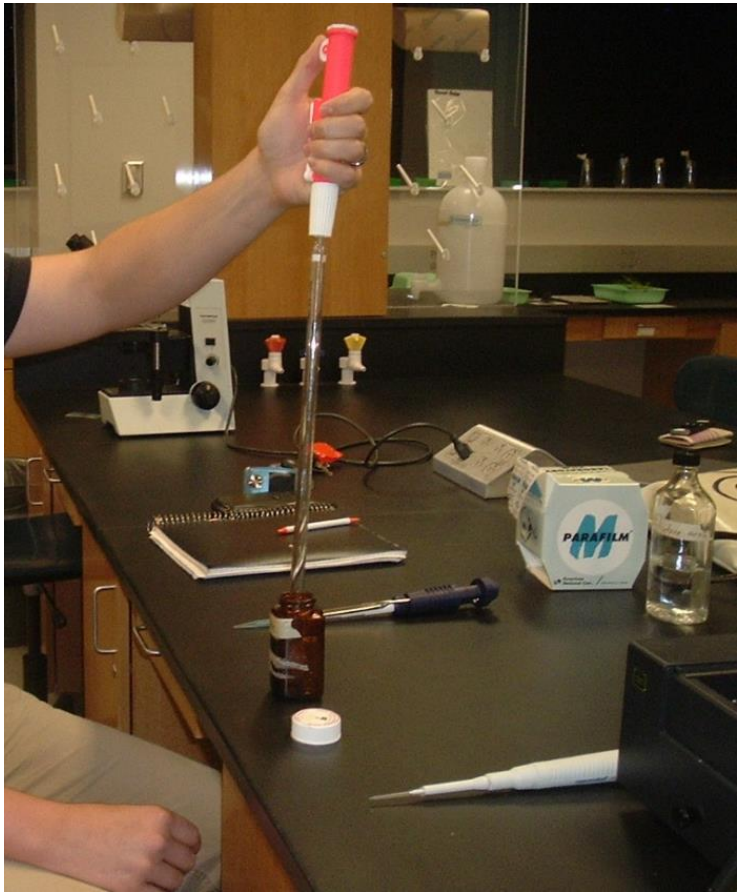


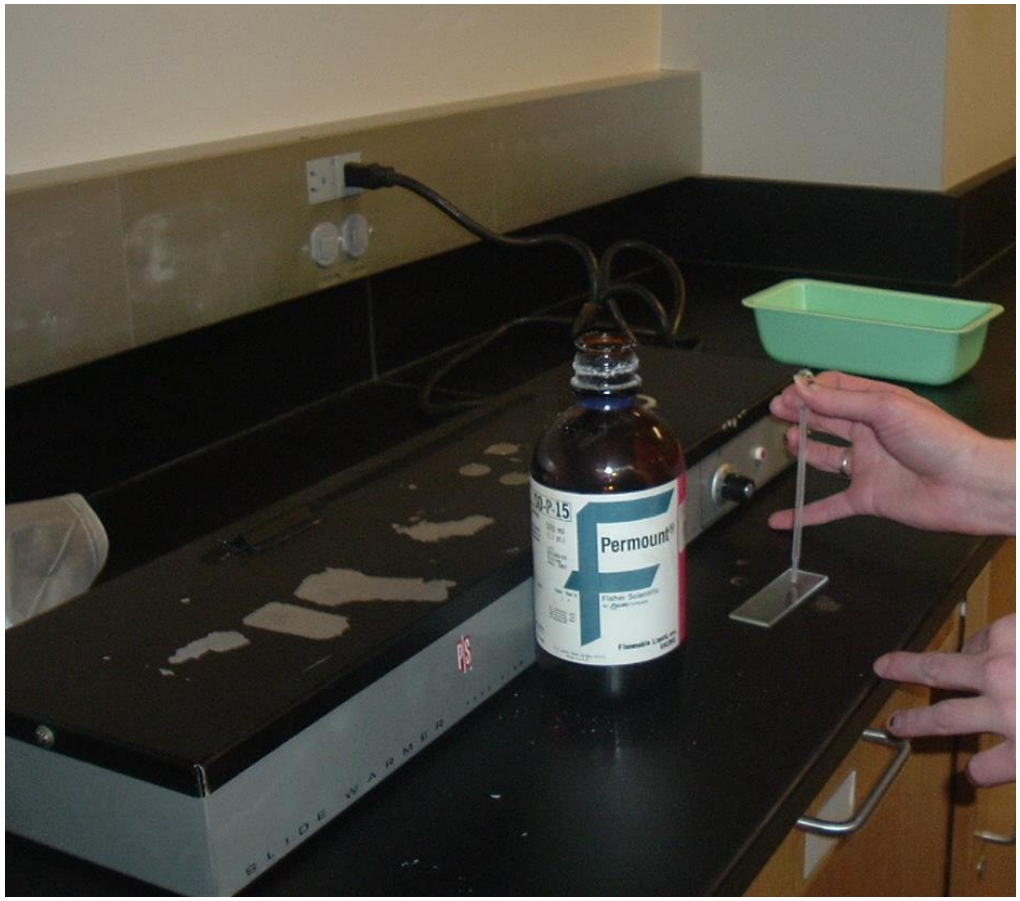
Coelastrum microporum

Ankistrodesmus falcatus

Diatoms

- were cleaned in 2.6 % sodium hyperchlorite and mounted onto glass slides.





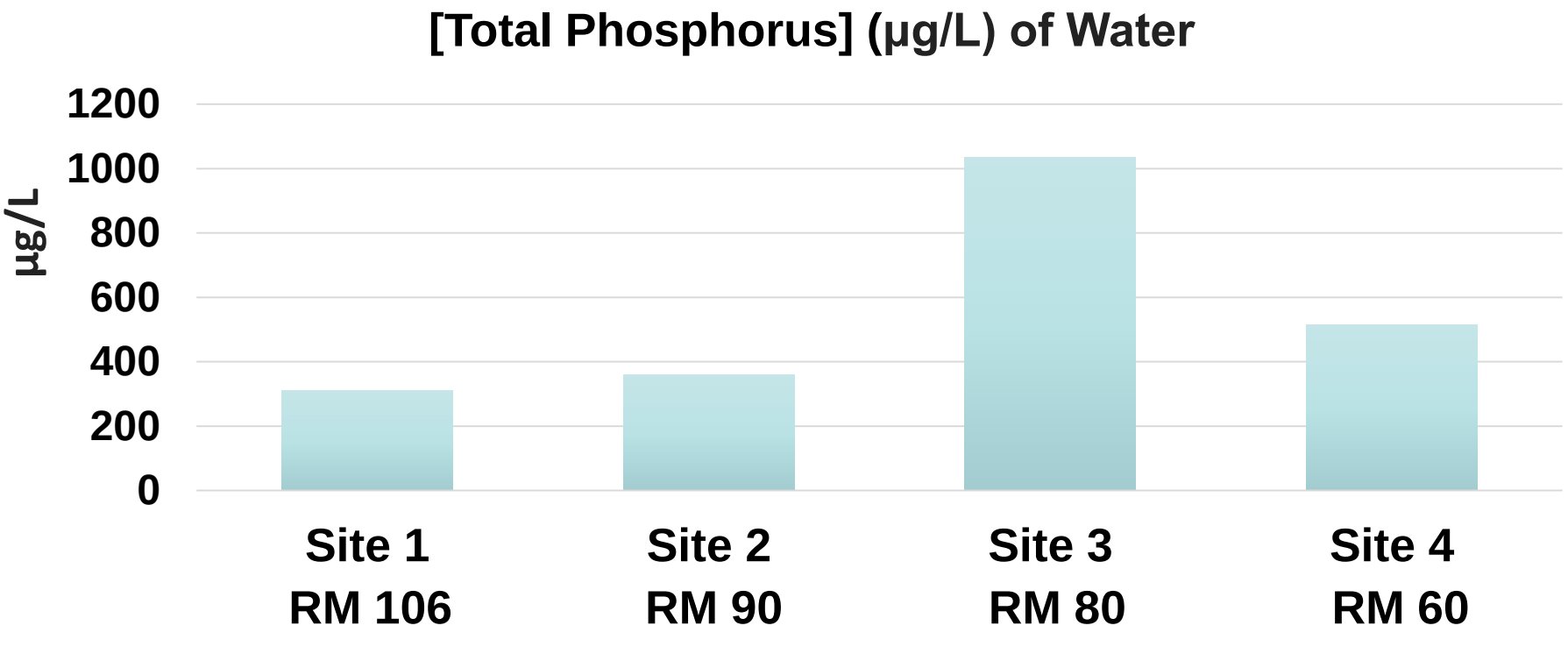
Diatoms

- were cleaned in 2.6 % sodium hyperchlorite and mounted onto glass slides identified and tallied using 1000 X magnification.

Results

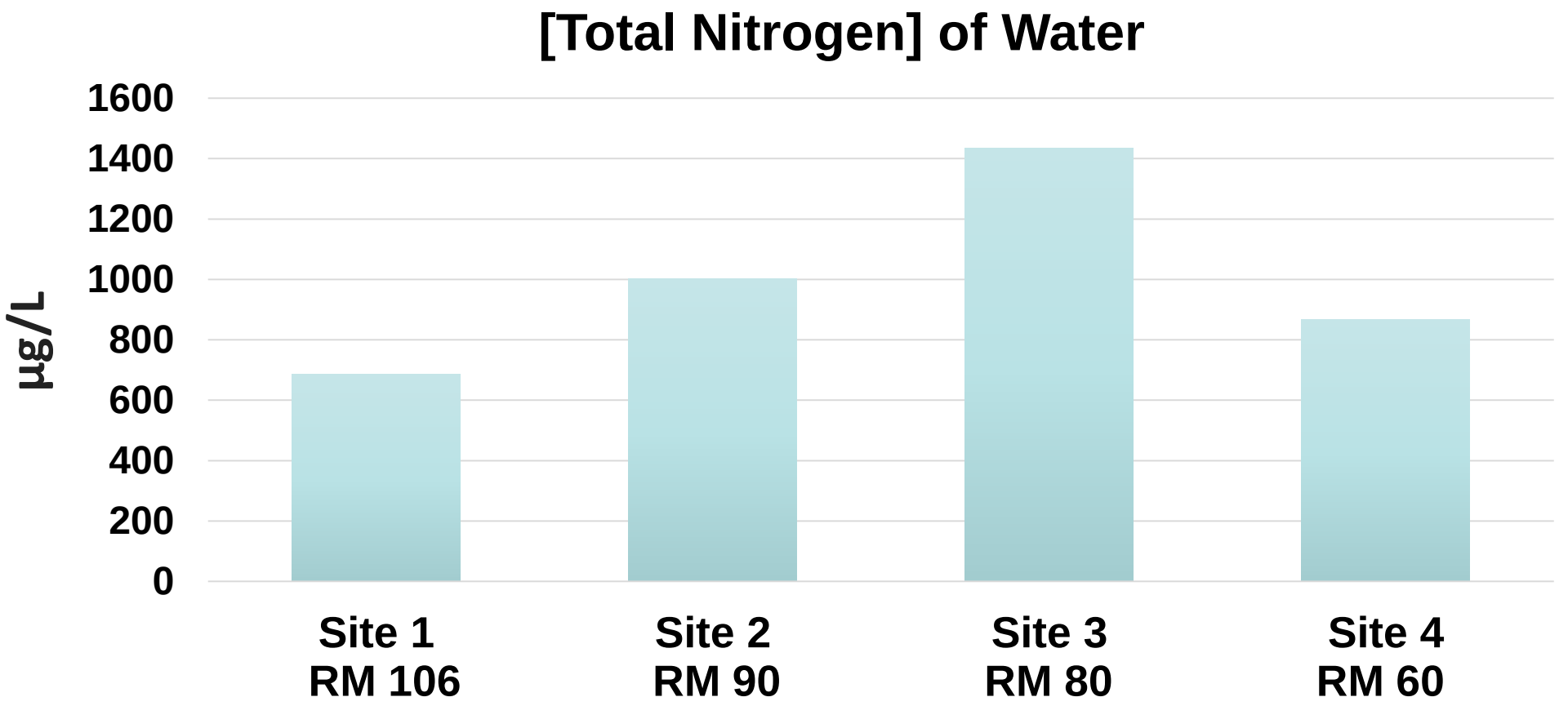
[Total Phosphorus] of water samples

- above Dodds et al. (1998) threshold values used to designate eutrophic conditions (75 µg/L).
- greatest at site 3 located 5 km downstream of the wastewater treatment plant.



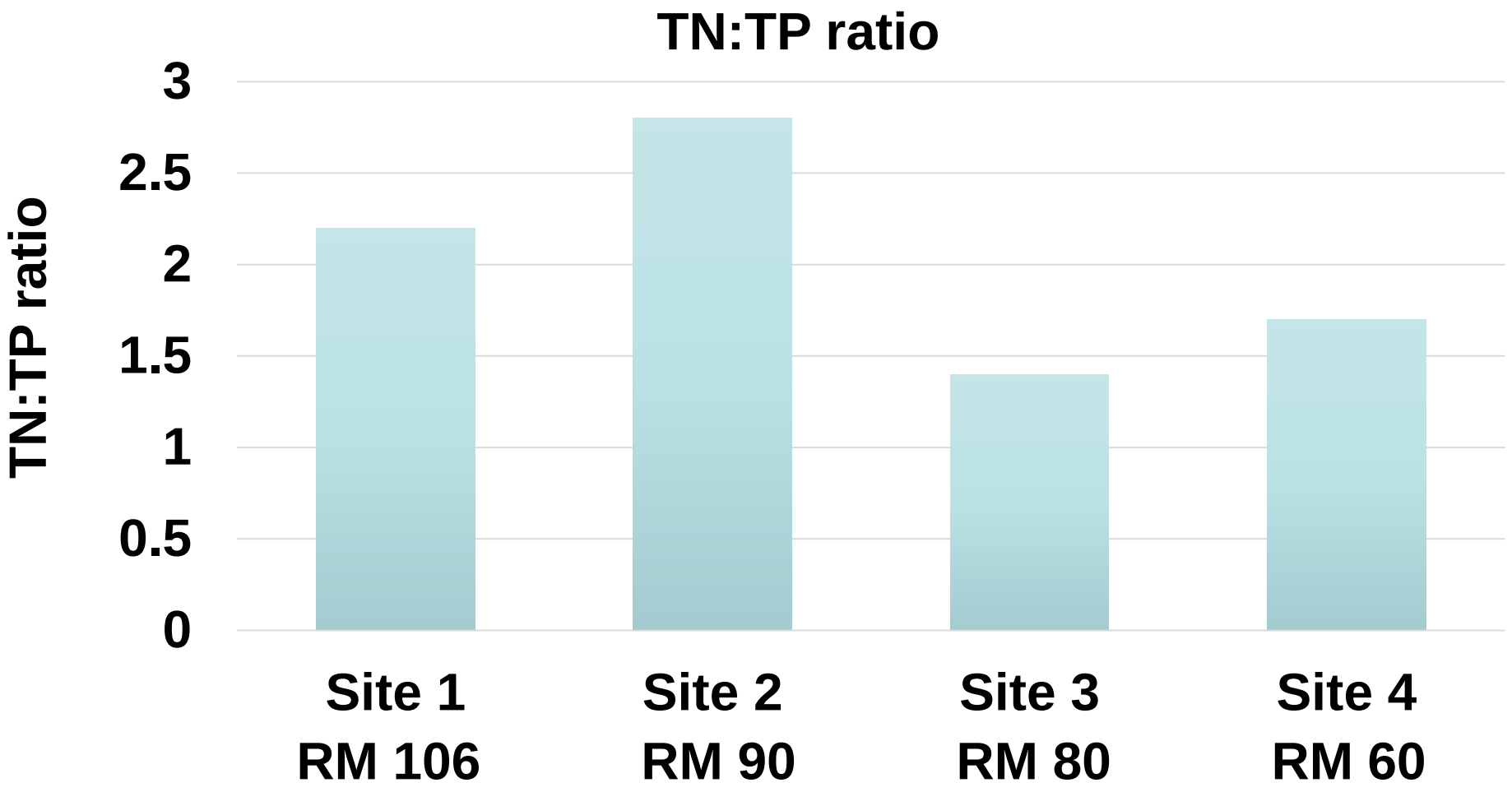
[Total Nitrogen]

- in the range typical of mesotrophic conditions (700 – 1500 µg/L).



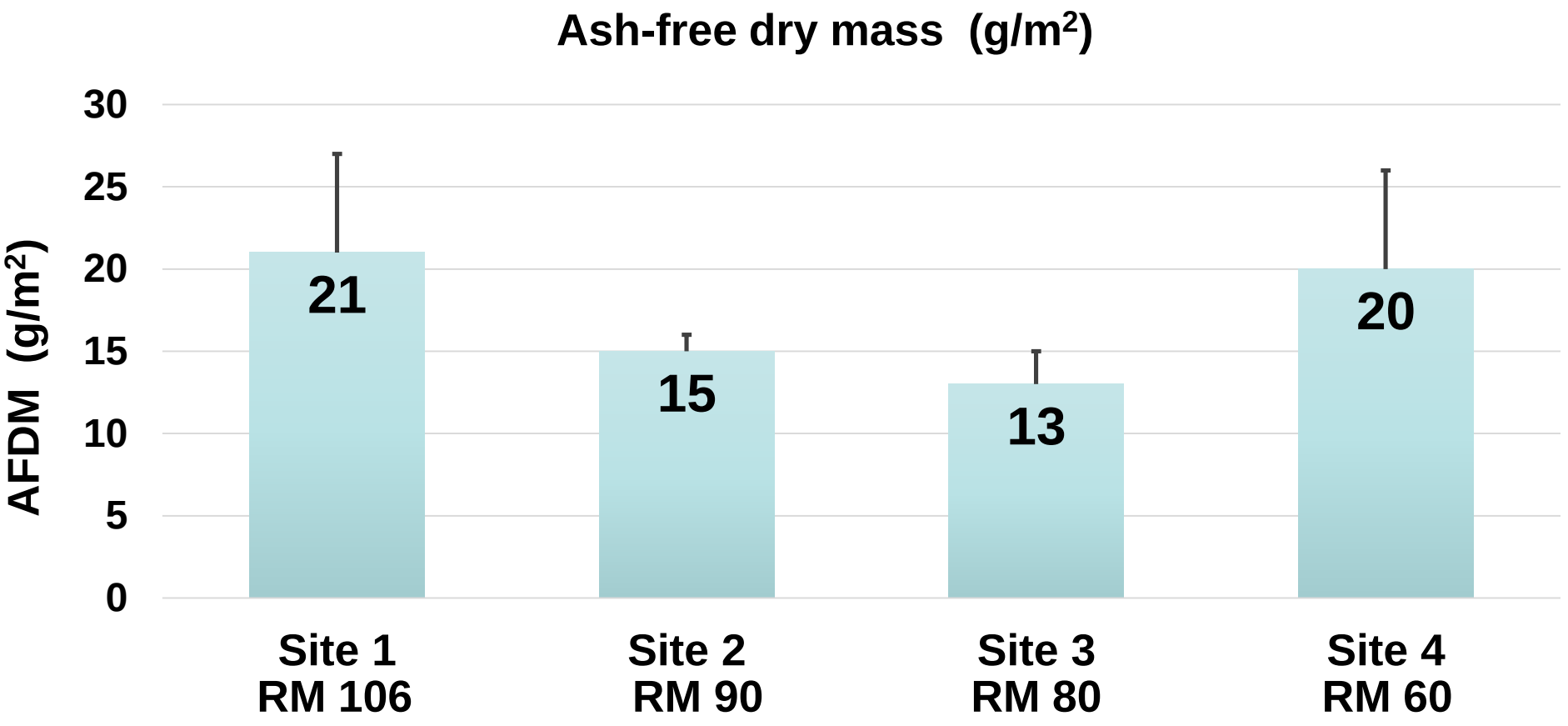
TN:TP ratios

- below threshold value (<10) hypothesized to limit algae growth (Dodds 2003).
- may suggest N limits algae biomass in the Nashville Basin?



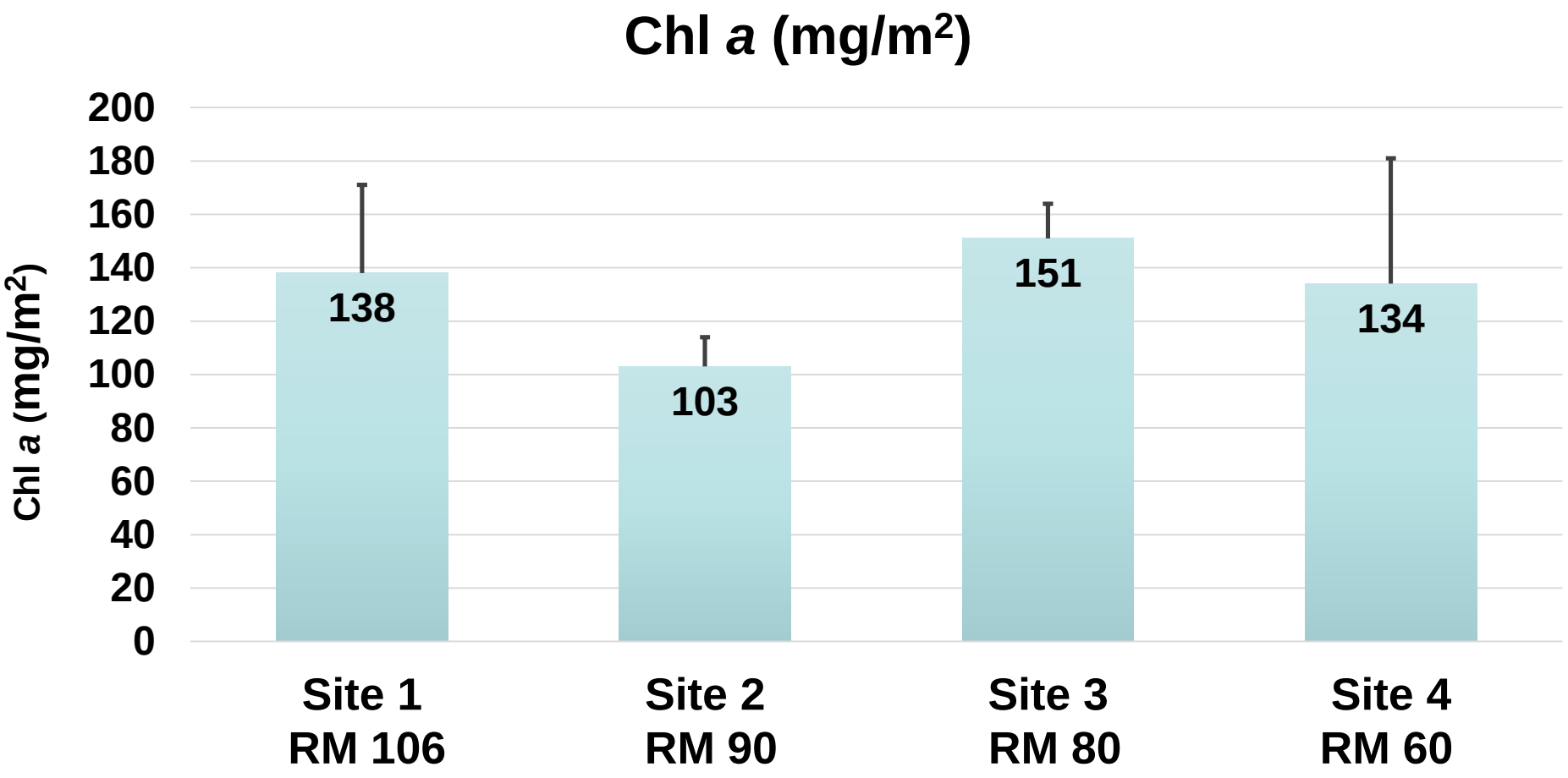
[AFDM]

- all > than the threshold value (10 g/m^2) used to designate sites as eutrophic.
- not significantly different.

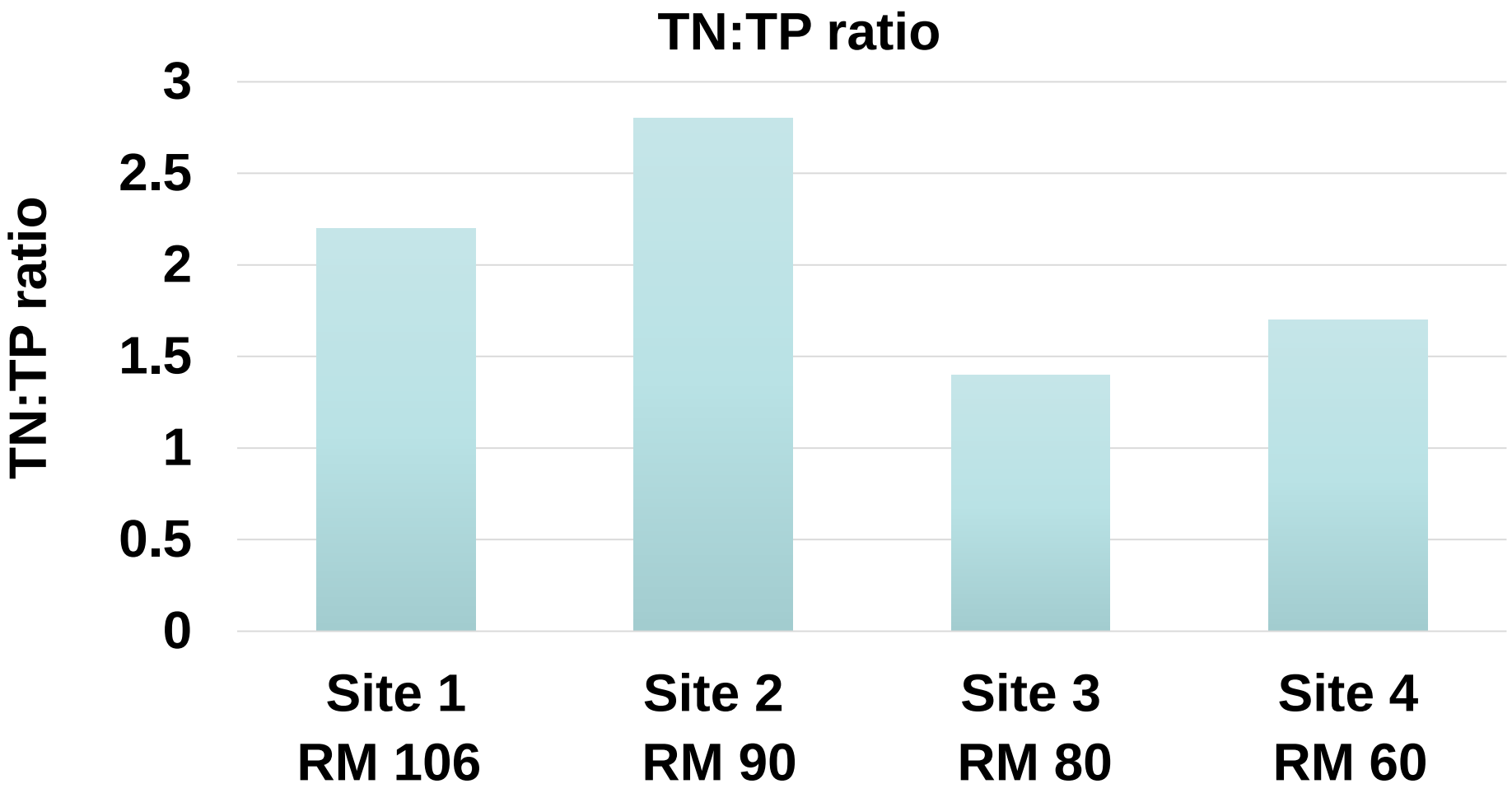


Periphyton [chl *a*]

- all > than the threshold value (70 mg/m^2) used to designate sites as eutrophic.
- not significantly different.



- lack of significant differences in [chl *a*] due to N limitation?



Soft-algae taxa

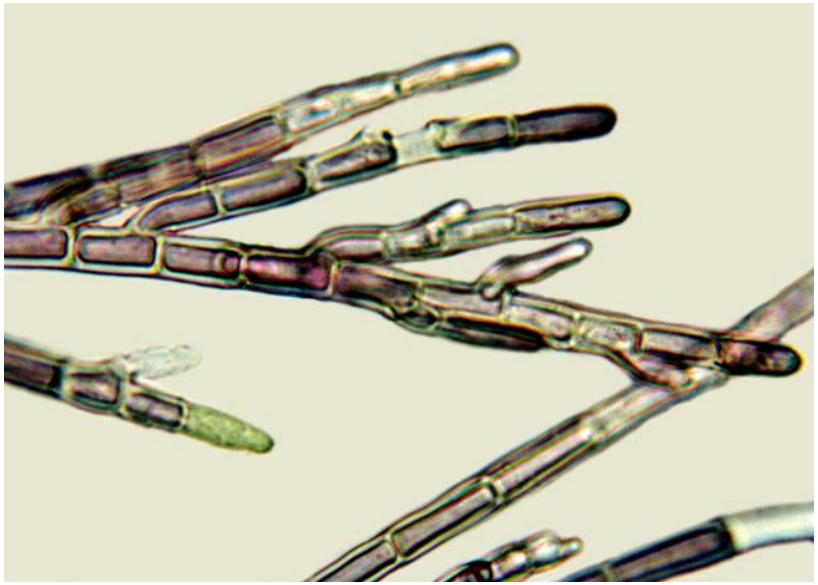
- 92 taxa were identified and % composition at each site determined.

Table 10. Percent composition of soft-algae taxa.

Site 1. River mile 106	Site 2. River mile 90.5	Site 3. River mile 80.0	Site 4. River mile 62.4
P. diguetii (29)	*A. hermannii (22)*	*A. hermannii (19)* *C. glomerata (19)*	*L. angustissimum (24)*
P. fragile Gomont (16)	*L. foveolarum (25)*	*Oedogonium sp. (10)*	*A. hermannii (23)*
L. foveolarum (11)	*P. diguetii (13)*	*G. cyanea (9)*	*L. foveolarum (8)*

Soft-algae taxa

- 92 taxa were identified and % composition at each site determined.
- most abundant overall were:
  - *Audouinella hermannii* (16 %)
    - due to high abundance at the 3 lowermost sites.
    - an indicator of eutrophic conditions.



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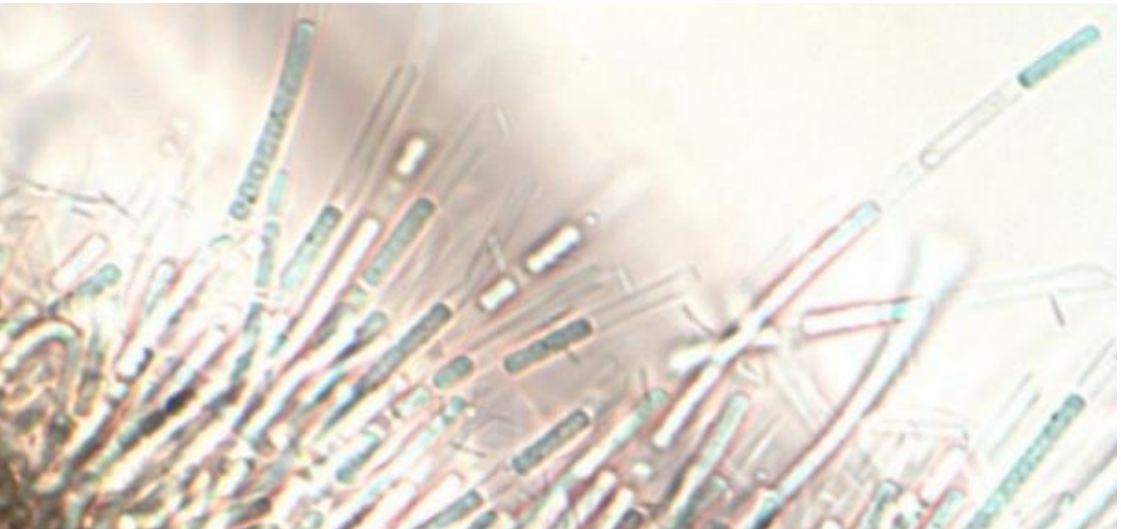
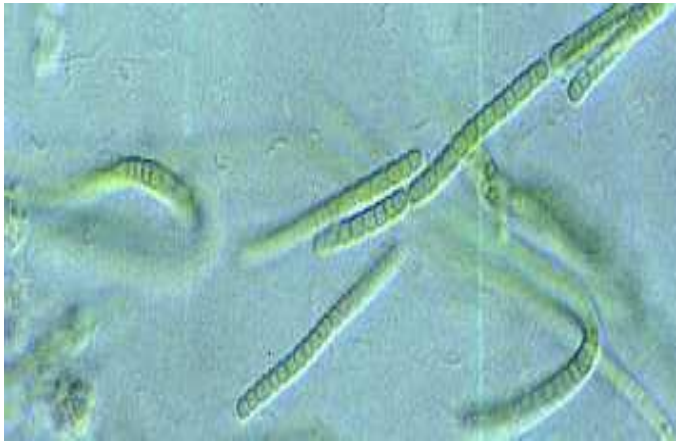
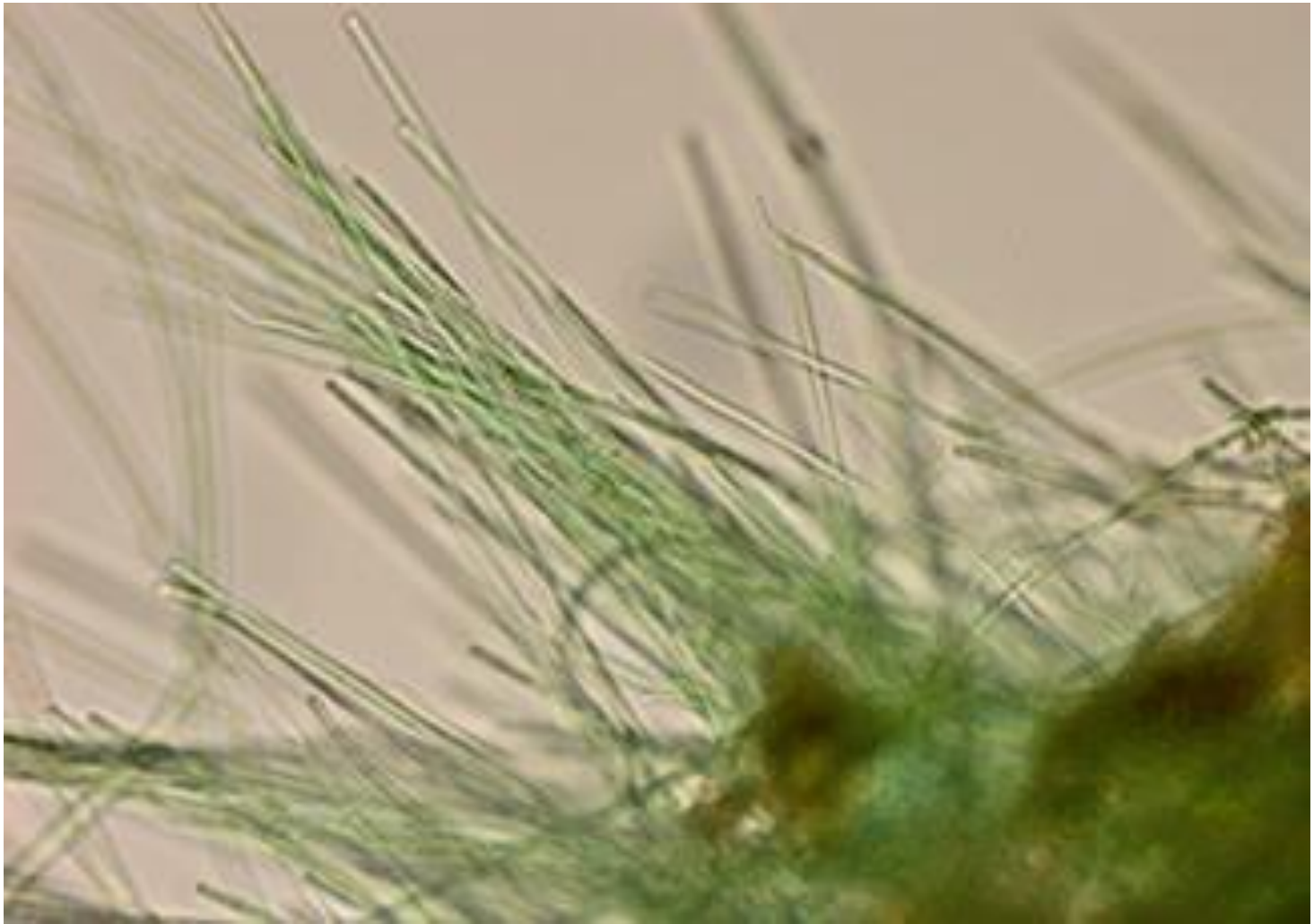
  - *Leptolyngbya fovularum* (11 %)

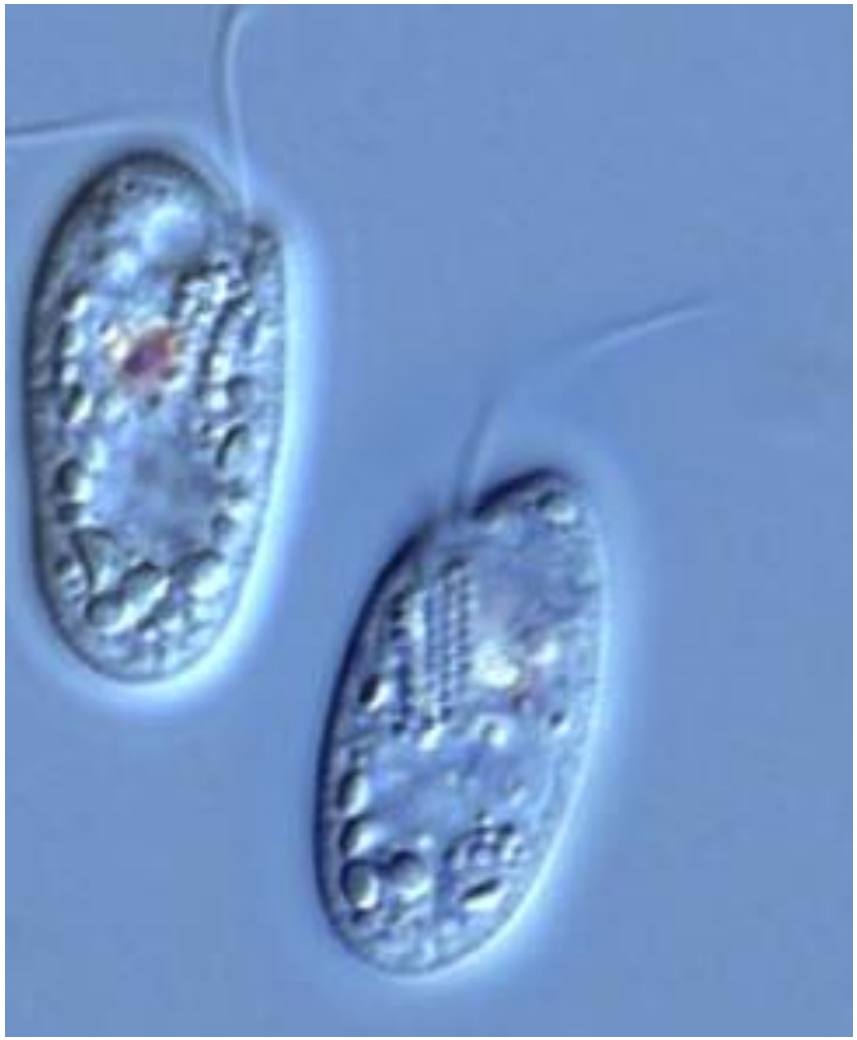




- *Phormidium diguettii* (10 %)
    - the most abundant taxon at site 1.
    - abundant in oligotrophic and mesotrophic conditions.



- numerous taxa were identified not previously known to occur in TN:
  - *Chilomonas* sp.
    - a nonphotosynthetic Cryptophyta.

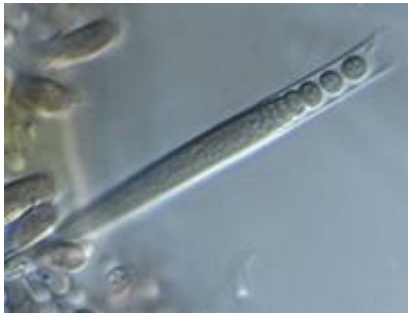


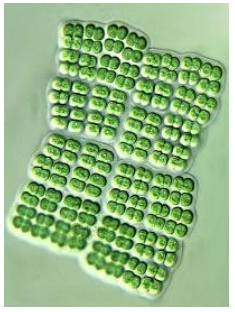
- *Paulinella chromatophora*
    - Rhizaria supergroup, Phylum Cercozoa.
    - has primitive, cyanobacteria-like chloroplasts.
        - suggests the endosymbiosis of cyanobacteria → chloroplasts of the Archaeplastida supergroup occurred more than once.

Algae Trophic Index (ATI)

- calculated to evaluate the impact of trophic state.

$$ATI_{site} = \frac{\Sigma_{all\ taxa}\ [\text{a taxon's abundance} \times \text{taxon's trophic indicator value}]}{\text{total no. of algae}}$$





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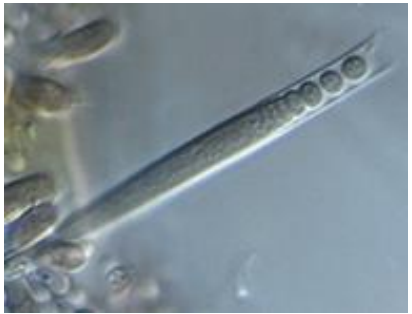
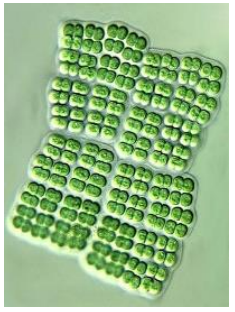
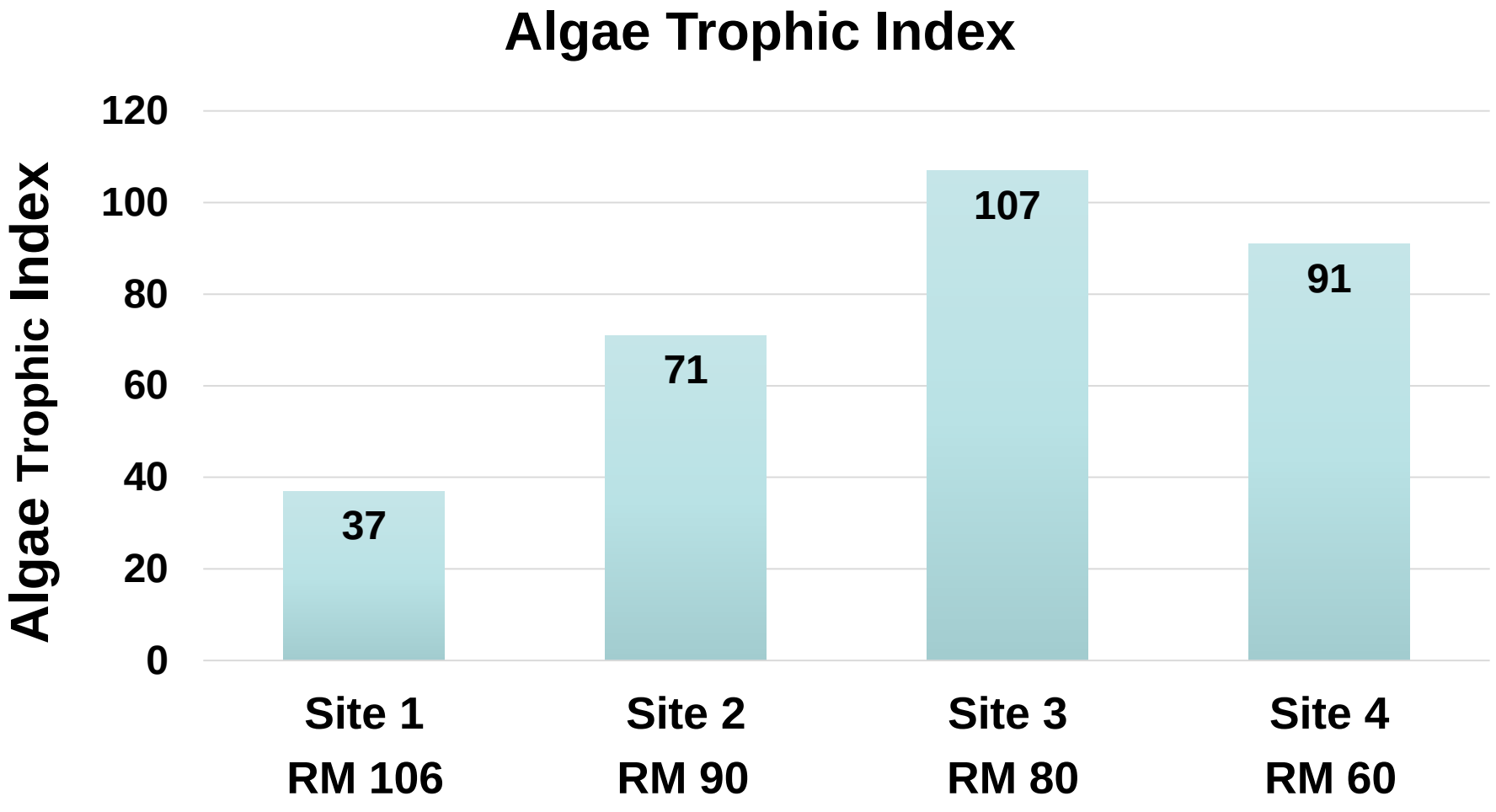
- trophic indicator value
  - = abundance-weighted average for chl *a* (Grimmett and Lebkuecher 2017, J. Freshwater Ecology).
  - if a species is more abundant at sites with high [chl *a*], that sp. has a high trophic indicator value.





ATI values for the assemblages
- indicate that site 3 is most impacted by nutrient enrichment.



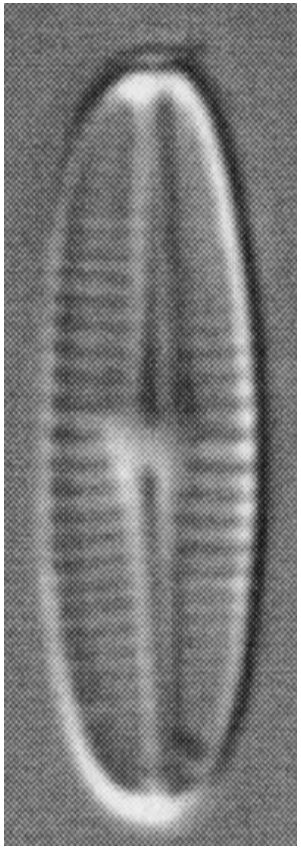
Diatoms

- 94 diatom taxa were identified.

Site 1. River mile 106	Site 2. River mile 90.5	Site 3. River mile 80.0	Site 4. River mile 62.4
A. rivulare (16.5) *C. affinis* (16.5)	*A. rivulare* (15.0)	*N. cryptotenella* (8.6)	*N. minima* (11.4)
A. minutissimum (11.0)	*Psammothidum* sp. (7.4)	*M. varians* (5.9)	*A. rivulare* (7.6)
A. deflexa (8.0) *Navicula minima* (8.0)	*A. minutissimum* (7.3)	*N. minima* (5.4)	*N. cryptotenella* (5.2)

Diatoms

- 94 diatom taxa were identified.
- most abundant overall were:
    - *Achnanthidium rivulare* (10.4 %)
        - common throughout SE U.S.



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        - indicator of eutrophic habitats.

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- most abundant overall were:
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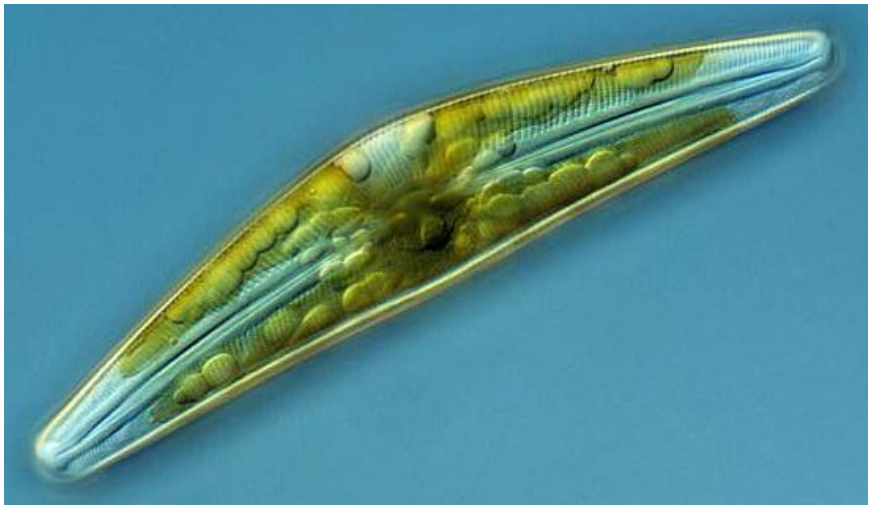
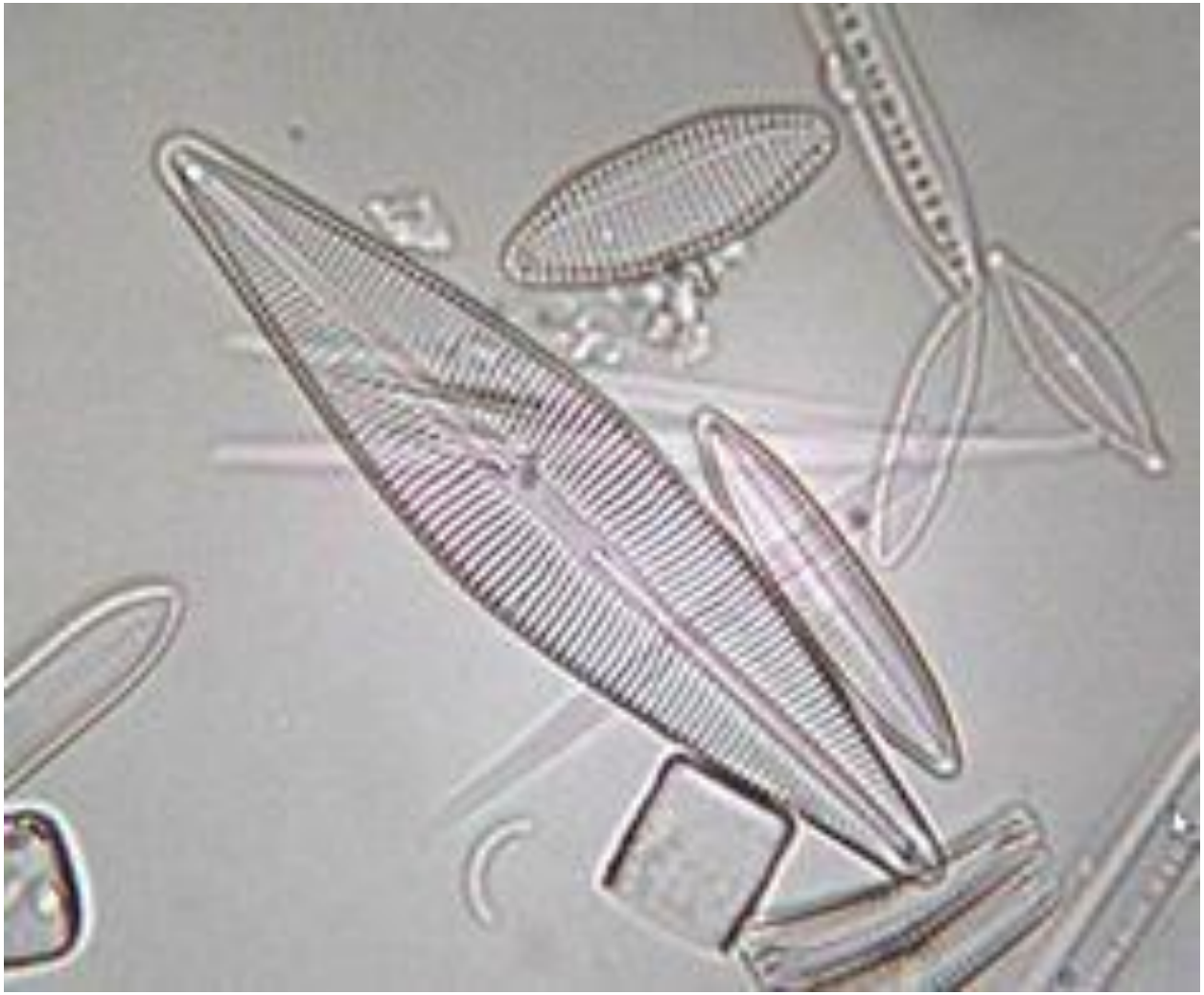
        - common throughout SE U.S.
    - *Navicula minima* (7.6 %)
        - indicator of eutrophic habitats.
    - *Cymbella affinis* (6.8 %)
        - most abundant at site 1.
        - more abundant in oligotrophic and mesotrophic water.



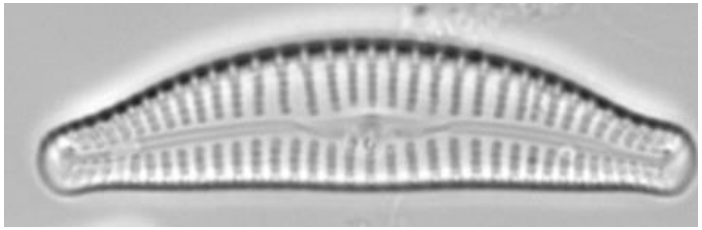
Pollution Tolerance Index for Diatom Assemblages (PTI)

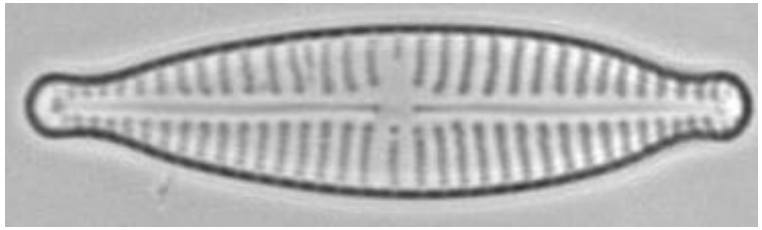
- used to infer trophic state of stream sites.



$$PTI = \frac{\Sigma_{\text{all taxa}} [\text{taxon's abundance X the taxon's trophic-indicator value}]}{\text{total no. of diatoms}}$$

- Trophic-indicator values range from 4 to 1.
  Cymbella affinis = 4 (in oligotrophic water)
  Gomphonema parvulum = 1 (in eutrophic water)

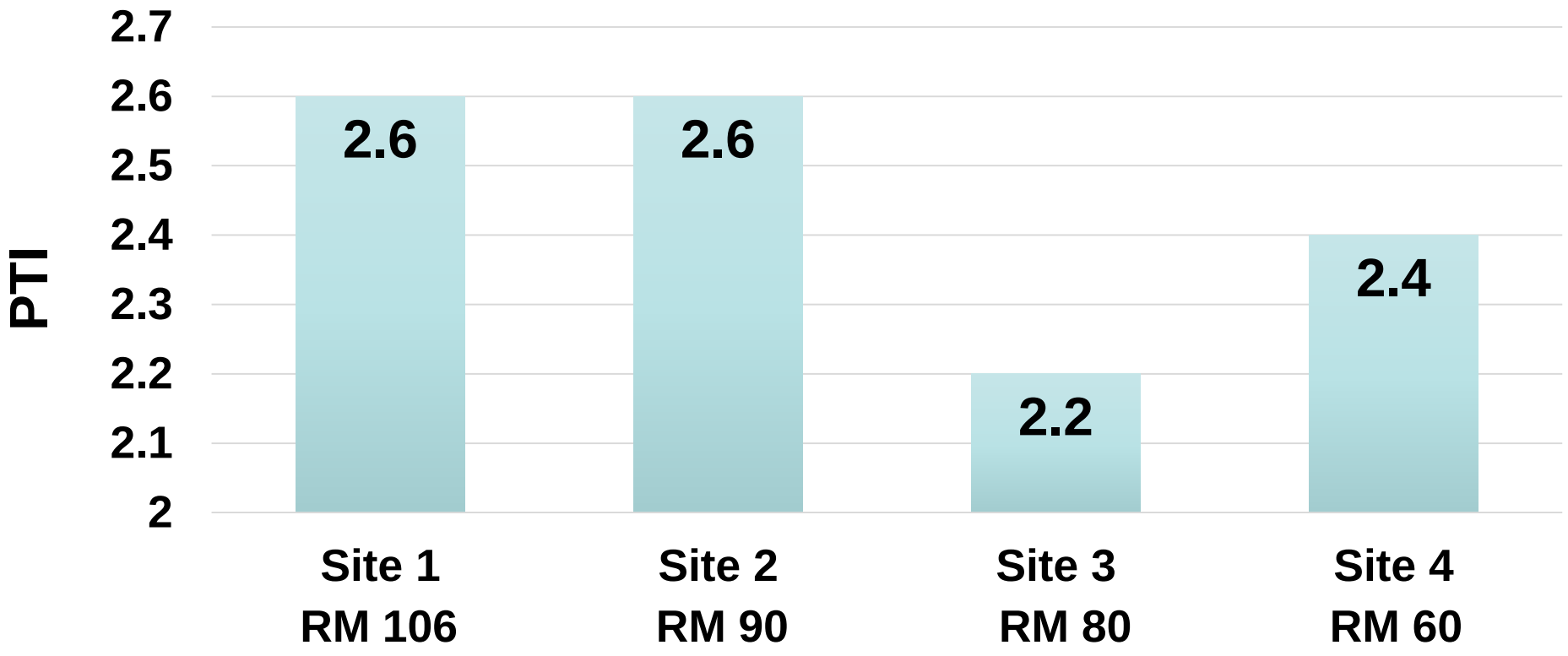




PTI
- ranges from 4 to 1.
- sites w/ numerous taxa w/ low trophic indicator values have low PTI values.

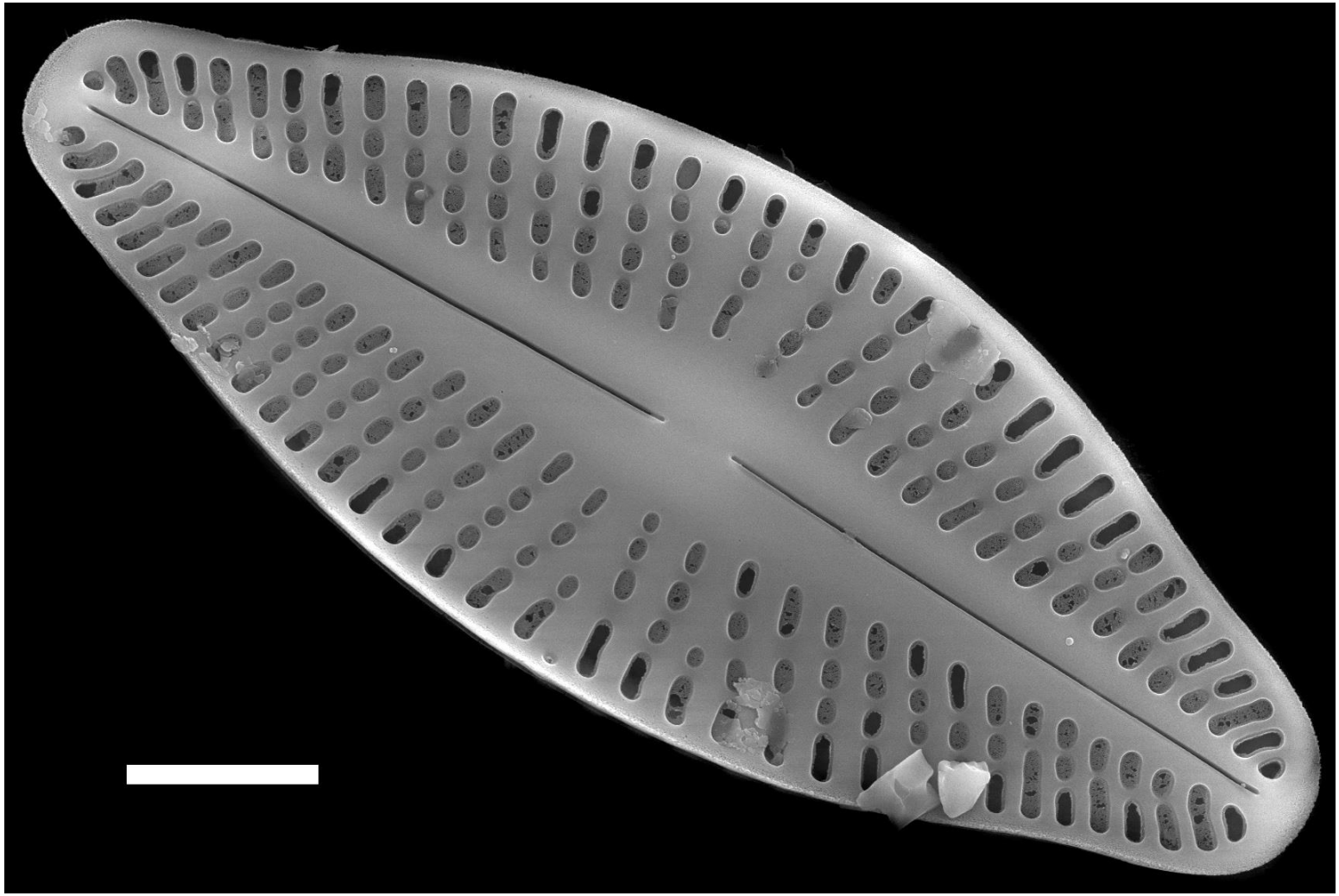
Values for the PTI

- ≤ 2.6 indicate eutrophic environments.
- indicate:
  - the sites are impacted by nutrient enrichment.
  - site 3 is the most impacted .



Motile diatoms

- have a raphe (longitudinal slit in glass wall).



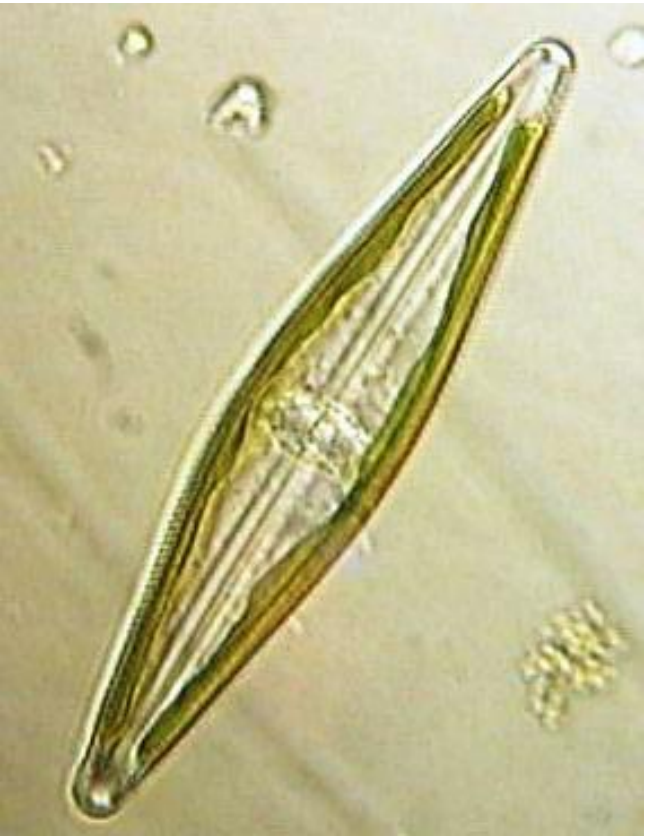
Karia cleve, scanning electron micrograph, 1000 X

Motile diatoms

- have a raphe (longitudinal slit in glass wall).
- able to avoid being buried by sediments.
- abundant at sites covered w/ sediments.

Siltation Index

= % motile diatoms of the genera *Navicula, Nitzschia, Surrirella.*



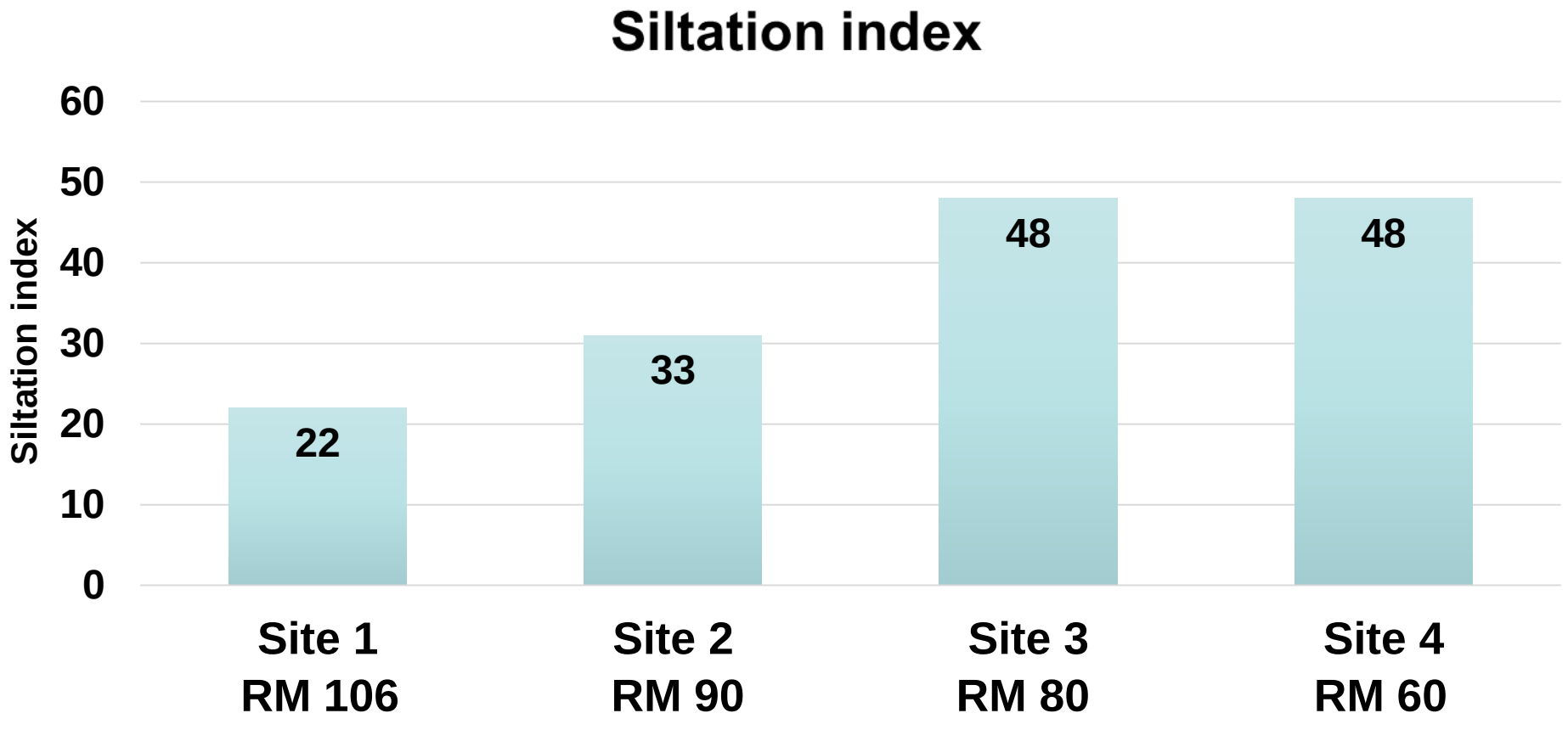
Navicula

Nitzschia

Surirella

Values for the Siltation Index

- > 40 indicate a negative impact of excessive sediments.
- are greatest for sites 3 and 4.

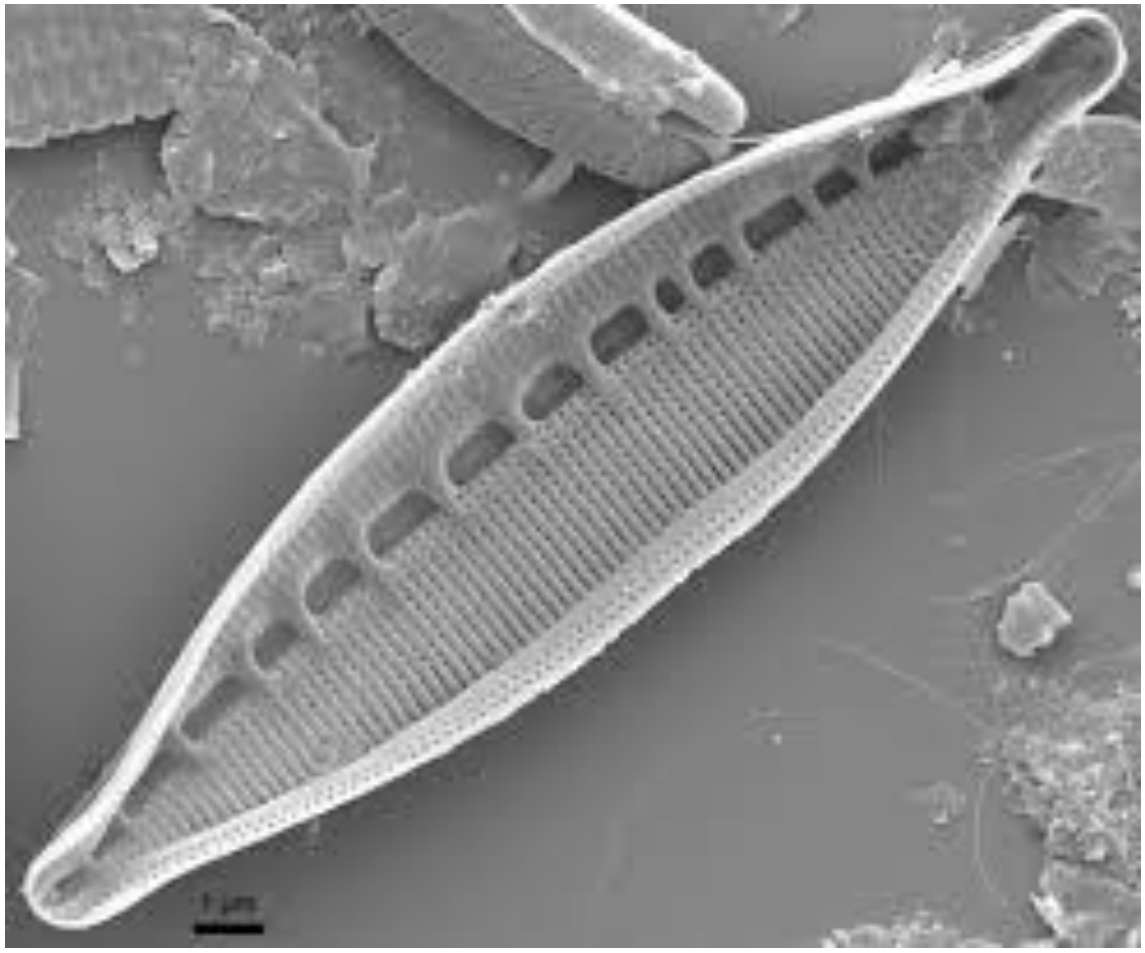


Organic pollution

- results from erosion of organic soil, input of manure or sewage, and overgrowth of algae.

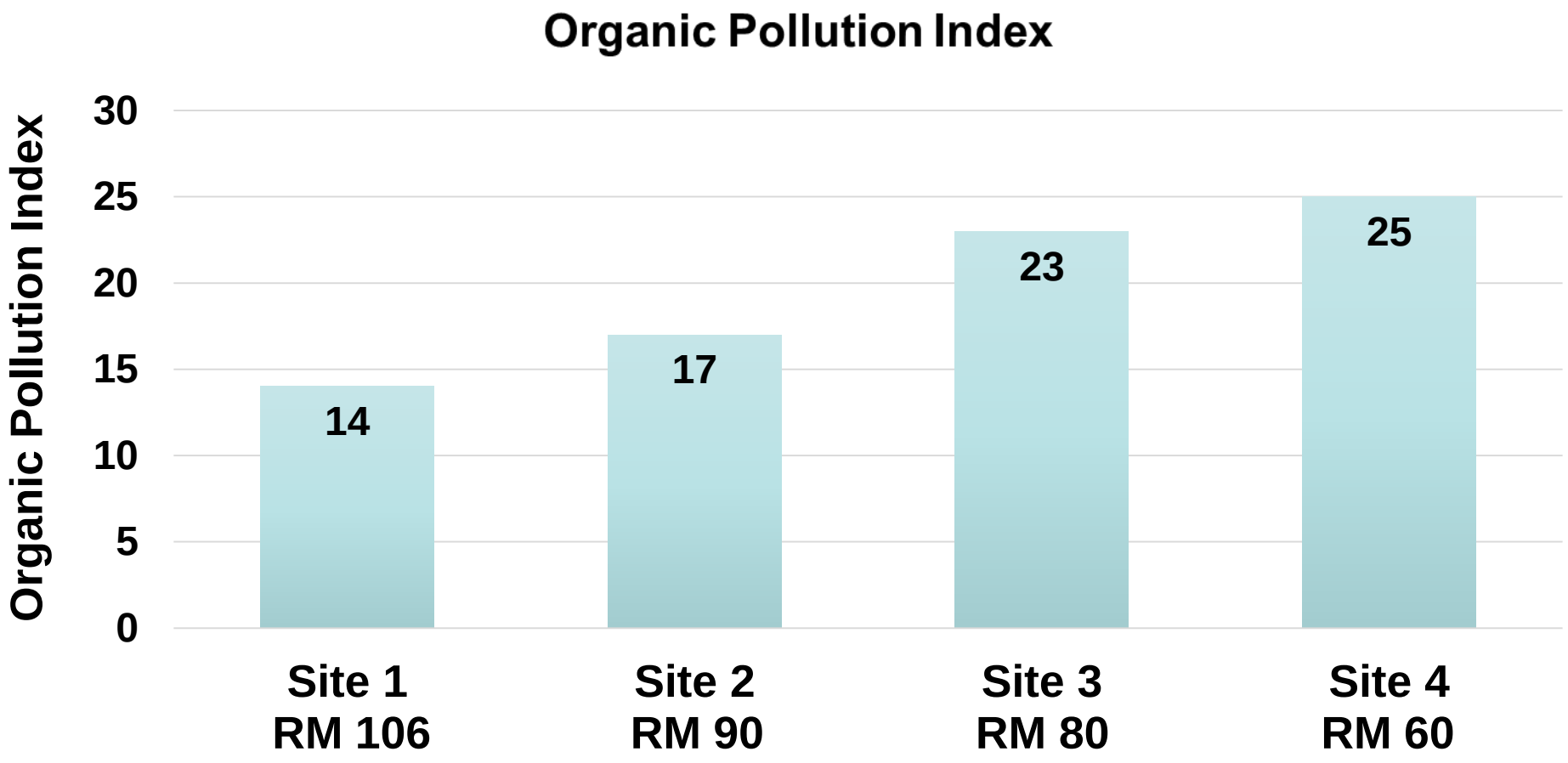
Organic Pollution Index

= % of diatoms tolerant of organic pollution (includes many *Nitzschia* sp.).



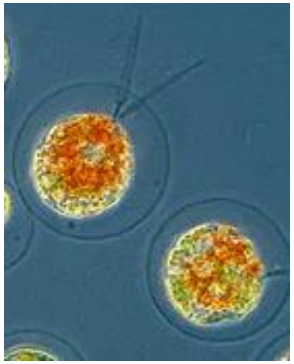
Values for the Organic Pollution Index

- > 20 suggest a negative impact of high [organics].
- sites 3 and 4 are negatively impacted by high [organics].



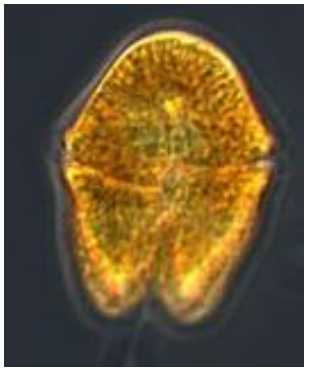
Conclusions

- 186 taxa of algae were identified and % composition determined.



Haematococcus

Starastrum



Gymnodinium

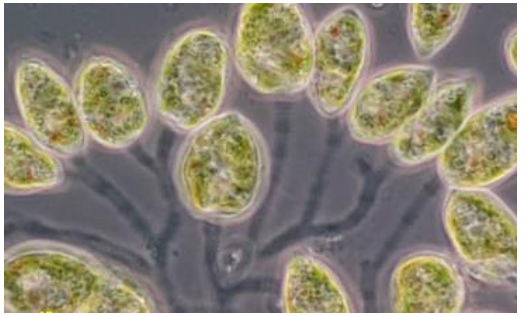
Synura

Chroococcus

Bulbochaetae

Cosmarium

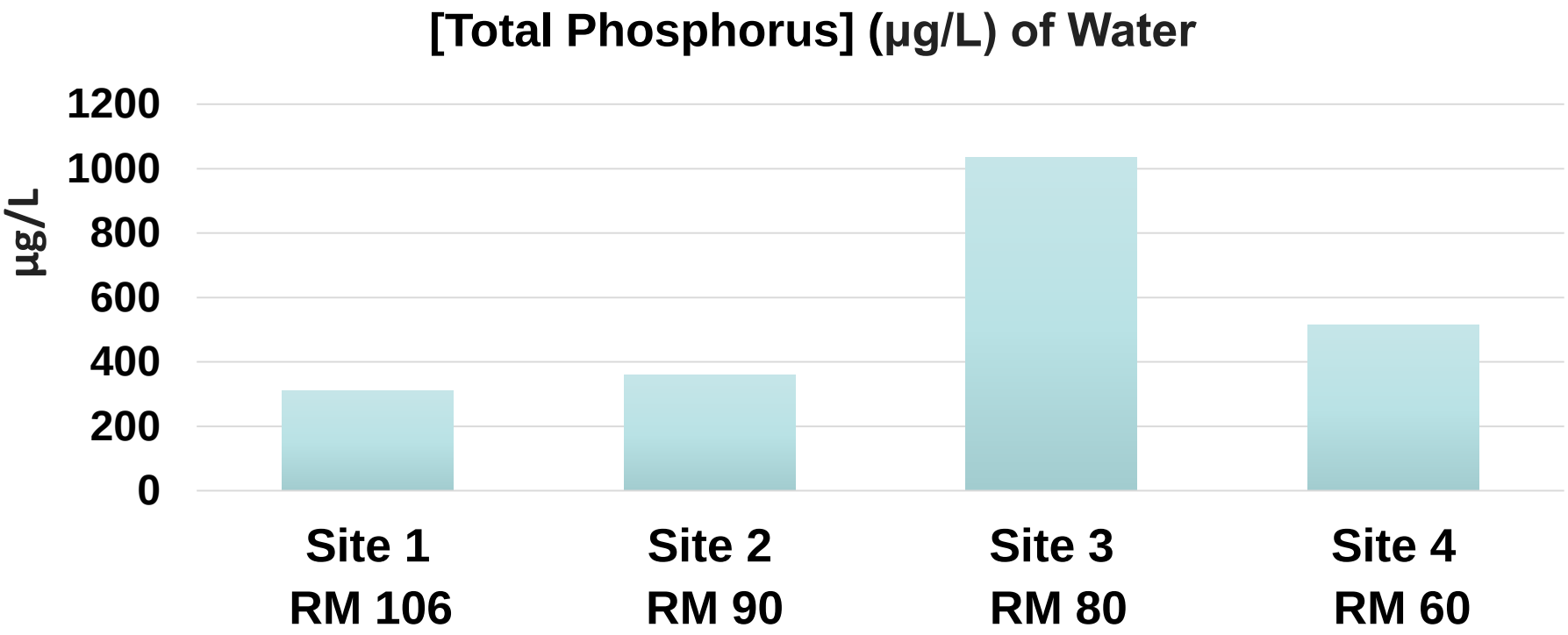
Phacus



Colacium

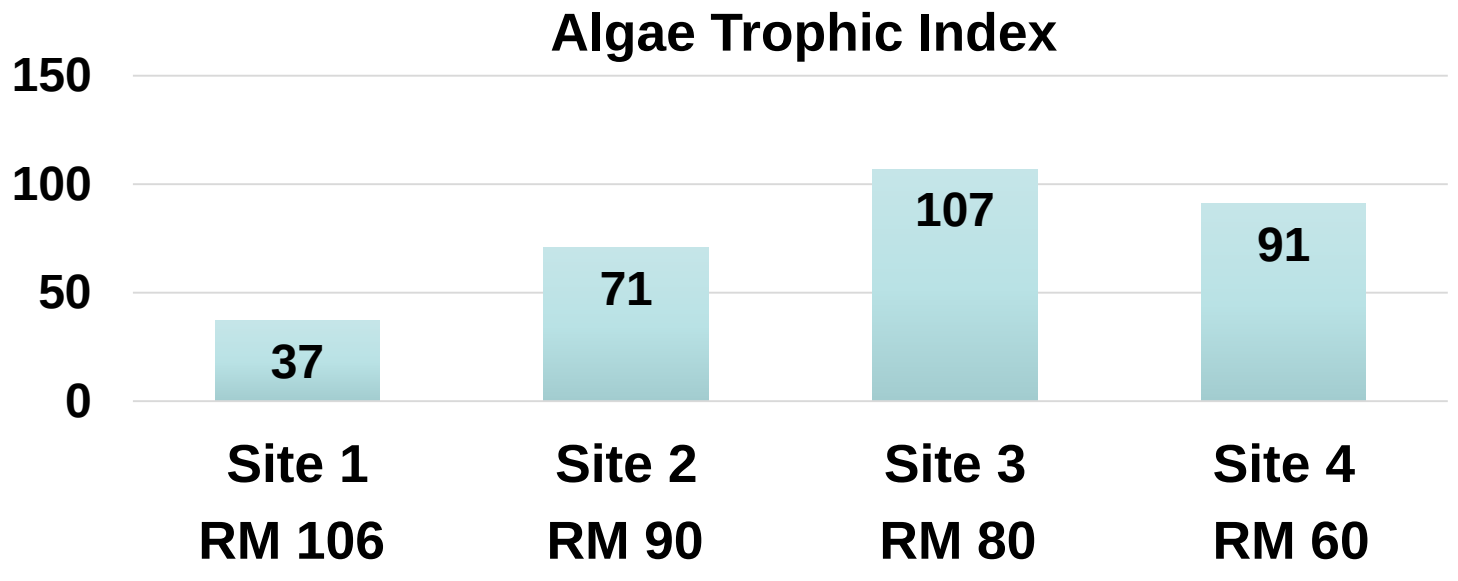
Conclusions

- 186 taxa of algae were identified and % composition determined.
- The quality of water is degraded as the river flows through Franklin, TN.
    - site 3:
        - greatest [TP].



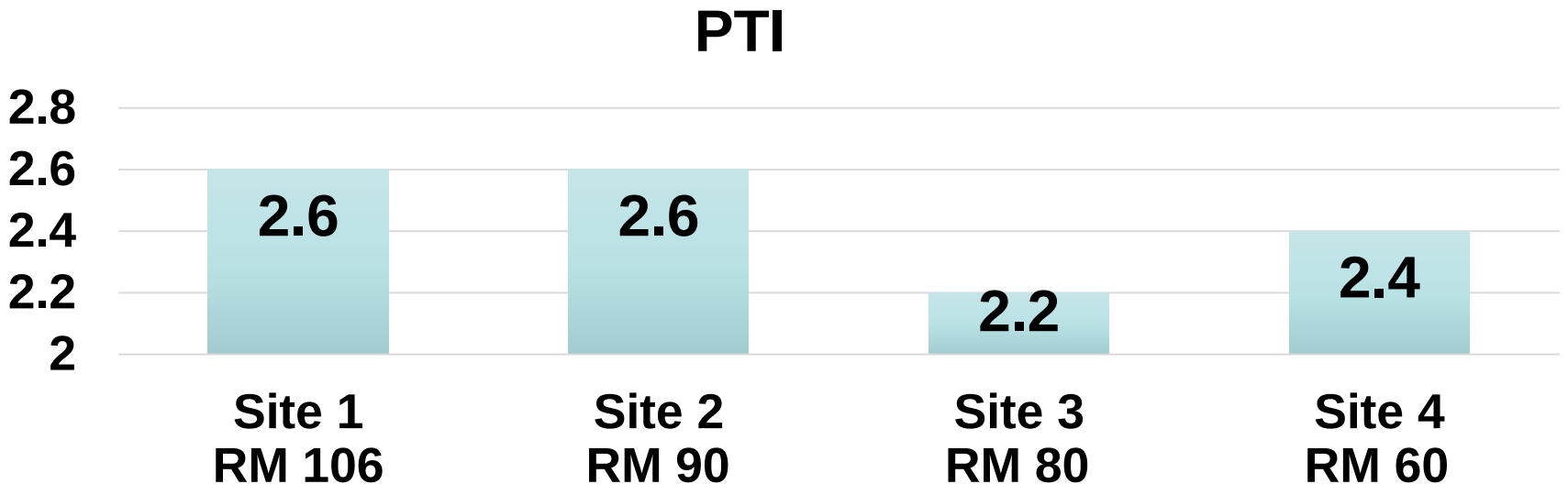
Conclusions

- 186 taxa of algae were identified and % composition determined.
- The quality of water is degraded as the river flows through Franklin, TN.
    - site 3:
        - greatest [TP].
        - greatest ATI value.

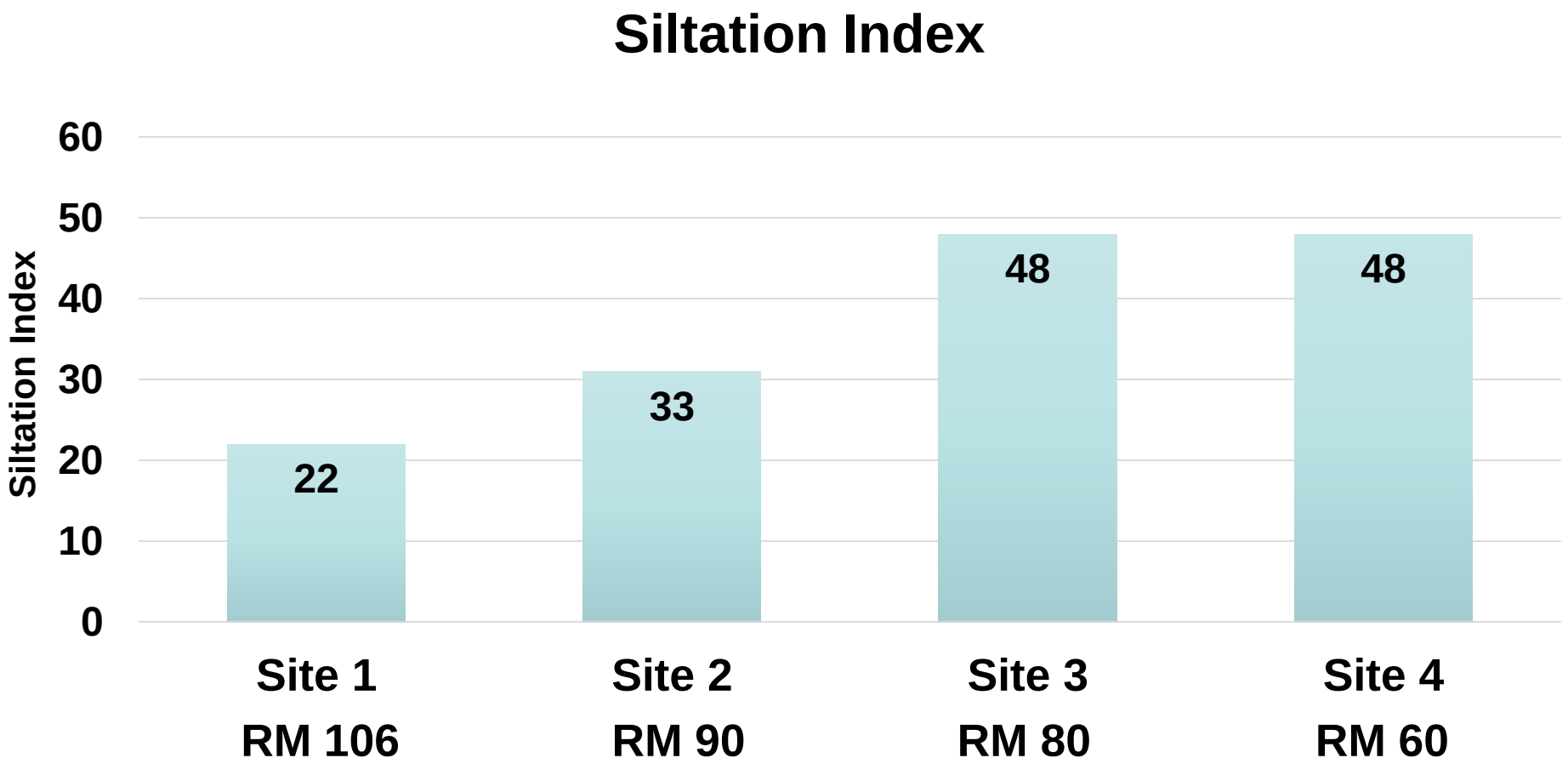


Conclusions

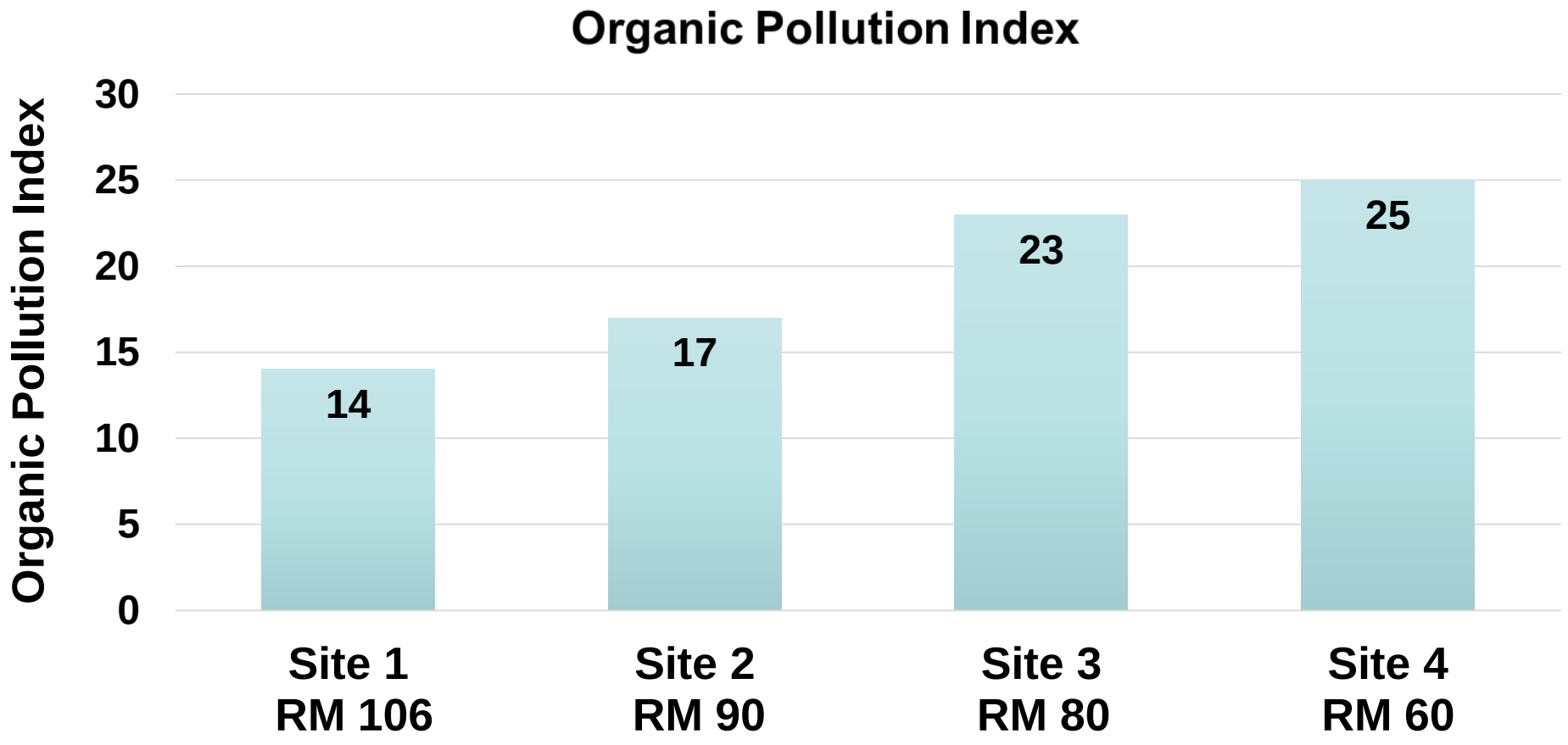
- 186 taxa of algae were identified and % composition determined.
- The quality of water is degraded as the river flows through Franklin, TN.
    - site 3:
        - greatest [TP].
        - greatest ATI value.
        - lowest PTI value.



- sites 3 and 4 downstream of Franklin:
    - greatest Siltation Index values.

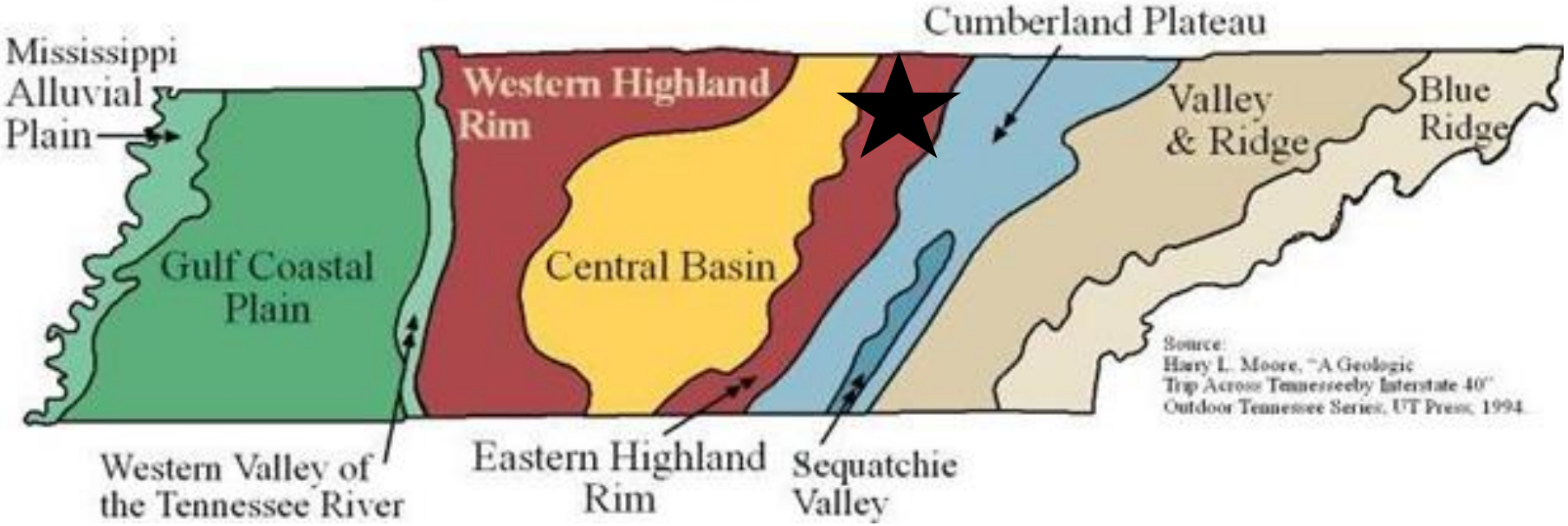


- sites 3 and 4 downstream of Franklin:
    - greatest Siltation Index values.
    - greatest Organic Pollution Index values.



Change from P to N as the Limiting Nutrient for Algal Growth due to Eutrophication of a Stream on the Highland Rim in Middle Tennessee

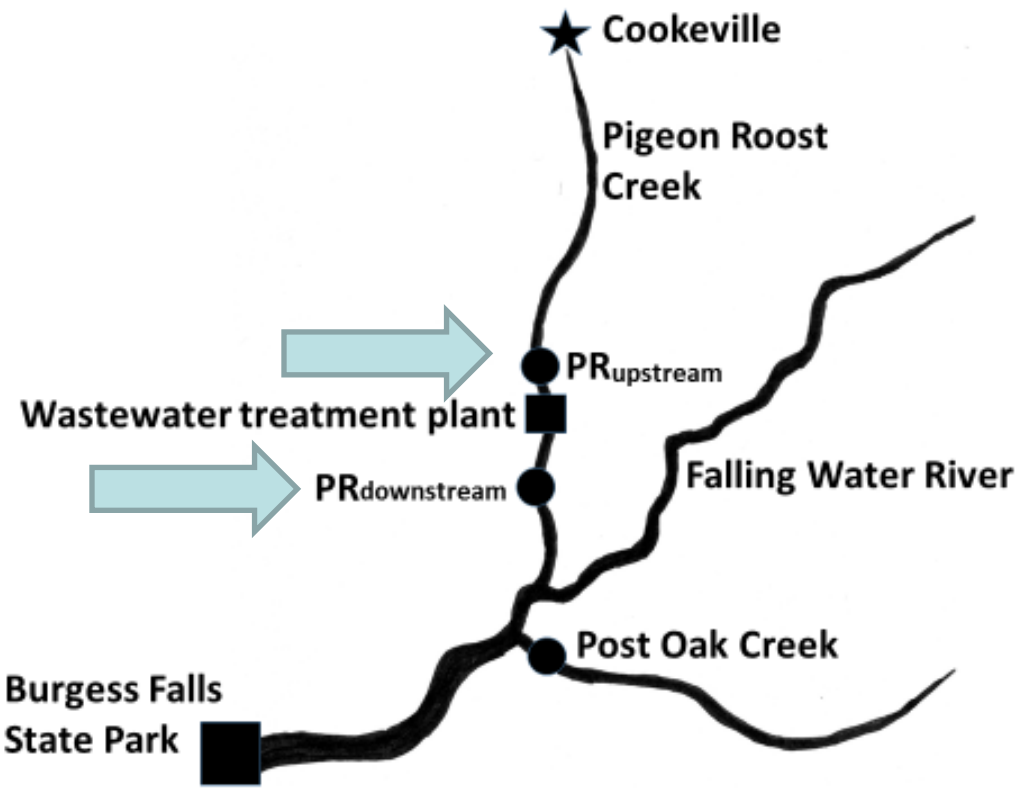
Jefferson G. Lebkuecher and James M. Mauney
Biology Department, Austin Peay State University, Clarksville, TN 37044



Methods

Sampled 3 sites in the Falling Water River Watershed

- $PR_{upstream}$ site upstream of the Cookeville Wastewater Treatment Plant.
- $PR_{downstream}$ site is downstream of the treatment plant.

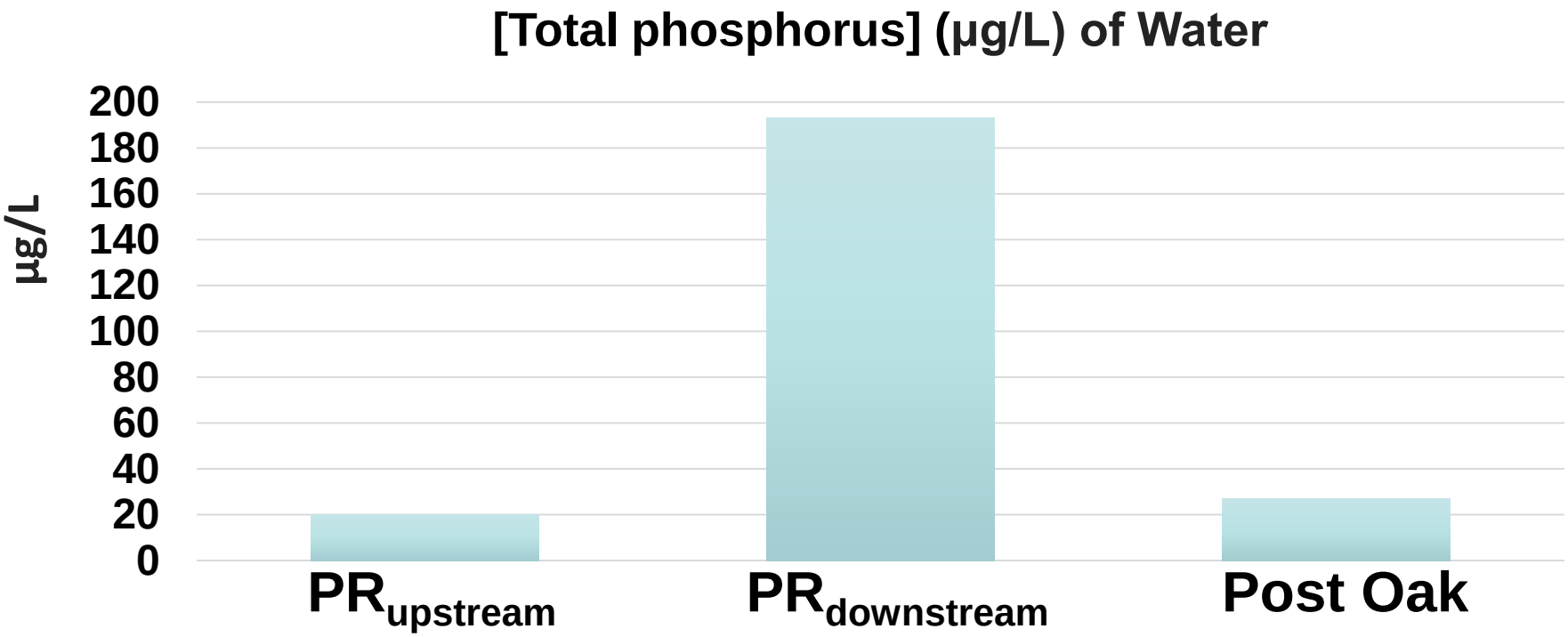


Methods

Sampled 3 sites in the Falling Water River Watershed

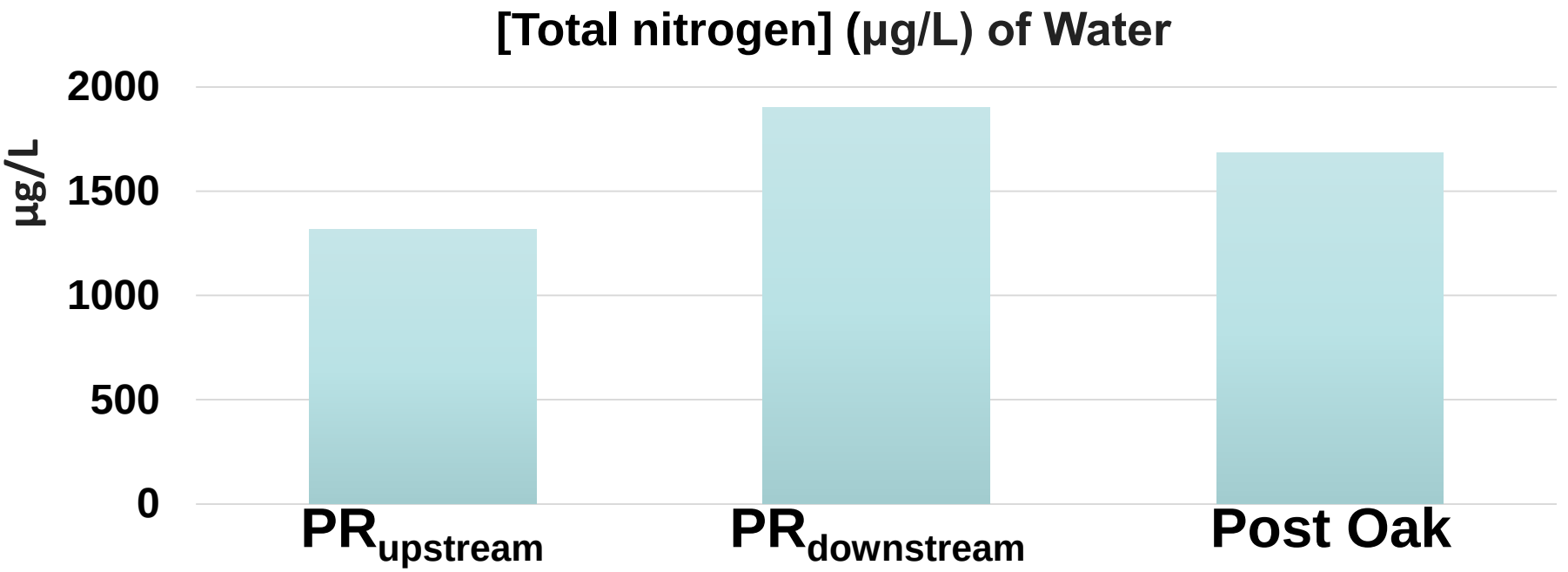
- $PR_{upstream}$ site upstream of the Cookeville Wastewater Treatment Plant.
- $PR_{downstream}$ site is downstream of the treatment plant
- 1 in Post Oak Creek.

- [TP] at the $PR_{downstream}$ site was 7 X > relative to the $PR_{upstream}$ and Post Oak sites.



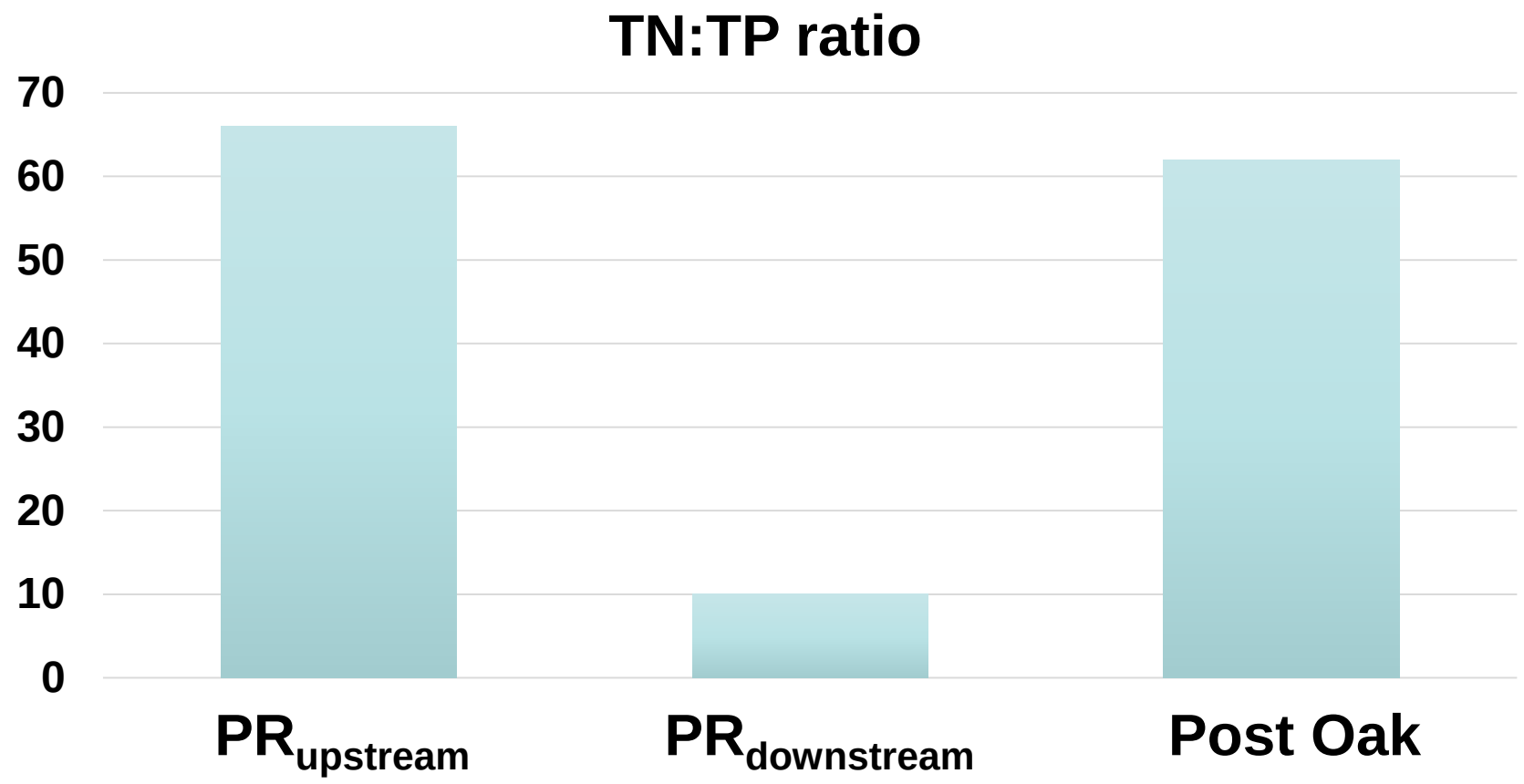
[Total nitrogen]

- range from mesotrophic (700 - 1,500 µg TN/L) to eutrophic [TN].



TN:TP ratio

- lowest at $PR_{downstream}$ site (TN/TP = 9.8).
- is at the value hypothesized to result in N limitation for algae growth ($\leq$ 10).



Tested null Ho: no change in the nutrient that limits algal growth due to P enrichment of the $PR_{downstream}$ site

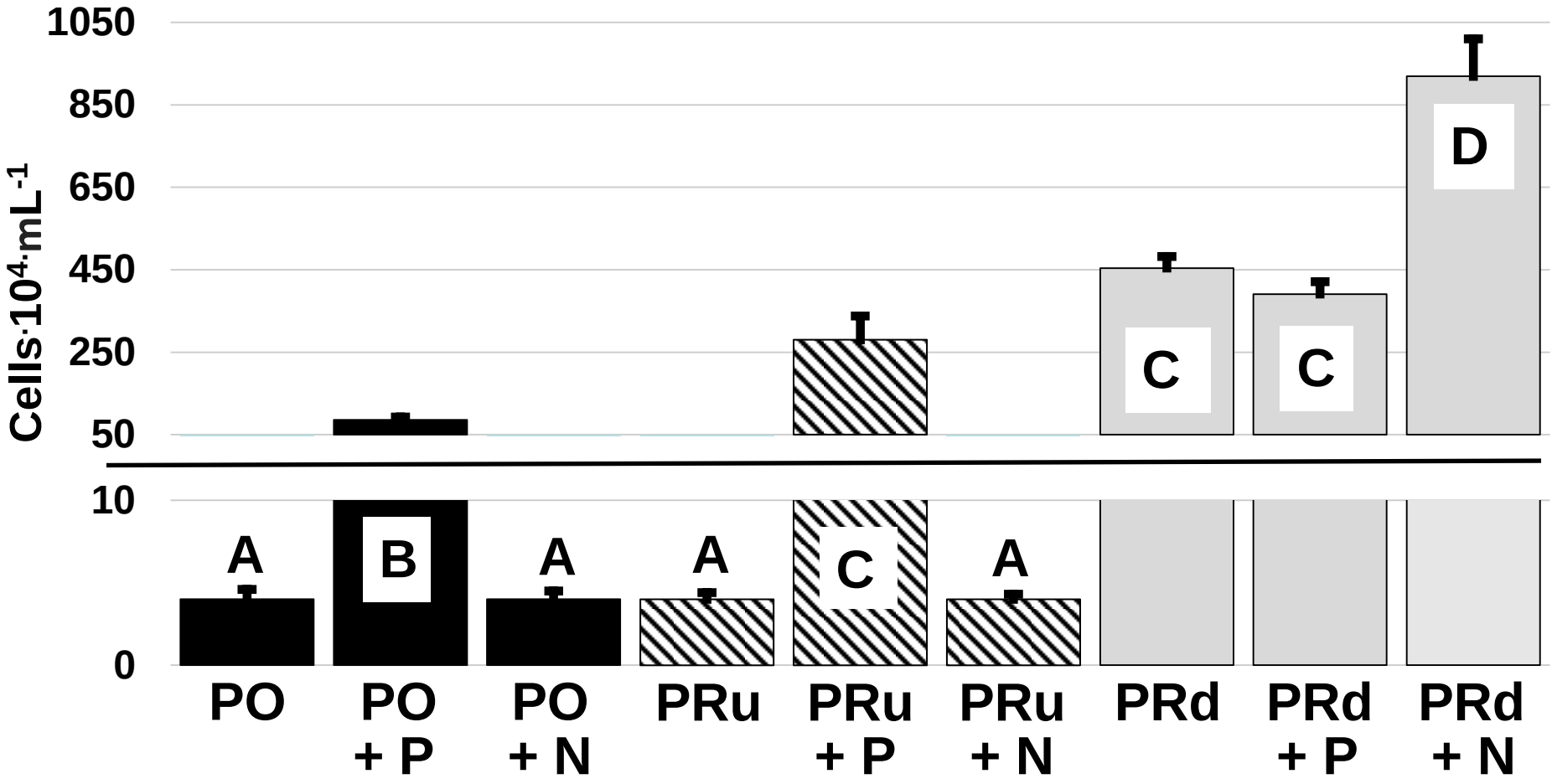
Algal Growth Potential Tests

- *S. capricornutum* cells (1 X 10^4 cells/mL) were added to collected stream water.

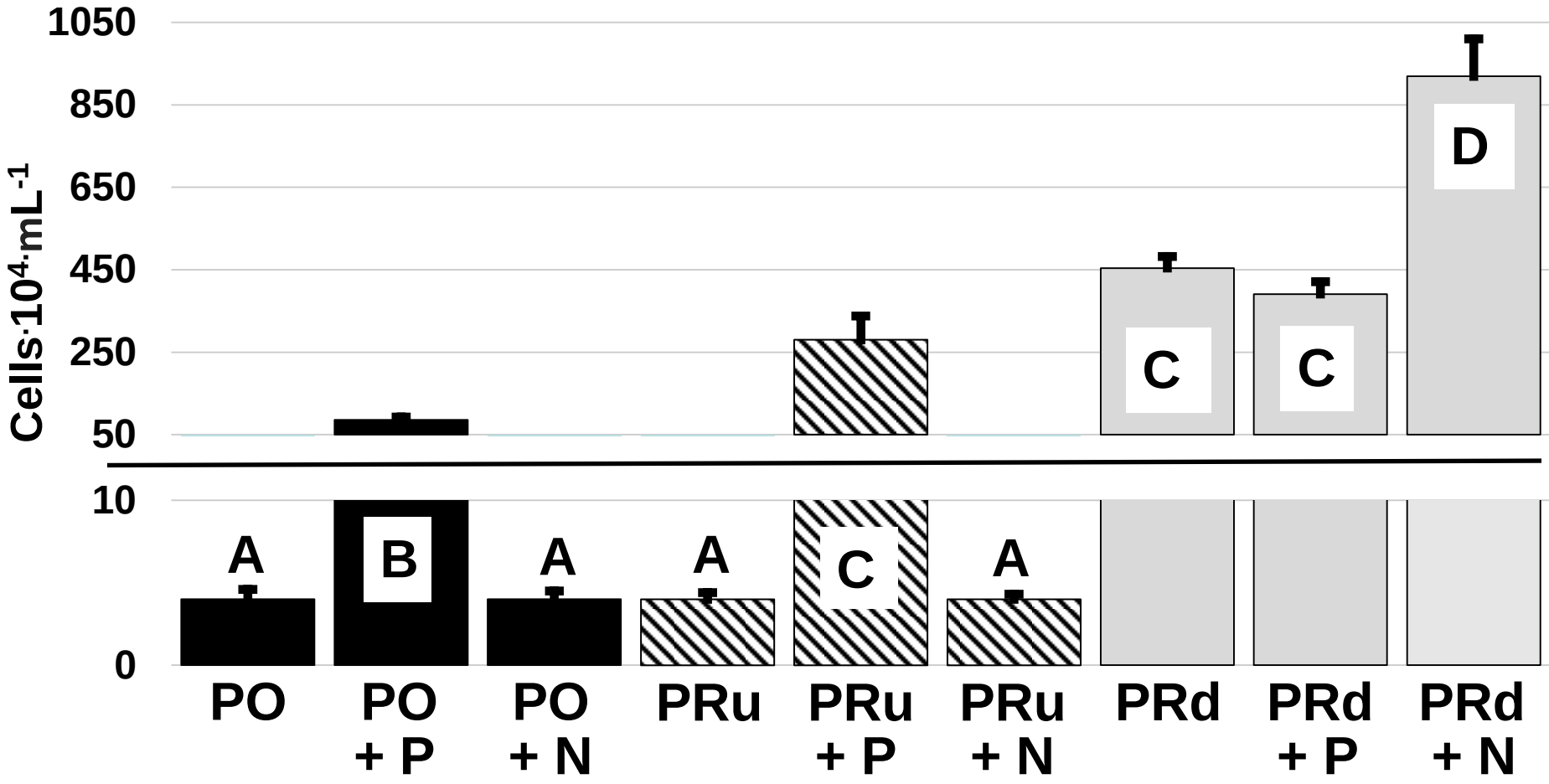
- water subjected to 3 nutrient treatments (4 replicates/treatment):
    1. Controls (no nutrients added).
    2. + P (200 µg $P0_4$/L)
    3. + N (2000 µg NO_3/L)

- cells were grown under standard conditions (50 umol photons·m^{-2}·s^{-1}, 30 rotations/min at 24^{O}C) for 10 d.

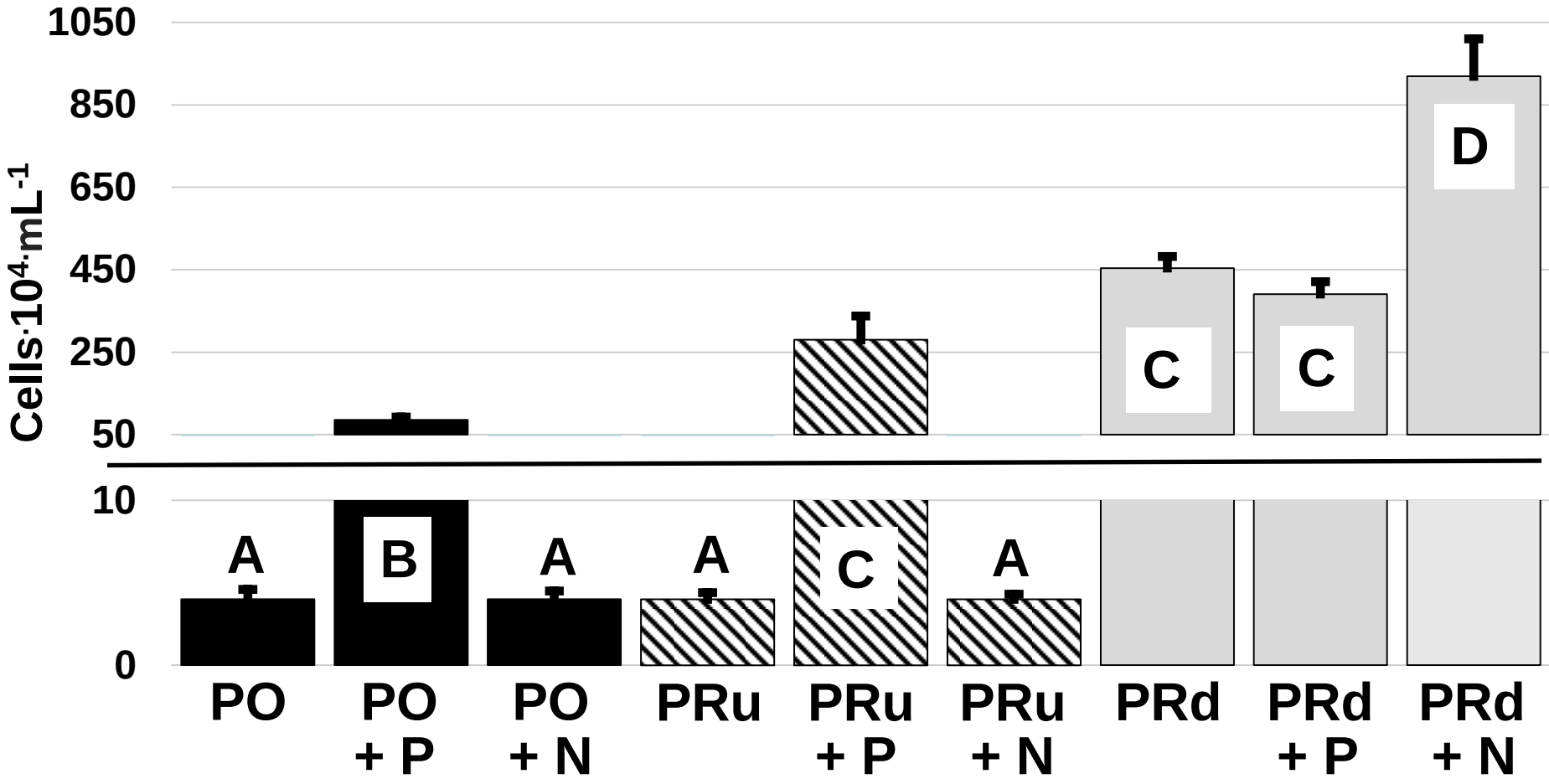
Fig. 3. Carrying capacity (cells·10^4·mL^{-1}) for *S. capricornutum* of Post Oak (PO), Pigeon Roost upstream (PRu), and Pigeon Roost downstream (PRd) sites with no nutrients added (controls), + P treatments, and + N treatments.
Means are significantly different if they do not share the same letter.



- P limited growth in water from $PR_{upstream}$ site.
  - mean carrying capacity for $PR_{upstream}$ + P treatment > the $PR_{upstream}$ control and $PR_{upstream}$ + N treatments.



- N limited growth in water collected at the $PR_{downstream}$ site.
  - mean carrying capacity for the $PR_{downstream}$ + N treatment is > carrying capacity of all other treatments.



Conclusions

- Reduction of the TN:TP ratio between the $PR_{upstream}$ and $PR_{downstream}$ sites changed the nutrient that limits the carrying capacity for *S. capricornutum* from P to N.

- Negative impacts of P enrichment of a watershed may be masked at sites near the P source due to N limitation of growth.

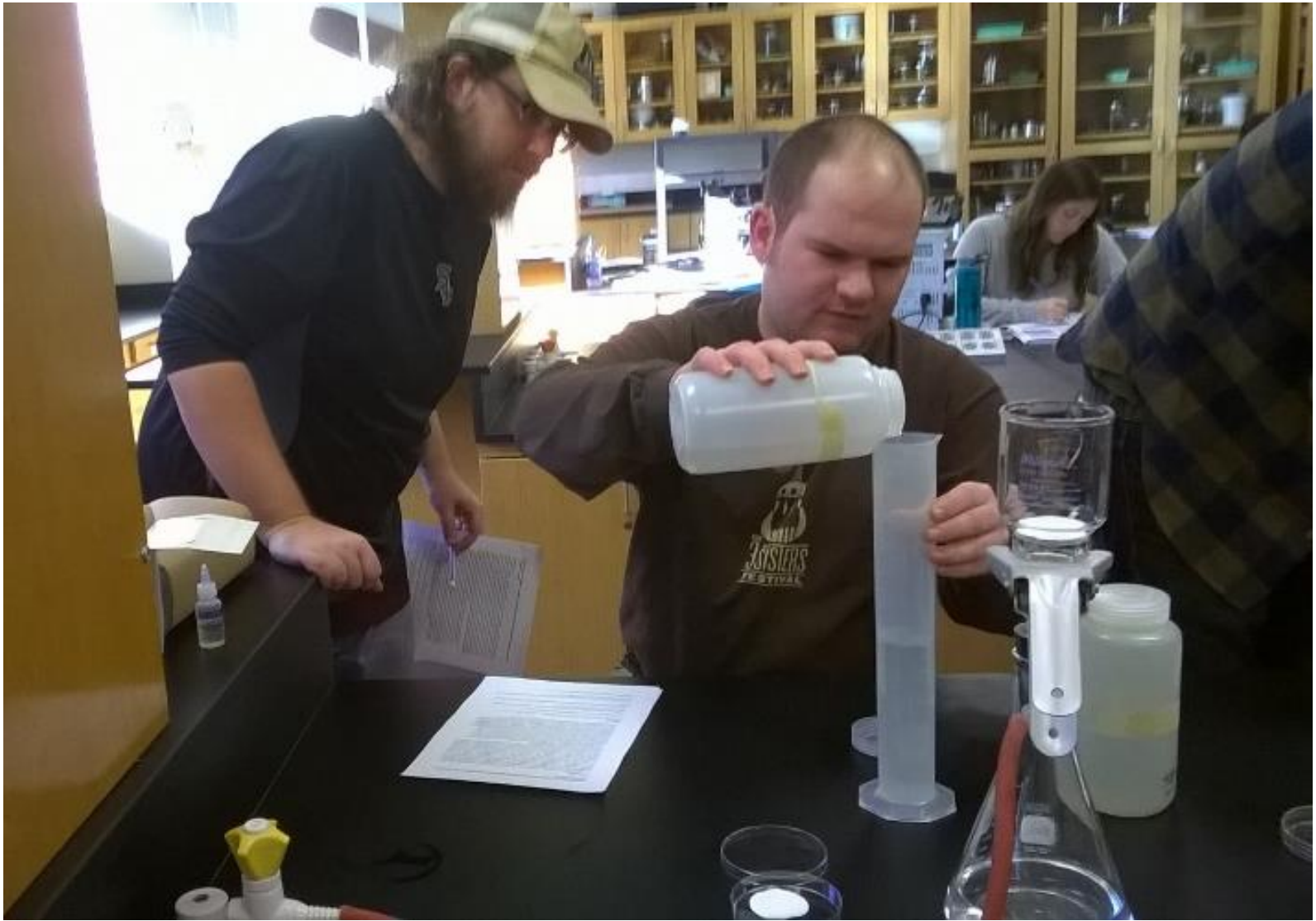

HARPETH
SM
CONSERVANCY

- [P] limits algae growth in most freshwater systems in Europe and North America (Schindler et al. 2016).

Cut phosphorus to reduce algae blooms, say scientists
Schindler et al. 2016

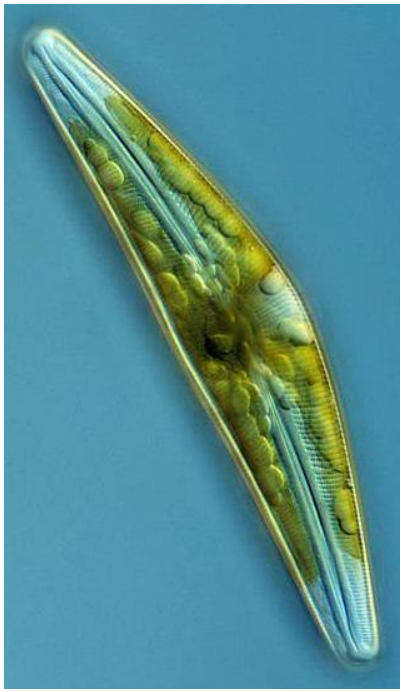
Several prominent Canadian and American scientists are urging governments around the world to focus on controlling phosphorus to decrease the frequency and intensity of algal blooms in freshwaters.

Algal bloom in Manitoba's Lake Killarney.


3SISTERS

Diatom trophic indices

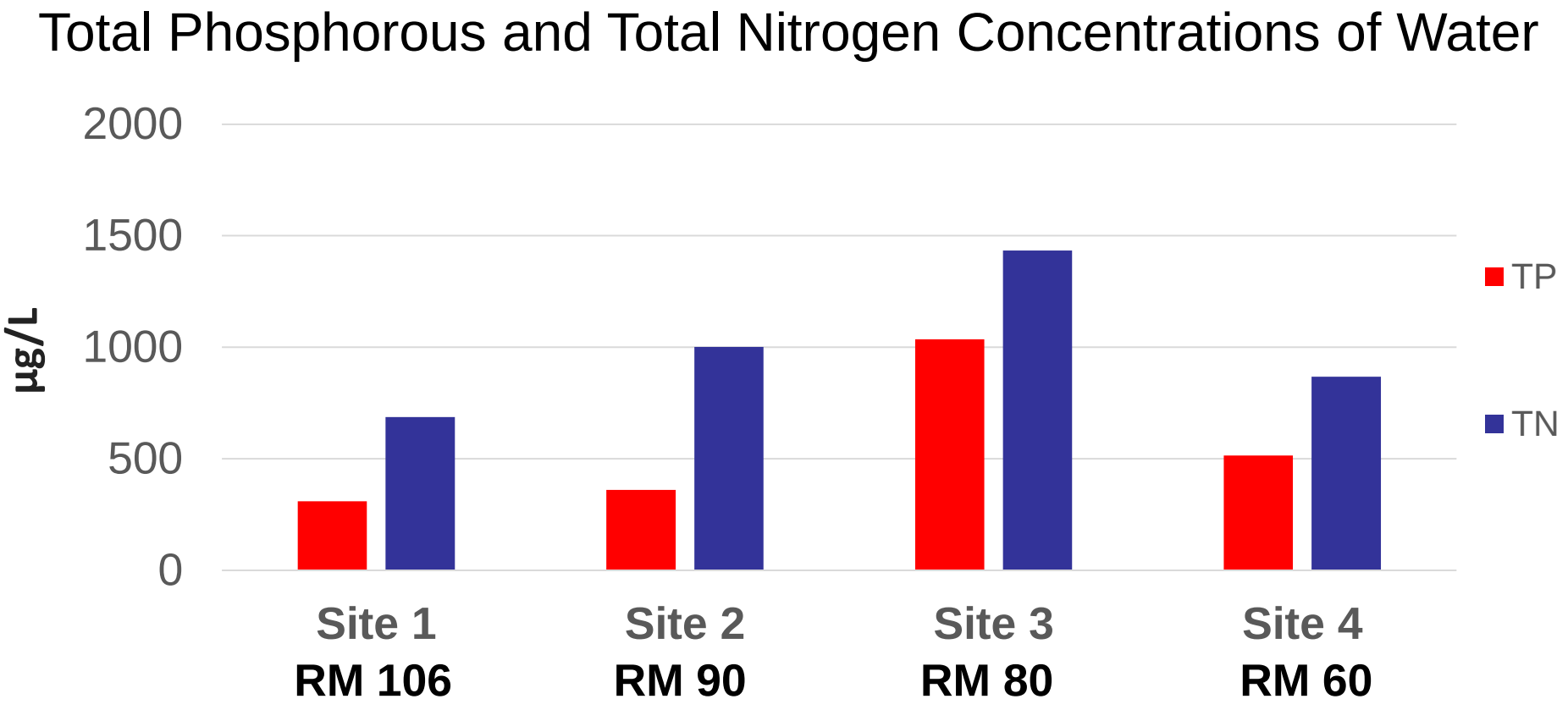
- based on the relative abundances of sp. w/ known preferences for [nutrient].
- used to follow changes of water quality by many European countries and states, including TX, OK, MT, KY, TN.



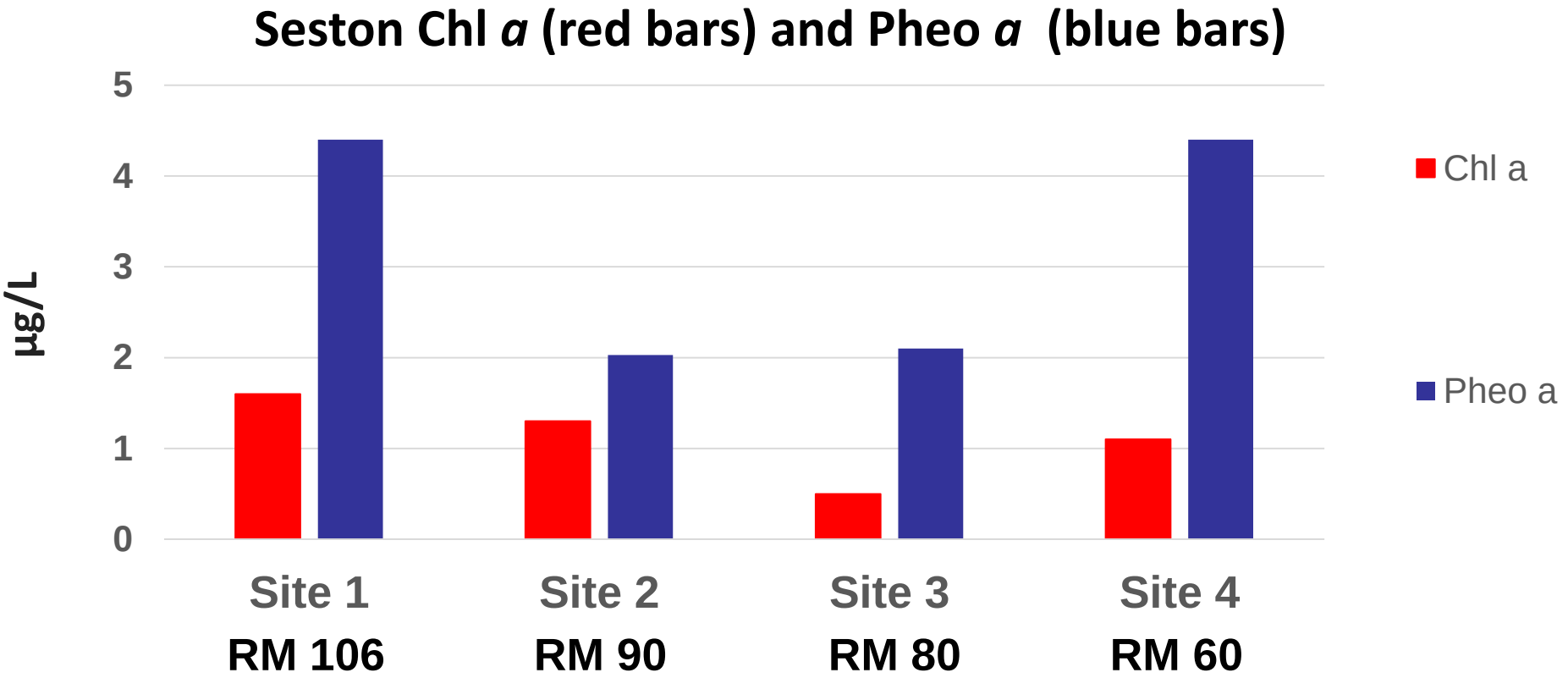
Cymbella affinis

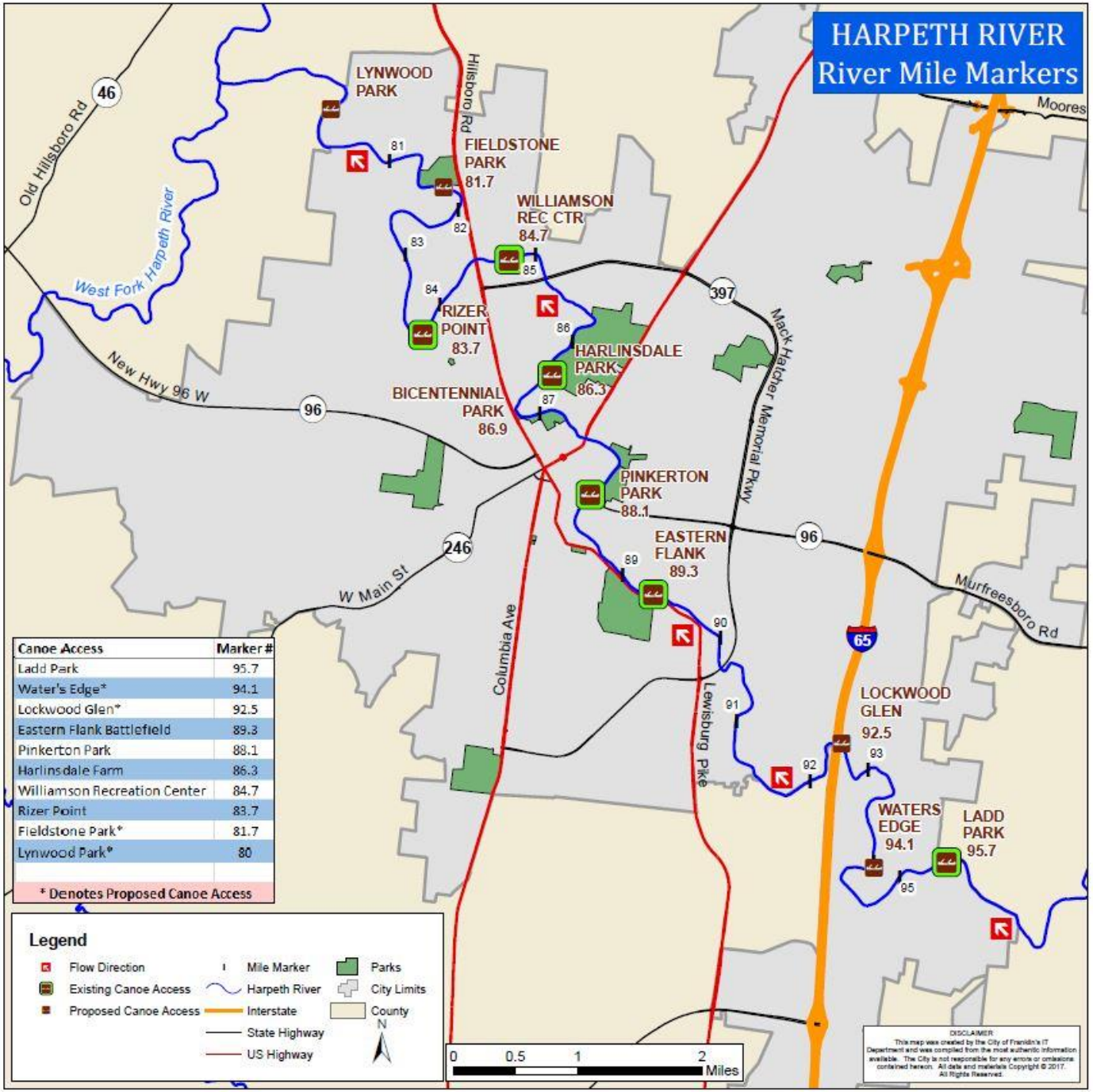
- abundant in mesotrophic water.

Total Phosphorous and Total Nitrogen Concentrations of Water

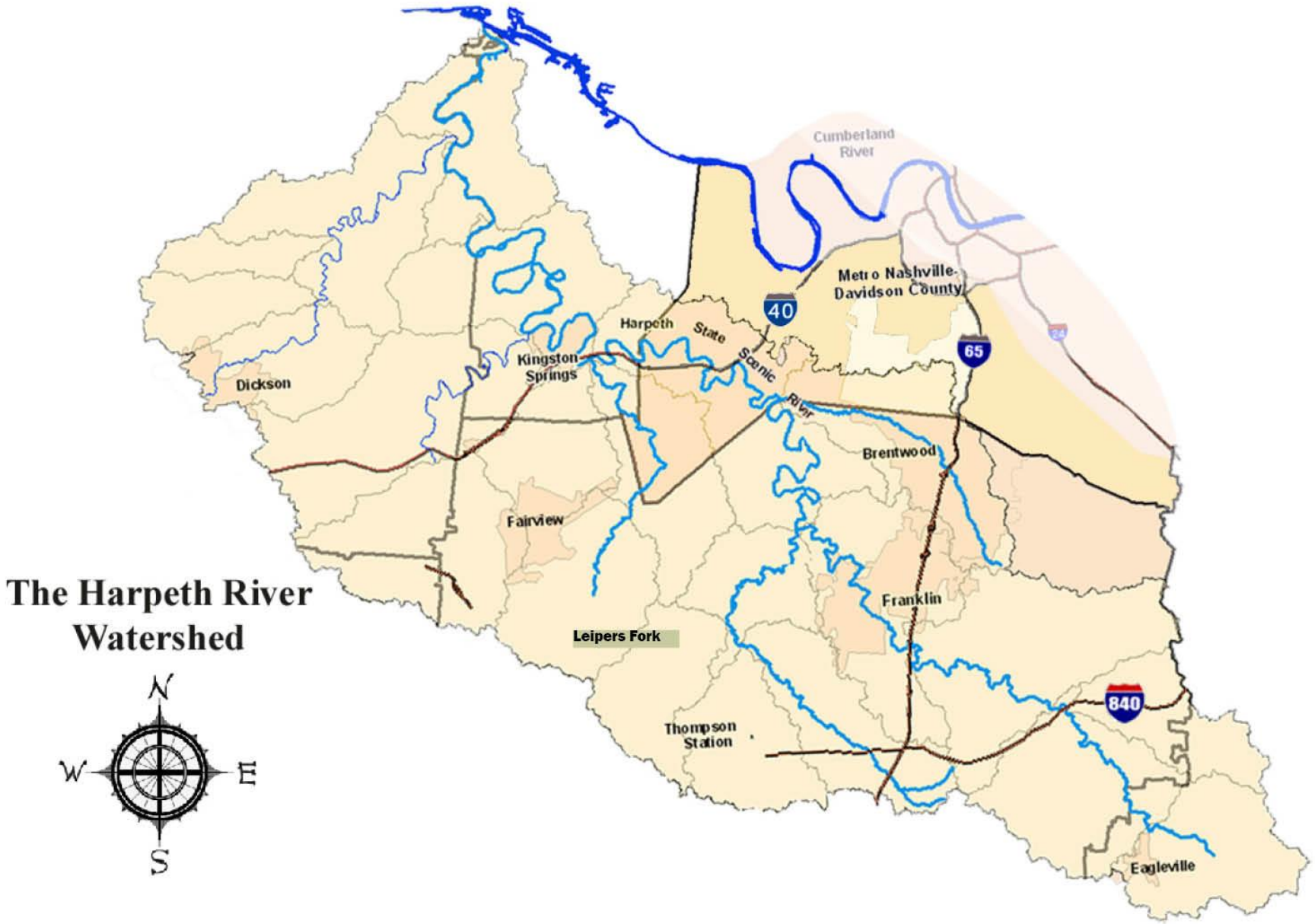


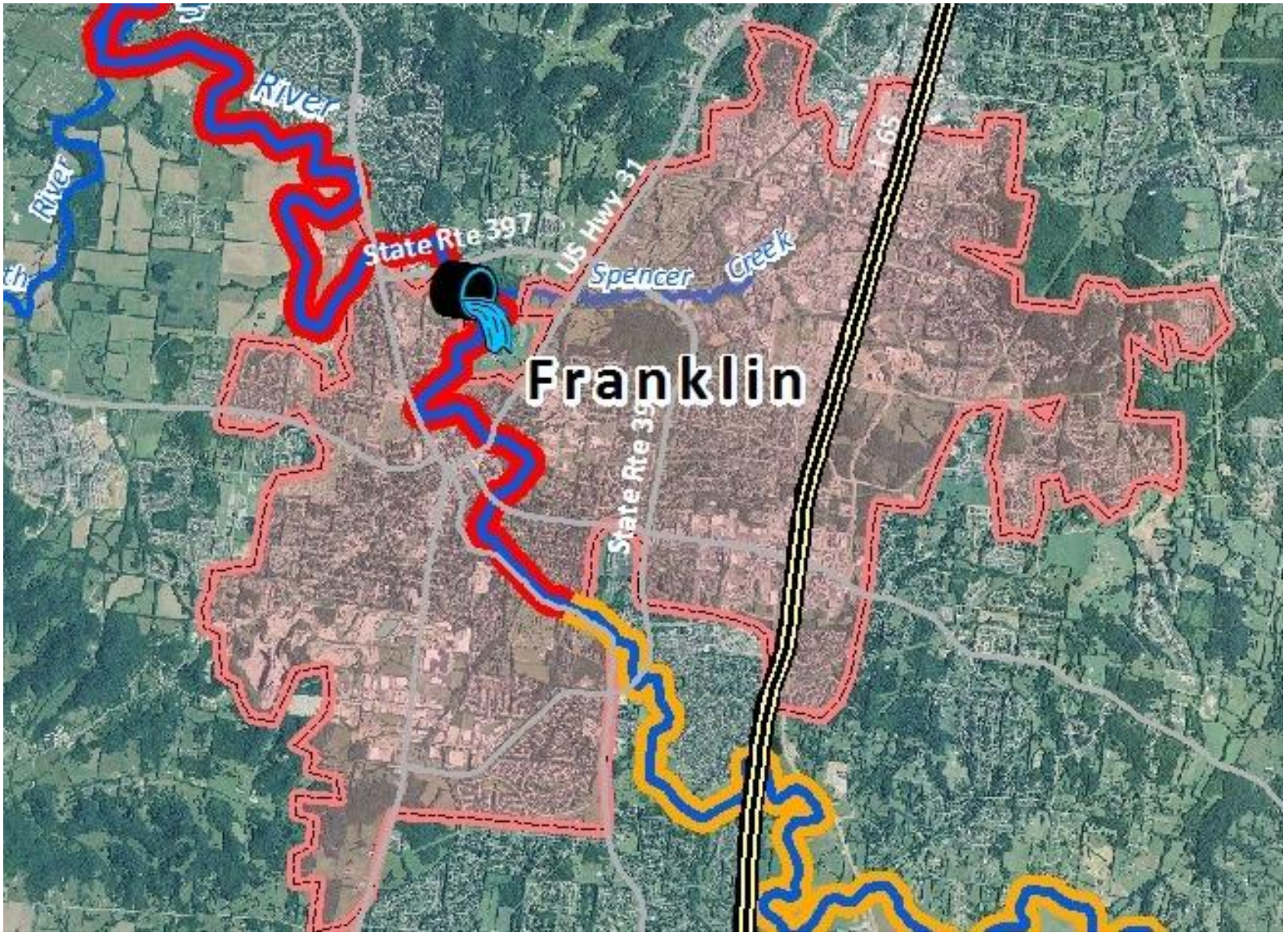
- seston [chl a]
  - below threshold (8 µg/L) used to designate eutrophic status (Dodds 2006).

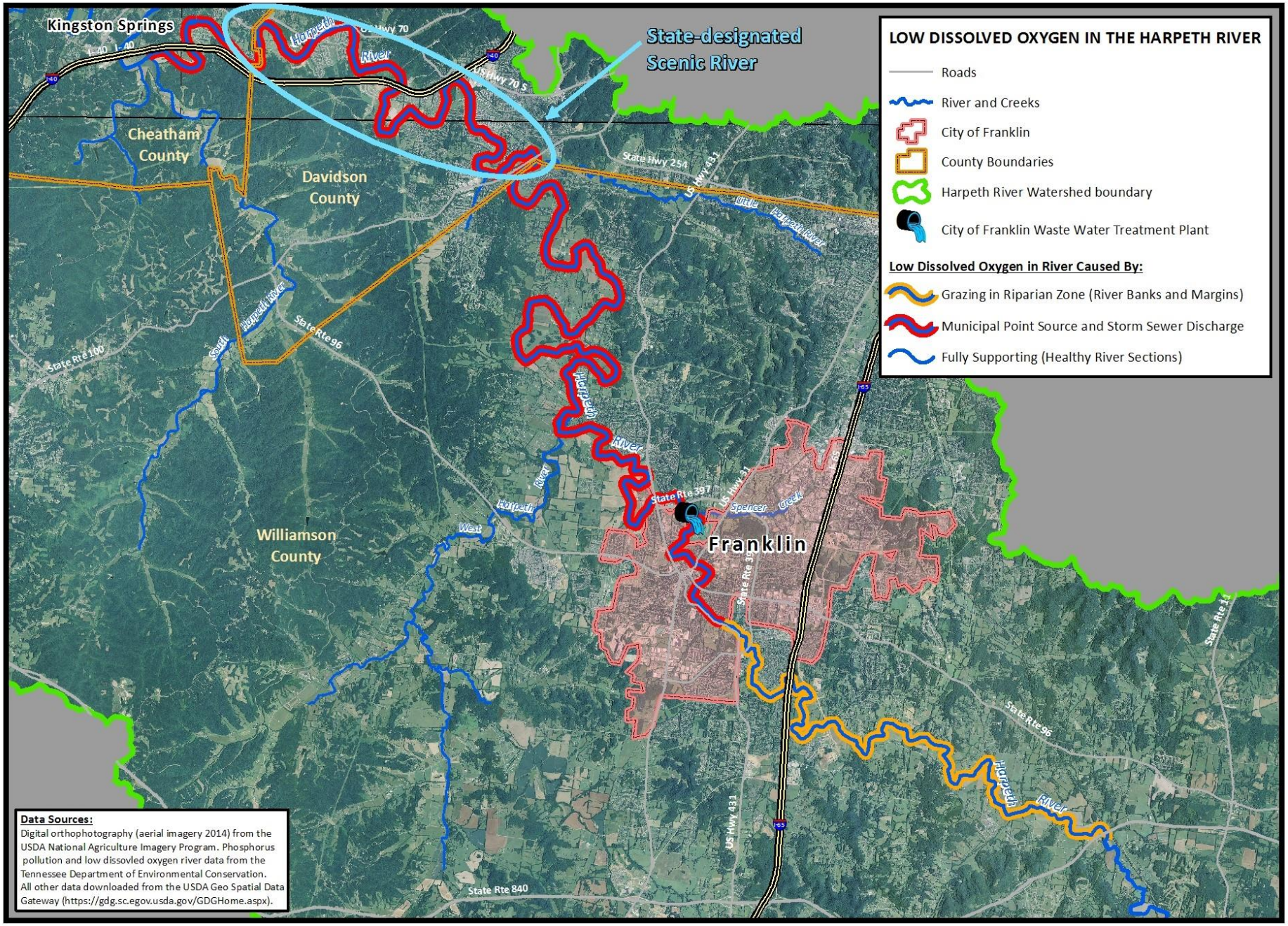



HARPETH RIVER
River Mile Markers
LYNWOOD PARK
FIELDSTONE PARK 81.7
WILLIAMSON REC CTR 84.7
RIZER POINT 83.7
HARLINSDALE PARK 86.3
BICENTENNIAL PARK 86.9
PINKERTON PARK 88.1
EASTERN FLANK 89.3
LOCKWOOD GLEN 92.5
WATERS EDGE 94.1
LADD PARK 95.7
Old Hillsboro Rd
Hillsboro Rd
West Fork Harpeth River
New Hwy 96 W
W Main St
Columbia Ave
Lewisburg Pike
Mack Hatcher Memorial Pkwy
Murfreesboro Rd
Moores
46
96
246
397
65
81
82
83
84
85
86
87
89
90
91
92
93
95
Canoe Access | Marker #
Ladd Park | 95.7
Water's Edge* | 94.1
Lockwood Glen* | 92.5
Eastern Flank Battlefield | 89.3
Pinkerton Park | 88.1
Harlinsdale Farm | 86.3
Williamson Recreation Center | 84.7
Rizer Point | 83.7
Fieldstone Park* | 81.7
Lynwood Park* | 80
* Denotes Proposed Canoe Access
Legend
Flow Direction
Existing Canoe Access
Proposed Canoe Access
Mile Marker
Harpeth River
Interstate
State Highway
US Highway
Parks
City Limits
County
N
0 0.5 1 2 Miles
DISCLAIMER
This map was created by the City of Franklin's IT Department and was compiled from the most authentic information available. The City is not responsible for any errors or omissions contained hereon. All data and materials Copyright © 2017. All Rights Reserved.


rpeth River
tershed
N
E
S
Cumberland River
Metro Nashville-Davidson County
Harpeth State Scenic River
Kingston Springs
Dickson
Fairview
Brentwood
Franklin
Leipers Fork
Thompson Station
Eagleville
40
65
840

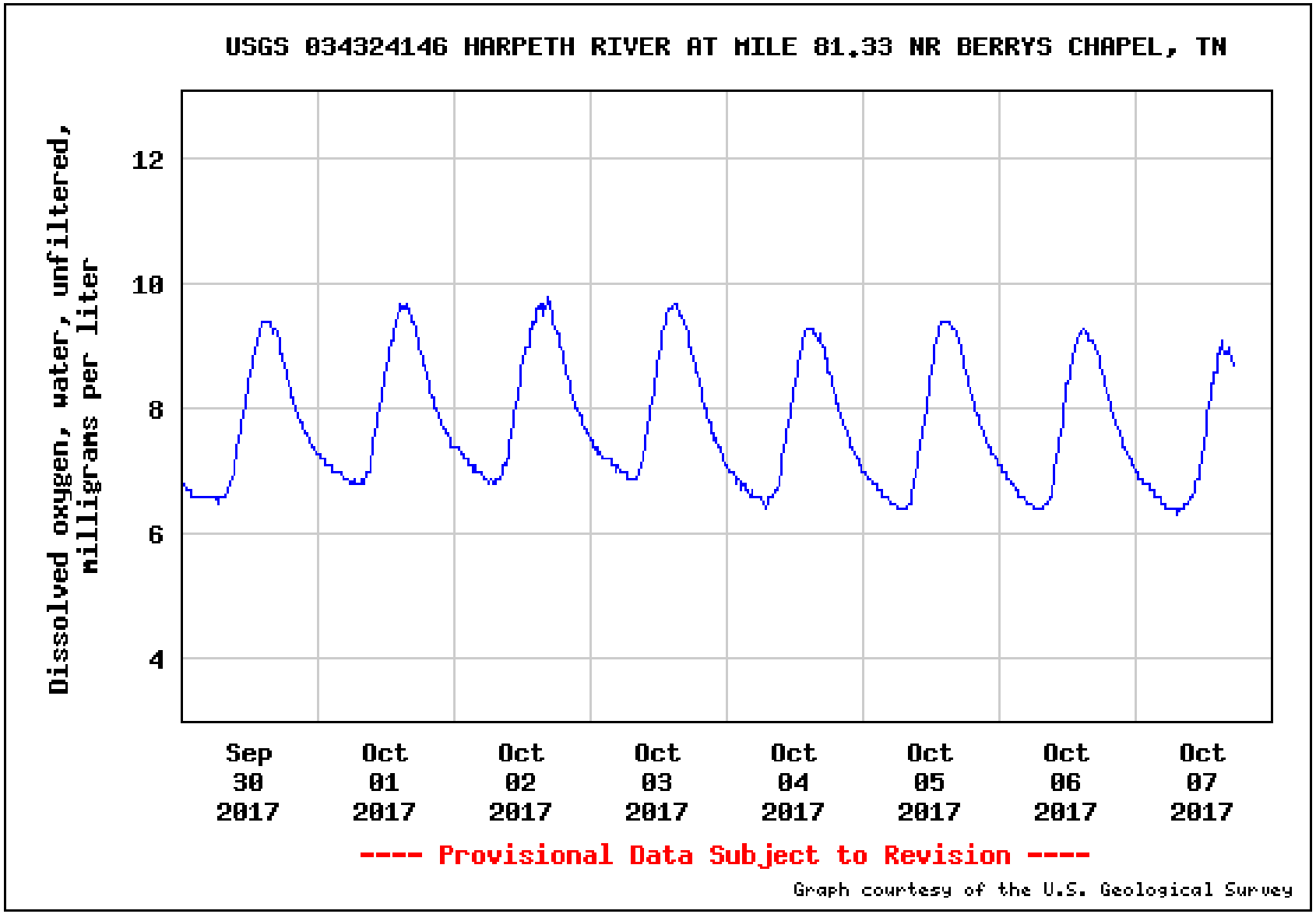

The Harpeth River Watershed
N
W
E
S
Cumberland River
Metro Nashville-Davidson County
40
65
840
Harpeth State Scenic River
Kingston Springs
Dickson
Fairview
Leipers Fork
Brentwood
Franklin
Thompson Station
Eagleville

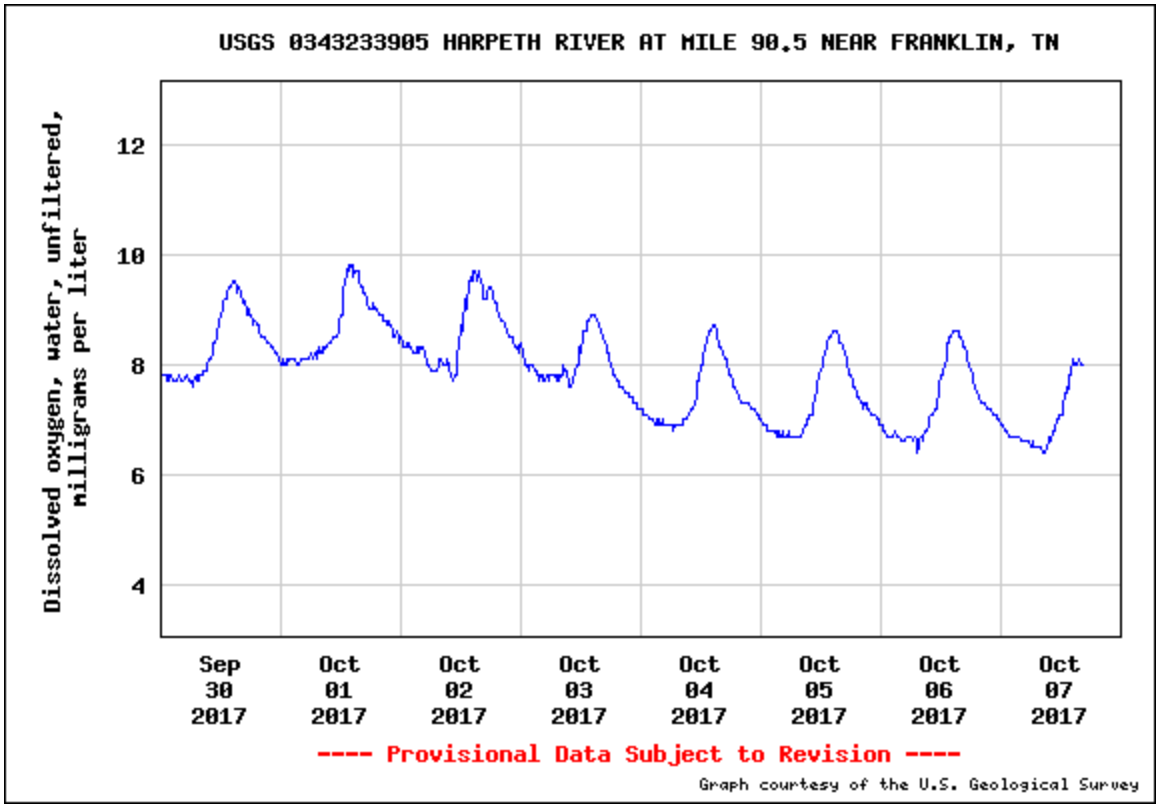

River
River
State Rte 397
US Hwy 31
Spencer Creek
I-65
Franklin
State Rte 39

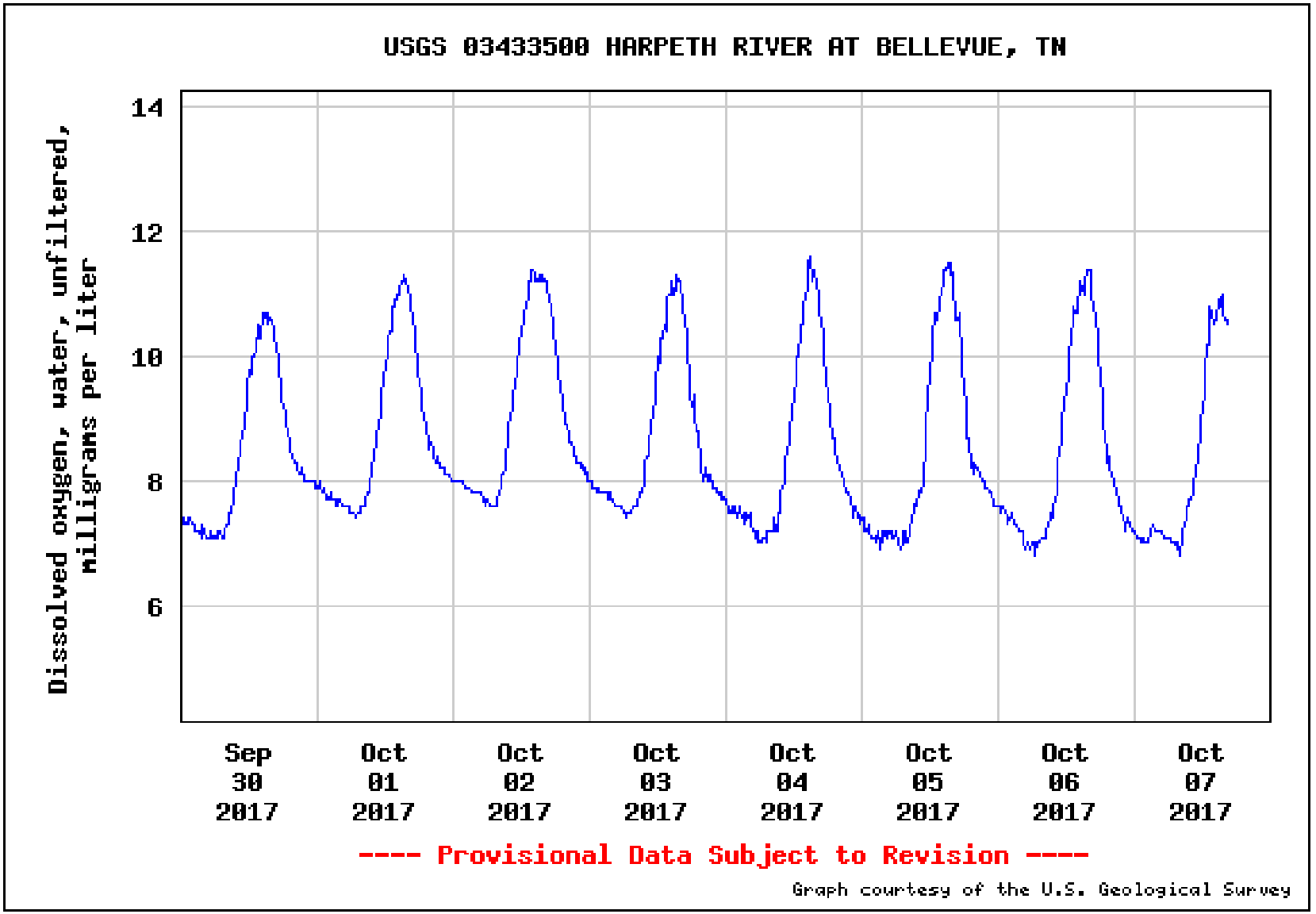

LOW DISSOLVED OXYGEN IN THE HARPETH RIVER
Roads
River and Creeks
City of Franklin
County Boundaries
Harpeth River Watershed boundary
City of Franklin Waste Water Treatment Plant
Low Dissolved Oxygen in River Caused By:
Grazing in Riparian Zone (River Banks and Margins)
Municipal Point Source and Storm Sewer Discharge
Fully Supporting (Healthy River Sections)
State-designated Scenic River
Kingston Springs
Cheatham County
Davidson County
Williamson County
Franklin
Harpeth River
Little Harpeth River
South Harpeth River
West Harpeth River
Spencer Creek
I-40
I-65
US Hwy 70
US Hwy 70 S
US Hwy 431
State Hwy 254
State Rte 96
State Rte 100
State Rte 397
State Rte 840
State Rte 11
Data Sources:
Digital orthophotography (aerial imagery 2014) from the USDA National Agriculture Imagery Program. Phosphorus pollution and low dissovled oxygen river data from the Tennessee Department of Environmental Conservation. All other data downloaded from the USDA Geo Spatial Data Gateway (https://gdg.sc.egov.usda.gov/GDGHome.aspx).

http://www.harpethconservancy.org/watershed-info/water

Lots of info!

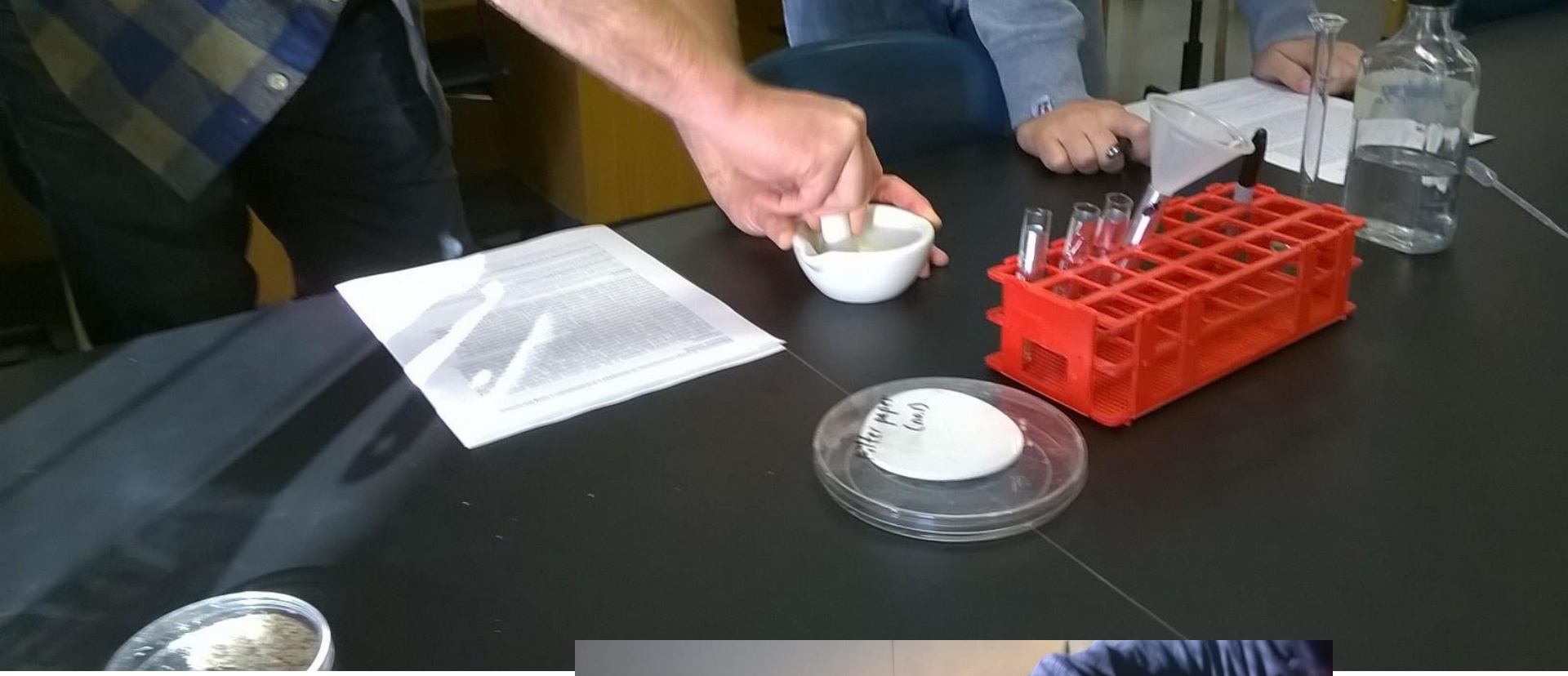

USGS 034324146 HARPETH RIVER AT MILE 81.33 NR BERRYS CHAPEL, TN
Dissolved oxygen, water, unfiltered, milligrams per liter
12
10
8
6
4
Sep 30 2017
Oct 01 2017
Oct 02 2017
Oct 03 2017
Oct 04 2017
Oct 05 2017
Oct 06 2017
Oct 07 2017
---- Provisional Data Subject to Revision ----
Graph courtesy of the U.S. Geological Survey

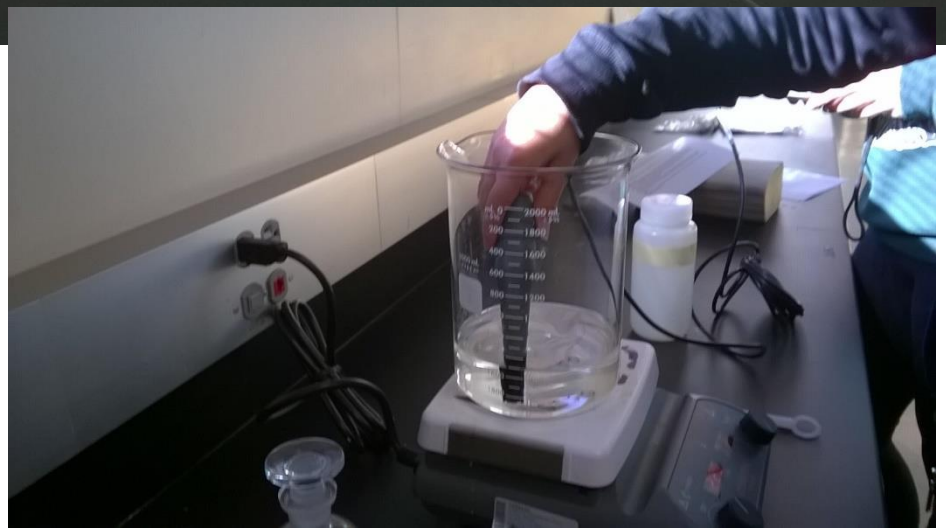

USGS 0343233905 HARPETH RIVER AT MILE 90.5 NEAR FRANKLIN, TN
Dissolved oxygen, water, unfiltered, milligrams per liter
12
10
8
6
4
Sep 30 2017
Oct 01 2017
Oct 02 2017
Oct 03 2017
Oct 04 2017
Oct 05 2017
Oct 06 2017
Oct 07 2017
---- Provisional Data Subject to Revision ----
Graph courtesy of the U.S. Geological Survey

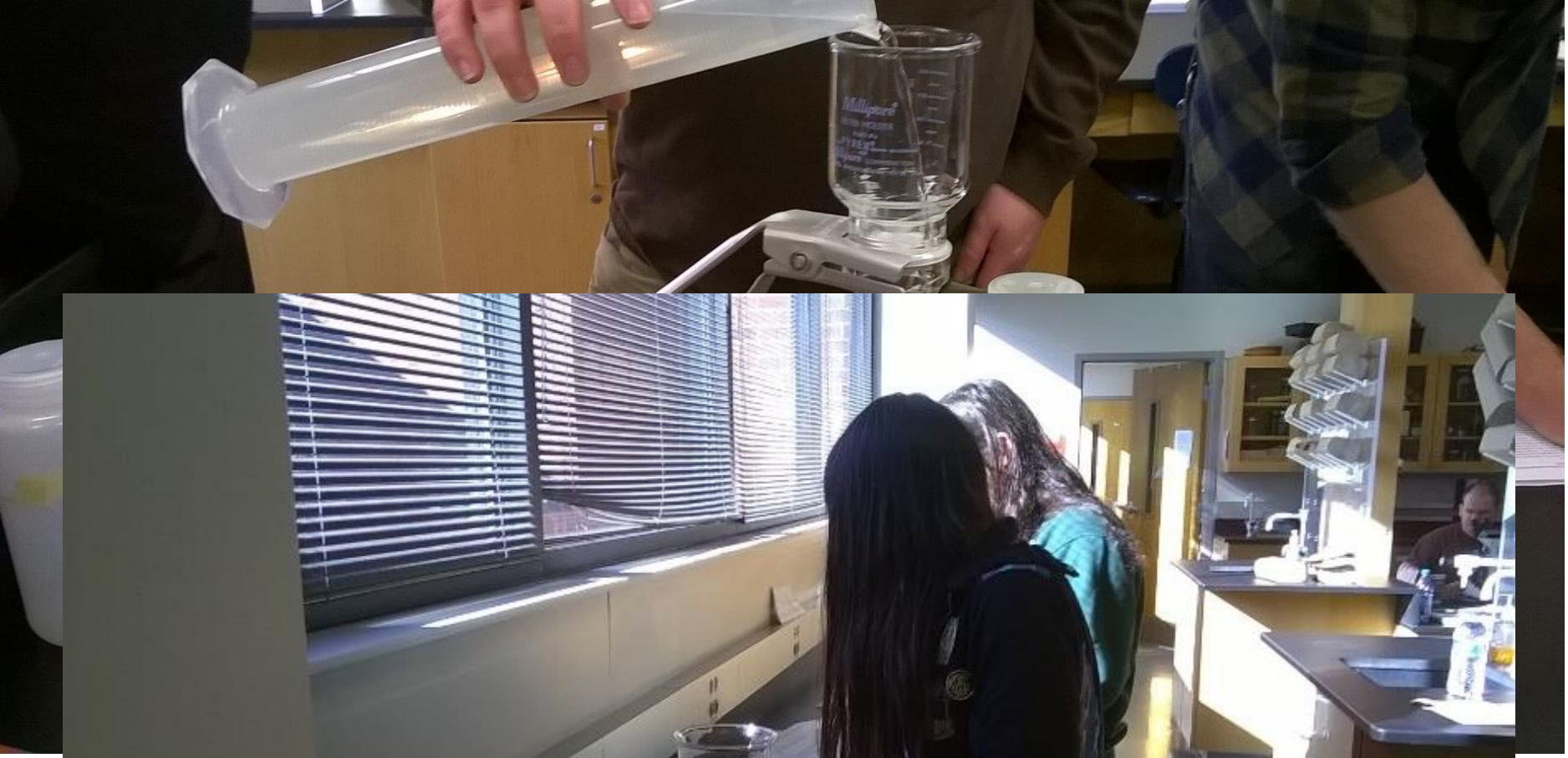

USGS 03433500 HARPETH RIVER AT BELLEVUE, TN
Dissolved oxygen, water, unfiltered, milligrams per liter
14
12
10
8
6
Sep 30 2017
Oct 01 2017
Oct 02 2017
Oct 03 2017
Oct 04 2017
Oct 05 2017
Oct 06 2017
Oct 07 2017
---- Provisional Data Subject to Revision ----
Graph courtesy of the U.S. Geological Survey

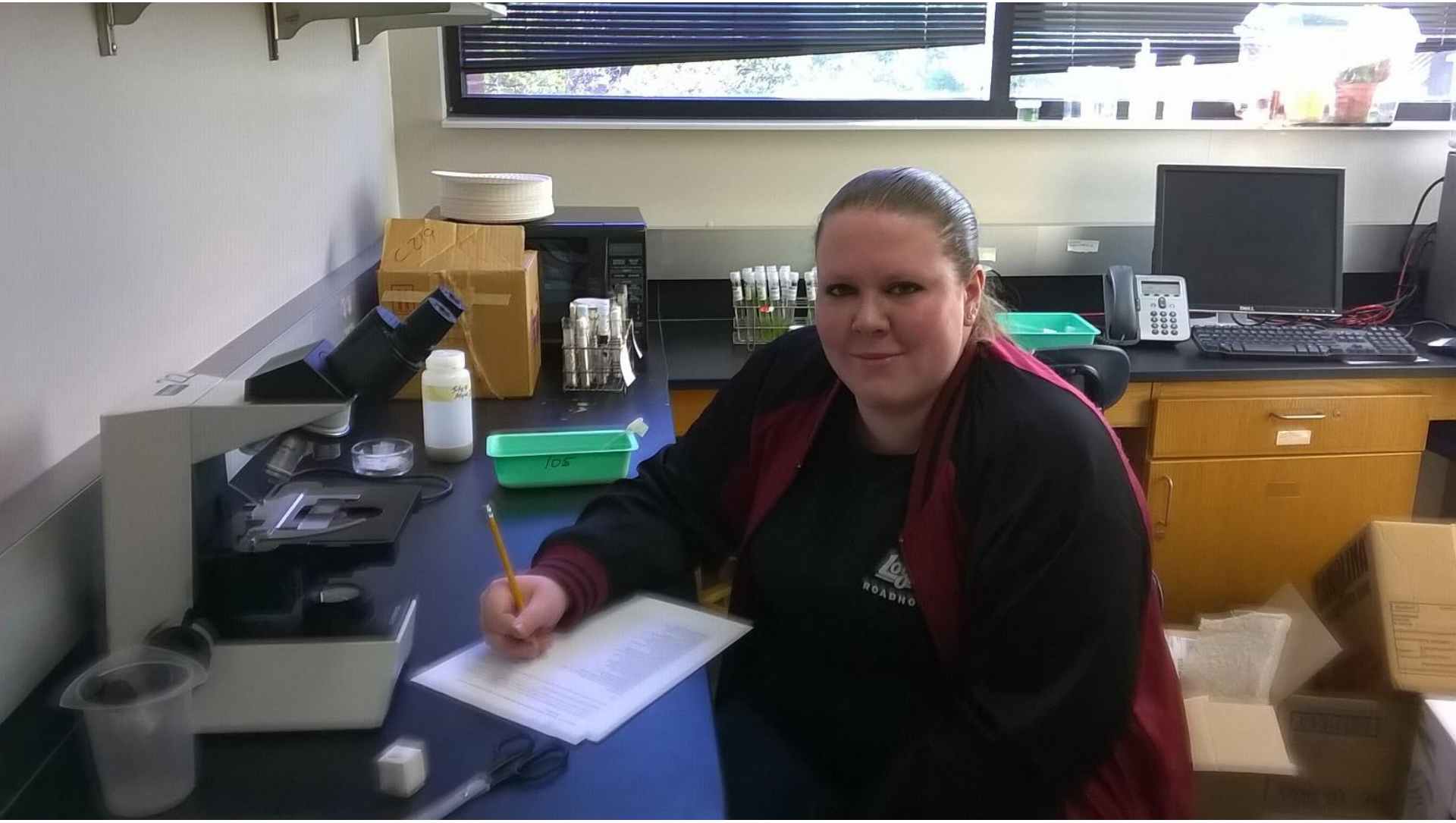
site 1 (RM 106) is located 12 km east-southeast of Franklin, TN in a rural, agricultural region.

Sites two (river mile 90.5) and three (river mile 80) are located densely populated, urban areas of Franklin, TN, 3 km east-southeast of downtown and 5 km northwest of downtown, respectively.



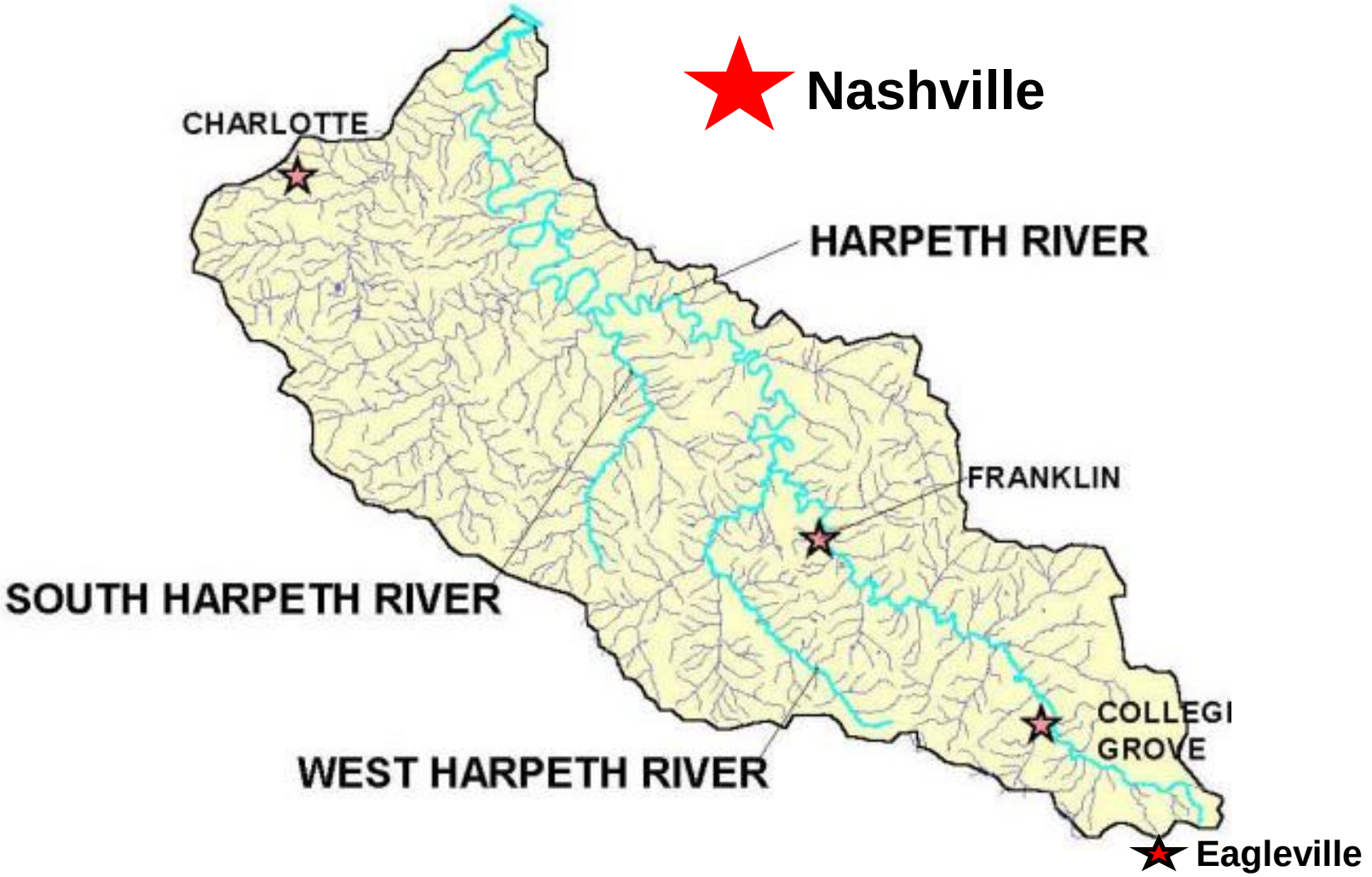



Millipore



The Harpeth River

- flows northwest 185 km from its source near Eagleville, TN.
- enters the Cumberland River northwest of Nashville, TN.



Suggested Boundaries for Trophic Classifications of Streams

Trophic level	TP ($\mu g \cdot L^{-1}$)[A]	TN ($\mu g \cdot L^{-1}$)[A]	Chl a ($mg \cdot m^{-2}$)[A]	AFDM ($g \cdot m^{-2}$)[B]	Seston chl a ($\mu g/L$)[C]
Oligo-trophic	< 25	< 700	0 - 19	< 5	
Meso-trophic	25 - 75	$\underline{\geq}$ 700 - 1500	20 - 69	5 - 10	
Eu-trophic	> 75	> 1500	> 70	> 10	> 8

[A] Dodds et al. (1998).

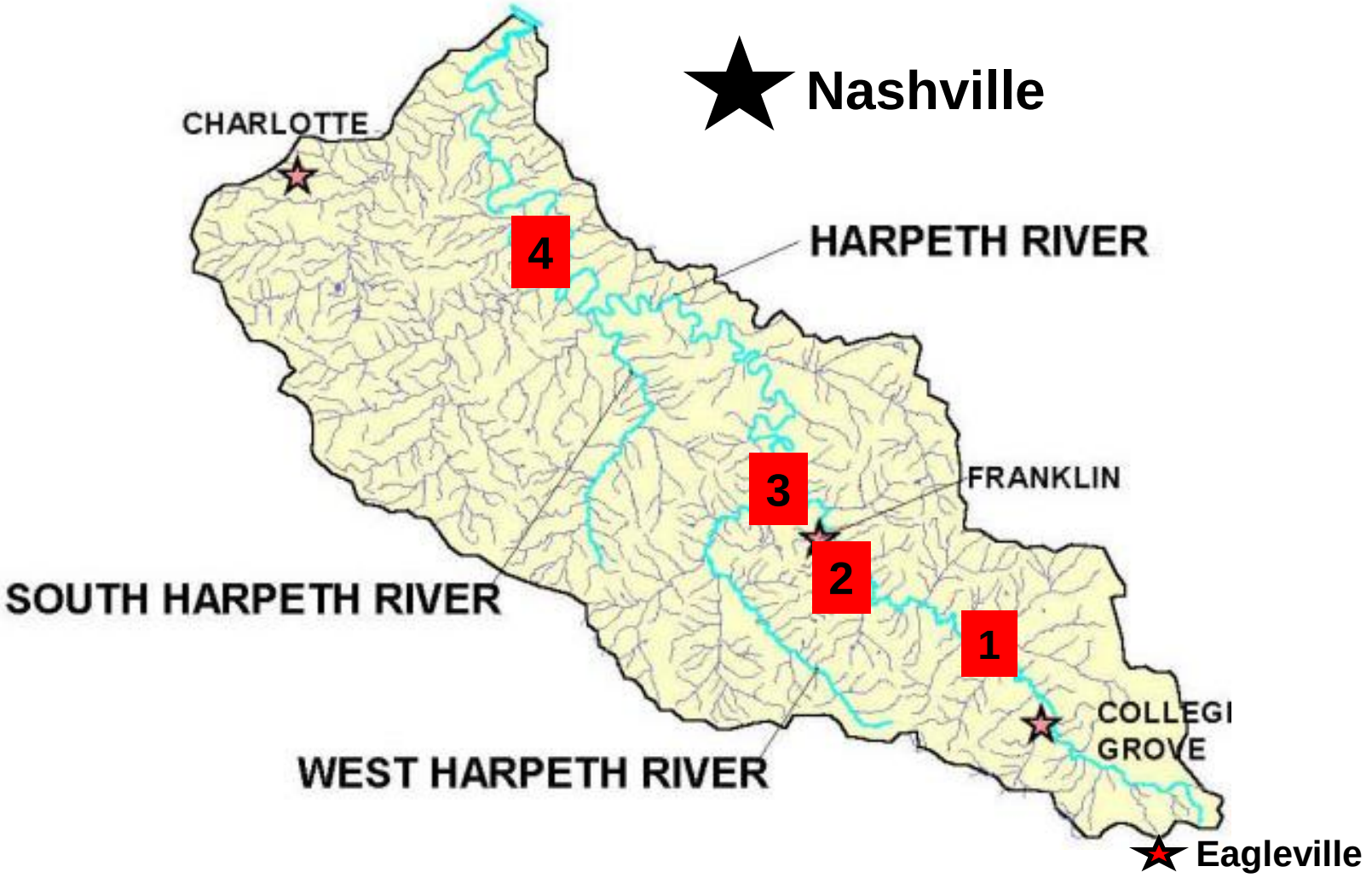
[B] Estimates based on data from Lebkuecher et al. (2015), Grimmett and Lebkuecher (2017), O'Brien and Wehr (2010).

[C] Dodds (2006).

City of Franklin Wastewater Treatment Plant

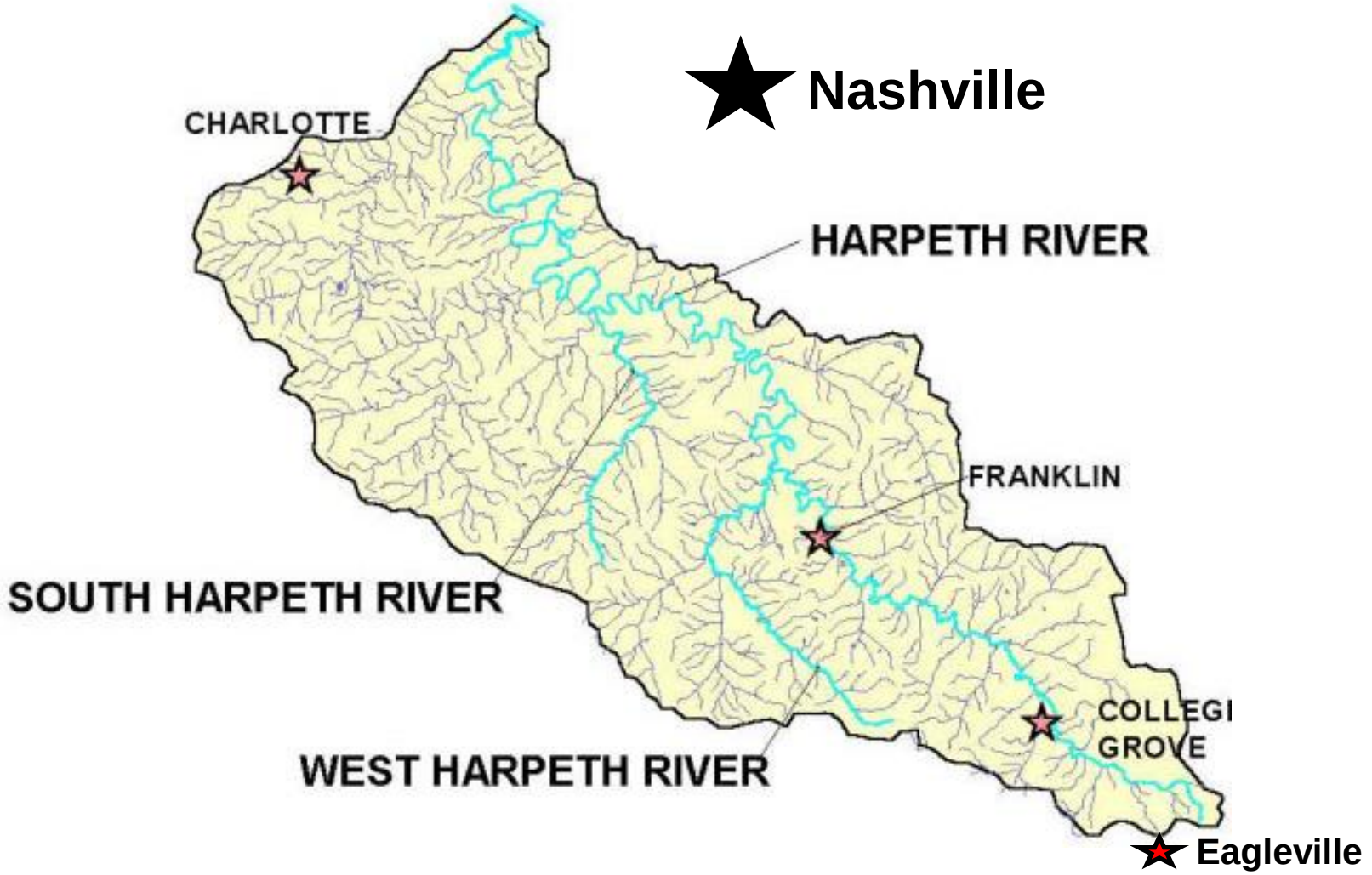
The Harpeth River

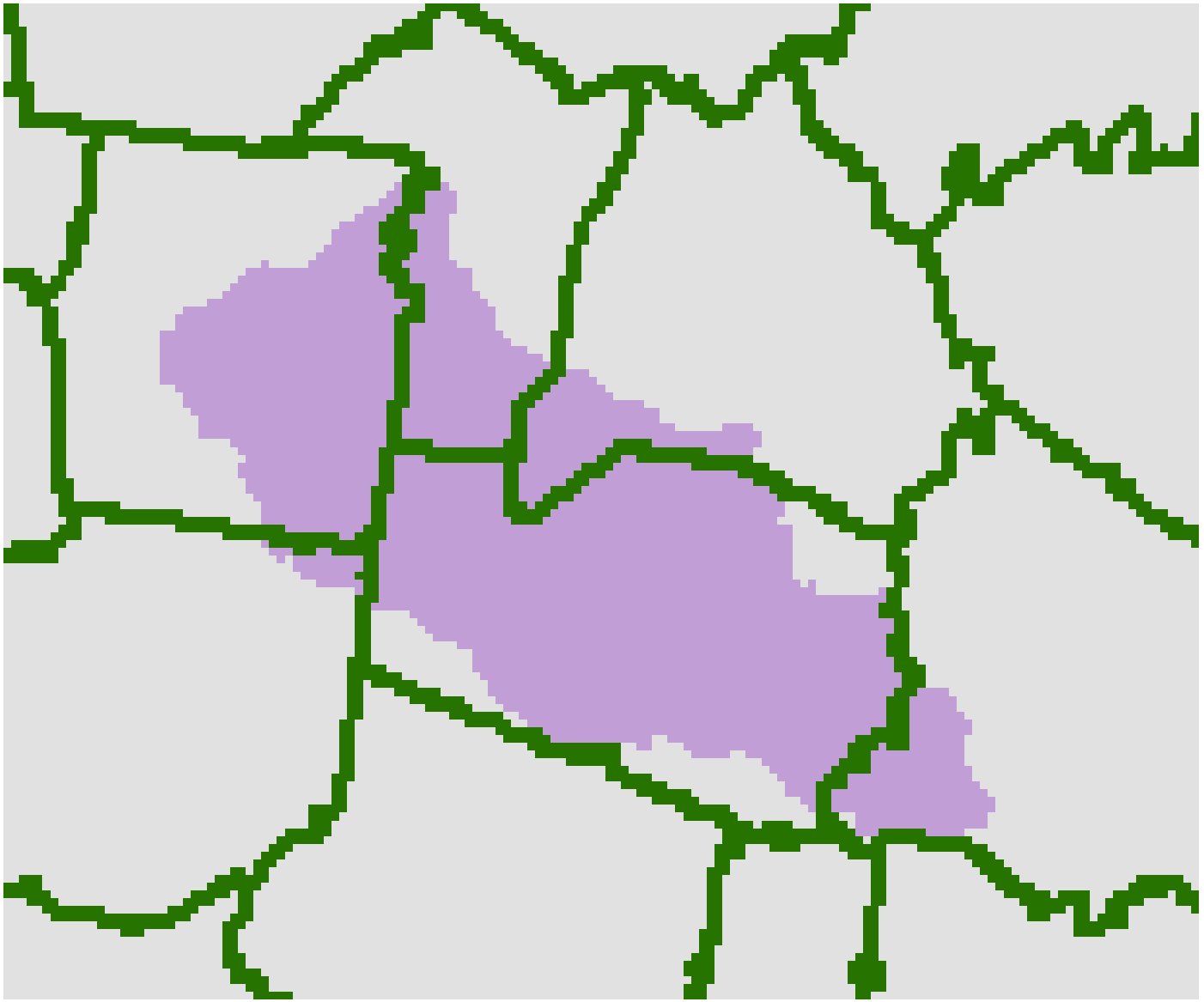
- flows northwest 185 km from its source near Eagleville, TN.
- enters the Cumberland River northwest of Nashville, TN.

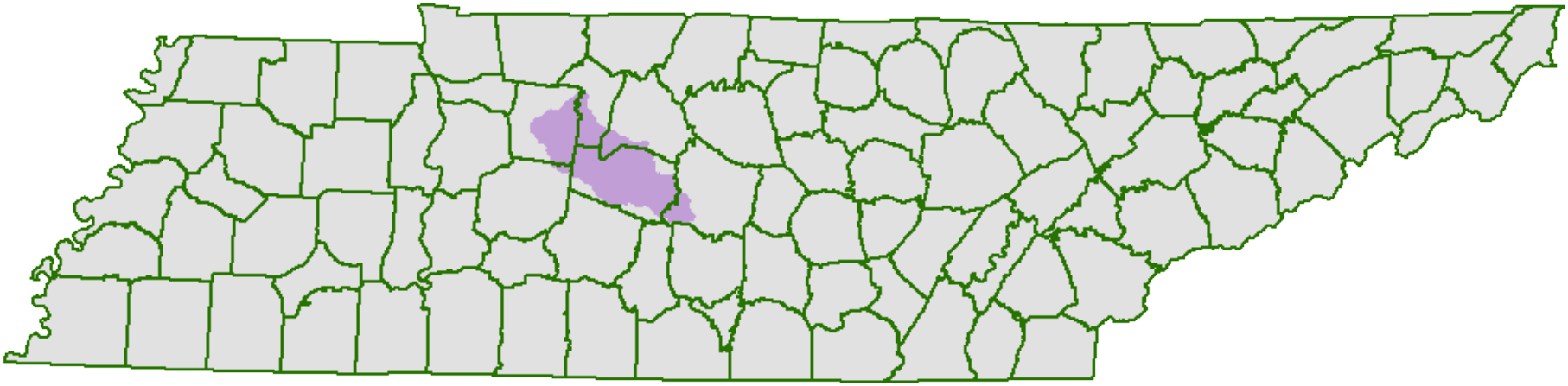


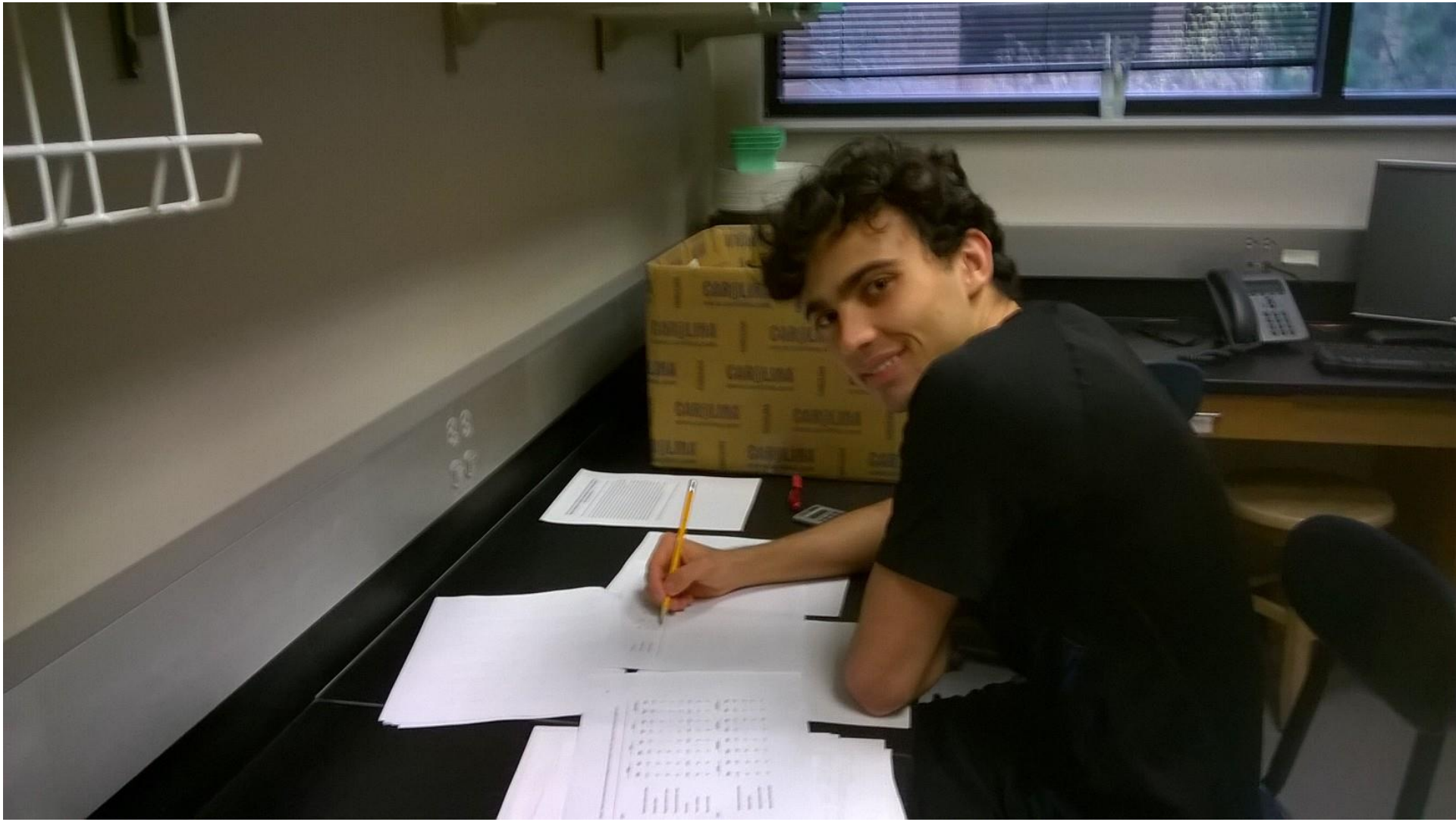
The Harpeth River

- flows northwest 185 km from its source near Eagleville, TN.
- enters the Cumberland River northwest of Nashville, TN.

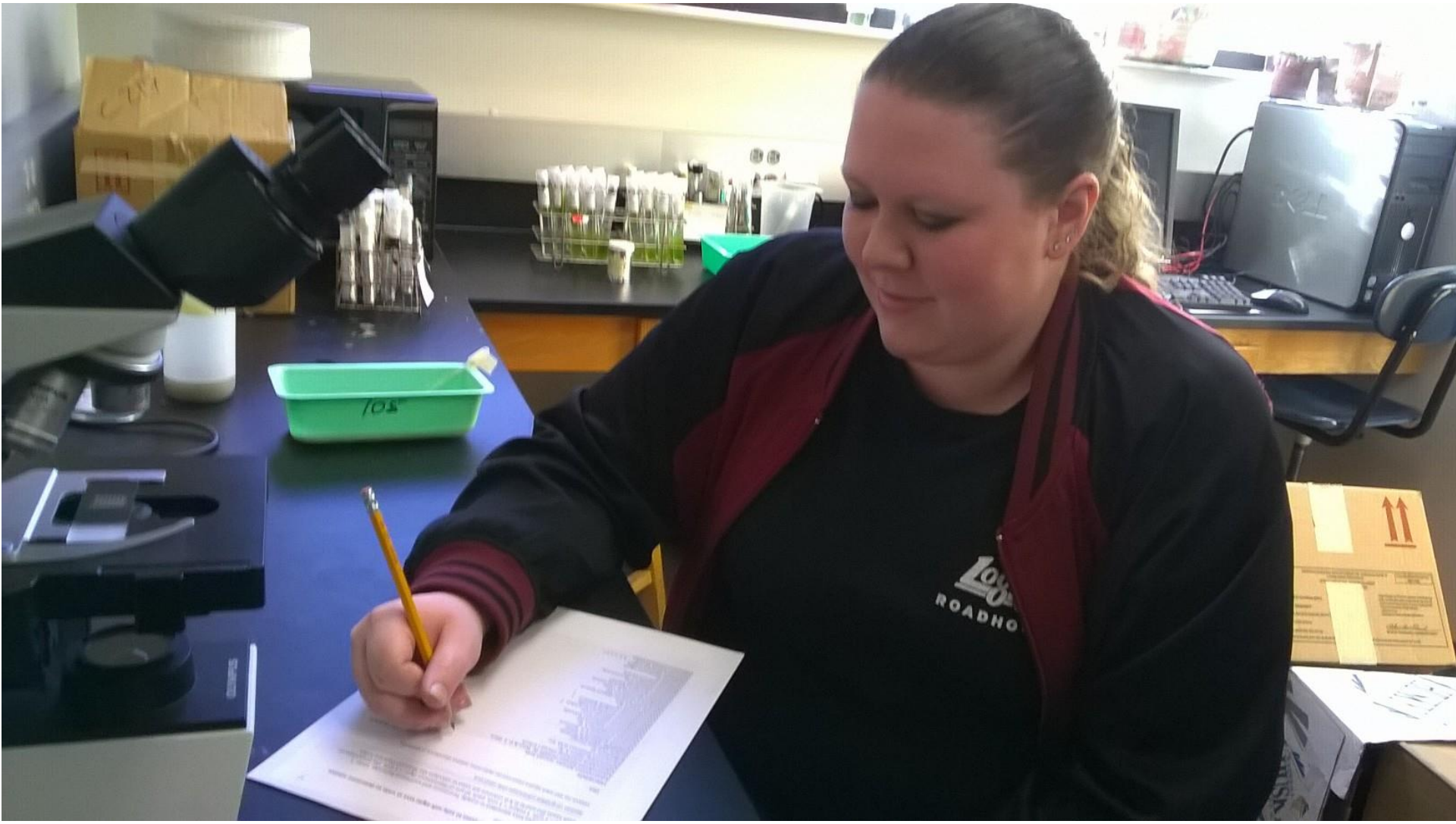








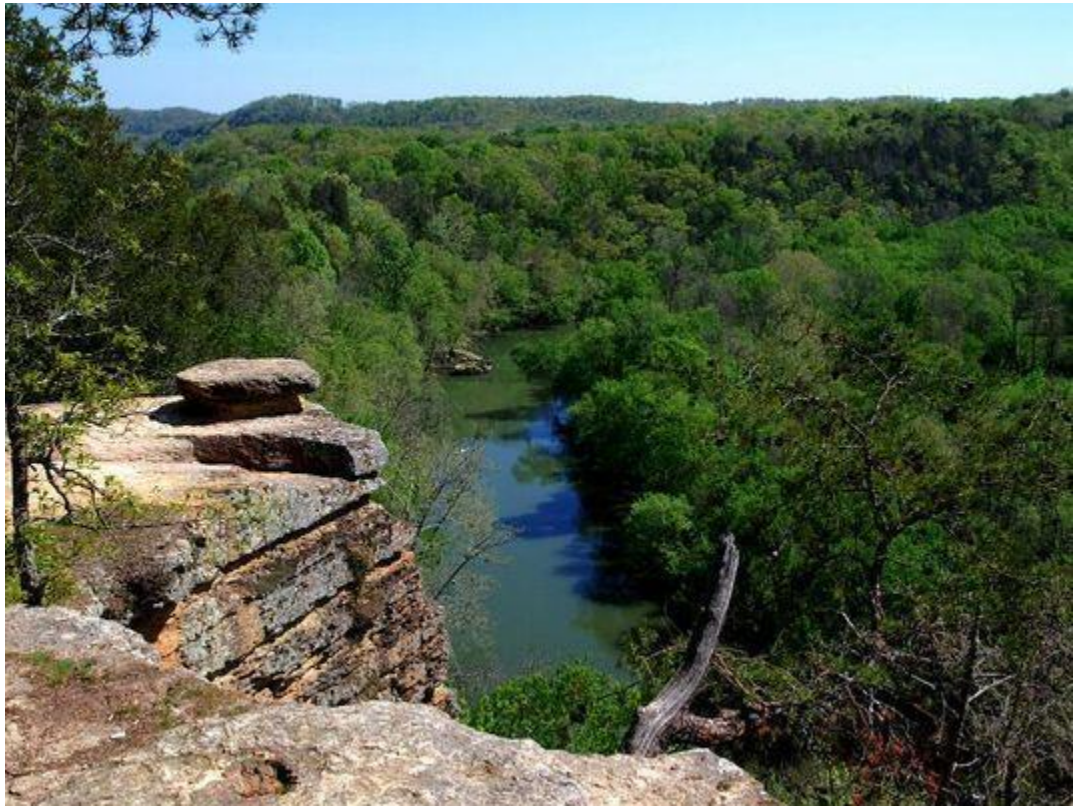
Tes M. Tsokov



Tiffanie R. Kelly

Trophic-State Measurements of the Upper and Middle Reaches of the Harpeth River in Middle Tennessee

Department of Biology, Austin Peay State University
Clarksville, TN 37044

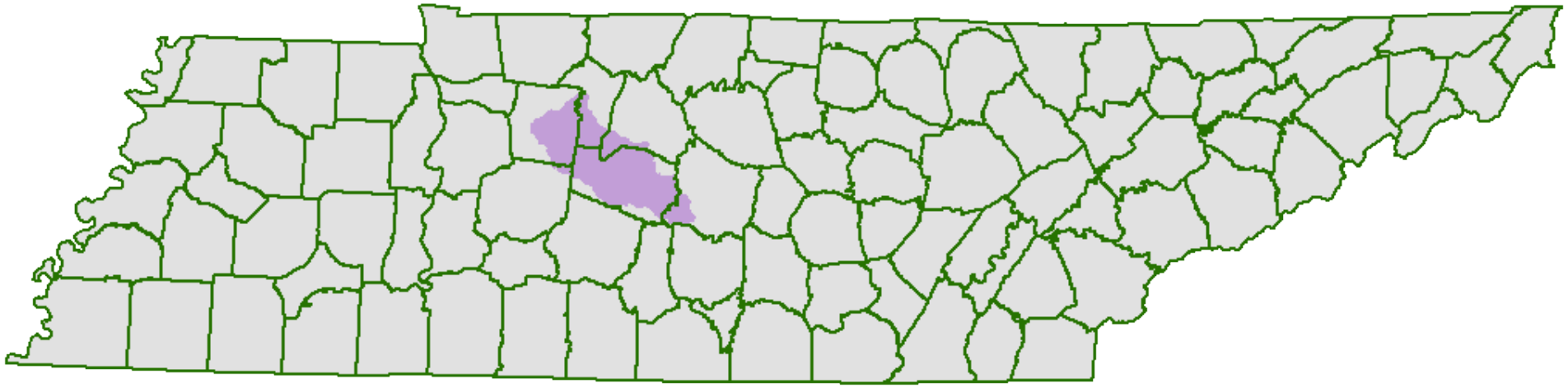


The Harpeth River

- flows northwest 185 km from its source near Eagleville, TN.
- enters the Cumberland River northwest of Nashville, TN.

Introduction

The Harpeth River Watershed
- drains 223,516 ha of Middle Tennessee.



- upper portion
    - flows through a rural, agriculture region.

- upper portion
  - flows through a rural, agriculture region.
  - considered relatively unimpaired.

- middle portion
    - flows through Franklin, TN.

- middle portion
  - flows through Franklin, TN.
  - serves as the region's water supply and sewage disposal.
  - impaired by nutrient enrichment.

City of Franklin Wastewater Treatment Plant

- the lower portion
  - impaired by nutrient enrichment.
  - designated as a scenic river under the Tennessee Scenic Rivers Act.

Objectives

- document at the upper and middle reaches:
  - the trophic state.

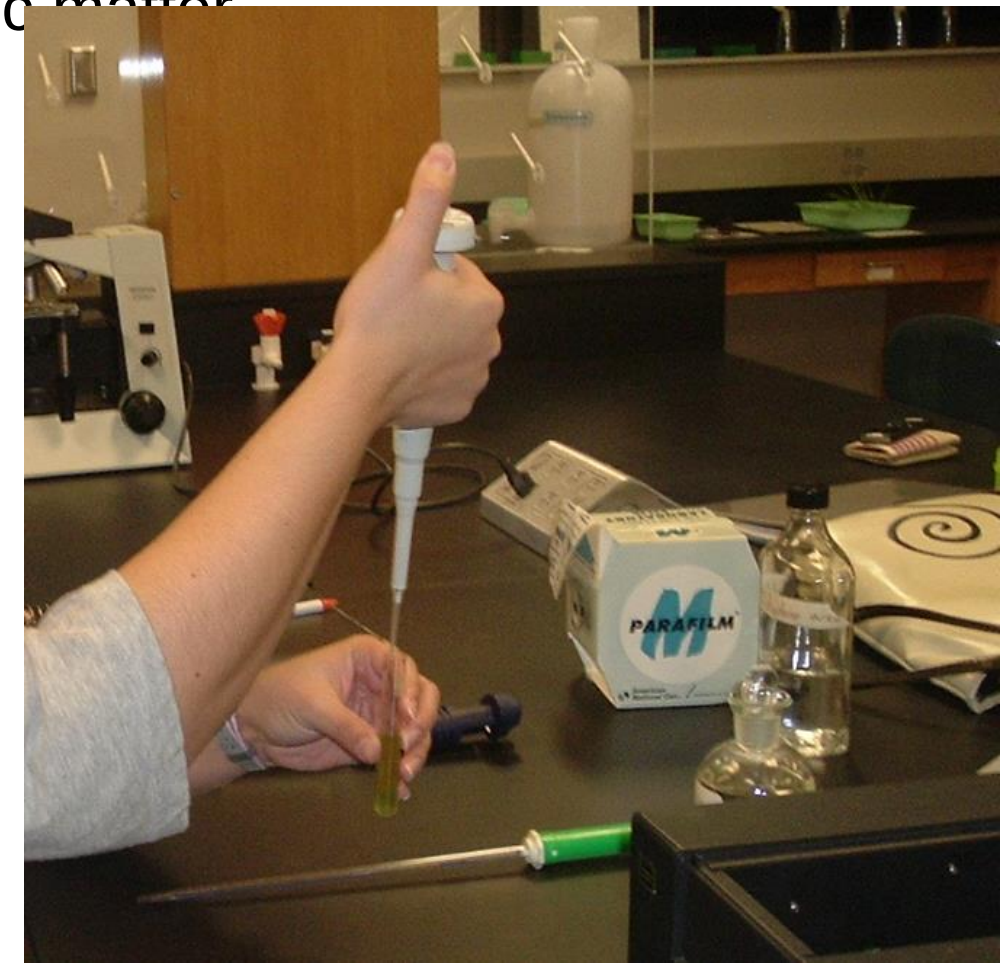
- site 4 is located:
    - 15 km north-northwest of Franklin.
    - 15 km southeast of downtown Nashville

Periphyton characteristics

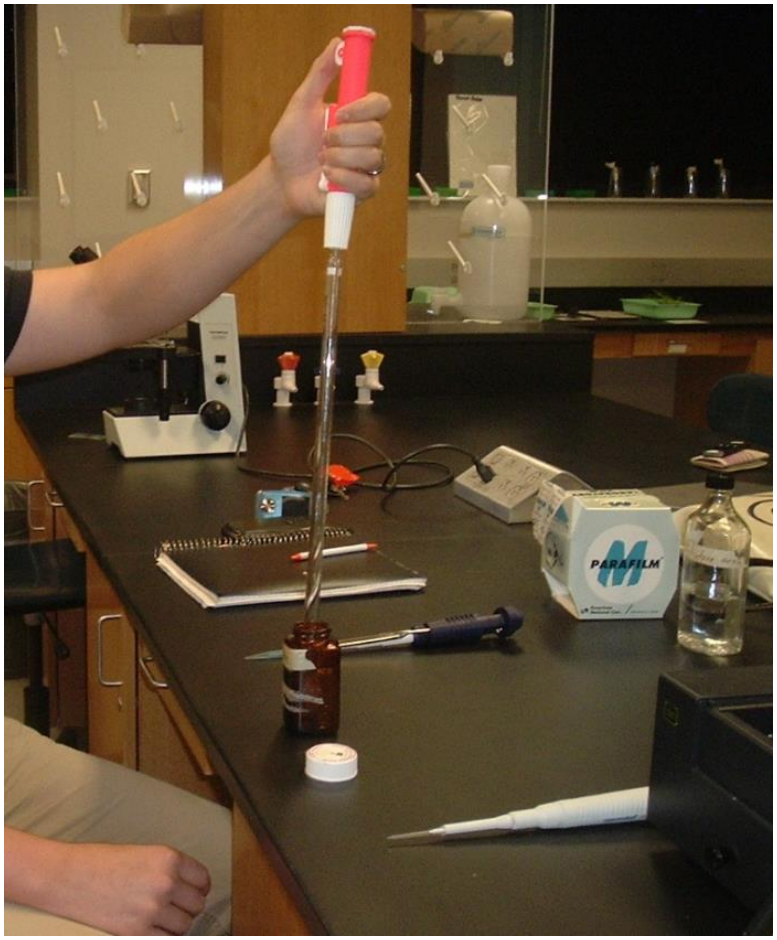
- were determined from cobbles removed from 4 replicate plots.

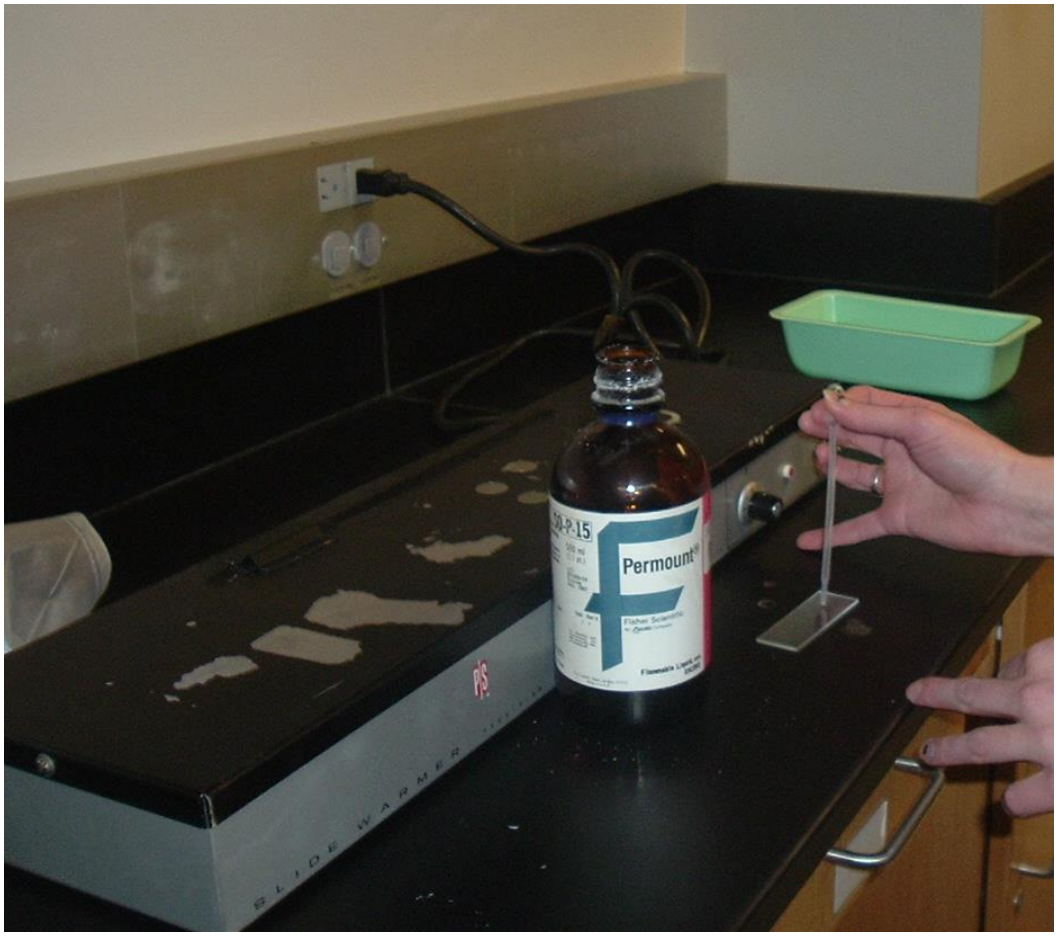
Periphyton characteristics

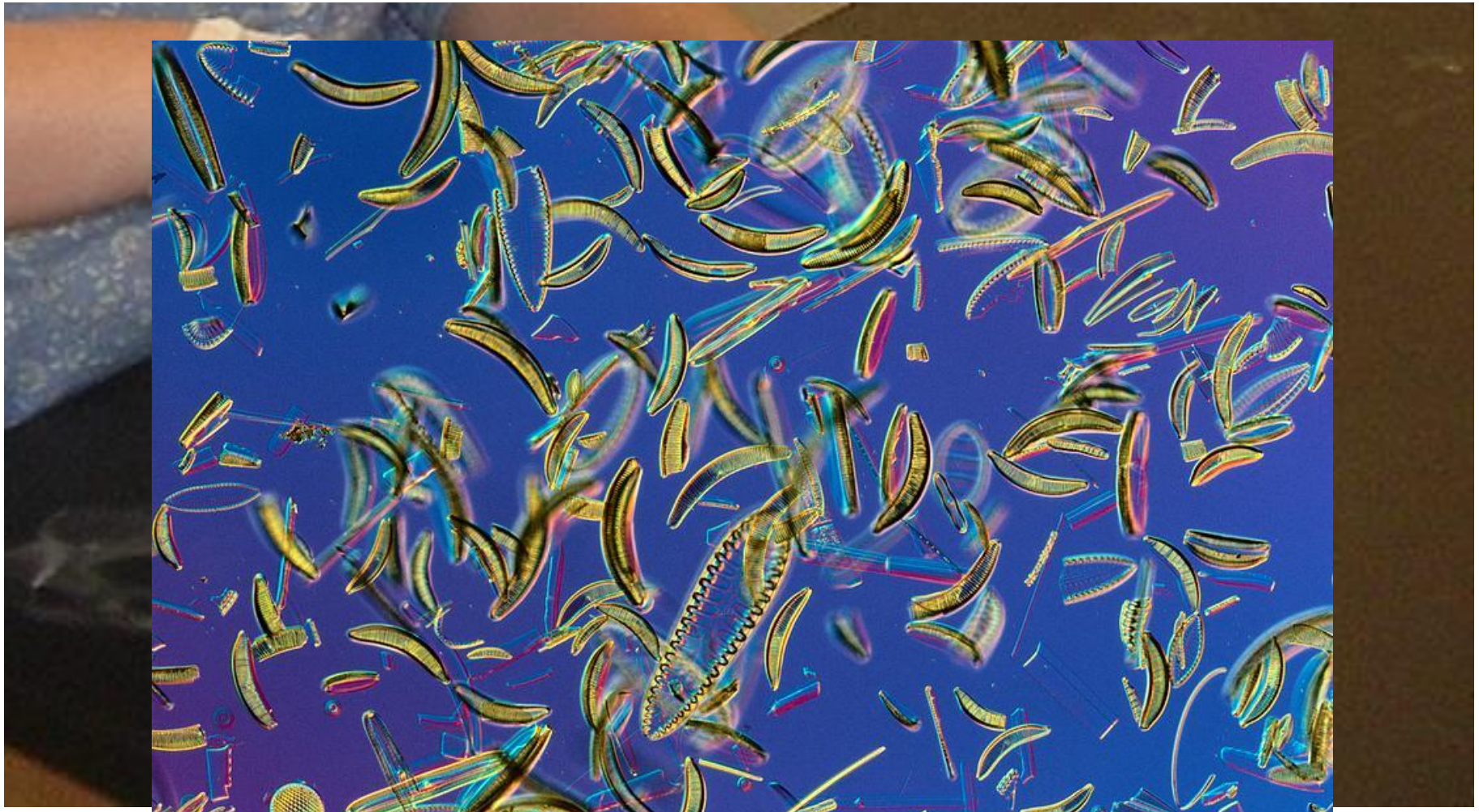
- were determined from cobble removed from 4 replicate plots.
- included:
  - AFDM of benthic organic matter.
  - [chl *a*].
  - [nutrient] of benthic organic matter.



- diatoms
  - were cleaned (in 2.6 % sodium hyperchlorite) and mounted onto glass slides.







Results and Discussion

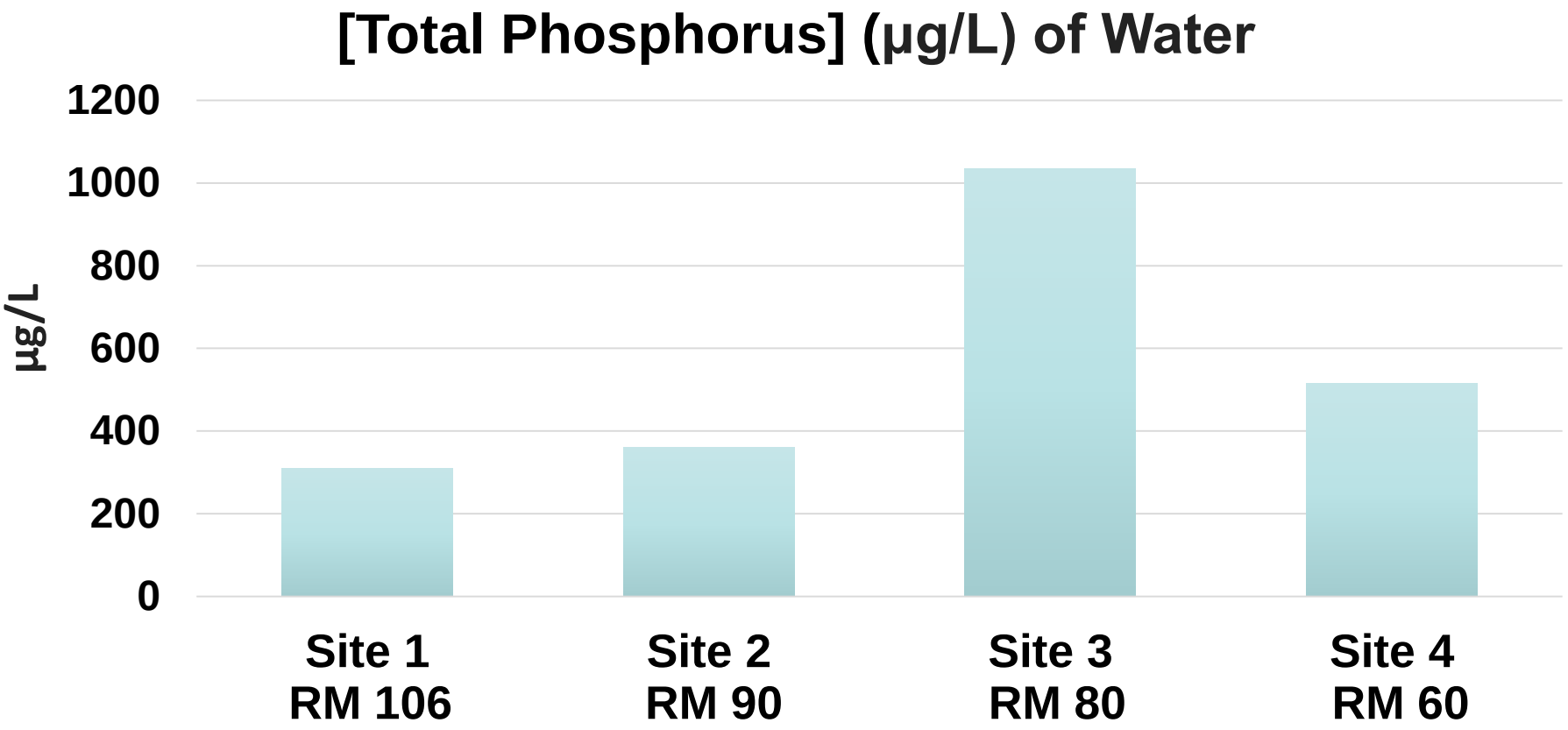
Suggested Boundaries for Trophic Classifications of Streams

Trophic level	TP ($\mu g \cdot L^{-1}$)[A]	TN ($\mu g \cdot L^{-1}$)[A]
Oligotrophic	< 25	< 700
Mesotrophic	25 - 75	$\underline{\geq}$ 700 - 1500
Eutrophic	> 75	> 1500

[A] Dodds et al. (1998).

[TP]

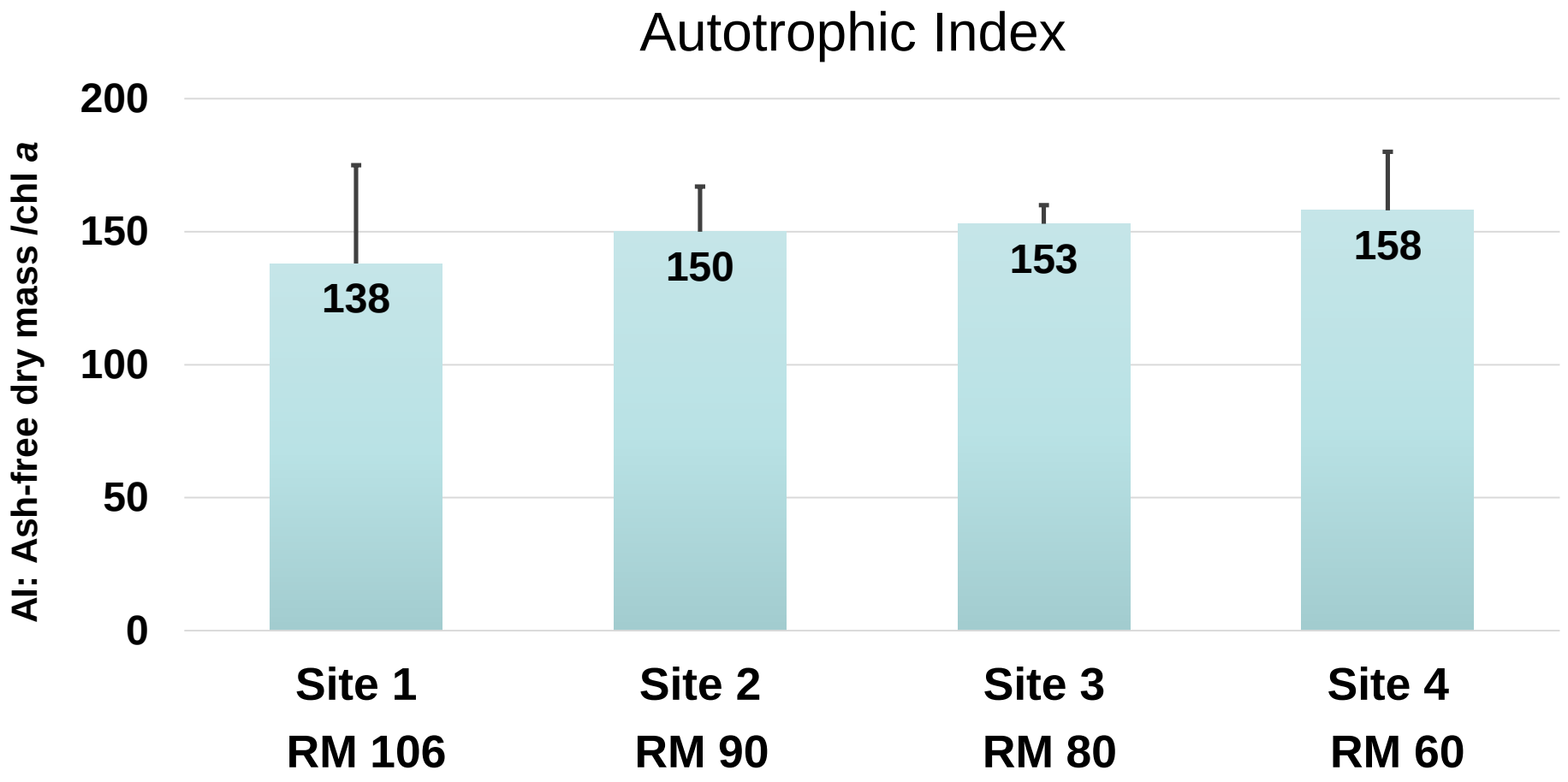
- 180 µg/L are suggested to be a more realistic expectation of moderate levels of P in surface waters in the Nashville Basin.
- 1000 µg/L have been recorded in ground water samples from the Nashville Basin.



Autotrophic index

= ash-free dry mass/chl *a.*

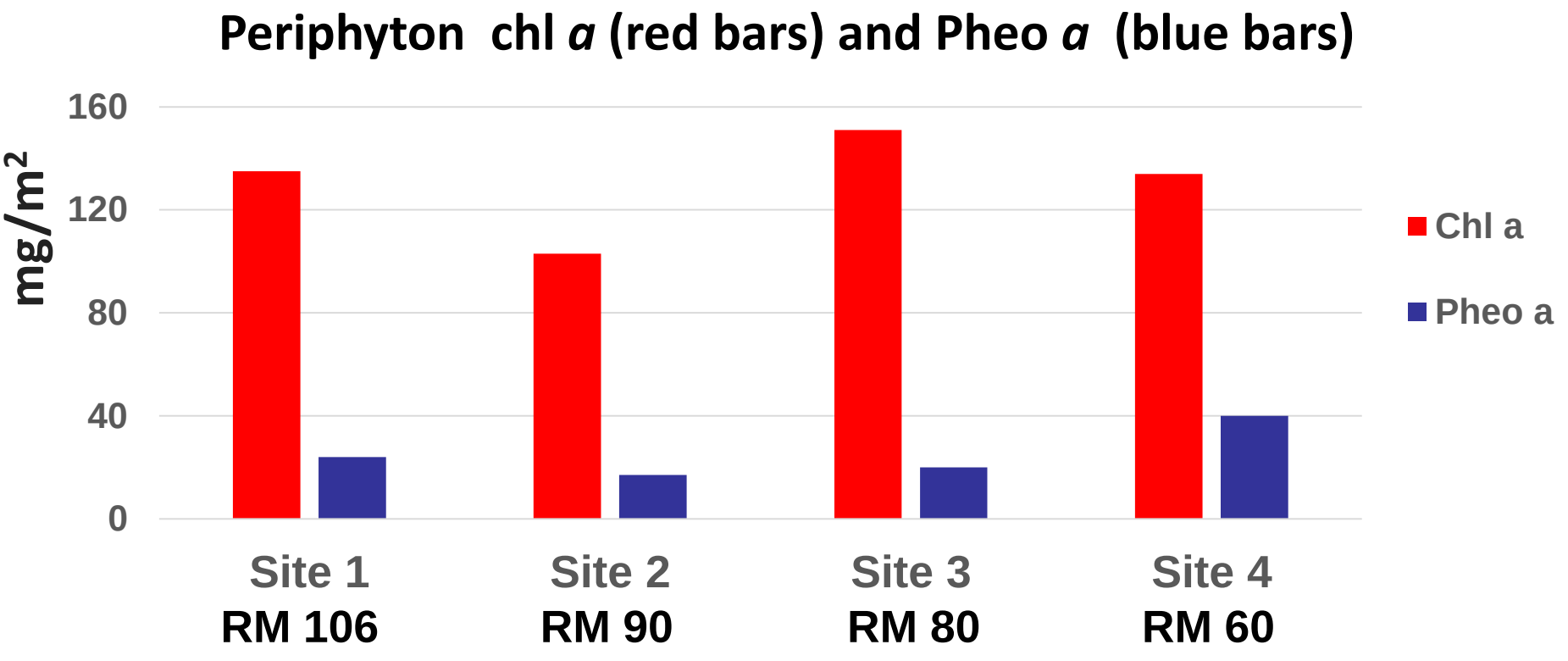
- is < threshold value (300) used to designate sites as impaired by organic enrichment.



Pheo *a*

- is a degradation product of chl *a*.
- yellow.

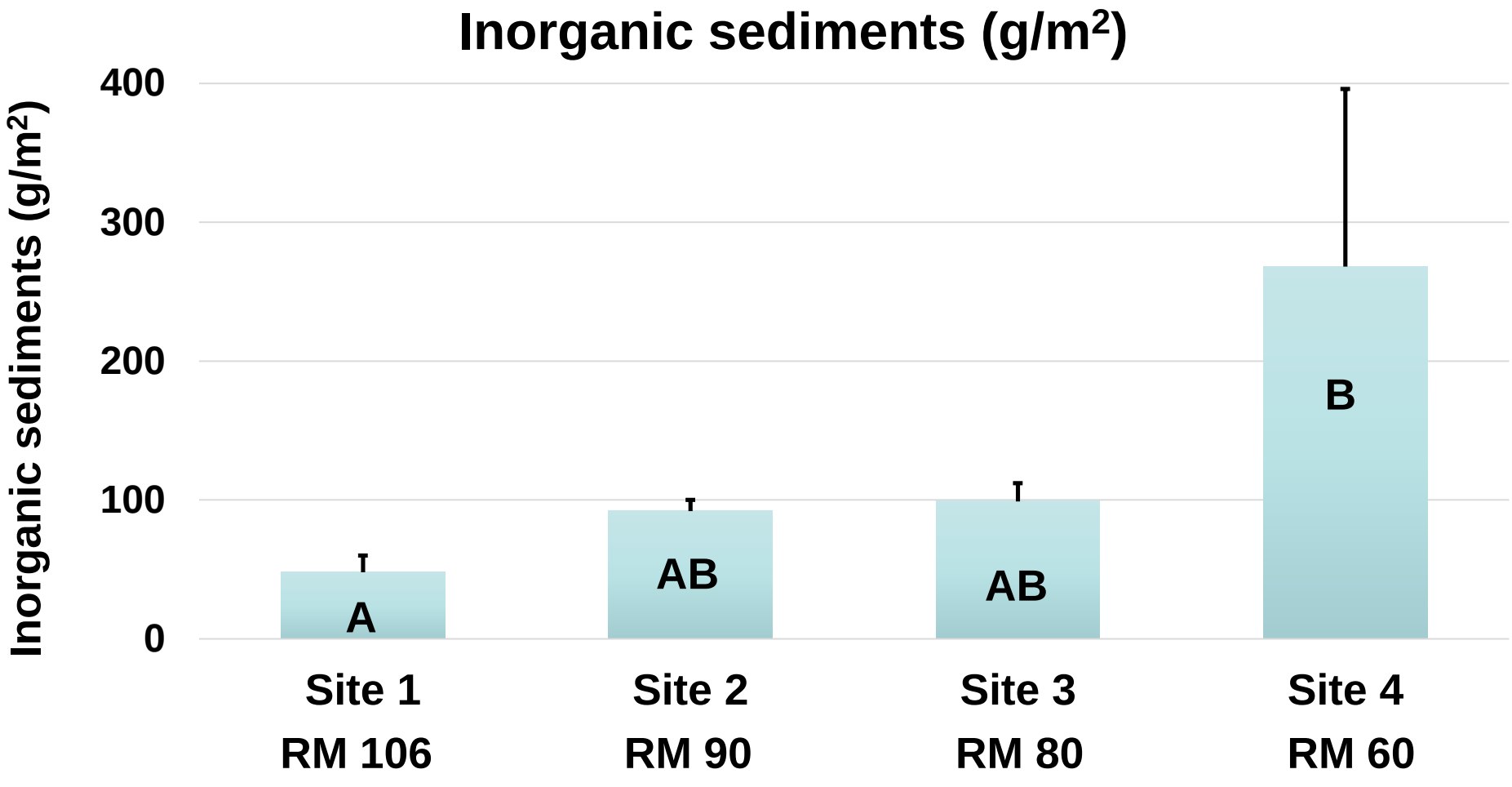
- Periphyton [chl *a*]
  > [pheo *a*].



- OD_{664} : OD_{665} ratio of pigment extracts from periphyton
  - used to infer chl *a* : pheo *a* ratio (because pheo *a* values may be undetectable in healthy algae).

- OD_{664} : OD_{665} ratio of pigment extracts from periphyton
  - used to infer chl *a* : pheo *a* ratio (because pheo *a* values may be undetectable in healthy algae).
  - not significantly different.
  - above the threshold (>1.5) used to designate phytoplankton or periphyton as healthy.

- inorganic sediment wt.
  - is > at site 4 lowermost site.
  - suggests that best management practices which limit riparian zone destruction and reduce of erosion may benefit the ecological integrity of the middle reaches.



Seston

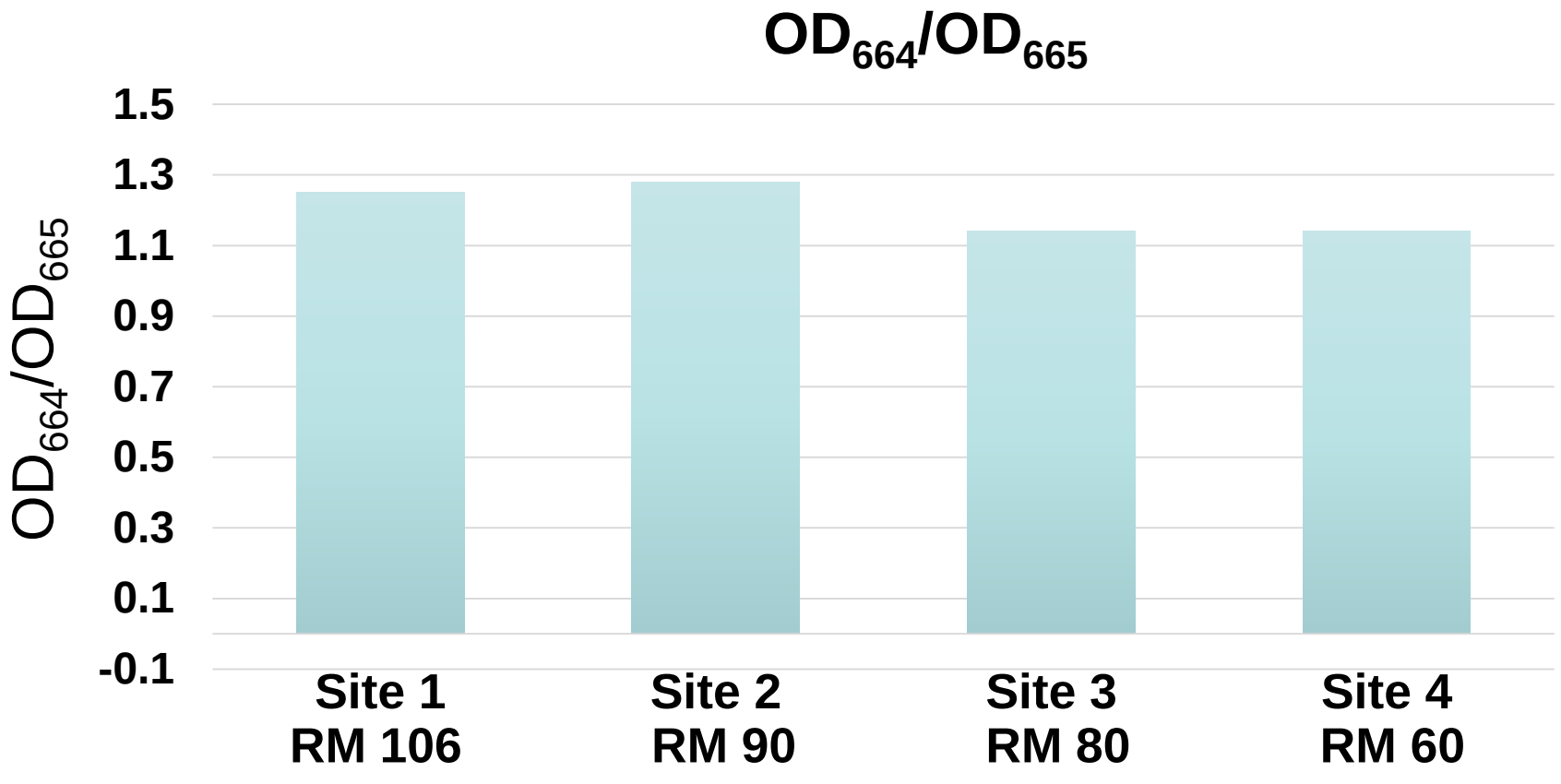
= particles suspended in water and includes plankton, dislodged periphyton, and organic and inorganic debris.

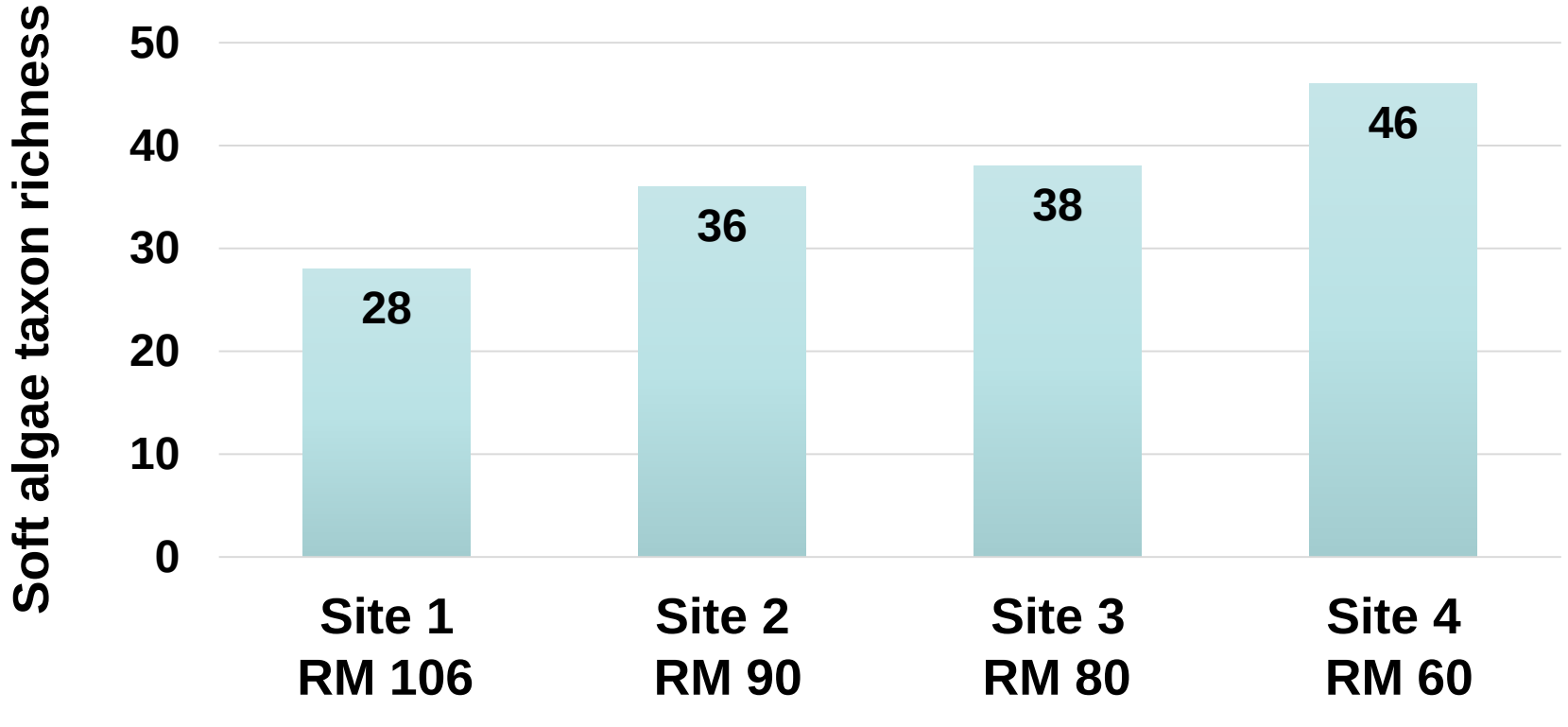
Dodds (2006)

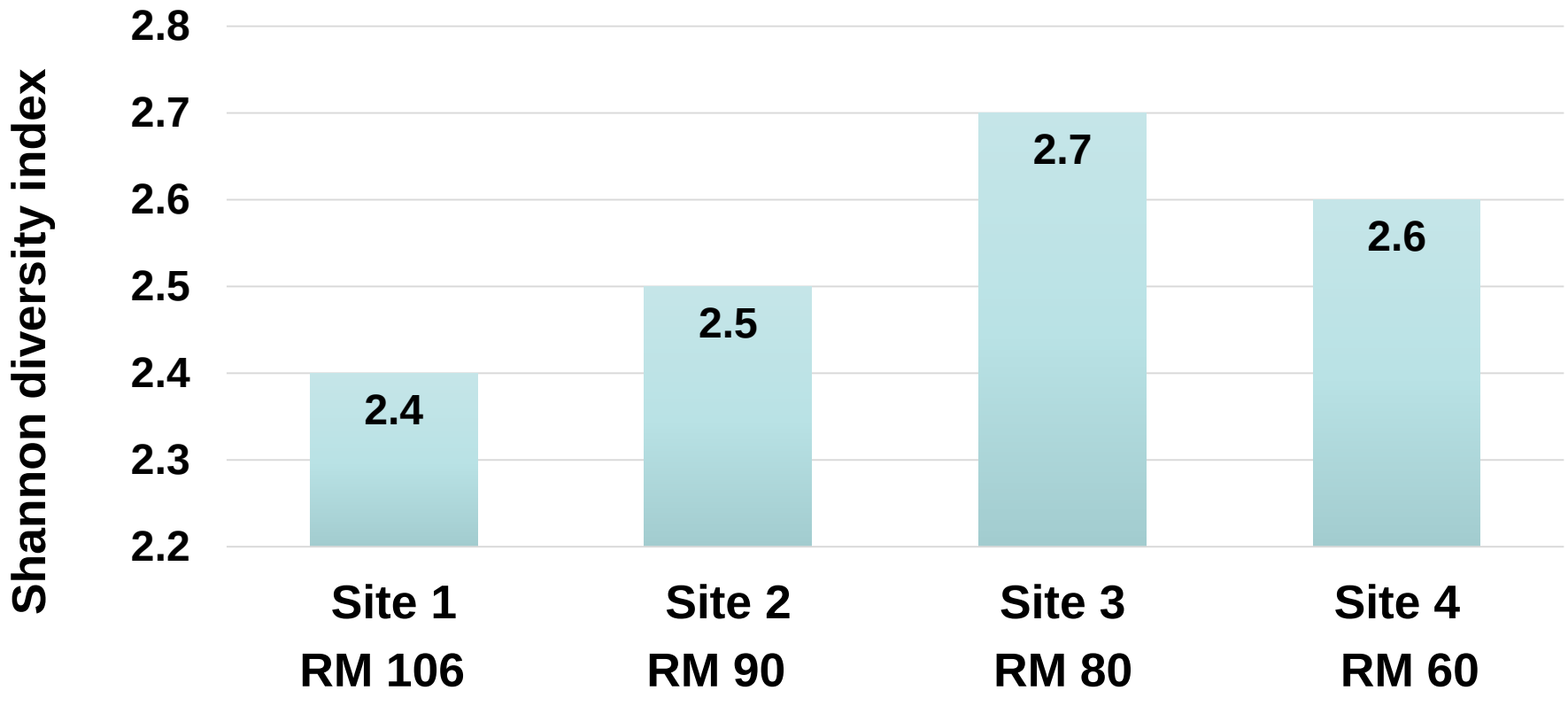
- summarized seston [chl a] of streams and rivers across U.S.
- suggested values > 8 ug/L may imply eutrophic conditions.
- smaller streams have much lower [seston chl *a*] which are strongly dependent on watershed conditions.

OD_{664} : OD_{665} ratio

- below threshold (>1.5) used to designate phytoplankton or periphyton as healthy.
- may reflect the fact that seston of smaller lotic systems consists largely of dislodged, senescing periphyton and plant debris.




Soft algae taxon richness
50
40
30
20
10
0
28
36
38
46
Site 1
RM 106
Site 2
RM 90
Site 3
RM 80
Site 4
RM 60


Shannon diversity index
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.4
2.5
2.7
2.6
Site 1
RM 106
Site 2
RM 90
Site 3
RM 80
Site 4
RM 60

- organic pollution
  - results from erosion of organic soil, input of manure or sewage, and overgrowth of algae.
  - provides respiratory substrate for decomposers, increases respiration (decreases O_2).

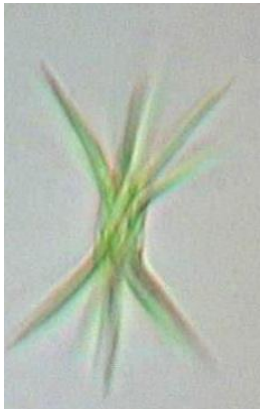
Guatemala City

Objectives

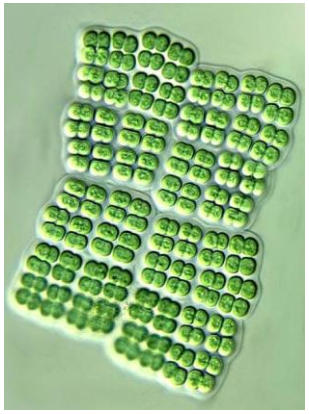
- document at the upper and middle reaches of the Harpeth River:
  - the composition of algae assemblages.
  - the impacts of trophic state.

Synechococcus

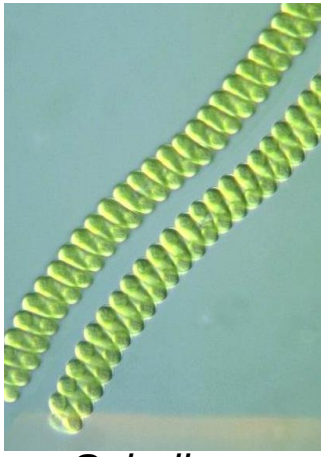
Gloeocapsa



Dactylococcus



Merismopedia



Spirulina

Anabaena

Lyngbya

Trichodesmium

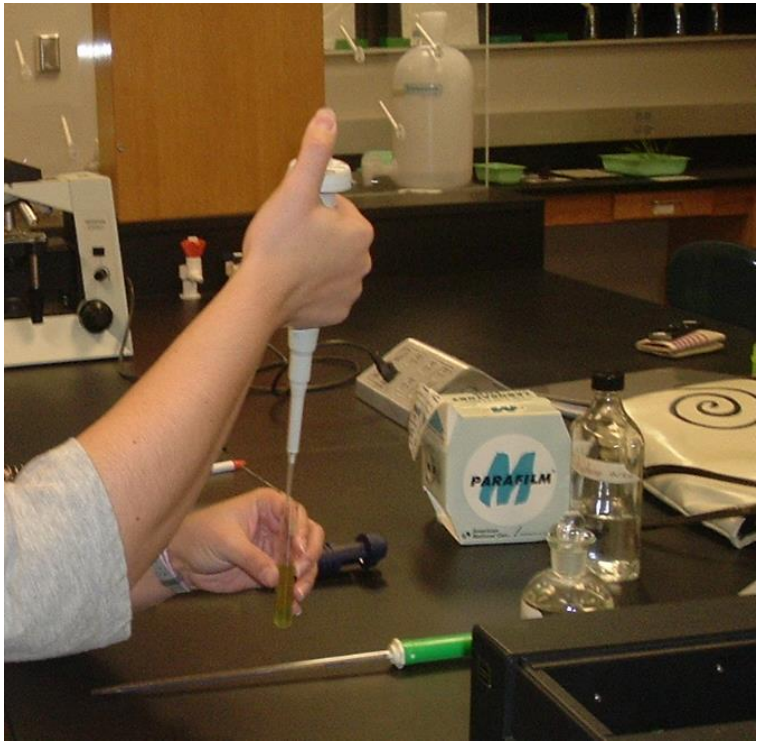
- used 0.25 m^2 midstream plots (8 replicates).

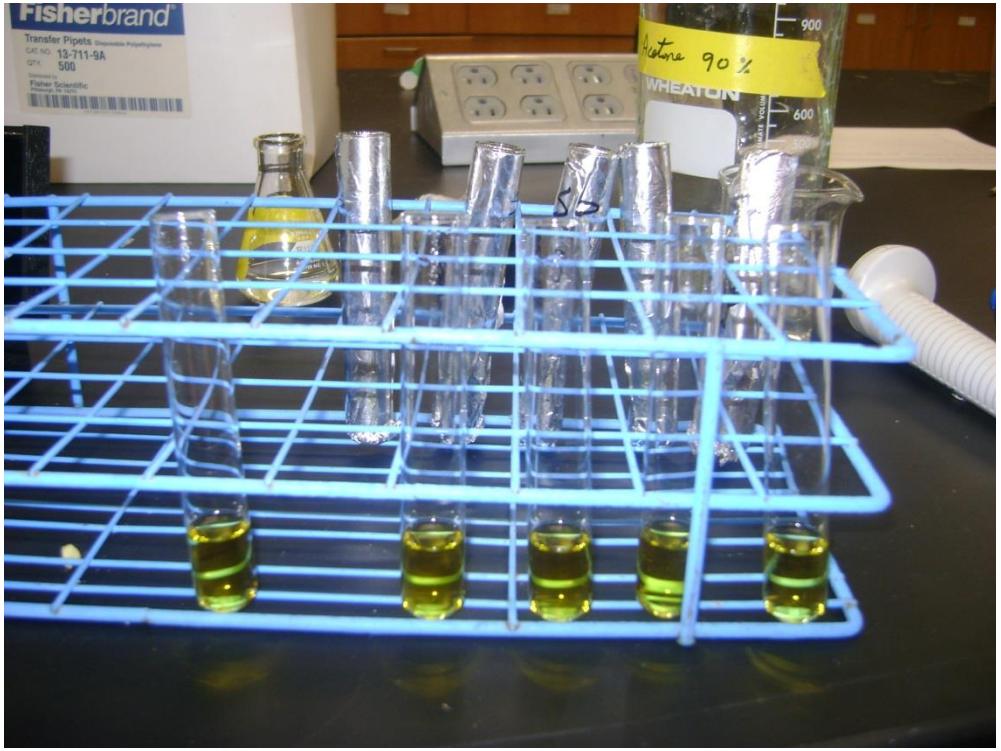
Photoautotrophic periphyton (benthic algae)

- removed from cobble collected from 4 replicate plots (0.25 m^2) at each site.

Photoautotrophic periphyton (benthic algae)

- removed from cobble collected from 5 replicate plots (0.25 m^2) at each site.
- pigments extracted using 90 % acetone.
- [chlorophyll *a*]
  - calculated following optical density measurements at 664 nm of filtered extracts.





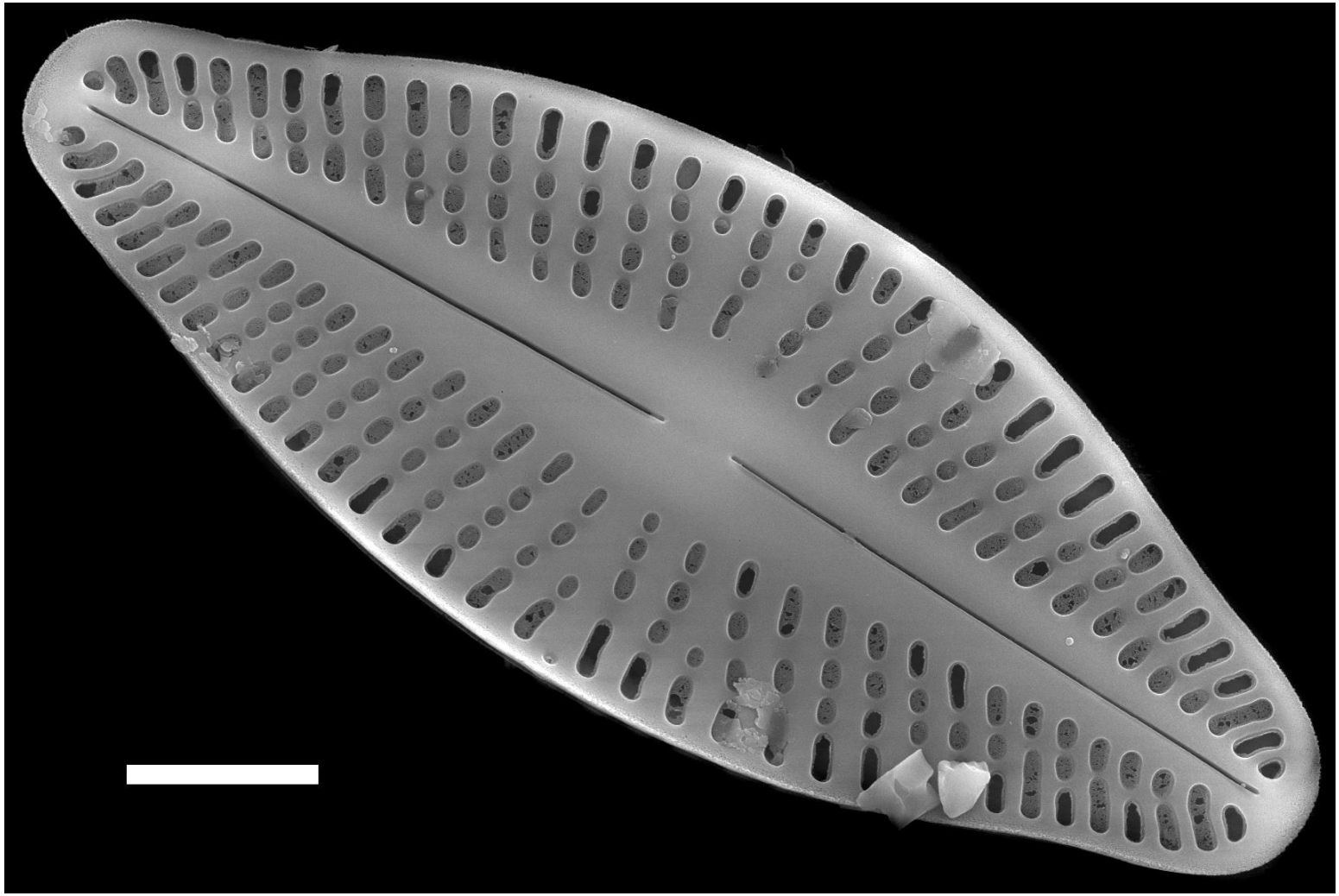
Photoautotrophic periphyton

- removed from cobble collected from 4 replicate plots (0.25 m^2) at each site.

- *Paulinella chromatophora*
    - Rhizaria supergroup, Phylum Cercozoa.
    - has primitive, cyanobacteria-like chloroplasts.
    - sited as evidence that the Archaeplastida supergroup (descendants from an ancestor which acquired chloroplasts from a cyanobacterium) may not be monophyletic.

Motile diatoms

- have a raphe (longitudinal slit in glass wall).



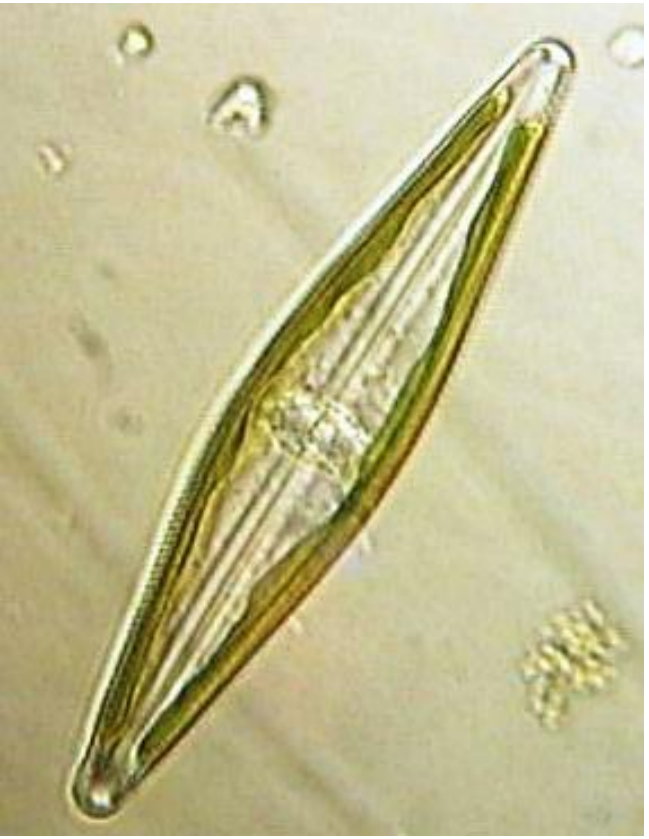
Karia cleve, scanning electron micrograph, 1000 X

Motile diatoms

- have a raphe (longitudinal slit in glass wall).
- able to avoid being buried by sediments.
- abundant at sites covered w/ sediments.

Siltation Index

= % motile diatoms of the genera *Navicula, Nitzschia, Surrirella.*



Navicula

Nitzschia

Surirella

Periphyton characteristics

- were determined from cobbles removed from 4 replicate plots (0.25 m^2) established 1.25 m apart at each site.
- included:
    1. AFDM of benthic organic matter.

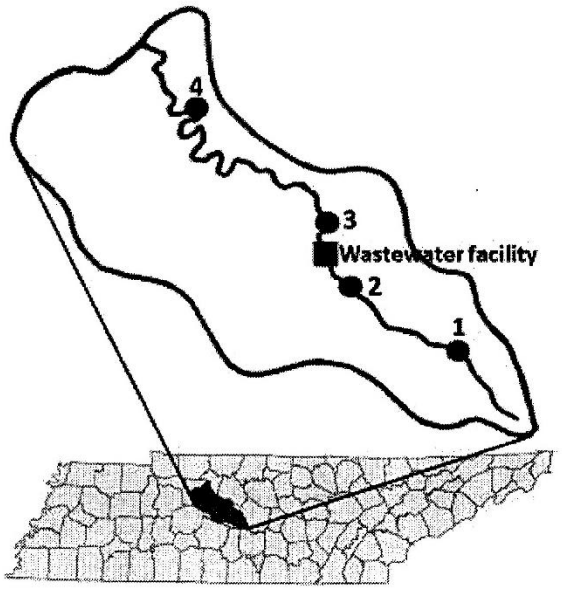
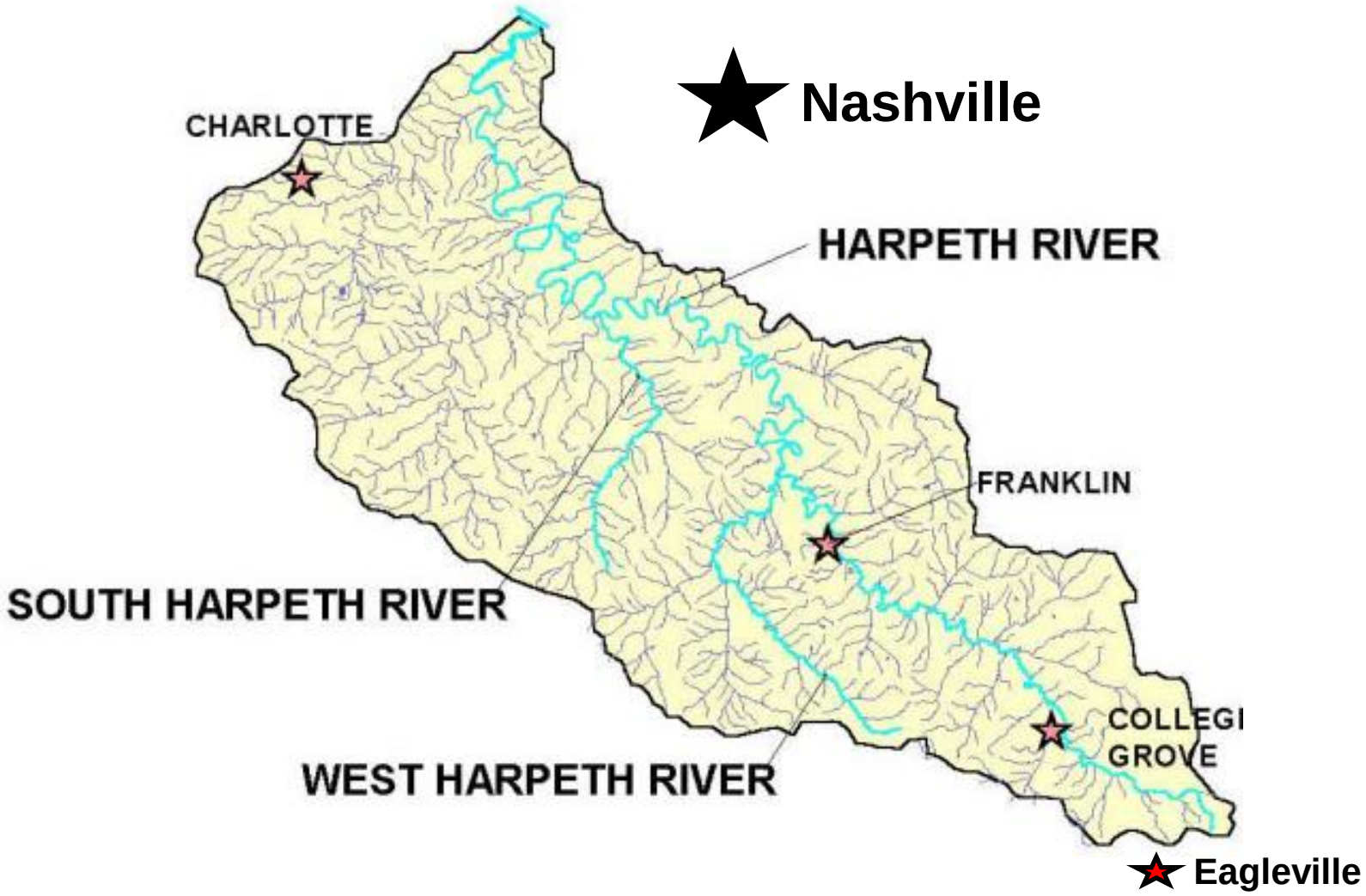


Figure 1. Location of Harpeth River Watershed (black area) in Tennessee, location of the Franklin Wastewater Treatment Facility (square), and locations of the four sampling sites (circles). Sites 1 and 2 are upstream and Sites 3 and 4 are downstream of the Franklin Wastewater Treatment Facility.

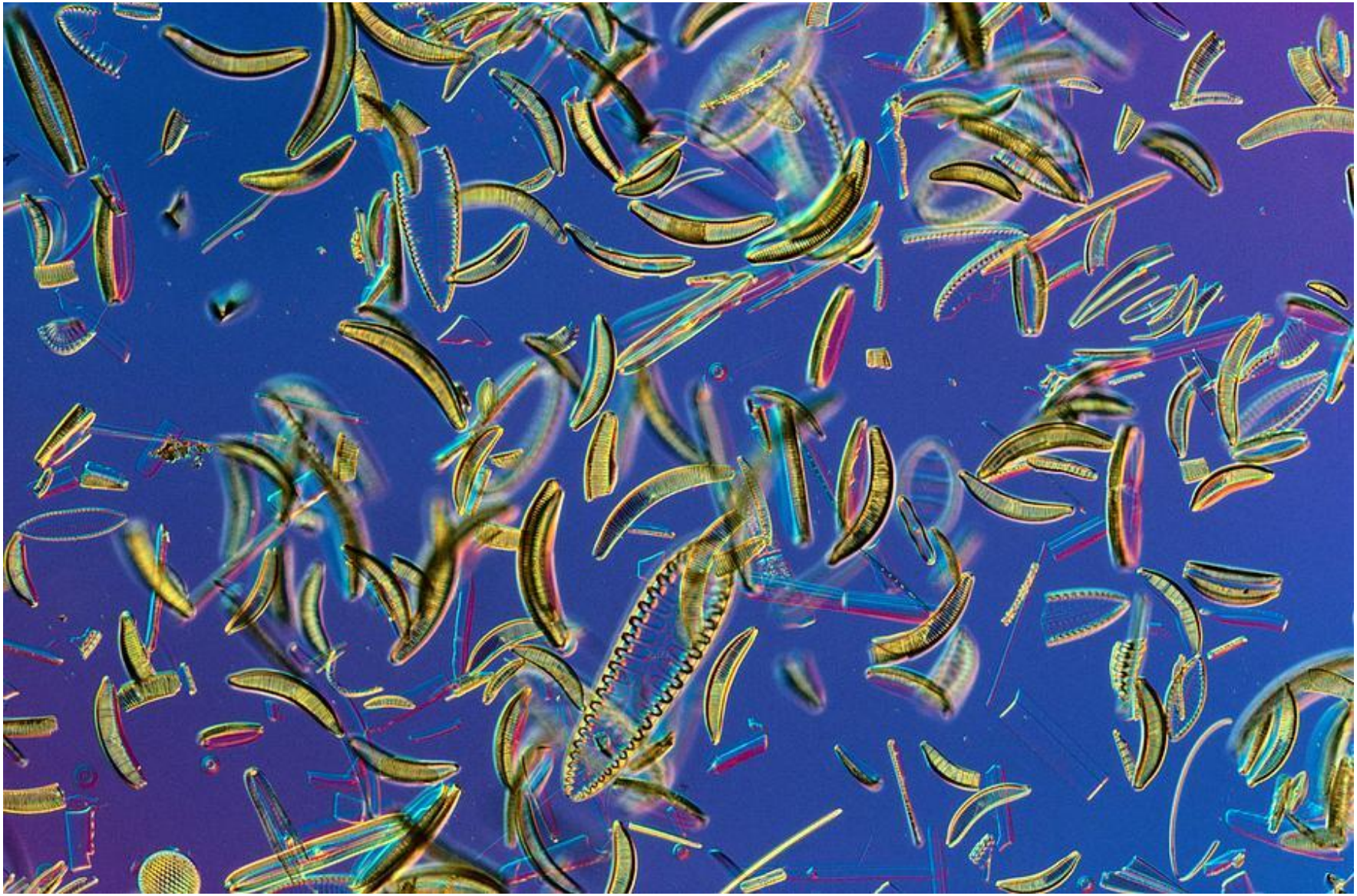
Harpeth River

- flows northwest 185 km through Franklin,TN.
- enters the Cumberland River 25 km northwest of Nashville, TN.



Diatoms

- 94 diatom taxa were identified and % composition determined for each site.



- OD_{664} : OD_{665} ratio of pigment extracts from periphyton
  - used to infer chl *a* : pheo *a* ratio (because pheo *a* values may be undetectable in healthy algae).

[Total phosphorus and total nitrogen]

- were determined from water samples collected 5 cm below the surface.
- TP: persulfate digestion and ascorbic-acid method.
- TN: persulfate digestion and cadmium-reduction method.
- using a LaChat QuickChem 8000 Flow Injection Analyzer (Hancock Biological Station)