CLWN Comments on the draft TMDL
to Reduce Phosphorus in Cayuga Lake
July 8, 2021

Introduction

Thank you for the opportunity to submit comments on this important document, which has the potential to deeply affect the future health of Cayuga Lake during a time of tumultuous climate change.

The Cayuga Lake Watershed Network ('Network') was founded in 1999 as a grassroots membership organization for the public, in tandem with the Cayuga Lake Watershed Intermunicipal Organization. We are a 501 c3 with a Board of Directors, two paid staff, and a membership of around 500. We have earned the respect and attention of municipalities, agencies, and the public across the Cayuga Lake watershed.

Our mission statement: The Cayuga Lake Watershed Network identifies key threats to Cayuga Lake and its watershed, and it advocates for solutions that support a healthy environment and vibrant, sustainable communities.

We work closely with the certified water lab Community Science Institute on Harmful Algal Blooms monitoring and reporting, and we founded CSI-trained, QAPP-compliant citizen science water quality sampling projects on creeks around the Seneca and Cayuga County shorelines. We coordinate (and help pay for) the several CSLAP sampling sites on Cayuga Lake. We provide public outreach for the new DEC-led Cayuga Lake Hydrilla Management Plan.

From 2015-7, Network staff updated the Cayuga Lake Watershed Restoration and Protection Plan. Our Water Quality Committee, chaired by Bill Ebert, is partnering in 2021 with SUNY ESF and the Upstate Freshwater Institute on a microbial source sampling study at the mouths of nine creeks around the Cayuga and Seneca county shorelines.

During 2020 the Network co-founded the Lake Friendly Living Coalition of the Finger Lakes; and developed and launched our 2021-24 Strategic Plan. Goal #1 of our Strategic Plan: Monitor the impacts of climate change on the watershed and lead the effort to engage the community and organize mitigation efforts.This introduction serves both to inform about who we are, and provides context for the focus of our comments on the dTMDL.

Over the past several months during the comment period, we have witnessed the deep upwelling of scientific response that can, if you have the courage to use it, provide your draft document with the fact-based realities of the living Cayuga Lake. Thanks to the visionary work of Roxy Johnston and Darby Kiley in tandem with the Cayuga Lake Watershed Intermunicipal Organization, the comments received by you, DEC, are of a depth and quality that must be put to good use in revising this draft TMDL for real world success.

We fervently hope that you intended the initial draft, which is shallow, dismissive of much of the recent available data, and based on vague, boiler-plate ridden-verbiage – as the first step in the longer process of making a TMDL that actually works in the real world for the improvement and protection of the health of Cayuga Lake. Having listened to the research and monitoring experts and agency leaders debate and discuss their response to your draft, we call on you to meet these needs:

- Plan for actual, real-world implementation of the TMDL;
- Focus more on the northern two-thirds of the lake;
- Conceptualize the lake as a single body of water, not as several separate water bodies;
- Use data past 2013 in order to begin to grapple with ongoing climate change;
- Revise the modeling to account for the many limitations, bad assumptions, and gaps;
- Identify the funding or other NY State resources with the necessary regional authority that will be or could be made available to tackle the intense and long term project implicit in the vital goals the TMDL will establish;
- Respect and integrate the data collected by non-DEC researchers;
- Recognize and make room for the public to help.

Following are our specific comments, developed and submitted principally by:

Bill Ebert, retired processor system modeler at IBM; Chair of the Water Quality Committee, Cayuga Lake Watershed Network; member of the CLWN Issues Committee and CLWN Board of Directors.

George Adams, retired from a career in software with numerous important companies and agencies; presently a leader in numerous Tompkins County conservation and water entities; and Chair of the Issues Committee, Cayuga Lake Watershed Network.

With input and guidance from community colleagues and members of our Board and Issues Committee.

With assistance from Hilary Lambert, Executive director, Cayuga Lake Watershed Network.

Consider the lake as a whole, not as the sum of separate parts.
Please update the watershed map to include the entire watershed, as shown on websites of the Cayuga Lake Watershed Network and Cayuga Lake Watershed Intermunicipal Organization. This mistake was made in the HABs Action Plan and has not been corrected in the draft TMDL. The Seneca County Board of Supervisors has submitted an excellent comment for this process and their presence in the Cayuga Lake watershed needs to be correctly acknowledged.

Cayuga Lake is a single waterbody, not segmented as in the present TMDL. The concept of lakewide modeling is not a good fit with this old-fashioned concept of a lake in discrete segments. You cannot propose actions for one so-called segment and assume that the actions will affect only that one area. What happens in one area of the lake will affect the others. Research shows that water coming out of the Cayuga-Seneca Canal can flow south of the railroad tracks. Water flows north from the south end and exits via the Seneca River. Seiches and storms shift waters from one lake "segment" into another. Sediment plumes from Taughannock Creek can flow south. Bidirectional flow of different sediment plumes in layers were recently documented for Cayuga Inlet as a result of seich activity. Other tributaries have yet to be studied.

More recent data must be made part of the TMDL, notably for the northern two thirds of the lake.

We understand that the draft TMDL was originally intended to focus on the southern third of Cayuga Lake, and was only belatedly expanded to include the northern two-thirds of the lake. The data used – and excluded – reflect this hurried and partial update. Much of the data collected about water quality trends around the Cayuga and Seneca county shorelines has only been collected since 2014, a year after the close out date of the data used for the draft TMDL. These recent data also begin to capture the recently emerging climate change impacts that will be the driving force for change into the future.

With that in mind, more attention should be given to the North End and recent CSLAP data from 2017 to 2020. The (attached) CSLAP data show many high nutrient data points at Sites 5 and 1 at north end in addition to the other sites. The north end has many creeks draining into the lake that have been tested and documented (CSI) to have high nutrient content. In addition, the Seneca-Cayuga Canal has two Sewage treatment plants (Seneca Falls WWT and Waterloo WWT) emptying into the Canal which enters the Lake at the north end. The Mud Lock was closed for nearly two months this year to fill the drought stricken Lake. It was also closed for two months last summer to help maintain Lake level. This means that the Canal outflow is probably making its way to a larger portion of the north end of the Lake.

This water last year could have had an impact on the large number of HABs reporting from the north end. Per the Community Science Institute (CSI) website the north end had 63 reports of HABS out of a total of 90 reports. Yes, about 65%. The decision to open the Lock is based on Lake level, and not on Canal flow, as it should be. This means that low levels of rain in the Spring and Summer would mean that this Canal water will flow south to the north end of the Lake.

Also, the CSLAP data, plus that collected by the CLWN Water Quality Committee team (in cooperation with CSI) along the northwest and northeast shorelines for seven years, indicate that there is a lot more active flow of P (and N) into the lake from the Seneca and Cayuga County creeks than used in the lake model, the results of which are thus way out of date. Please re-run the lake model using these data. Also, why was it decided to only use data directly produced or overseen by DEC, when CSI has a DEC-approved QAPP? Please drop this exclusion. Could USGS data also be used?

The two sewage plants plus MS4's and other SPDES sources should be listed as to the Unimpaired Northern End Segment on Page 31. This will give these sources visibility to get grant monies when available to provide clean water to Cayuga Lake and the Seneca River.

(See attachment, CSLAP Data.)

Where is the guidance for specific actions, monitoring, measuring indicators of success?
In the draft TMDL, we see words like “suggested” and “voluntary.” We see “guidelines” where there should be specific lists of actions tailored to particular land uses, and charts indicating measures of success, with timelines for implementation. We see the empty shell of the HABs Action Plan dropped in as a substitute for the necessary, detailed P-reducing actions that will bring about measurable success.

The management and measurements needed to make this a successful program.
Who is in charge of this TMDL at the DEC, and who is designated to oversee the program management within the Watershed? DEC personnel and a watershed organization must be named as responsible for the execution of the TMDL at the onset of the program. Their Leadership is essential.

- Funding needs to be provided to the Cayuga Watershed Management team to hire a Lake Steward. The position of the Steward needs to be funded for multiple years to attract capable individuals. This person will oversee the BMPs defined for individual locations and manage the total restoration process. The Cayuga Lake Watershed Intermunicipal Organization could be the Lake Organization, as they represent all municipalities in the watershed.

- Lake-wide measurement criteria needs to be defined and then methods established so progress can be documented showing achievement toward the 32% - 33% reduction in phosphorus. CSLAP needs to be fully funded by the DEC for continuity of one lake-wide measurement data bank. Individual creeks should be monitored to show restoration progress.

- The TMDL draft is calling for a 32 percent reduction in nutrients in the lake. What is the timeline and goals for this to happen? How is it going to be funded? Who is going to manage the goals? Who and how is the watershed going to change to bring the nutrients down over what timeline? This is a BIG goal that is being set. What does a reduction of 32 percent mean for the lake? Who is going to be held accountable? We need to have transparency in the whole process.

- We – DEC and samplers – need an agreement on which creeks to sample and how we judge improvement. Yearly average, rainfall amount, etc. At the Northern end we know that more farming BMPs are needed, now. This will be difficult. Road ditches are probably an easier place to start.

- These specific actions must be top priority for your next TMDL iteration. Other adjustments can be made later. A Timeline and Workplan are necessary, soon.

We need leadership defined and "Boots on the Ground" measurements defined up front. Financial support to achieve these measurements needs to be provided by immediate funding from the DEC. Some measurement equipment could also be needed. At this point we recommend staying with the TMDL approach. We've defined it to be better than a 9E approach due to EPA support and have waited quite a while for this opportunity. To request a switch now could lose valuable time and some support. The draft TMDL desperately needs specific goals, defined and operationalized. Let's get started on achieving them.

Modeling comments and concerns

A model is only as good as the data it uses, and is fraught with the likelihood of not accurately reflecting the real-world conditions of the enormously complex natural systems it attempts to replicate for use in real-world planning and implementation. Over reliance on a flawed model could mean disastrous failure for this proposed TMDL. The following comments are centered around these concerns:

- Quality and lapses of the model.
- Likely failures of the model as climate change kicks in.
- How dismissing legacy phosphorus may affect P loading errors, and in what direction are the errors likely to trend.

Stepping back for the wider view, we recognize that DEC may not have provided any general way to assess the "complete" cost of rising concentrations of P. Lacking such a tool or formula, the various places where commenters ask how to make the many cost/benefit decisions that must come in the wake of a mandated TMDL all go unanswered and we in the watershed would be left to come up with our own very divergent methods. Granted, the full cost would be a model in itself, encompassing many effects on many activities:

- Cost of replacing drinking water sources that have relied on the lake water quality
- Loss of tourism income and less tangible harms like value of lake front real estate,
- Cost of devising upland sinks to absorb P and other nutrients that we never paid attention to before.
- Loss of native species to the onslaught of invasives.
- The costs [varying greatly among the farm, municipal WW facilities ,etc] which each of these segments of watershed users will know how to calculate in their individual cases only when they know what new measures they must take.
- etc.

Climate change, the watershed, and modeling

Climate change related weather events have arrived in the Cayuga Lake watershed since the last data were collected for this study in 2013. Recognizing, monitoring, measuring, and mitigating climate change impacts all must become an integral part of this TMDL going forward.

Other literature and the TMDL draft itself note that high runoff events do the lion's share of the P delivery [that is when we harvest non-point sources]. Based on the emergence of significant climate change related extreme weather events over the past decade, we suggest that these question needs to be addressed:

- Does a model based on the climate of 2013 and the data of prior years used to validate it adequately allow for the greater dynamic inputs of ensuing years, or might it fail to reflect important changes in the watershed behavior?

Biological delivery of legacy P must be proven to not be legacy P loading.
The mussels are already making measurable differences in SRP and have since 2004 as noted in section 4.16.1 of the TMDL. Anything that causes an acceleration of their biological productivity will liberate more SRP, and more of that SRP may reach the epilimnion as the stratification season is extended by global warming, but punctuated by mixing as winter comes on.

Two effects of climate warming will increase the delivery of SRP by mussel populations below thermocline. The characteristic slow warming of the deeper lake waters during the stratification period terminates after about 270 days of the annual stratification cycle according to Sundaram and Rehm's 1971 Seasonal Thermal Structure of Deep Temperate Lakes.

But more recent research shows that climate change will gradually add up to 30 days to the stratification period leading to a longer condition of increasing warmth at depths of 30 to 45 meters. This longer period of greater warmth at depths where mussels are known to be established will increase excretion of SRP. The lake's increasing SRP concentration at depth, but growing upward into the water column over the course of the stratification season, clearly depicted in figure 5-51 of the *Phase 1 Final Report* may be the signature of the bioturbation of sediment P by the mussels present at those depths at the time that data was captured.

There is a blanket dismissal of legacy P loading stated in §4.1.6 pg 33 of the *Draft TMDL for Phosphorus*:

- *4.1.6.1 Internal Loading/Recycling*
  According to monitoring data and the CLM, Cayuga Lake does not experience internal TP loading; however, Cayuga Lake does experience internal nutrient cycling. Internal loading within some lakes is the phosphorus release from the anoxic sediments into the overlaying waters. This exchange depends on a variety of physical, chemical and biological factors (Wetzel 2001) that do not occur in Cayuga Lake.

With the two mechanisms by which climate warming may bring more bioavailable P from its normally unavailable conditions in sediments, even deep sediments, that are documented in the discussion of the Phase 1 model, it would give readers and stakeholders greater confidence that the clear and blunt dismissal of legacy P was supported by documentation and evidence of resorption of P and transport back to sediments in unavailable forms by mechanisms, little affected by climate change, and at a rate and on a scale that matched or exceeded the effects of the mussels.

If strong P cycling is claimed, the demonstration of the full cycle, not just the biological delivery from sediment, should be provided together in one section of the TMDL with explanation clarifying to readers just how the mechanisms counter each other to avoid net loading of P from sediment.

And because the summary of the *Phase 1 Cayuga Lake Model Report* states that mussel growth is the likely explanation for a doubling of SRP:

> *5.4.2.5. Summary*
> *Long-term monitoring detected a doubling (nearly 4 µg/L increase) in the concentration of soluble reactive phosphorus (SRP) within the hypolimnion of Cayuga Lake, NY after 2004. Increased levels of phosphorus raises concern of eutrophication of this high quality water resource. This increase occurred despite large reductions in municipal point source loading and few changes in watershed landuse and development trends. We hypothesize that excretion by expanding nonindigenous dreissenid mussels (Dreissena polymorpha (zebra mussels) and Dreissena rostriformis bugensis (quagga mussels)) could have contributed to the observed SRP increase in the hypolimnion...*

There should be a description of how the gathered data or tested modeling features show that increased SRP is confined to the hypolimnion and cannot mix with surface waters to degrade water quality in the parts of the lake humans depend on for recreation and have used for drinking water.

It may be helpful to watershed stakeholders and future readers of the TMDL if there is a section that clearly defines the terms and makes the distinctions between LOADING with legacy phosphorus and CYCLING. Cycling may mean that lower pH, plant and mussel growth or hypoxia temporarily convert unavailable P to biologically available P but with at least as much P returning to non-available forms....and yet for the duration of its biological availability, can't that P participate in eutrophication?

Needs much more attention in the model: pH and legacy phosphorus

The role of pH is not apparent in the model building. Adobe Reader was used to search "pH", twice. This is puzzling. In a number of the papers reviewed for these comments, pH DOES matter and it gets involved in quite a number of inorganic chemistry mechanisms so following are a series of modeling concerns with a thread of pH running through them.

Many of the graphs and much of the discussion of Phase 1 considerations for modeling the dispersion of particulate phosphorus, sediment and turbidity drawn from the data collected in 2013 mention that that period was one of unusually heavy rainfall. If, as stated, it was the 32nd wettest year of the 89 year record, then the Fall Creek drainage appears to have its own climate.

The NRCC NOW data (see attachment) for monthly precipitation in the region from 2000 to 2020 shows that regional rainfall for the April-October period of 2013 was equal [< 1% difference] with the 20 year average for that same period.
This raises questions:

- Was Fall creek flow gauge seeing more rain than the USGS gauges on other tributaries and if so why?
- At the time that data was collected it was above average but has precipitation increased enough in the last 8 years to drown the significance of that year?
- Are there really divergent weather patterns within the watershed and if so, how could they be modeled to capture what the watershed is really doing?

A linear regression was run on the yearly precipitation totals from NRCC. There is a clear upward trend in regional rainfall over the last 20 years. Translated into the average year-over-year increase in the amount of rainfall that falls directly into the lake, the increase amounts to a little over 1000 added acre feet of rainwater each year. Is that due to climate change? Assuming that over a year, rain falls uniformly on the watershed, the trend in the NRCC data amounts to over 0.5% average annual increase. This begins to affect the turnover or residence time of water in the lake.

The reported data does show the lake waters have sufficient dissolved oxygen throughout the water column and that eliminates one abiotic mechanism that would release legacy P from the sediment.

Another abiotic mechanism to free up precipitated P is acidity, which does affect severely eutrophic waters. The term "pH" does not appear once in the text of the *Phase 2 Final Report* so it is unclear that any consideration was taken for natural range of pH of the lake waters. Over the range of pH values that have been measured for the lake, there would be little or no liberation of precipitated P forms. pH would have to be closer to 6 to free bound P which is below the natural range of the lake waters. But within that range the pH change can drive the ratio of two bioavailable phosphate species. Should there have been a statement in the TDML that pH just isn't and can't be an issue?

The lake surface is one eighth of the entire area of the watershed. The pH of the rainwater is less acidic than it was before EPA cleaned up the coal fired power plants but it is typically less than 5.5, The manner in which it is delivered does not cause much stirring [though the accompanying winds may] and the rain water diffuses into the surface of the lake for up to a day before the much higher pH water from the tributaries flows in. In the temporarily lowered pH, formation of more bioavailable phosphate species is favored. This episodic dip in pH would be most significant in the shallow “shelf” regions of the lake where temperature and nutrient influx is already driving HABs.

Can that effect of rainfall on pH be modeled? If it had any effect on HABS it would be fleeting and not temporally correlated with other observables except rainfall episodes. Any model of processes that evolve from inputs must have a sense of time allowing it to compute in small steps of time so that the outputs for each moment can become inputs to the next. What step time increment does the proposed model use? Would that be a fine enough division of time to handle phenomena that transpire in as little as 24 hours?

One reason water quality is NOT strictly tied to TP or SRP alone is pH. One eighth of the water in that lake is rain that falls directly onto the surface, and it lands with a pH lower than 5.5, to mix with the rest of the water only by diffusion...not mixed by currents as the higher pH tributary water must. The lower the pH, the more bioavailable SRP fraction there is. This may account for the observed water quality improvements that coincided with EPA success in cleaning up acid rain.

- Does the model account for temporal variations in pH and particularly for variations with depth?

There is a "stratification season" in which the thermocline becomes more of a barrier to mixing and which season is expected to increase by anywhere from two weeks to a full month depending on whether humanity can hold the line at the 1.5°C or not. The higher the air temps and the longer high temperatures hang over the waters, the more rigid that thermocline becomes.

- Does the glib and seemingly absolute dismissal of inadequate dissolved oxygen in the benthic zone depend on a rate of mixing that climate change may reduce? More anoxic waters become more acidic. See question 1.

While the jury is still out on whether the influx of sediment from tributaries, with its known load of mineral and reactive P is not doing all the damage it could due to higher pH of water in the creeks, the fact of great long term significance is that TP is absolutely increasing in the lake sediments, not being flushed, even on the scale of the 9 year residence time for the water. Increasing temperature and increasing biological processing of P from the sediment is mentioned in the draft as a mechanism by which legacy phosphorus is delivered to the water.

- Where does the draft TMDL account for the nullification of this legacy input, which they must provide to support the claim "*According to monitoring data and the CLM, Cayuga Lake does not experience internal TP loading; however, Cayuga Lake does experience internal nutrient cycling*"?

We strongly recommend that the next iteration of the dTMDL includes an analysis of the USGS flow data [15 minute intervals since 2012] from their Cayuga Inlet gauge, to determine whether or not there is a significantly increasing trend for the portion of tributary volume being delivered in pulses of intense runoff.

Phosphate species as a function of pH. Optimum growth occurs at or below lower end of the lake's range 7.3 to 7.9

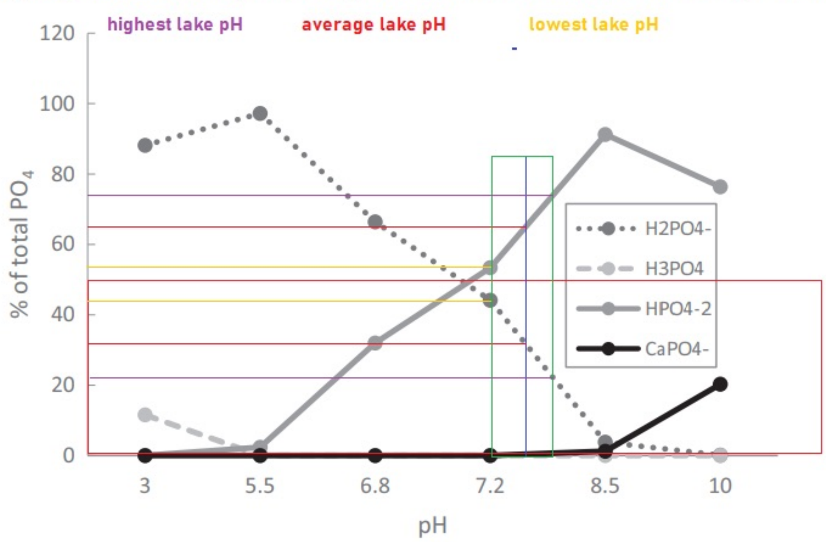


Fig. 2. Speciation of the major forms of P in aquaponics solution as a function of pH as simulated in Visual MINTEQ.

Brunno da Silva Cerozi Bioresource Technology #219, ppg 778-781 , 2016
, Kevin Fitzsimmons

(See attached NRCC data.)

Forestry

In the Tompkins County Department of Planning and Sustainability comments on the part 7 [Implementation Plan] of the draft TMDL, their question 2.d. asks whether timber harvest BMP will accomplish a 15% reduction.

Our response is that is most unlikely. The DEC timber harvest BMP is only guidance and only meaningful in an area being harvested. It is largely a set of guidelines to reduce erosion that results from heavy equipment used to gather and remove timber via skid trails, particularly around water bodies. These BMPs can only achieve a RELATIVE reduction of liberation and discharge of P to creeks compared to a bad job of logging that does not follow those BMPs. Since most forested land goes unharvested in any given year and since the suggested BMPs will not decrease but only prevent a larger increase in released P, it does not appear feasible to mandate an overall 15% reduction of P release from the segment of the watershed that is forested.

Only certain harvests of state forests and in towns which have and enforce their own timber harvest ordinances is there any certainty that BMPs will be enforced. The fact that only some towns regulate and inspect timber harvesting means the answer to question 4 about who can implement BMP, or more accurately who can enforce BMPs is variable from town to town. Uniform achievement of BMP would require uniform enforcement of BMPs over the entire watershed.

The state is the only authority that could institute a program of uniform timber harvesting regulation in place of the present patchwork of town regulations. At present, the DEC policy restricting burning of agricultural waste is probably the most important protection of lakes and streams against sudden, intermittent loads of P [and other dissolved nutrients] that may enter water from the land borne by runoff after a fire.

That regulation being in force since at least 2014 and generally followed in commercial and private logging operations, there is little further reduction of P from logging that could be gained by new regulations or enforcement.

Other options that are within the jurisdiction of the DEC to consider and that could reduce P runoff include redefinition of exceptions to the burn ban: Under (Statutory authority: Environmental Conservation Law, §§ 19-0301, 19-0303), Part 215, the exceptions to the burn ban should restrict or eliminate burning of agricultural wastes including slash from logging which are currently allowed under 215.3(d) and Prescribed Burns allowed under Part 194 should be limited to situations where the burn significantly reduces a threat of a wildfire that would consume more biomass. Burns to suppress nuisance species can be replaced by mechanical cultivation or at least only be permitted if the alternatives, including herbicides, would also increase P content of runoff.

There is one study that pulls together many others showing the exceptional loads of nutrients that hit the waters when rain falls on acres of ashes. .
https://pubs.usgs.gov/of/2004/1296/pdf/OFR2004-1296.pdf

Thank you again for this important opportunity to comment on a draft plan that will significantly affect the Cayuga Lake watershed. We must all work together over the long term to make this a success.

Bibliography

[1]
Phosphorus Legacy: Overcoming the Effects of Past Management Practices to Mitigate Future Water Quality Impairment
Andrew Sharpley Helen P. Jarvie Anthony Buda Linda May Bryan Spears Peter Kleinman

First published: 01 September 2013 https://doi.org/10.2134/jeq2013.03.0098

Abstract

> *The water quality response to implementation of conservation measures across watersheds has been slower and smaller than expected. This has led many to question the efficacy of these measures and to call for stricter land and nutrient management strategies. In many cases, this limited response has been due to the legacies of past management activities, where sinks and stores of P along the land–freshwater continuum mask the effects of reductions in edge-of-field losses of P. Accounting for legacy P along this continuum is important to correctly apportion sources and to develop successful watershed remediation. In this study, we examined the drivers of legacy P at the watershed scale, specifically in relation to the physical cascades and biogeochemical spirals of P along the continuum from soils to rivers and lakes and via surface and subsurface flow pathways. Terrestrial P legacies encompass prior nutrient and land management activities that have built up soil P to levels that exceed crop requirements and modified the connectivity between terrestrial P sources and fluvial transport. River and lake P legacies encompass a range of processes that control retention and remobilization of P, and these are linked to water and sediment residence times. We provide case studies that highlight the major processes and varying timescales across which legacy P continues to contribute P to receiving waters and undermine restoration efforts, and we discuss how these P legacies could be managed in future conservation programs.*

CSLAP Data
Long term averages

CSLAP Data

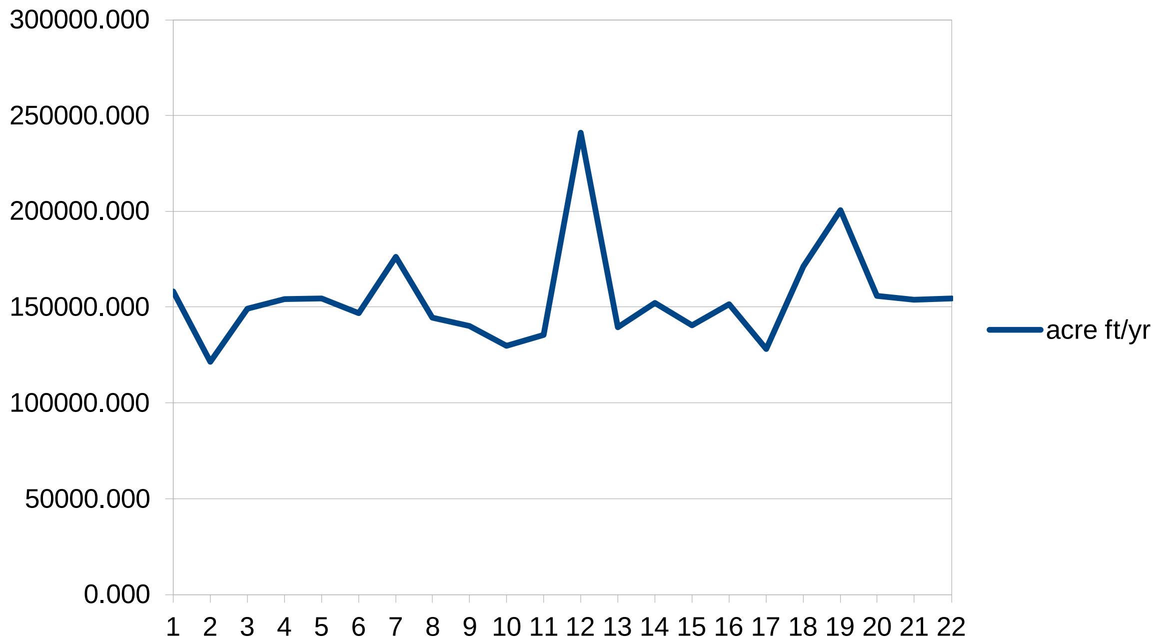
Site	Date	TP/surface ug/L	TP/deep ug/L	TDP/surface ug/L	TDP/deep ug/L	N/surface mg/L	N/deep mg/L	Chl.a ug/L
North								
5	2017	x	x	x	x	x	x	x
	2018	19	x	6	x	0.537	x	6
	2020	24.04	x	6.35	x	0.533	x	7.18
1	2017	19	13	x	x	1.052	x	7.3
	2018	17	12	9	x	0.98	x	5.9
	2020	15.01	12.85	6.41	6.22	0.99	0.922	5.02
4	2017	x	x	x	x	x	x	x
	2018	14	7	5	x	1.231	x	3.6
	2020	10.56	9.73	5.5	5.41	1.04	1.04	6.23
2	2017	11	9	x	x	1.19	x	3.4
	2018	12	8	6	x	1.23	x	3.9
	2020	10.76	6.04	5.51	4.1	1.09	1.35	6.76
3	2017	x	x	x	x	x	x	x
	2018	16	x	6	x	0.92	x	4.1
	2020	15.74	x	7.52	x	1.11	x	3.3
South								

All data from DEC reporı rts. Data may not be taken on the same date for the diffenernt sites.

WSE 5/10/2021

Monthly Rain

year	Jan						
2000	2.94	3.4	3.25	6.47	7.04	4.69	3.76
2001	0.95	1.56	5.41	0.73	1.99	8.6	2.5
2002	2.17	1.94	3.84	3.72	5.45	7.09	1.49
2003	2.3	2.44	2.3	2.47	4.16	4.96	4.92
2004	1.96	1.01	1.85	3.34	5.28	1.53	7.67
2005	3.93	2.3	3.58	4.37	0.81	2.96	1.81
2006	3.27	1.25	1.63	2.61	2.37	11.45	5.52
2007	3.05	1.6	3.27	3.01	2.93	3.26	5.37
2008	1.68	4.57	6.32	2.02	2.57	3.06	4.46
2009	1.85	1.27	2.96	1.89	4.14	5.48	3.75
2010	3.04	1.45	2.93	2.26	2.63	5.02	3
2011	1.71	4.92	3.9	8.55	7.48	4.33	1.4
2012	3.04	1.25	1.68	2.65	4.19	3.73	3.5
2013	2.25	2.3	1.9	3.34	3.37	5.24	6.52
2014	2.94	2.75	2.68	2.77	4.22	4.37	3.84
2015	1.93	2.01	1.99	4.21	3.41	9.74	5.15
2016	1.31	4	1.4	2.83	2.85	3.04	2.89
2017	3.79	2.48	5.6	5.61	6.97	5.74	6.93
2018	2.8	3.4	2.92	2.37	3.73	3.89	6.05
2019	3.82	2.41	1.56	3.69	5.24	5.35	3.31
2020	2.77	3.4	2.35	4.5	2.91	4.02	2.35
Mean inches	2.55	2.46	3.02	3.5	3.99	5.12	4.1
mean feet	0.2125	0.205	0.252	0.292	0.333	0.427	0.342



				Dec	year	acre ft/yr	cubic meters/yr
2.46	2.39	4.05	1.98	2.23	44.66	158178.277	195109740.703
2.21	4.61	1.6	1.84	2.29	34.29	121449.465	149805486.088
1.79	4.34	4.27	3.22	2.74	42.06	148969.510	183750911.195
2.15	7.06	4.73	2.85	3.13	43.47	153963.495	189910891.813
4.28	7.33	2.14	3	4.18	43.57	154317.678	190347769.871
4.84	1.94	7.92	4.91	2.02	41.39	146596.482	180823828.206
6.53	3.76	4.34	4.86	2.19	49.78	176312.463	217477897.272
2.45	3.27	4.33	4.35	3.86	40.75	144329.708	178027808.635
3.67	2.5	2.97	2.12	3.63	39.57	140150.345	172872647.551
4.75	2.65	4.41	1.63	1.81	36.59	129595.682	159853681.422
3.84	5.21	3.72	3.13	2.04	38.27	135545.962	167193232.797
8.9	16.58	4.09	3.08	3.11	68.05	241021.758	297295518.469
6.08	3.18	3.5	1.34	5.2	39.34	139335.723	171867828.017
5.37	2.91	2.81	3.5	3.44	42.95	152121.742	187639125.911
5.46	1.91	3.29	2.1	3.3	39.63	140362.855	173134774.385
3.08	2.2	2.74	2.64	3.61	42.71	151271.702	186590618.572
5.23	1.03	5.83	2.11	3.59	36.11	127895.602	157756666.744
2.62	1.26	4.13	1.76	1.41	48.3	171070.550	211012102.014
8.88	8.66	5.18	6.07	2.71	56.66	200680.277	247535107.663
3.41	1.87	7.85	1.65	3.83	43.99	155805.248	192182657.714
5.96	2.24	3.99	3.08	5.88	43.45	153892.658	189823516.201
4.47	4.14	4.19	2.92	3.15	43.6	154423.933	190478833.288
0.373	0.345	0.349	0.243	0.263	3.633		

Lake Surface	
Lake area, sq mi	66.41
Lake area, acres	42502
Calibration year vs 20yr avg.	
2013 baseline	29.56
20yr mean	29.51

Regression

Regression Model		Linear

LINEST raw output

	1042.763668	-1942241.91
	1053.093259	2117252.71
	0.051657211	27156.7413
	0.980478593	18
	723091784.6	1.3275E+10

Regression Statistics

R^2	0.05165721
Standard Error	27156.7413
Count of X variables	1
Observations	20
Adjusted R^2	-0.0010285

Analysis of Variance (ANOVA)

	df	SS	MS	F	Significance F
Regression	1	723091785	723091785	0.98047859	0.33520562
Residual	18	1.3275E+10	737488600		
Total	19	1.3998E+10			

Confidence level 0.95

		Coefficients	Standard Errc	t-Statistic	P-value	Lower 95%	Upper 95%
Intercept		1042.76367	1053.09326	0.99019119	0.33520562	-1169.70317	3255.23051
	2000	1042.76367	1053.09326	0.99019119	0.33520562	-1169.70317	3255.23051

2000	Predicted Y	158178.277	Residual
2001	2087612.86	121449.465	-1966163.4
2002	2088655.63	148969.51	-1939686.12
2003	2089698.39	153963.495	-1935734.9
2004	2090741.15	154317.678	-1936423.48
2005	2091783.92	146596.482	-1945187.44
2006	2092826.68	176312.463	-1916514.22
2007	2093869.45	144329.708	-1949539.74
2008	2094912.21	140150.345	-1954761.86
2009	2095954.97	129595.682	-1966359.29
2010	2096997.74	135545.962	-1961451.77
2011	2098040.5	241021.758	-1857018.74
2012	2099083.26	139335.723	-1959747.54
2013	2100126.03	152121.742	-1948004.29
2014	2101168.79	140362.855	-1960805.94
2015	2102211.55	151271.702	-1950939.85
2016	2103254.32	127895.602	-1975358.72
2017	2104297.08	171070.55	-1933226.53
2018	2105339.85	200680.277	-1904659.57
2019	2106382.61	155805.248	-1950577.36
2020	2107425.37	153892.658	-1953532.71