Water Quality and Methane Emissions at Lake Waynoka

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1. Background:

The US Environmental Protection Agency (USEPA) is conducting an investigation of methane (CH_4) dynamics in reservoirs. CH_4 is a potent greenhouse gas that is produced by microorganisms in reservoir sediments. The objective is to estimate the magnitude of CH_4 emissions from reservoirs in the United States.

The USEPA measured CH_4 emissions from 32 reservoirs in Ohio, Indiana, and Kentucky during the summer of 2016. We designated a minimum of 15 sampling sites in each reservoir (depending on reservoir size), where we measured CH_4 emissions and several water quality indicators. CH_4 emissions were measured using a device which captures CH_4-rich bubbles as they rise through the water column toward the atmosphere. A sonde was used to measure chlorophyll a, dissolved oxygen, pH, specific conductivity, water temperature, and turbidity just below the water surface at each of the 15 sites. Additionally, nutrient chemistry was analyzed at one shallow and one deep site for each reservoir.

This preliminary report presents results from the USEPA 2016 meausurement campaign relevant to Lake Waynoka. These data will be included in a formal peer-reviewed publication to be submitted for publication in early 2018. This preliminary report includes:

1. This background information
2. A map showing the location of the sampled sites
3. A 3D map of the reservoir showing the measurement results for :
    - CH_4 emissions
    - Chlorophyll a
4. Figures showing how Lake Waynoka compared to the other 31 reservoirs in the study in terms of:
    - CH_4 emissions
    - Total phosphorus
    - Total nitrogen
    - Chlorophyll a
5. Tables summarizing the other measured water quality values at each site within Lake Waynoka

Thank you for your help in including Lake Waynoka in this project.

2. Map of Sampled Sites

We sampled Lake Waynoka on July 26th - 27th of 2016. The sampling sites were chosen using a generalized random tesselation stratified design ("GRTS"), an approach which combines elements of systematic and random survey designs which allows for the random allocation of sampling sites with maximum spatial coverage of the reservoir. We used a GPS and geographic information system (GIS) software to locate each sampling site (+/- 30 meters).

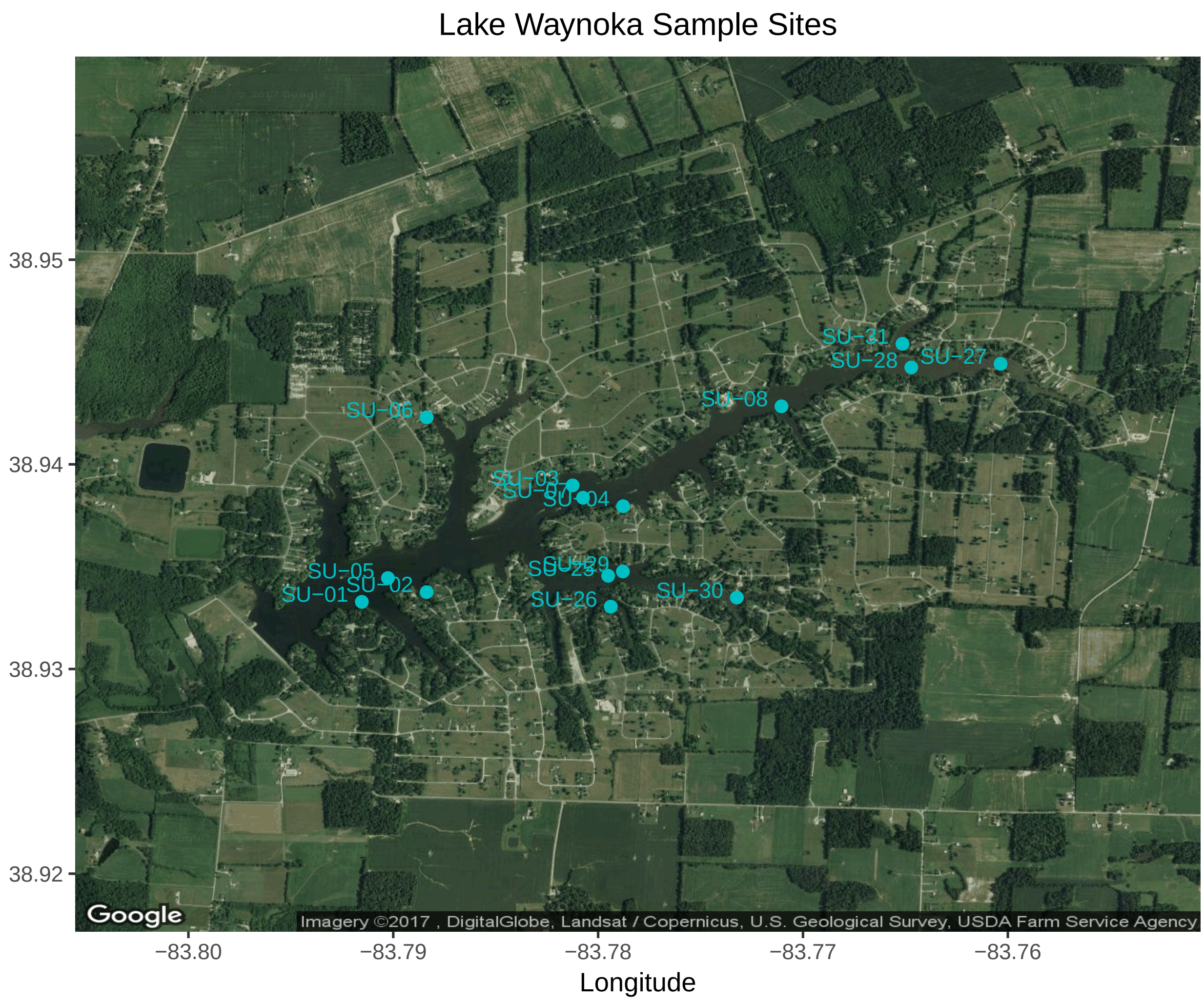

Figure 1: *Location of the fifteen sample sites within Lake Waynoka. Satellite image from Google Maps.*

3. Within-lake values of methane emissions and chlorophyll a concentrations

Previous studies have found a general pattern of higher CH_4 emissions in the river-reservoir transition (tributary) area, and lower emissions in the deeper downstream waters. This pattern was not observed at Lake Waynoka; with the exception of one "hot spot" on the southwest portion of the reservoir, similar CH_4 emissions were measured across the reservoir.

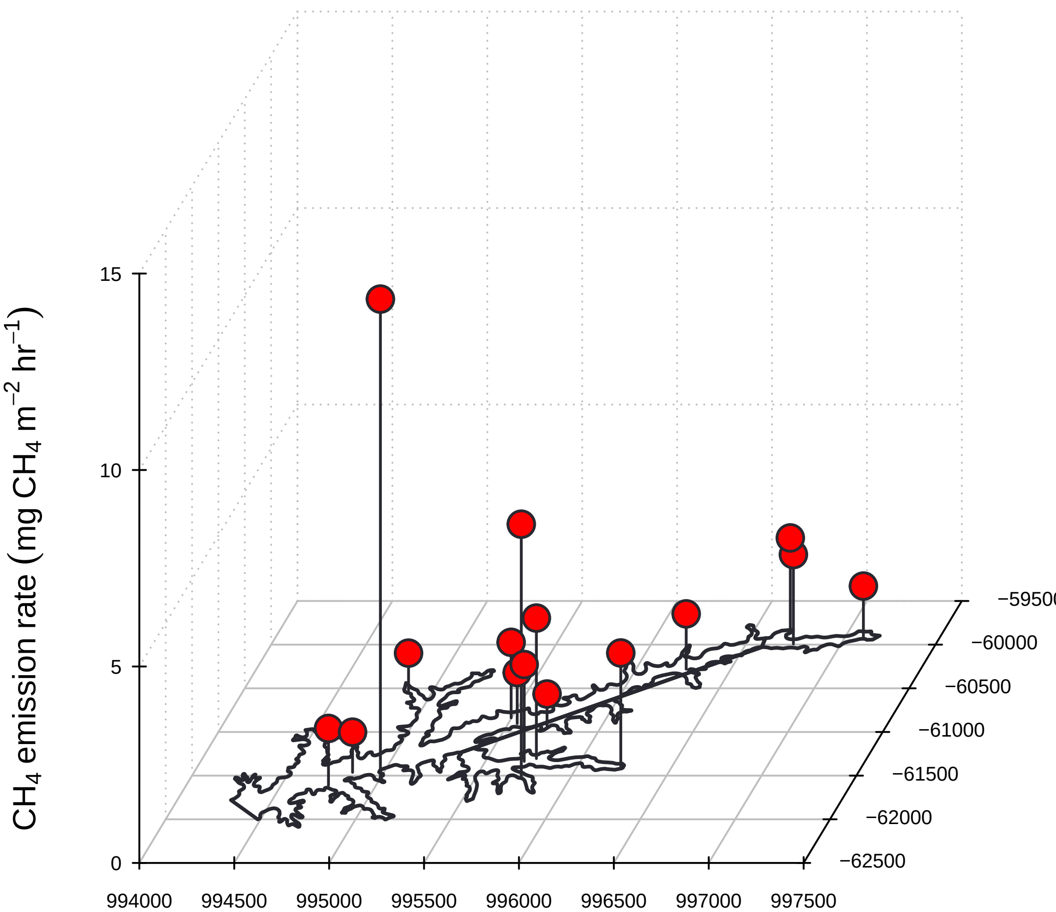

Figure 2: *Methane emissions measured at the 15 sample sites within Lake Waynoka. The height of each "lollipop" corresponds to the emission rate shown on the vertical z-axis in units of milligrams CH_4 per square meter of lake surface per hour.*

However, chlorophyll a concentrations in Lake Waynoka did show a clear gradient from upstream (NE) to downstream (SW) sites.

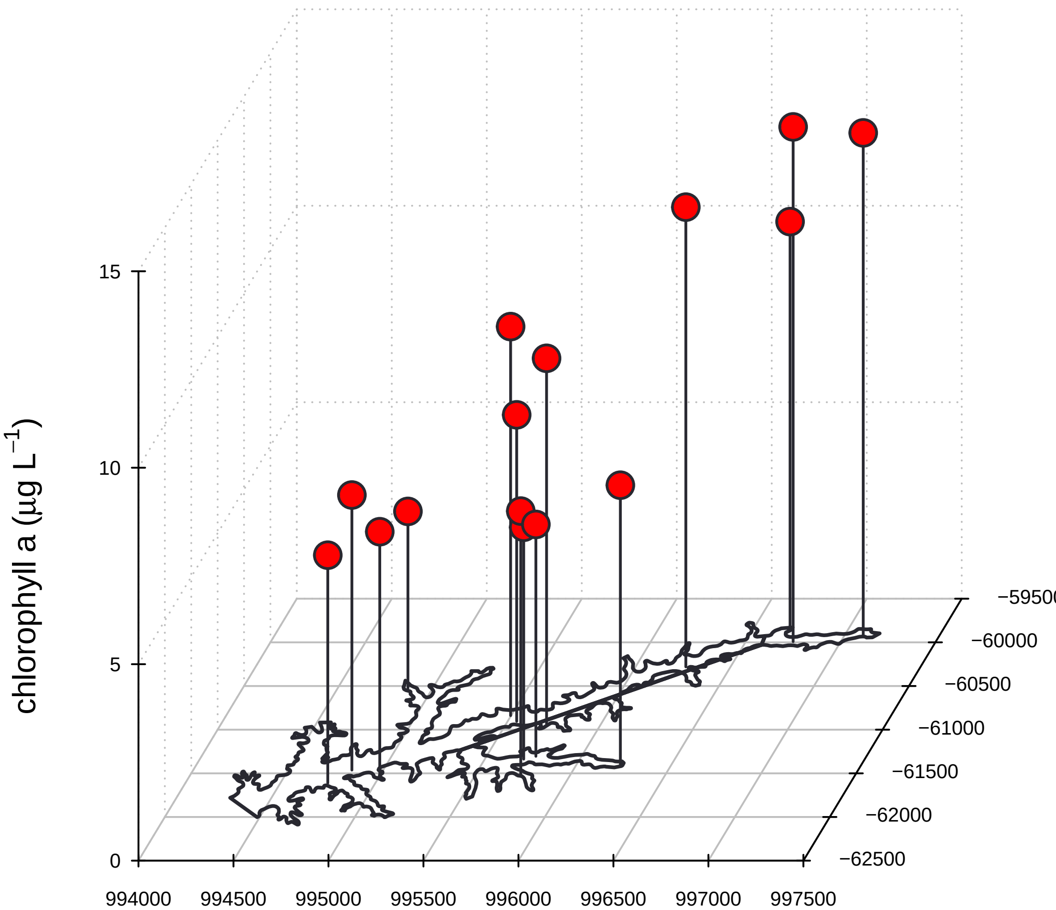

Figure 3: *Chlorophyll a concentrations measured at the 15 sample sites within Lake Waynoka. The height of each "lollipop" corresponds to the concentration shown on the vertical z-axis in units of micrograms per liter of water.*

4. Comparative plots

We used the results from the individual measurement sites to calculate mean values and an uncertainty range for the reservoir. The uncertainty measure we used is the 95% confidence interval (CI), which is similar to two standard deviations (sd) from the mean in a normally distributed data set (where 2*sd = 95.45%). In the case of this study, the majority of the uncertainty is due to the spatial variability of a given parameter within the reservoir, rather than uncertainty due to analytical errors.

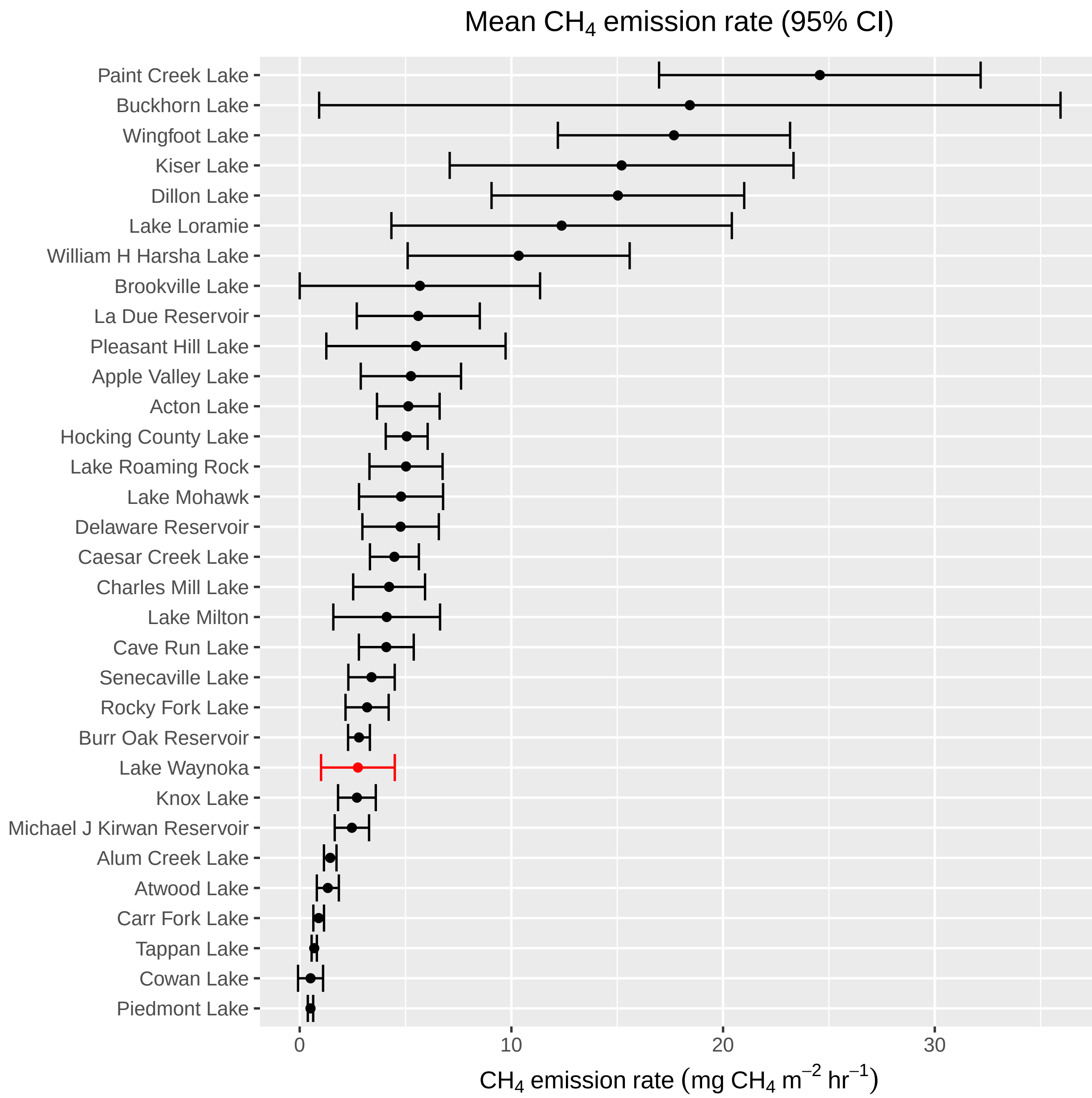

Figure 4: *Mean and 95% confidence interval (CI) of the CH_4 emission rate for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

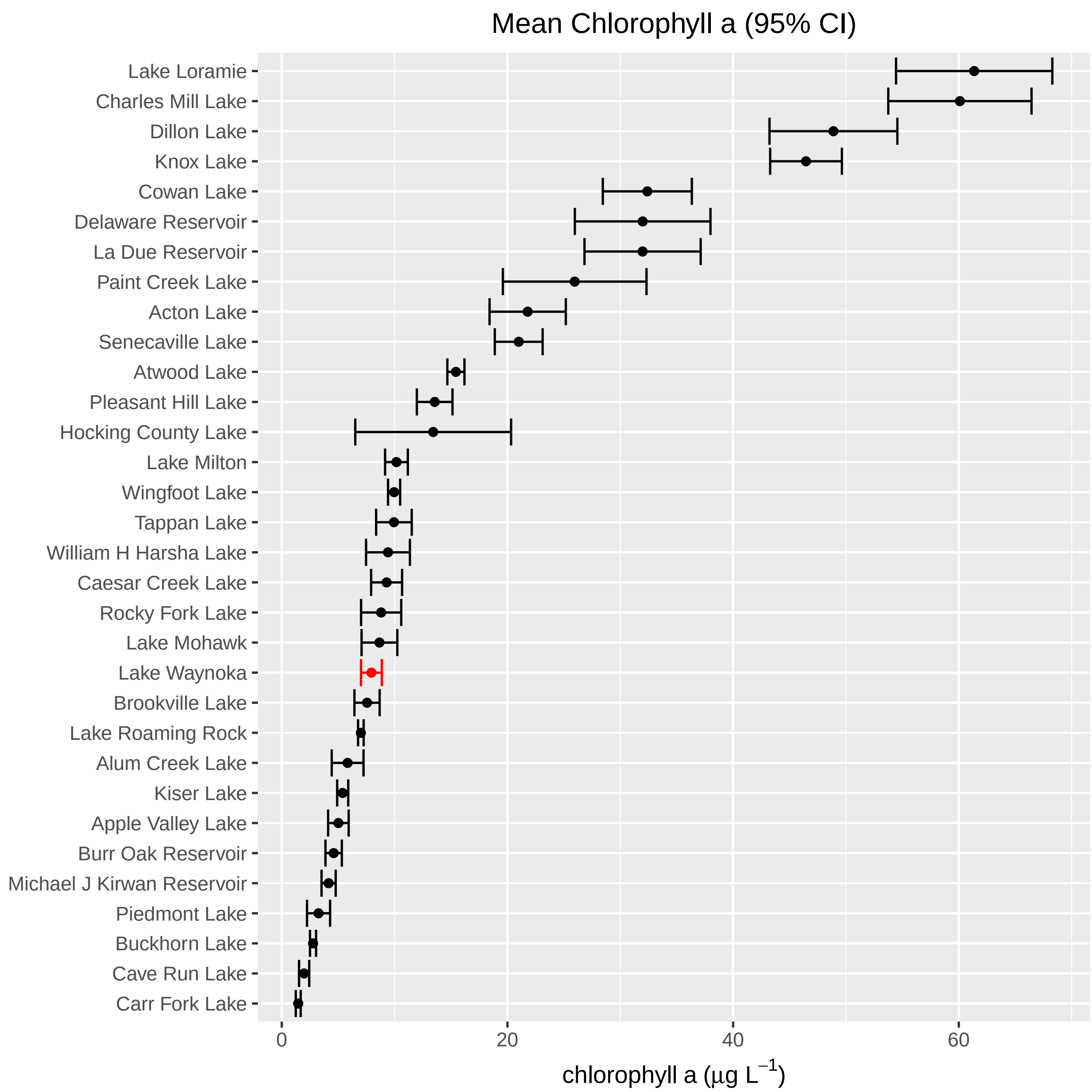

Figure 5: *Mean and 95% confidence interval (CI) of the chlorophyll a concentration for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

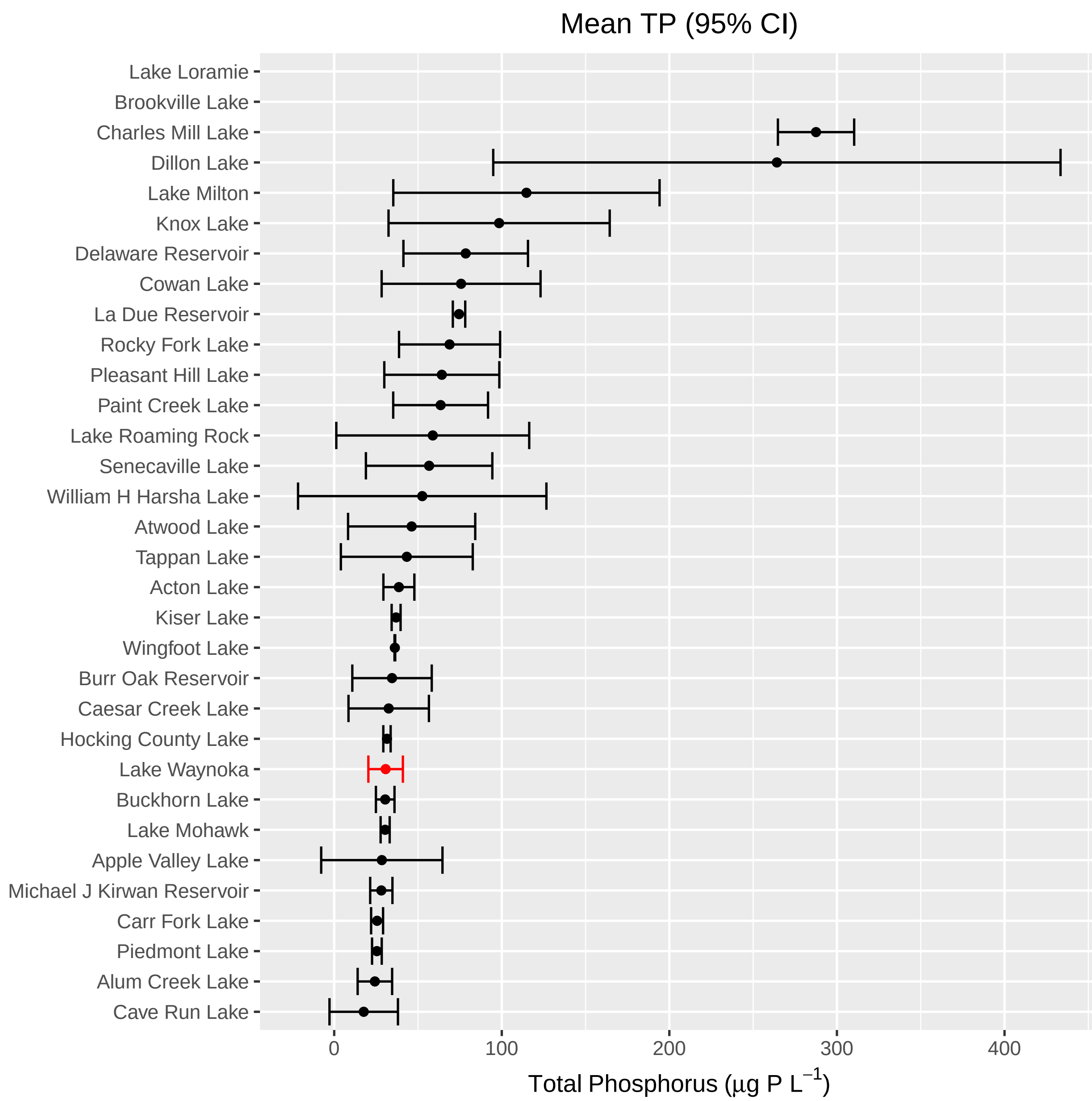

Figure 6: *Mean and 95% confidence interval (CI) of the total phosphorus (TP) concentration for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

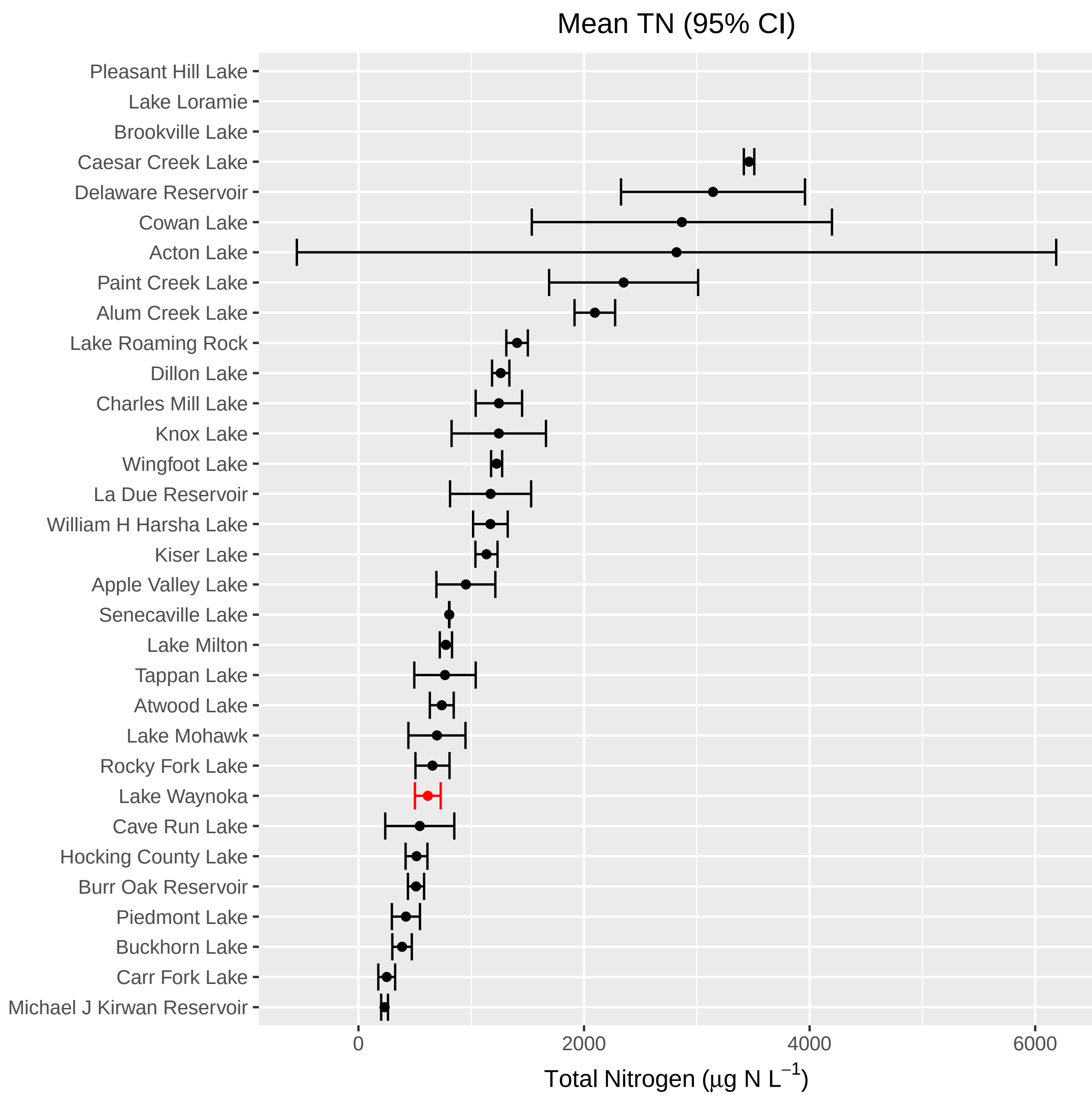

Figure 7: *Mean and 95% confidence interval (CI) of the total nitrogen (TN) concentration for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

5. Tables of measured values at each site

Table 1: Water quality parameters measured via sonde at each site

Site ID	Latitude	Longitude	Depth (m)	Chl a (ug/L)	DO (mg/L)	pH	Sp. Cond	Water Temp (C)	Turbidity
SU-01	38.93323	83.79152	4.3	5.8	7.8	8.0	217	29.6	3.8
SU-02	38.93370	83.78849	1.4	6.2	8.0	8.2	216	29.8	4.2
SU-03	38.93905	83.78126	4.8	9.9	9.1	8.5	215	30.3	5.4
SU-04	38.93798	83.77870	1.5	9.3	9.1	8.4	216	30.2	6.0
SU-05	38.93449	83.79006	9.1	7.0	8.2	8.2	217	29.9	4.0
SU-06	38.94232	83.78835	1.2	4.5	7.6	8.2	218	30.3	6.2
SU-07	38.93832	83.78070	6.2	7.8	9.1	8.5	216	30.6	5.5
SU-08	38.94286	83.77093	2.7	11.7	9.9	8.7	215	30.8	9.0
SU-25	38.95683	83.77946	3.6	5.9	8.7	8.5	221	31.9	5.6
SU-26	38.93308	83.77936	1.5	6.7	8.3	8.4	221	30.5	7.1
SU-27	38.94500	83.76034	0.9	12.8	8.3	8.5	223	31.5	16.0
SU-28	38.94610	83.76480	1.2	13.1	9.0	8.6	218	31.3	13.1
SU-29	38.93478	83.77877	2.4	5.9	9.0	8.5	222	31.7	6.5
SU-30	38.93351	83.77319	0.9	7.1	8.1	8.4	228	31.8	13.3
SU-31	38.94591	83.76527	0.9	10.4	9.4	8.6	218	31.6	11.7

Table 2: Water chemistry parameters measured at one shallow and one deep site

Site ID	Latitude	Longitude	Depth (m)	NH4 (ugN/L)	NO2.3 (ugN/L)	Total N (ugN/L)	Reactive P (ug/L)	Total P (ugP/L)
SU-01	38.93323	83.79152	4.3	11	44	575	22	27
SU-30	38.93351	83.77319	0.9	13	46	723	24	40

6. EPA disclaimer

I have a call into John Olszewski about this.