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Wapato Lake Water Quality Monitoring Data Report

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Scope of Work

In early 2017, University of Washington Tacoma (UWT) was contracted to provide monitoring before, during and after an alum treatment being conducted on May 9, 2017, in Wapato Lake, Tacoma, WA. Specifically, researcher Jim Gawel, Associate Professor of Environmental Chemistry and Engineering, and undergraduate student Kimberly Oliva-Membreno were contracted to carry out the following tasks:

Task 1. Short-Term Impact Monitoring occurs 1 day before treatment, 2 days after treatment, and 2 weeks after treatment. Monitoring at one station includes water quality profiles for field parameters, Secchi depth, and collecting samples from near the surface and bottom for lab analysis of alkalinity, SRP, TP, chlorophyll, dissolved and total aluminum.

For the 3 days listed above at 1 station:

- Lake water column monitoring using a datasonde to collect field measurements (temperature, dissolved oxygen, specific conductivity and pH)
- Secchi depth
- Lake water column sampling and analyses at 2 depths for the following:
    - total P and dissolved P
    - alkalinity (Gran titration)
    - chlorophyll *a* (fluorescence)
    - dissolved and total aluminum (ICP-MS)

Task 2. Twice Daily Monitoring occurs in the morning and evening of each treatment day and includes only water quality profiles and alkalinity field test.

For the 1-2 days listed above, twice a day at 1 station:

- Lake water column monitoring using a datasonde to collect field measurements (temperature, dissolved oxygen, specific conductivity and pH)
- Lake surface water alkalinity field testing at 2 depths

Task 3. Random Monitoring every hour on each treatment day (between twice daily) and includes a pH profile at the site treated one hour previously, and alkalinity from surface and bottom if pH < 6.

For the 1-2 days listed above at 1 station:

- Lake water column monitoring using a datasonde to collect field measurements (temperature, dissolved oxygen, specific conductivity and pH)
- (if needed) Lake surface water alkalinity field testing at 2 depths

Task 4. Produce data summary report to Herrera by December 31, 2017.

Methods

A regular water quality sampling station was established in advance of the alum treatment at the deepest location in Wapato Lake, and marked using an anchor and buoy on May 8, 2017. Monitoring for Tasks 1 and 2 (May 8, 12, and 24) was conducted at this location. Task 3 also regularly collected data and samples at this location (May 9), but additional random

measurements for pH were also collected at other locations in the lake during periods of lower pH that occurred during the alum application.

Lake water quality profile measurements (depth, temperature, specific conductivity, pH and dissolved oxygen) were collected using a multi-parameter water quality probe (In Situ smarTROLL MP) calibrated daily. Water samples were collected from depth using a Niskin bottle. Samples for alkalinity and chlorophyll were collected in clean HDPE sampling bottles. Samples for TP, SRP, and total and dissolved aluminum were collected in acid-washed and DI-rinsed HDPE sampling bottles. SRP and dissolved aluminum samples were filtered (0.4 µm syringe filter) in the field. All samples were stored on ice for transport to the lab. Nutrient samples were then frozen prior to analysis. Samples for filtered and unfiltered aluminum concentrations were acidified with trace metal grade nitric acid (1% v/v). Unfiltered aluminum samples were stored a minimum of 60 days prior to analysis to release refractory metal species into the dissolved phase.

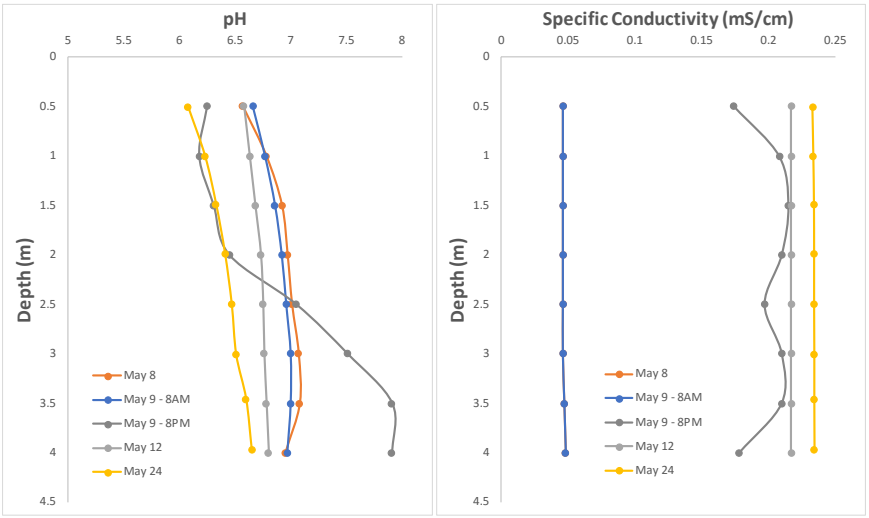

Figure 1: Water quality profiles for pH and specific conductivity in Wapato Lake.

Date	Depth	Chl *a* (µg/L)
5/8/2017	Surface	1.76
	Bottom	1.07
5/12/2017	Surface	0.06
	Bottom	0.07
5/24/2017	Surface	0.34
	Bottom	0.01

Table 1: Chlorophyll *a* concentrations in Wapato Lake.

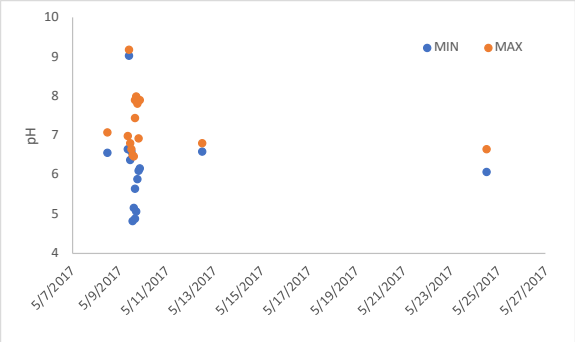

Figure 2: Minimum and maximum pH values recorded in Wapato Lake (any depth) before, during and after alum treatment.

Alkalinity was analyzed via Gran titration either at UWT (within 4 hours of sampling on May 8, 12, and 24) or in the field (within 30 minutes of sampling on May 9). The acid titrant was normalized daily using a sodium bicarbonate standard. Chlorophyll samples were filtered on GF/F filters, extracted in 90% acetone, and analyzed via fluorescence at UWT (Strickland and Parsons 1972). Filtering and extraction were carried out the same day as sampling and extracts were stored in the dark in the freezer prior to measurement.

Concentrations of total and dissolved aluminum were determined by inductively-coupled plasma mass spectrometry (ICP-MS) on an Agilent 7900 at the University of Washington Tacoma. Calibration was performed using certified multi-element standards. TP samples were persulfate-digested in an autoclave (SM 4500-P J). Digested TP samples and SRP samples were analyzed via the ascorbic acid method (SM 4500-P E) on a Westco SmartChem 200 discrete autoanalyzer.

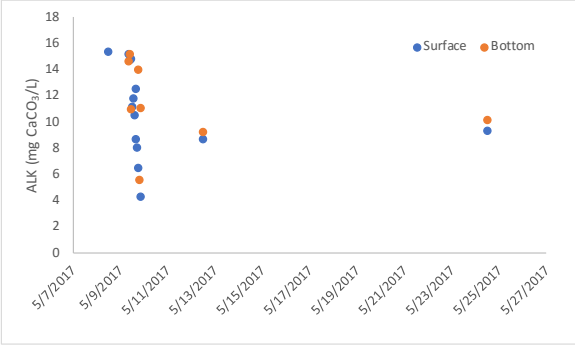

Figure 3: Alkalinity values recorded in Wapato Lake (near surface and bottom) before, during and after alum treatment.

Results

Secchi depth in Wapato Lake reached the bottom of the lake at more than 14 ft. every day sampled, May 8, 9, 12 and 24. Chlorophyll *a* values were low before treatment, less than 2 µg/L, and decreased after treatment below 1 µg/L (Table 1). Water quality profiles for pH and specific conductivity are shown in Figure 1. The alum treatment resulted in a drop in pH of about 0.5 in the lake by the end of the treatment day. Specific conductivity increased about 3-fold due to added salts.

Date	Depth	Total P (µg/L)
5/8/2017	Surface	41.0
	Bottom	42.8
5/12/2017	Surface	15.3
	Bottom	7.8
5/24/2017	Surface	19.9
	Bottom	3.4
Date	**Depth**	**SRP (µg/L)**
5/8/2017	Surface	6.9
	Bottom	6.4
5/12/2017	Surface	9.5
	Bottom	12.3
5/24/2017	Surface	20.0
	Bottom	3.7

Table 2: TP and SRP concentrations measured in Wapato Lake (near surface and bottom) before and after alum treatment.

Short term fluctuations in pH during treatment were greater than this however (Figure 2). The pH temporarily reached below 5.0 and above 9.0, but had equilibrated between 6.0-8.0 by the end of the treatment day and on subsequent monitoring days May 12 and 24. Alkalinity (Figure 3) decreased from a pre-treatment level of 15 mg $CaCO_3$/L to below 5 mg $CaCO_3$/L, before rebounding to close to 10 mg $CaCO_3$/L by May 24.

Dissolved Al (µg/L)	Surface	Bottom
5/8/2017	6.9	14.5
5/9/17 8:00 AM	44.4	7.7
5/9/17 8:00 PM	69.0	659.2
5/12/2017	20.8	16.7
5/24/2017	80.8	103.4
Total Al (µg/L)	**Surface**	**Bottom**
5/8/2017		
5/9/2017	18.9	29.9
5/9/2017	3268.8	5036.5
5/12/2017	248.3	255.2
5/24/2017	209.8	226.2

Table 3: Dissolved and total aluminum concentrations in Wapato Lake (near surface and bottom) before, during and after alum treatment.

Pre-treatment TP concentrations were around 40 µg P/L, and SRP was around 7 µg P/L (Table 2). After treatment, by May 24, TP and SRP were about equal, ranging from 3-20 µg P/L at different depths in the lake.

Dissolved and total aluminum concentrations (Table 3) before the treatment were below 45 µg Al/L. After treatment they remained higher on May 24, 81-103 µg Al/L dissolved and 210-226 µg Al/L total.