Technical Memo

WENCK
Responsive partner.
Exceptional outcomes.

To: Judie Anderson, Shingle Creek Watershed Management Commission

From: Sarah Nalven, Wenck Associates, Inc.
Joe Bischoff, Wenck Associates, Inc.

Date: August 3, 2018

Subject: Bass and Pomerleau Lakes Alum Dosing and Cost Estimate

Bass Lake and Pomerleau Lakes are deep, eutrophic lakes in Plymouth, MN. In 2002 the Minnesota Pollution Control Agency (MPCA) listed both lakes as impaired for excess nutrients. The most recent analysis of phosphorus loading to Bass and Pomerleau Lakes (Wenck 2017a) estimated that internal phosphorus loading accounts for a substantial portion of total annual phosphorus loading to both lakes: 21% (479 lbs/yr) for Bass Lake and 47% (305 lbs/yr) for Pomerleau Lake. Aluminum sulfate (alum) treatment of both lakes has therefore been considered to reduce internal phosphorus loading. The primary goal of this technical memorandum is to determine alum doses and associated cost estimates. Note that a previous memorandum was written with the same purpose (Wenck 2017b), but since then additional investigation of sediment chemistry has allowed refinement of alum dosing calculations.

Phosphorus Release Rates

Anaerobic phosphorus release rates were measured from the sediment of Bass and Pomerleau Lakes. Bass Lake's anaerobic sediment phosphorus release rate averaged 10.9 $mg/m^2/day$ (Table 1), while Pomerleau Lake's anaerobic sediment phosphorus release rate averaged 11.8 $mg/m^2/day$ (Table 2). These release rates are considered high, falling above the 75^{th} percentile for release rates measured in the Twin Cities Metropolitan Area. These elevated release rate measurements corroborate modeled estimates that indicate internal load comprises a substantial portion of the phosphorus load in both lakes. These measurements also suggest that adding alum to Bass and Pomerleau Lakes would substantially reduce internal phosphorus loads and nuisance algae blooms in the lakes.

Table 1. Mean phosphorus release rates under anaerobic conditions for intact sediment cores collected at deep areas in Bass Lake.

Coring station	Anaerobic P Release ($mg/m^2/day$)	Standard Error
1	10.6	0.37
4	11.1	0.77
Average	10.9	0.57

Table 2. Mean phosphorus release rate under anaerobic conditions for intact sediment cores collected at a deep area in Pomerleau Lake.

Station	Anaerobic P Release ($mg/m^2/day$)	Standard Error
1	11.8	2.7

Sediment Chemistry

In addition to sediment phosphorus release rates, vertical sediment chemistry profiles were measured in Bass and Pomerleau Lakes. Vertical sediment chemistry measurements consisted of quantifying bulk density of the sediment and several fractions of phosphorus, such as iron-bound phosphorus and labile organic phosphorus. Sediment chemistry analysis indicated that iron-bound phosphorus levels were high in both lakes relative to other lakes sampled in the Twin Cities Metropolitan Area and that these levels peaked at the surface of the sediment. The presence of high iron-bound phosphorus that peaked at the sediment surface was another indicator that an alum treatment would be effective. Therefore, this sediment chemistry data was used to develop an appropriate alum dosing scheme.

Bass Lake

All of the vertical sediment profiles demonstrated elevated mobile phosphorus in the surficial sediments with the highest concentrations at stations 2 and 4 (**Figure 1**). Since the lake is relatively small, station 2 was used to determine the alum dose for the lake. It should be noted that alum doses were determined for every site and the highest dose was used to be conservative. The proposed alum dose was calculated to inactivate 90% of the mobile phosphorus in the top 6 cm of lake sediment.

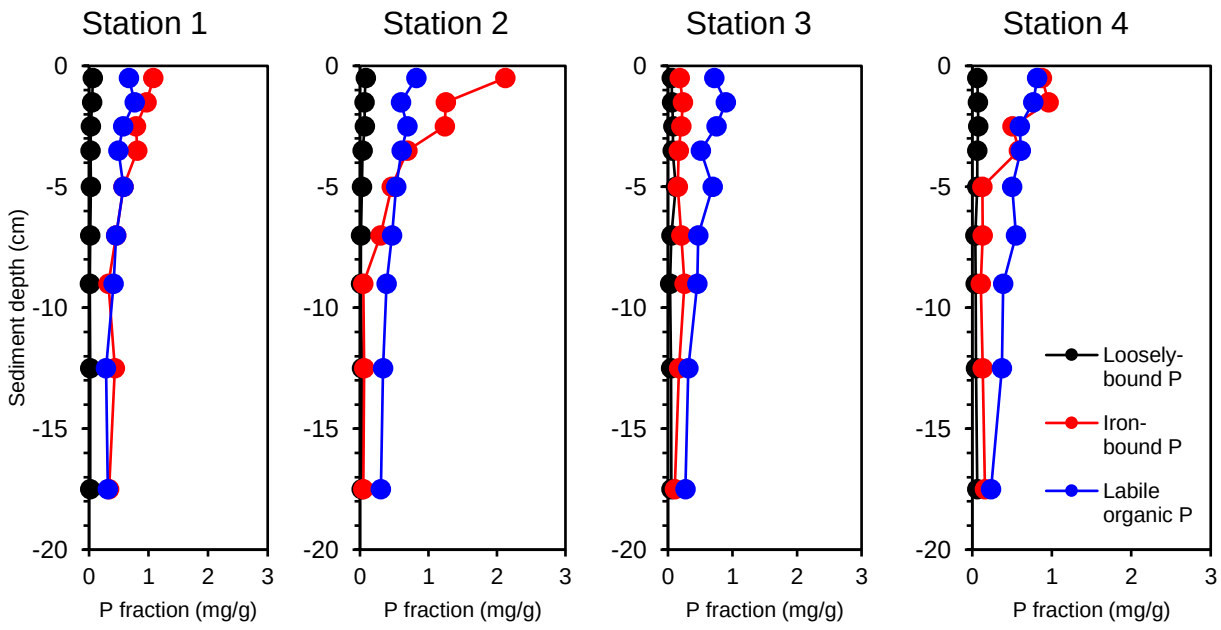


Figure 1. Sediment mobile phosphorus profiles in Bass Lake.

Pomerleau

All of the vertical mobile phosphorus profiles demonstrated elevated concentrations of mobile phosphorus in surficial sediments, with extremely high concentrations at station 1 (**Figure 2**). Further, high concentrations were measured as deep as 8 cm in the sediment

profile. Since the lake is small, station 1 was used to determine the overall alum dose for Pomerleau Lake. The proposed alum dose was calculated to inactivate 90% of the mobile phosphorus in the top 8 cm of lake sediment.

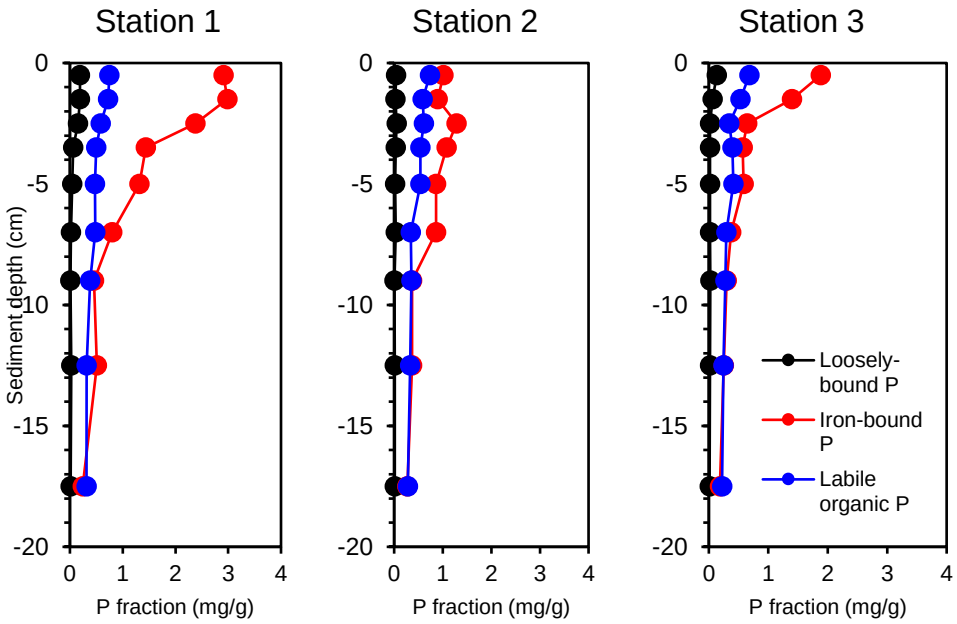


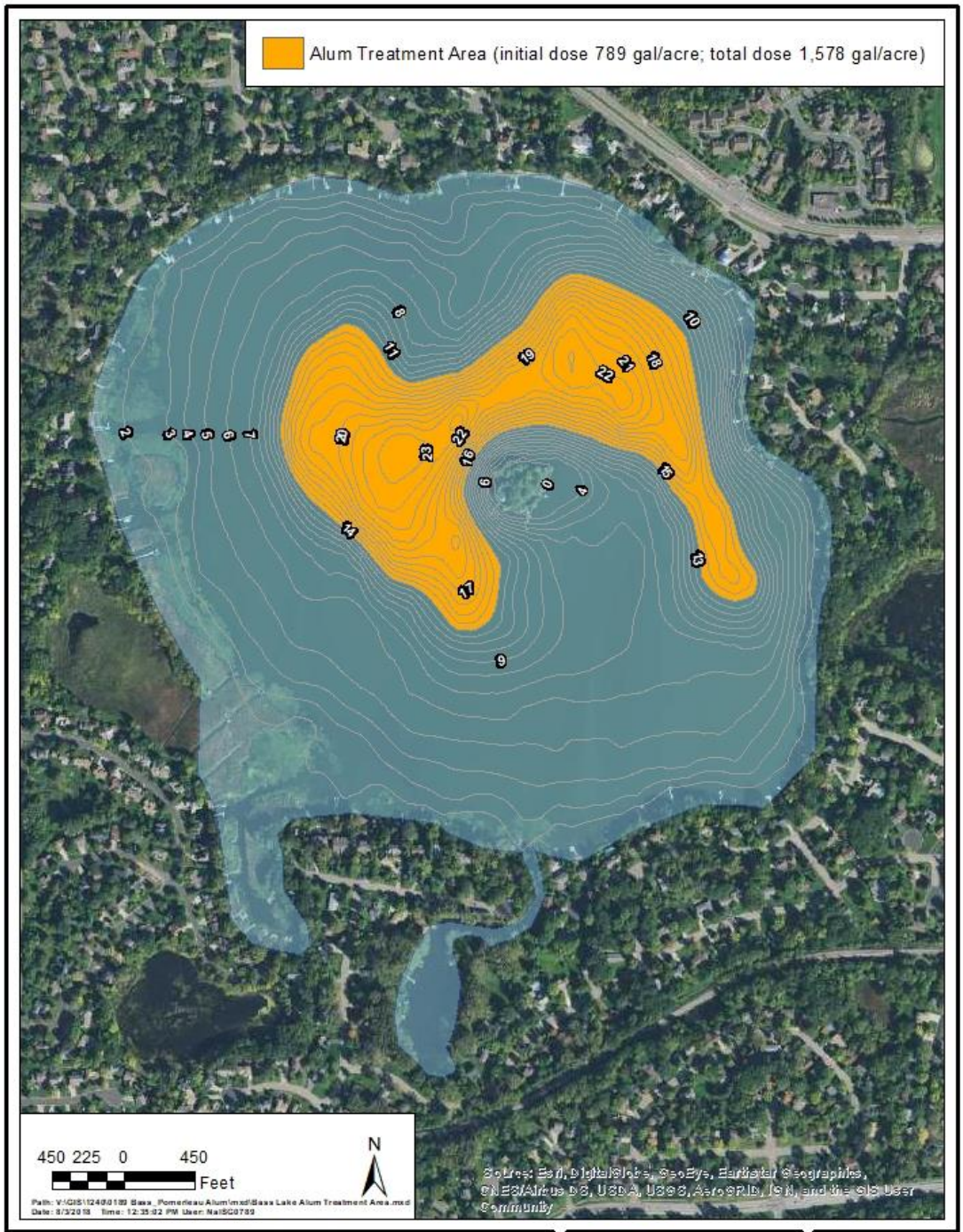
Figure 2. Sediment mobile phosphorus profiles in Pomerleau Lake.

Alum Dose Recommendation

Wenck used sediment chemistry data to develop an alum dose per square meter, and water column anoxia data to determine the alum-treated area. Based on this information, Wenck recommends the following:

- For Bass Lake, Wenck recommends applying **86 g Al/m²** (1,578 gal Al/acre) over all areas of the lake that are 13 feet and deeper, a **35-acre area** (**Figure 3**). This dose has been calculated to treat the top 6 cm of sediment and will cost approximately $100,000.

- For Pomerleau Lake, Wenck recommends applying **152 g Al/m²** (2,748 gal Al/acre) over all areas of the lake that are 7 feet and deeper, a **14-acre area** (**Figure 4**). This dose has been calculated to treat the top 8 cm of sediment and will cost approximately $70,000.


Alum Treatment Area (initial dose 789 gal/acre; total dose 1,578 gal/acre)
450 225 0 450
Feet
N
Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
BASS LAKE
Proposed 35-acre Alum Treatment Area
WENCK ASSOCIATES
Responsive partner. Exceptional outcomes.
AUG. 2018
Figure 3


Alum Treatment Area (intial dose 1,374 gal/acre; total dose 2,748 gal/acre)
150 75 0 150
Feet
N
Sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
POMERLEAU LAKE
Proposed 14-acre Alum Treatment Area
WENCK ASSOCIATES
AUG. 2018
Figure 4

To ensure no negative ecological effects arise from alum dosing, the maximum allowable alum dose was also determined by titrating lake water with alum. The maximum allowable dose is the highest non-buffered alum dose possible before addition of alum to lake water drives the water's pH below 6.0, the pH at which aluminum becomes toxic to fish. Maximum allowable doses for both Bass and Pomerleau Lakes will not be exceeded during half dose-applications of the dose recommended above. The maximum allowable dose for Bass Lake was measured at 18.75 mg/L, and alum concentrations will only reach 2.8 mg/L during a half-application at the recommended dose. The maximum allowable dose for Pomerleau Lake was measured at 22.5 mg/L, and alum concentrations will only reach 10.5 mg/L during a half-application at the recommended dose above.

The total cost of the combined alum treatments is $330,000, which includes acquiring quotes, application observation, and follow up monitoring (Table 3).

Table 3. Bass and Pomerleau alum application cost estimate.

Item	Unit	Quantity	Unit Cost	Total Cost
Bass Lake	Gal $AlSO_4$	55,222	$1.80	$100,000
Pomerleau Lake	Gal $AlSO_4$	38,469	$1.80	$70,000
Mobilization/Site Restoration				$25,000
Application observation and monitoring				$7,000
Follow-up Monitoring				$40,000[1]
Total Cost Estimate				**$242,000**

[1]Includes interim and final as-built coring events.

Application Recommendation

For both Bass and Pomerleau Lakes, Wenck recommends two half dose-applications using an adaptive management approach. This process will increase the effectiveness and longevity of the alum application by increasing the time that fresh alum is exposed to the uppermost sediment layer containing high phosphorus concentrations. Further, applying the dose in two half-applications allows adjustment of the second dose if sediment monitoring shows the first dose is not as effective as expected.

Application 1

Half of the overall dose should be applied in the fall or spring when water temperatures are above 40 degrees Fahrenheit and when the lake is well mixed or only weakly stratified. Application costs for the first half dose are included in Table 4. Application zones and areal application rates are included in **Figures 3 and 4**.

Table 4. Bass and Pomerleau alum application cost estimate for the initial half dose.

Item	Unit	Quantity	Unit Cost	Total Cost
Bass Lake Aluminum Sulfate Application	Gal $AlSO_4$	27,611	$1.80	$50,000
Pomerleau Lake Aluminum Sulfate Application	Gal $AlSO_4$	19,235	$1.80	$35,000
Mobilization/Site Restoration				12,500
Application Observation and Monitoring				$3,500
Follow Up Sediment Monitoring				$20,000
Total Cost Estimate				**$121,000**

Application 2

The second half dose should be applied a minimum of one year after the initial half dose. Application should occur in the fall or spring when water temperatures are above 40 degrees Fahrenheit and when the lake is well mixed or only weakly stratified. Application costs for the second half dose are included in Table 5. Final application zones and rates will be determined following the initial application and follow-up sediment monitoring. Cost estimates assume that the second half dose will use the same amount of alum as the initial dose.

Table 5. Bass and Pomerleau alum application cost estimate for the initial half dose.

Item	Unit	Quantity	Unit Cost	Total Cost
Bass Lake Aluminum Sulfate Application	Gal $AlSO_4$	27,611	$1.80	$50,000
Pomerleau Lake Aluminum Sulfate Application	Gal $AlSO_4$	19,235	$1.80	$35,000
Mobilization/Site Restoration				12,500
Application Observation and Monitoring				$3,500
Final Sediment Monitoring				$20,000
Total Cost Estimate				**$121,000**

References

Wenck Associates, Inc. 2017. Schmidt, Pomerleau and Bass Lakes Nutrient TMDL Five Year Review. *Prepared for Shingle Creek Watershed Management Commission.*

Wenck Associates, Inc. 2017. Bass and Pomerleau Lakes Alum Dosing Feasibility and Cost Estimate. *Prepared for Shingle Creek Watershed Management Commission.*