

Big Lake LMD Year End Report and Discussion of Cyanobacteria Management



Prepared for
Skagit County and LMD 1

Introduction

Big Lake has a long history of managing invasive aquatic weed issues. In the late 1990's, the lake littoral zone was completely infested with dense growth of Brazilian Elodea. Our firm was hired to develop an Integrated Aquatic Vegetation Management Plan to combat this problem. On completion of our study the County received two years of funding to implement a lake wide Sonar aquatic herbicide treatment that remove this noxious threat from the lake. A Lake Management District (LMD) was also formed to provide an ongoing maintenance program.

In 2024 our firm was selected to take on aquatic plant management work for the LMD and the contract was renewed for 2025 and 2026. This report will provide background on survey and treatment operations. It will also discuss cyanobacteria management as this is an emerging concern of the community.

Survey

After contracting was completed in the late spring of 2025, our biologists mobilized two mapping boats and crews to the lake on Monday June 30th. A complete survey of the littoral areas of the lake was performed to locate and map target aquatic vegetation.



Mapping boat equipped with Hydroacoustic mapping system and Trimble Submeter Global Positioning System to map location and species of aquatic plant growth found. The GPS data exports to ArcGIS mapping software for analysis

The team observed a number of nuisance species growing at levels that were impacting beneficial uses such as shoreline swimming and boating. These included pondweed species and native Elodea. No Eurasian Milfoil or Brazilian Elodea was observed by our teams during the survey. This is probably the result of the 2024 and earlier treatment work. There were small, scattered patches of White Water Lilies, a class C noxious weed and a plant that can pose a threat to swimmers in infested areas.



Typical aquatic plant growth observed in the littoral areas of Big Lake in the summer pre treatment survey.

Our team developed a treatment map from this data and reported conditions to the LMD. We then complied with permit notification requirements, the Washington Department of

Fish and Wildlife fish timing window and scheduled the herbicide treatment called for in the scope of work.

Weed Treatment

Based on our observations during the survey and species present a combination of Aquathol K and Tribune (diquat) was selected to target submerged vegetation. The White Water Lily growth was targeted with AquaNeat herbicide with a aquatic approved surfactant to ensure plant uptake.

We mailed a 10-day business and residential notice to all homes on the lake to inform the group of the upcoming treatment. This notice is required by Ecology as a permit condition to inform lakeshore owners of products used, water use restrictions if any and dates of treatment.

On July 21st we mobilized several crews to the lake to perform shoreline posting as required by the permit and to facilitate application of the herbicides. We got on the water at daybreak and performed the posting, placing signage on all lots subject to treatment. We completed that work and started application at 7:30 am. On large lakes like this we often deploy several posting and treatment teams to complete the application with minimal impact on lake use by the community. The submerged aquatic plants were treated first as mapped, and then White Water Lily growth was targeted.

Algae

In recent years, Big Lake has begun to experience significant cyanobacteria blooms in the mid to lake summer and into the fall.

Cyanobacteria or Blue Green Algae thrive in eutrophic lake systems. These species can produce toxins that are harmful to wildlife, pets and humans. Acute toxins produced can affect the liver and nervous systems of animals that ingest water from affected lakes. There are also known chronic toxins that are linked to diseases such as ALS through long term exposure.

While humans generally do not ingest water from lakes with this type of bloom, and are hence not subject to the effects of acute toxins that might be present, there are a number of pet and wildlife mortality events reported each year around the State and Nation.

Recent studies have shown that these toxins can aerosolize during wind events as low as 10 miles per hour and be transported for miles downwind of impacted lakes. As such there is potential for chronic exposure around and downwind of impacted lakes.



September cyanobacteria bloom on Big Lake, Skagit County

Eutrophication is the process of lake aging. Over time, nutrients flow downstream to lakes where they accumulate over the years. Plants and algae need phosphorus and nitrogen to thrive. Cyanobacteria are unique in that they can fix nitrogen from the atmosphere, so when phosphorus levels are elevated in a lake, they have a competitive edge.

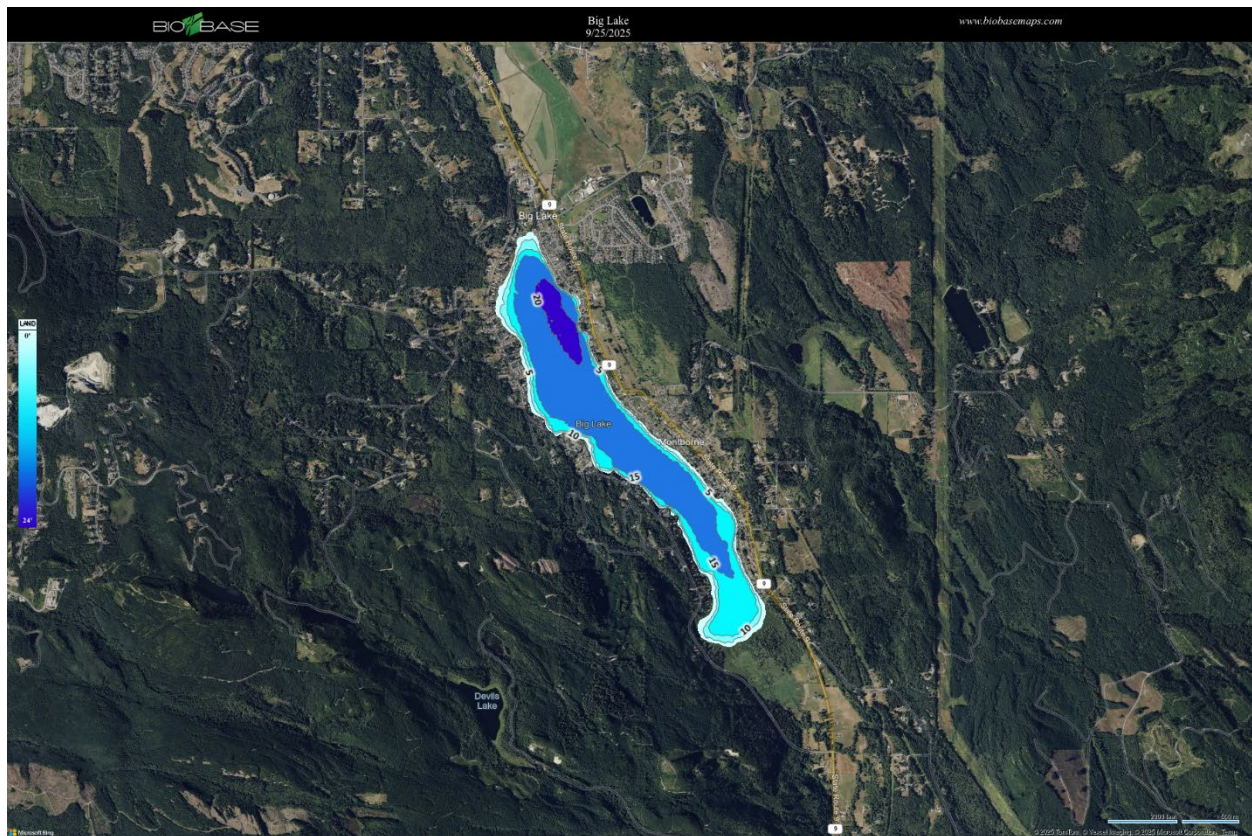
Expensive studies can develop a nutrient budget for a lake. A budget will calculate incoming and outgoing phosphorus movement and the internal cycling. While watershed

Big Lake LMD Year End Report

contributions can be something to take into consideration, in the vast majority of cases internal phosphorus cycling from the lake sediments is the primary driver of cyanobacteria blooms. In lake phosphorus management is the primary solution to cyanobacteria blooms. As such we collected the information necessary to develop treatment recommendations through a study performed in the late summer and early fall of 2025.

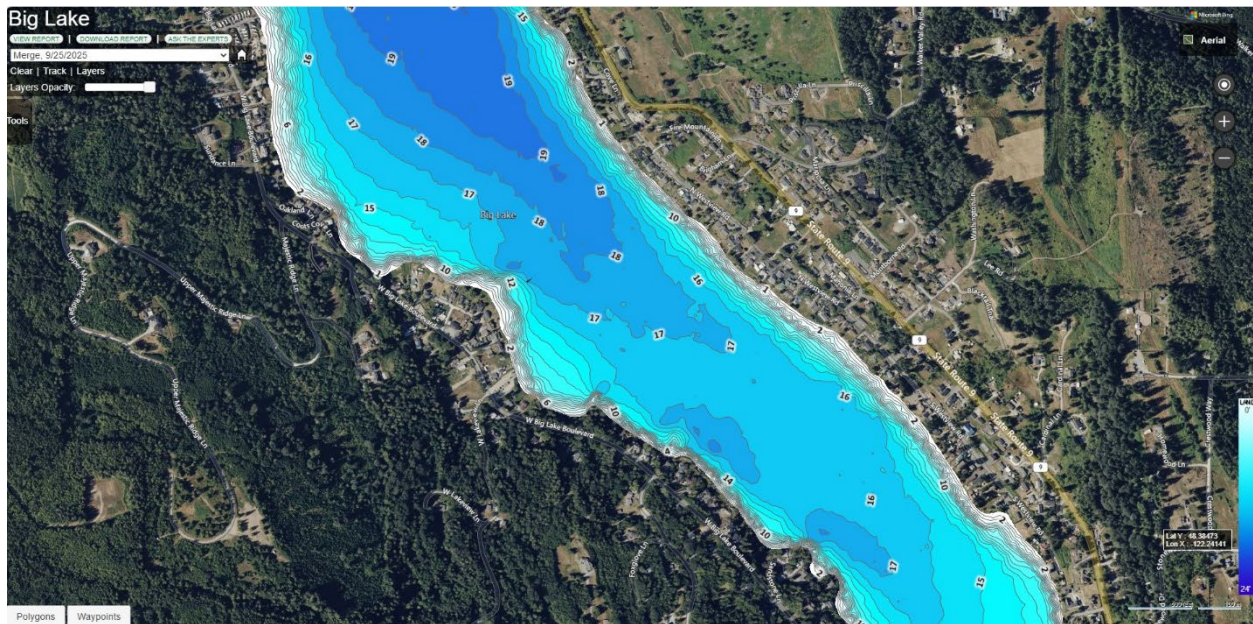
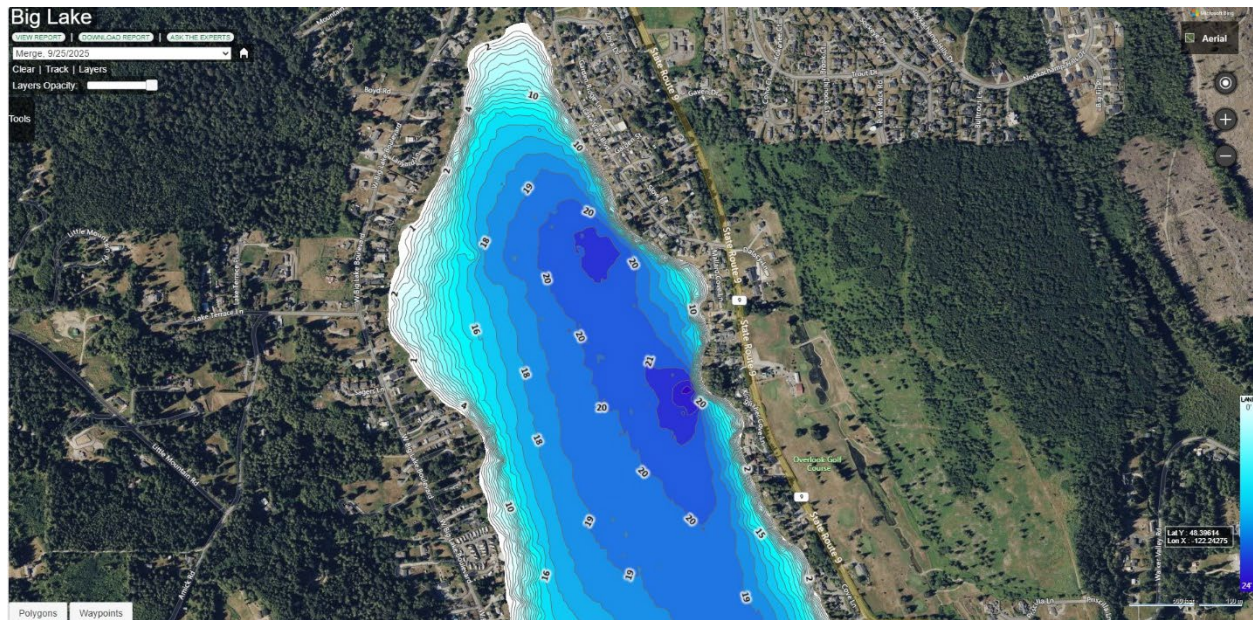
The information necessary to develop treatment recommendations are water volume, water column phosphorus levels, sediment levels of phosphorus that is considered mobile or loosely bound and the cost of phosphorus sequestering technologies.

Our team performed a hydroacoustic bathymetry mapping study to determine the lake water volume. A number of our mapping boats traveled along transects over the entire surface of Big Lake logging sonar data. This data was processed by the BioBase algorithms to develop a bathymetry map and to provide the volume of the lake.



The BioBase Bathymetry map of the lake is shown above. As resolution changes with the level of zoom, we have also provided three close up images on the following pages.

Big Lake LMD Year End Report





This report shows the survey and water volume as determined by the technique. There are 7,880 acre feet of water held in Big Lake at the lake level present at the time of survey. The report can be accessed by clicking on this link: [Analysis Report \(2025 October 01 - 16:07 \(UTC\)\)](#)

The next calculation would be to determine how much phosphorus is present in the lake water. The water quality sampling program collected water sample at the surface and at depth just above the lake sediments at three stations in the lake. Samples were collected and submitted to the Mount Vernon location of Edge Laboratories on September 25th and November 4th of 2025. While a number of water quality parameters were evaluated, the key ones for this exercise are Total Phosphorus and Ortho Phosphate. There were three sampling stations. The results are as follows:

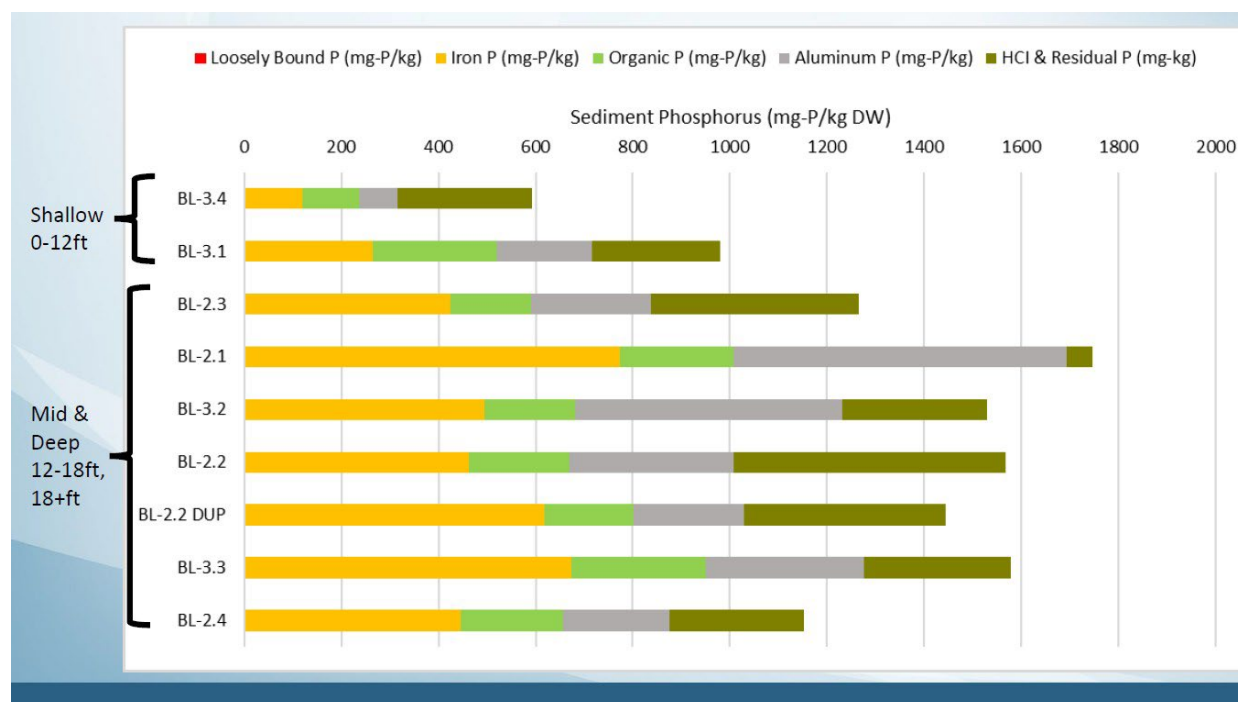
Station and Date	Total Phosphorus ug/l	Ortho Phosphate ug/l
B1 Surface 9/25	74	17
B1 Deep 9/25	65	20
B2 Surface 9/25	67	23
B2 Deep 9/25	62	22
B3 Surface 9/25	51	27
B3 Deep 9/25	61	32
Average	63	24
B1 Surface 11/4	39	Lab did not report
B1 Deep 11/4	40	
B2 Surface 11/4	45	
B2 Deep 11/4	46	

B3 Surface 11/4	38	
B3 Deep 11/4	47	
Average	43	

Using the September total phosphorus numbers and the lake volume, the calculated pounds of phosphorus present in Big Lake waters would be 1,337.84 pounds that would require sequestering. The September numbers are probably more representative of late summer phosphorus conditions present in the lake, after phosphorus was released by the sediments. Vertical profiles of dissolved oxygen and temperature collected on these dates indicate the lake was well mixed after the summer stratification and deep water anoxic period (high P release). By November phosphorus likely started to settle back to the sediments and there may have been dilution from watershed inflows. This number can be used to calculate costs for water column stripping applications.

The hydrology of the lake plays a significant role in the phosphorus dynamics of the lake. This lake has significant turn over during the fall/winter/spring seasons, during the months of July/August/September this inflow and outflow drops considerably.

Sediment or legacy phosphorus is generally the primary contributor of phosphorus to the water column during the summer months. Phosphorus accumulated in organic sediments over time and can be well bound or mobile. The sediment sampling work performed identified and calculated the pounds of phosphorus that would be considered mobile and contribute to cyanobacterial blooms. Sediments go anoxic in the summer months, the bonds holding phosphorus to the iron break and this phosphorus releases into the sediment pore waters and surface waters. Limited limnological data is available online from Washington Environmental Information Management System (EIM) but a few investigations performed in the 1990s indicate during the course of the summer that oxygen can be lost at 13-19ft below the surface (anoxia).



A summary of phosphorus forms in Big Lake Sediments. Releasable fractions in Big Lake would be Iron Bound and Organic P. This data is available in greater detail in the attached report. The Aluminum and HCl/Residual P are considered stable and would not contribute to cyanobacteria growth.

The mobile pounds of phosphorus present in Big Lake sediments were calculated and presented in this table.

Region	Sediment Mobile P (Pounds Per Acre)	Acres	Mobile P Pounds in Region
Shallow (0-12 feet)	34.7	120	4,164
Mid (12-18 Feet)	60.4	184	11,114
Deep (18 Plus Feet)	60.4	246	14,858

P Sequestration Treatment Based on the limnology of the system, targeting the mobile sediment phosphorus that annually releases in the summer (dry season) will be effective to reducing in-lake phosphorus levels. There are two in-lake management technologies commonly used that sequester phosphorus and reduce availability to fuel blooms.

Aluminum sulfate treatment is a technology that has been used for decades to control sediment phosphorus release. The alum is applied to the lake surface and forms a floc that

settles through the water column and onto the lake sediments. The floc will capture phosphorus dissolved in the water column as it settles chemically binding it. As the floc settles onto the lakebed it will also sequester phosphorus in the sediments.

There are a few disadvantages to this approach. In Western Washington, water hardness and alkalinity are such that application of alum without a buffer can cause rapid drops in pH and potential fish toxicity. When larger doses of alum are applied, a buffer is required to be added to help prevent this. The chemical bond between the alum and phosphorus can also be broken when pH levels in the lake sediments exceed 9 which is often the case. This means the sequestering bonds may not be as long lasting as other technologies.

Additionally in large shallow lakes, the alum floc doesn't stay in place and will move around the lake bottom to the deepest point, making it less efficient at targeting the phosphorus for much of the sediment area of Big Lake. The Washington Department of Ecology permit requires a significant amount of monitoring for the year post treatment that adds to the cost of application.

The other option is Lanthanum. This is a rare earth element that combines with phosphorus in the water column and sediments to form a mineral called Rhabdophane. The phosphorus converted to this mineral will never be biologically available again. There is a ration of 50 pounds of lanthanum modified clay (EutroSORB G) will convert 1 pound of phosphorus and sequester it. There is no impact to lake water quality as can be the case with alum applications and the Ecology permit monitoring requirements are much lower than alum treatments. The environmental impact to aquatic life is negligible or not present.

P Sequestration Costs

Costs for this operation are going to be expensive based on the size of the lake and the accumulated phosphorus present that requires mitigation to decrease cyanobacteria growth. There are a couple ways to approach this. With an unlimited budget, you would want to do a total reset targeting all the mobile sediment phosphorus (mid and deep sediments, 430 acres).

The cost to target all the phosphorus in the targeted sediments with an Alum/Sodium Aluminate (buffer) assuming targeting 60.4 pounds per acre would be approximately \$3,750,000.00 plus a monitoring budget for permit compliance of \$34,000.00

The cost to target all the phosphorus in the system sediments with EutroSORB G (trade name for Lanthanum) would be \$5,100,000.00. There would be no monitoring budget for permit compliance, and this technology will not release phosphorus under any condition. Alum treatments can fail based on sediment pH over time.

Both costs are outside the scope of LMD current funding. With a limited annual budget, partial dosing performed annually over multiple years following adaptative management principles can be implemented. We have used this approach on several similar lakes in Washington State with similar problems where we perform smaller treatments each year, monitor results and adapt the program in the next year based on effectiveness.

Long Lake in Thurston County is a 330 acre waterbody with similar characteristics in terms of depth and sediment phosphorus levels. We have applied two treatments with lanthanum modified clay per year at a cost of approximately \$200,000.00 annually. This significantly reduced cyanobacteria blooms in year one and has largely eliminated them in the three years since. To date we have sequestered over 30% of sediment phosphorus, while seeing a great reduction in sediment P release each year. We have similar experience on Kitsap Lake in Bremerton.

We estimate that this approach would cost approximately \$340,000.00 annually for Big Lake. Based on funding and follow on monitoring, treatment costs could potentially drop in later years of the program.

In any event the next step needs to be funding this type of project. Review of grants opportunities, special appropriation from federal/state/local government, adjusting lake management district rates or private funding would all be options. We can assist with government appropriation work as requested.



PESTICIDE APPLICATION RECORD (Version 1)

NOTE: This form must be completed same day as the application and it must be retained for 7 years (Ref. chapter 17.21 RCW)

Washington State Department of Agriculture
Pesticide Management Division
PO Box 42560
Olympia WA 98504-2560
(877) 301-4555

1. Date of Application - Year: 2025 Month: July Day: 21st Start Time: 7:30 am
Stop Time: 2:00 pm

2. Name of person for whom the pesticide was applied:

Firm Name (if applicable): Skagit County Noxious Weed Board

Street Address: 1800 Continental Pl City: Mt. Vernon State: WA Zip: 98273

3. Licensed Applicator's Name (if different from #2 above): Terry McNabb License No.: 7973

Firm Name (if applicable): AquaTechnex Tel No.: 360-330-0152

Street Address: P.O. Box 118 City: Centralia State: WA Zip: 98531

4. Name of person(s) who applied the pesticide (if different from #3 above): Braden O'Neil, Scott Conrade

License No(s). If applicable: 87689, 102514

5. Application Crop or Site: Big Lake - Potamogeton spp., Elodea canadensis

6. Total Area Treated (acre, sq. ft., etc.): 63 acres

7. Was this application made as a result of a WSDA Permit? ☒ No ☐ Yes (If yes, give Permit No.) #

8. Pesticide Information (please list all information for each pesticide, including adjuvants (buffer, surfactant, etc.), in the tank mix):

a) Full Product Name	b) EPA Reg. No.	c) Total Amount of Pesticide Applied in Area Treated	d) Pesticide Applied/Acre (or other measure)	e) Concentration Applied
Aquathol K	70506-176	94.5	1.5 gal / Acre	
Tribune	100-1390	94.5	1.5 gal / acre	
AquaNeat	228-365	0.47 gal	/	1.5%
Agri-dex	5905-50094	0.47 gal	/	1.5%
			/	

9. Address **or exact location** of application. NOTE: If the application is made to one acre or more of agricultural land, the field location must be shown on the map on page two of this form.

10. Wind direction and estimated velocity (mph) during the application: 3-8 mph from SW

11. Temperature during the application: 54-73 Degrees F

12. Apparatus license plate number (if applicable):

13. ☐ Air ☒ Ground ☐ Chemigation

14. Miscellaneous Information:



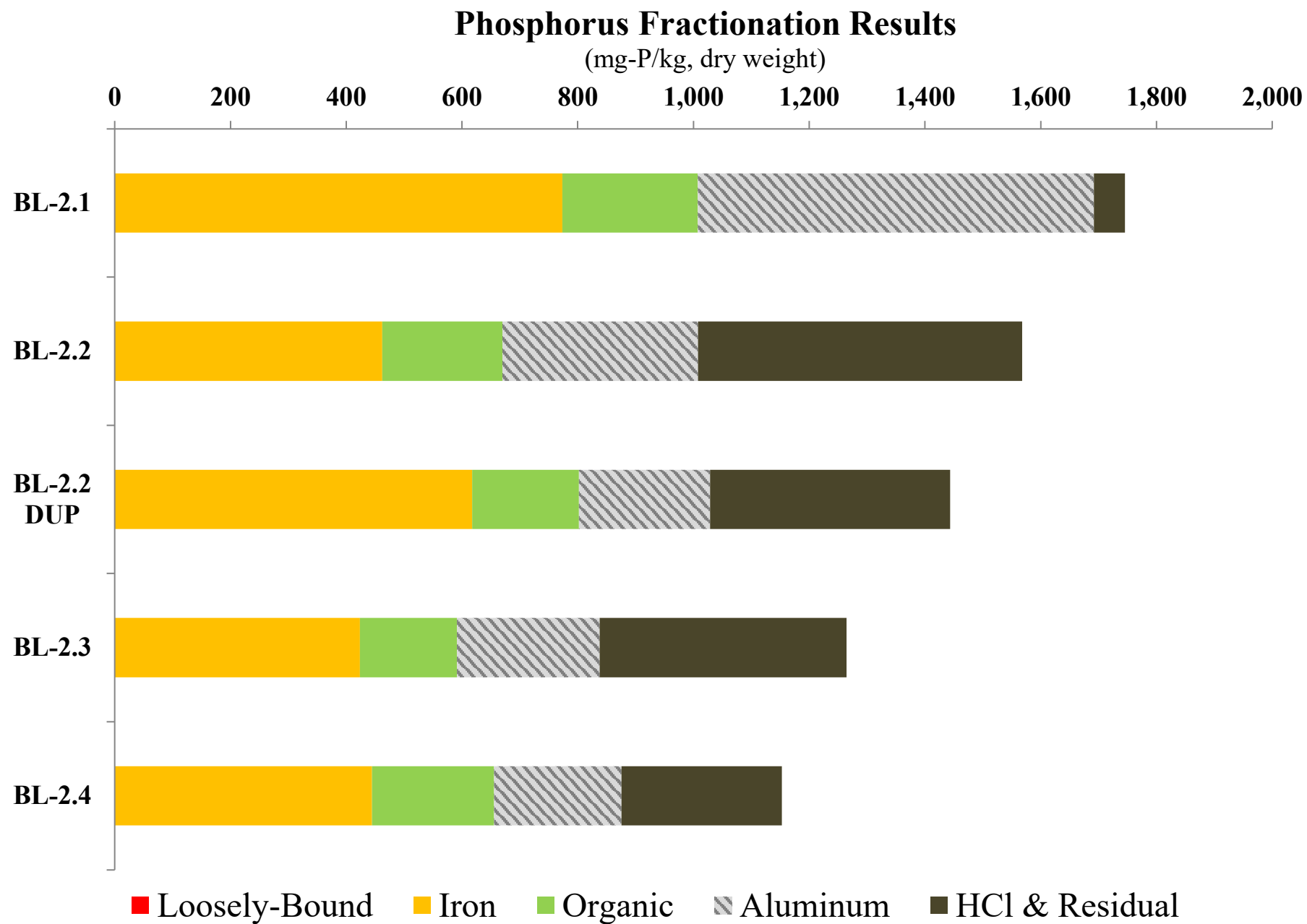
Company Name: AQUATECHNEX, LLC
Billing Address: 1801 Van Wormer St
City, State, Zip: Centralia, WA 98531
Project Name: Big Lake
Waterbody Name: Big Lake
Chain of Custody: eCOC20085
Report Date: 10/30/2025

Size (ac.): 552.41
Average Water Depth (ft): 14.24
Sample Collection Date: 10/23/2025
Contact Person: Scott Conrade
Email Address: scott@aquatechnex.com
Telephone: 360-399-9165

Comprehensive Level 2 Fractionation Results Summary

Sample Name	Site Depth (ft)	% Solids	Wet Bulk Density (kg/L)	Loosely-Bound P (mg-P/kg)	Iron P (mg-P/kg)	Organic P (mg-P/kg)	Aluminum P (mg-P/kg)	HCl & Residual P (mg-P/kg)	Total P (mg-P/kg)
BL-2.1	14.60	16%	1.09	*	773	234	685	53	1,745
BL-2.2	18.20	15%	1.10	*	462	208	338	560	1,568
BL-2.2 DUP	18.20	15%	1.09	*	618	184	227	415	1,443
BL-2.3	13.60	19%	1.10	*	424	167	247	427	1,264
BL-2.4	21.10	16%	1.06	*	445	211	220	277	1,153

* Concentration was less than reportable limits with 99% confidence
All concentrations are reported based on dry weight





Company Name: AQUATECHNEX, LLC
Billing Address: 1801 Van Wormer St
City, State, Zip: Centralia, WA 98531
Contact Person: Scott Conrade
Email Address: scott@aquatechnex.com
Telephone: 360-399-9165
Chain of Custody: eCOC20084

Report Date: 11/6/2025
Sample Collection Date: 10/23/2025
Waterbody Name: Big Lake
Project Name: Big Lake
Size (ac.): 552
Average Water Depth (ft): 14.24
Calculated Osgood Index: 2.9

Sample Name	Site Depth (ft)	Loosely-Bound P (mg-P/kg)	Iron P (mg-P/kg)	Organic P (mg-P/kg)	Aluminum P (mg-P/kg)	HCl-P (mg-P/kg)	Residual P (mg-P/kg)	Total P (mg-P/kg)
BL-3.1	10	*	265	256	196	149	113	979
BL-3.2	17	*	495	187	549	234	64	1,530
BL-3.3	19	*	673	277	326	250	51	1,577
BL-3.4	8	*	121	117	77	159	118	591

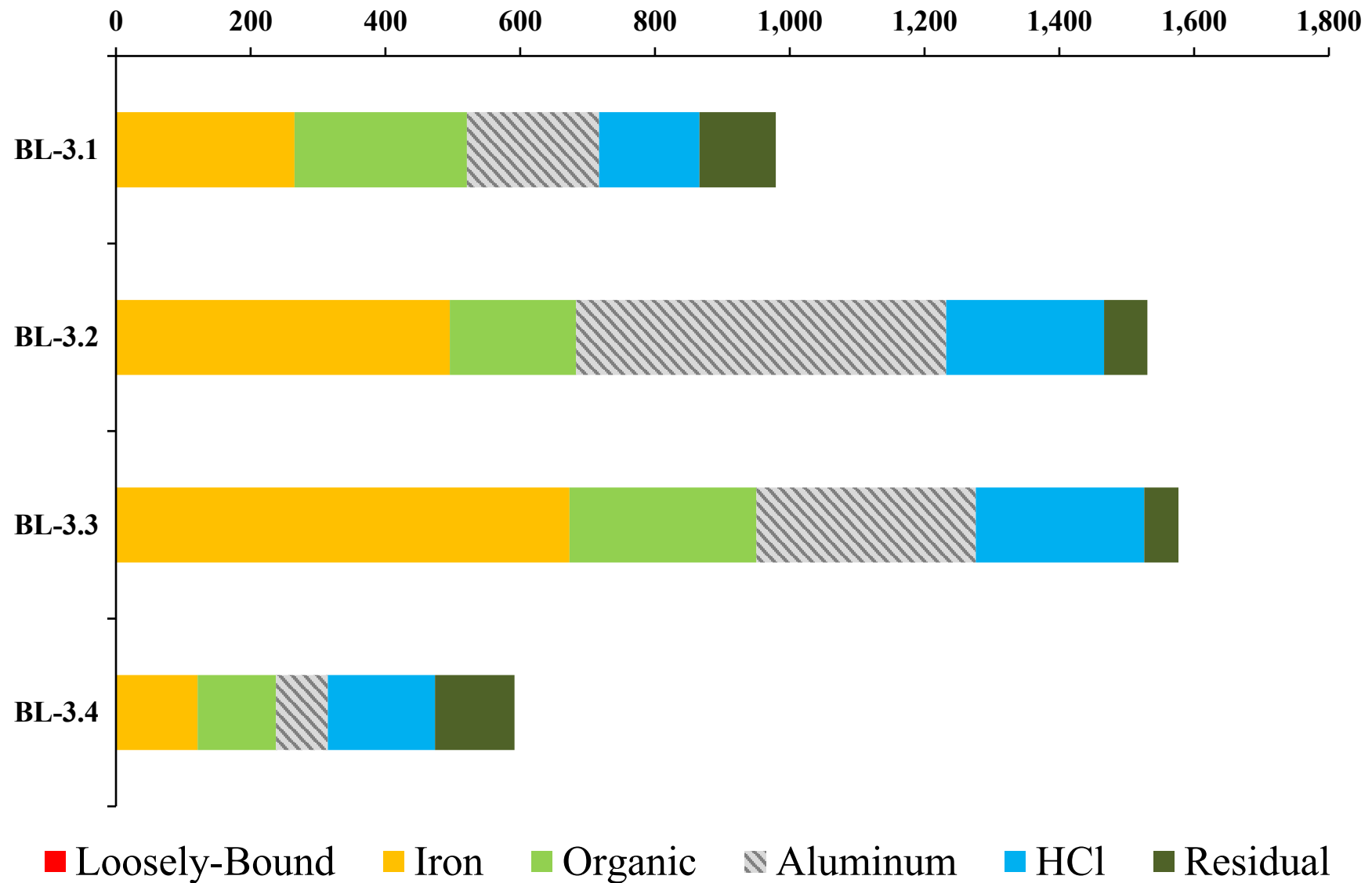
^All concentrations reported in dry weight (mg/kg)

* Concentration was less than reportable limits with 99% confidence

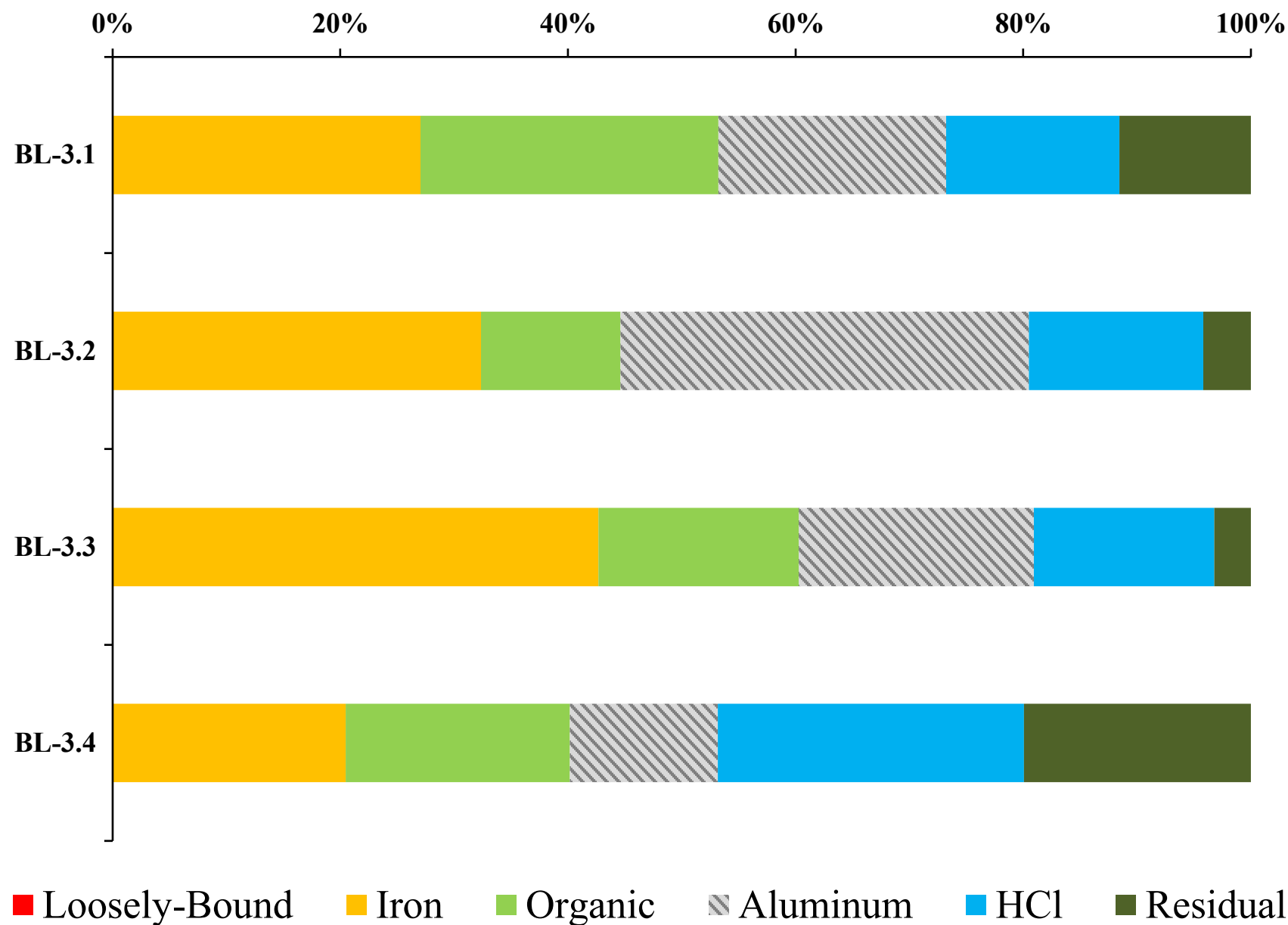
Sample Name	% Solids	Physical Release Potential	Iron Binding Potential	Organic P Releasability	Aluminum Binding Efficiency	HCl-P Formation Potential	Releasable P (mg-P/kg)	% Releasable P
BL-3.1	13%	Medium	Very Low	High	Very High	Low	470	48%
BL-3.2	15%	High	Very Low	Medium	Very High	Low	608	40%
BL-3.3	15%	Medium	Very Low	Medium	Very High	Low	839	53%
BL-3.4	29%	Low	Very Low	Medium	High	Low	191	32%

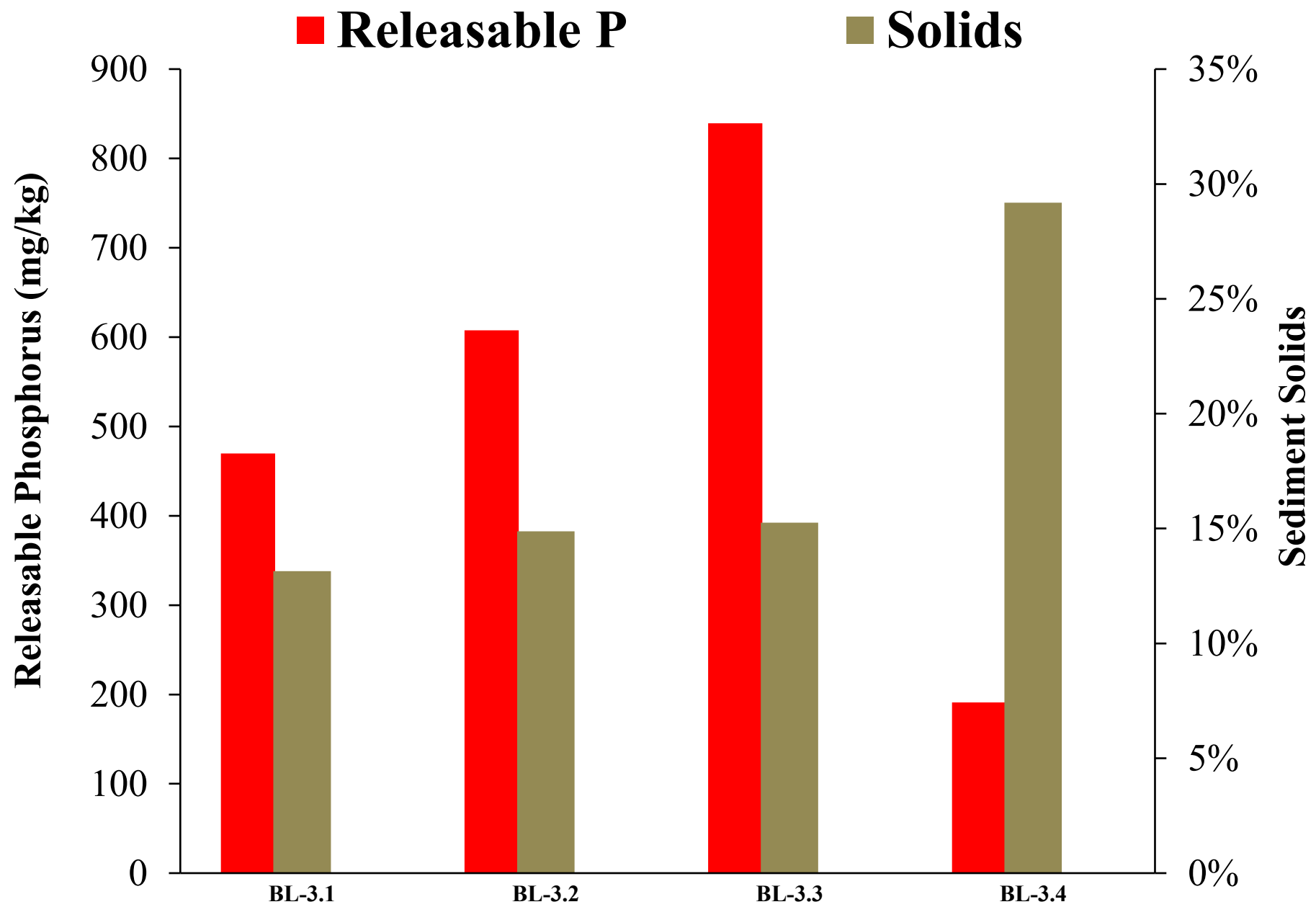
Phosphorus Fractionation Results

(mg/kg, dry weight)



Fractions as a Percent of Total Phosphorus





Geochemical Enrichment and Physical Properties

Sample Name	Depth (ft)	% Solids	Dominant Sediment Cation	Lake Specific Enrichment Factors				
				Extracted Iron	Organic Matter	Extracted Aluminum	Extracted Calcium	Total P
BL-3.1	10	13%	Iron	2.3	1.3	1.8	1.3	1.7
BL-3.2	17	15%	Iron	2.3	1.0	1.2	1.4	2.6
BL-3.3	19	15%	Iron	3.0	1.0	1.4	1.5	2.7
BL-3.4	8	29%	Iron	1.0	1.1	1.0	1.0	1.0

Sample Name	Depth (ft)	Dominant P-Binding Mechanism	Phosphorus Specific Enrichment Factors					
			Releasable P	Fe-P	Org-P	Al-P	HCl-P	Residual P
BL-3.1	10	Iron	2.5	2.2	2.2	2.5	1.0	2.2
BL-3.2	17	Aluminum	3.2	4.1	1.6	7.1	1.6	1.3
BL-3.3	19	Iron	4.4	5.6	2.4	4.2	1.7	1.0
BL-3.4	8	Calcium	1.0	1.0	1.0	1.0	1.1	2.3

Sample Name	Physical Release Potential	Physical Releasability Parameters						
		Diffusion				Disturbance & Sediment Stability		
		Wet Bulk Density (g/cm ³)	Dry Bulk Density (g/cm ³)	Porosity	% Solids	Total Organic Matter	Particle Density (g/cm ³)	Site Specific Osgood Index
BL-3.1	Medium	1.08	0.14	93%	13%	24%	1.96	2.0
BL-3.2	High	1.07	0.16	97%	15%	18%	4.81	3.4
BL-3.3	Medium	1.08	0.16	96%	15%	18%	4.43	4.0
BL-3.4	Low	1.08	0.31	79%	29%	19%	1.51	1.7

Oxygen, Iron and Organic-P Cycling

Sample Name	Oxygen Depletion Rate	Oxygen Depletion Potential			Mixing Potential		
		Bioavailable Organic Matter	% Dissolved Manganese	Porosity	Depth (ft)	Site Specific Osgood Index	Water Column Mixing Potential
BL-3.1	Very High	19%	90%	93%	10	2.0	Very High
BL-3.2	Very High	14%	90%	97%	17	3.4	High
BL-3.3	Very High	13%	86%	96%	19	4.0	High
BL-3.4	Very High	17%	87%	79%	8	1.7	Very High

Sample Name	Fe-P as a % of Total P	Iron Speciation						
		Iron-Binding Potential	Redox Fe to P Molar Ratio	Loosely-Bound P (mg/kg)	Total Relevant Iron (g/kg)	% Labile Iron	% Redox Sensitive Iron	% Metal Oxide Iron
BL-3.1	27%	Very Low	9	< 5	9.84	47%	43%	10%
BL-3.2	32%	Very Low	6	< 5	9.92	37%	57%	6%
BL-3.3	43%	Very Low	7	< 5	12.65	32%	63%	6%
BL-3.4	20%	Very Low	10	< 5	4.26	37%	50%	13%

Sample Name	Org-P as % of Total P	Organic P Release						Residual P as % of Total P
		Organic P Release Potential	Site Depth (ft)	Total Carbon to Org-P Ratio	Labile Carbon to Org-P Ratio	% Refractory Organic Matter	Residual P to Org-P Ratio	
BL-3.1	26%	High	10	208	163	22%	0.4	12%
BL-3.2	12%	Medium	17	220	168	76%	0.3	4%
BL-3.3	18%	Medium	19	143	109	76%	0.2	3%
BL-3.4	20%	Medium	8	368	329	89%	1.0	20%

Aluminum Binding Insights					
Sample Name	Al-P as % of Total P	Aluminum Binding Factors			
		Aluminum Binding Efficiency	Site Depth (ft)	Al to P Molar Ratio	Sediment pH
BL-3.1	20%	Very High	10	9	6.2
BL-3.2	36%	Very High	17	2	6.6
BL-3.3	21%	Very High	19	4	6.8
BL-3.4	13%	High	8	13	5.9

SeSCRIPT*
Analysis

SePRO Research & Technology Campus
16013 Watson Seed Farm Road, Whitakers, NC,

Stable Phosphorus Minerals							
Sample Name	HCl-P as % of Total P	Stable Mineral Formation					
		HCl-P Formation Potential	% Organic Matter	Extracted Ca Content (g/kg)	% Labile Ca	HCl Ca to P Molar Ratio	Lanthanum Content (mg/kg)
BL-3.1	15%	Low	24%	3.5	84%	3	7
BL-3.2	15%	Low	18%	3.7	84%	2	6
BL-3.3	16%	Low	18%	4.0	85%	2	6
BL-3.4	27%	Low	19%	2.7	76%	3	3

General Interpretation Guide	
Enrichment Factors demonstrate where compounds are enriched within the lake compared to the minimum value (1.0)	
Physical Release Potential is based on diffusion, susceptibility to disturbance, and settling rate of the sediment.	
Iron Binding Potential is based on the Redox Fe to P ratio and reactive iron-oxide saturation	
Organic P Releasability is based on site depth, the extent of the organic matter degradation, and residual P formation potential.	
Aluminum Binding Efficiency is based on the Al to P ratio compared to the SRTC database (> 100 samples)	
HCl-P Formation Potential is based on the abundance of HCl-P at the site compared to the SRTC database	
For more information and deeper insight, contact your EutroPHIX Technical Specialist	