AQUATIC ECOSYSTEM RESEARCH
A Freshwater Conservation Company

MEMO

Date: March, 14th 2021

To: Bantam Lake Protective Association

From: Aquatic Ecosystem Research

Re: Overview of Planning Study – Phosphorus Loading

Dear Connie Trolle, James Fischer, and BLP Association Members:

This memo outlines the results of the sediment analysis intended for use in planning a phosphorus mitigation aluminum treatment and to provide you a cost estimate for that project.

Firstly, the lake's water data was reviewed to determine the spatial extent of oxygen depletion during the summer season. In general, the deepest reaches of the lake contained less than 2mg/L of dissolved by mid to late May or early June. That zone of anoxia, which extended up 1m from the bottom, increased in volume to encompass about 50% of the total depth as the season progressed. Utilizing those data, we estimated that about 560ac could require treatment.

Aquatic Ecosystem Research divided the estimated 560ac in to 40 blocks; within those plots, 3 – spatially separated – sediment samples were taken and combined into a composite sample that would be analyzed and assumed to be representative of each individual block (see Appendix). Those composite samples (i.e., 40) were sent out for testing to determine the concentrations of various phosphorus fractions in the lake sediments. Those data resulting from sample analysis were summarized and presented in Table 1.

The raw data were sent to Ken Wagner for review and to estimate the cost of mitigating sediment phosphorus if necessary. His review confirmed our suspicions that internal phosphorus loading was a significant contributor to the overall phosphorus budget of Bantam Lake. Furthermore, his analysis elucidated that Bantam Lake is a good candidate for an Alum treatment because the major burden to the system is due to iron-bound and organic-bound phosphorus.

Dr. Wagner also noted that it might not be necessary to treat the organic bound phosphorus in the plan but that normally it would be with an increase in cost. To that end, he recommended that AER plot the results of each variable against the average depth of the block and undertake an assay study to determine the exact dose rate for a treatment. His estimate for just treating the iron-bound phosphorus utilizing historical

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prices was 1.4M; finally, he encouraged undertaking an assay study because it could result in a reduction in treatment and – more importantly – because it would allow us to tailor the dose rate in an exacting manner.

Table 1. Summary of phosphorus fractions in Bantam Lake sediments. Phos. = phosphorus; Stan. Dev. = standard deviation

	Total Phos. (ppm)	Iron Phos. (ppm)	Aluminum Phos. (ppm)	Biogenic Phos. (ppm)	Calcium Phos. (ppm)	Organic Phos. (ppm)
Average	2060.93	678.25	559.24	378.09	203.48	620.03
Stan. Dev.	375.58	166.40	140.45	109.80	47.54	146.92
Upper Bound	2177.32	729.82	602.77	412.11	218.21	665.56
Lower Bound	1922.53	626.68	515.72	344.06	188.74	574.49

Aquatic Ecosystem Research followed the directions of Dr. Wagner and plotted data against the depth variables to determine whether the treatment could be tailored to create multiple treatment rates based on depth. Unfortunately, our analysis showed that the sediment phosphorus concentration in relationship with depth resulted in a flat linear model, which means that there is not flexibility in treatment rate as it would apply to depth (see Appendix).

In summary, AER in conjunction Water Resource Services (WRS) have determined that Bantam Lake is a good candidate for an Alum treatment, that there is no need to tailor treatment rate as a function of depth, that an exact dose rate should be determined via an assay study, and that the treatment will cost between 1.0 and 1.4 million dollars. Please let us know if you have any questions about this; perhaps a conference call is in order to review these data and to discuss next steps.

Sincerely,
AQUATIC ECOSYSTEM RESEARCH

Mark June-Wells, Ph.D
Certified Lake Manager
ESA Certified Ecologist

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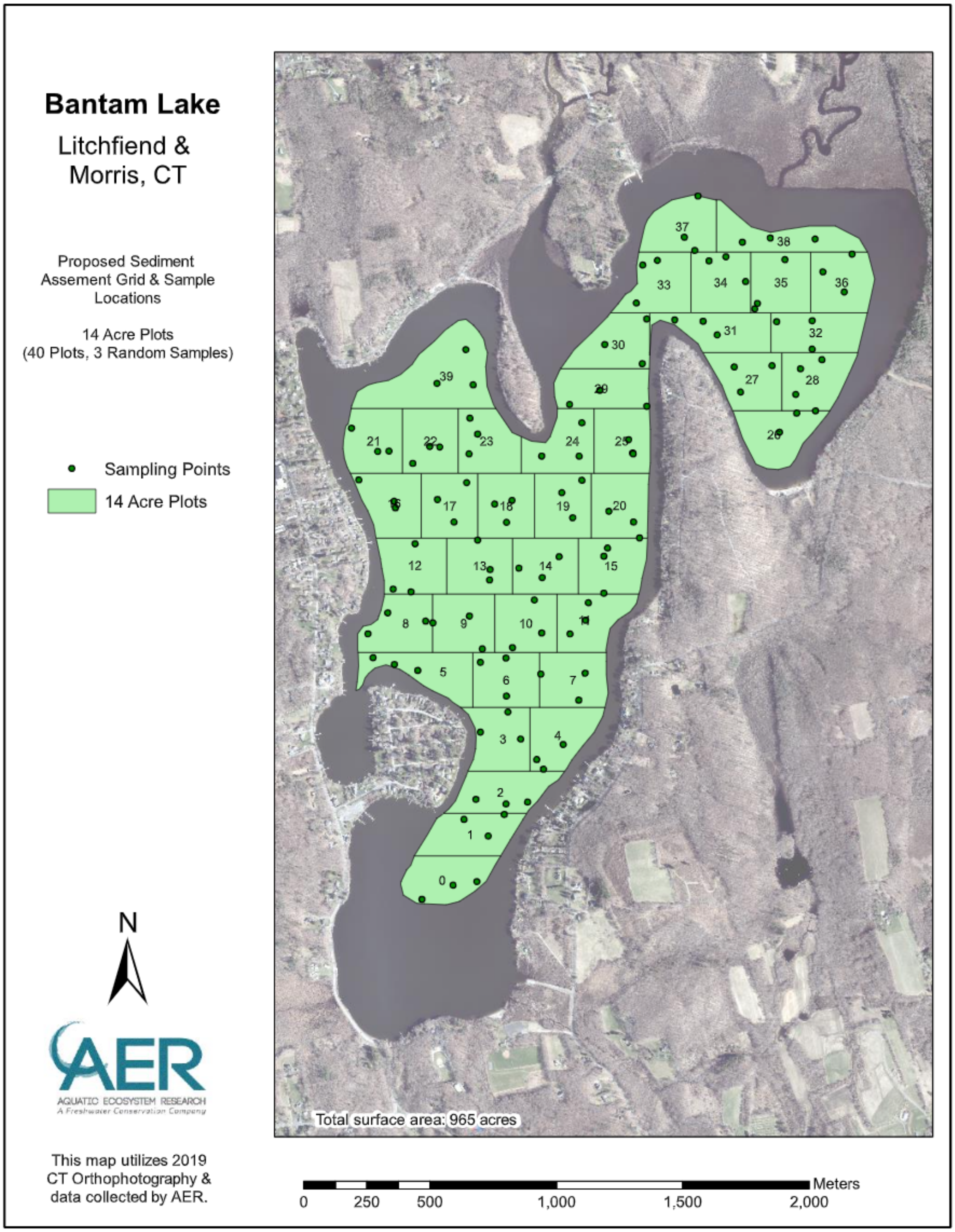
APPENDIX



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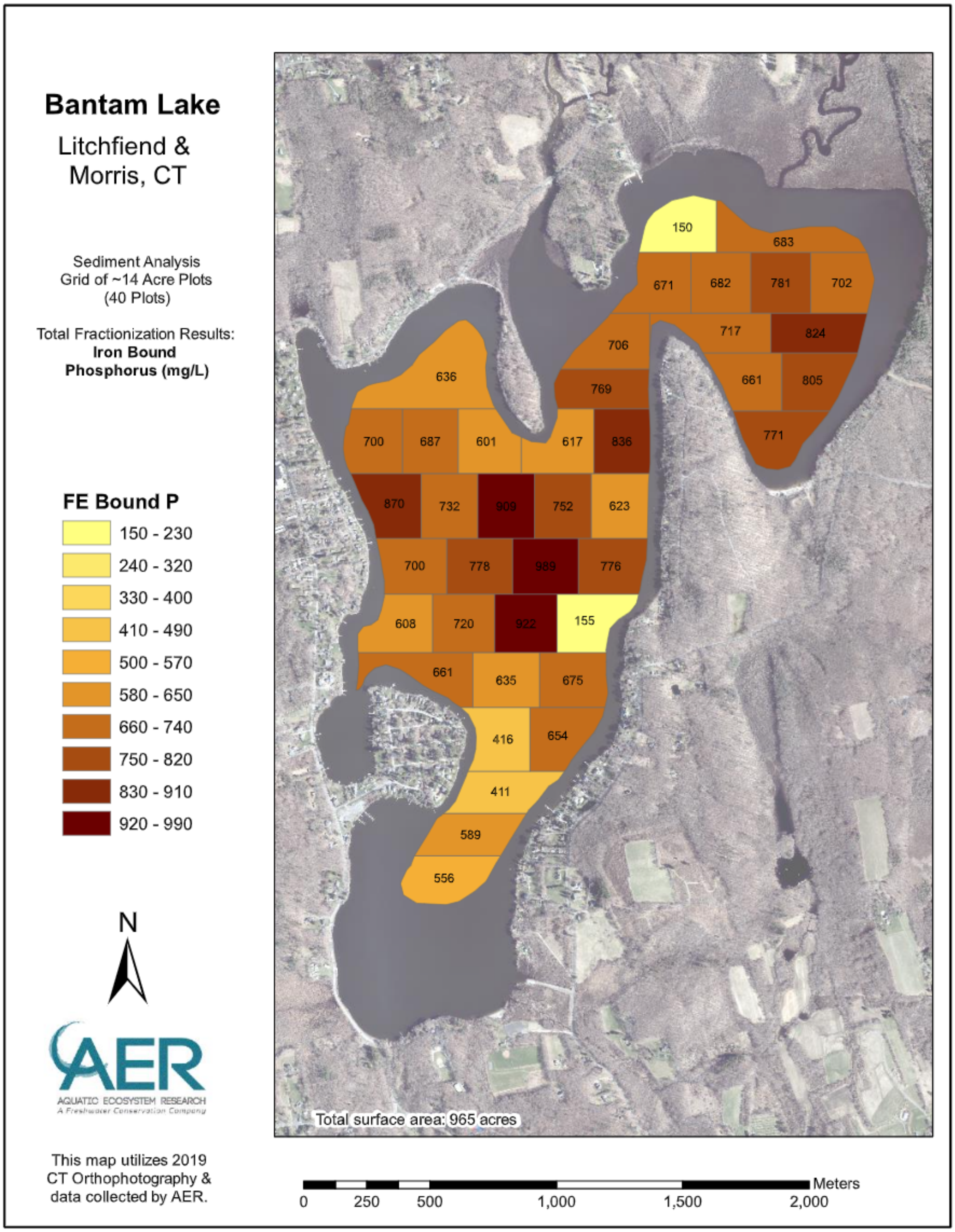

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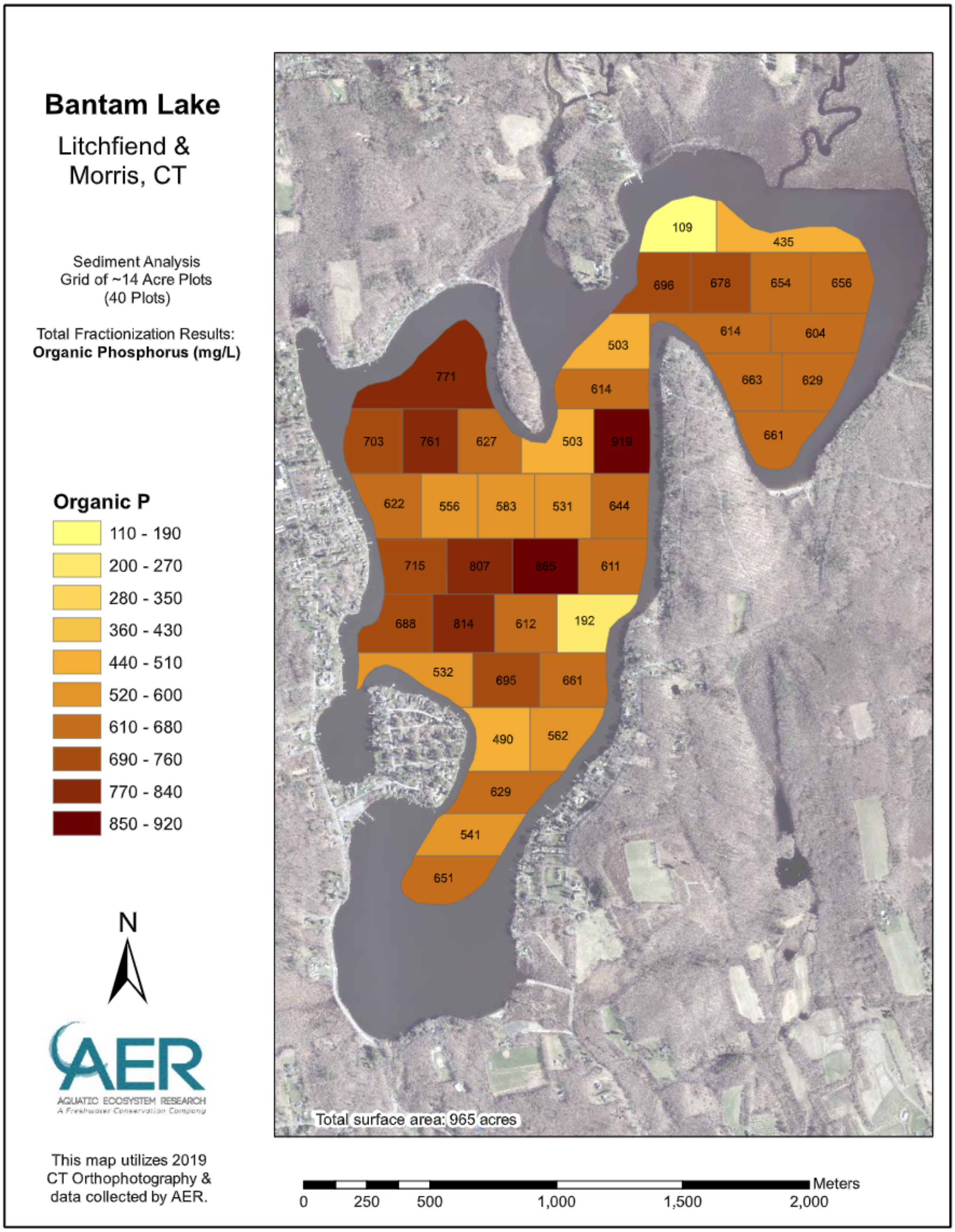

Bantam Lake
Litchfiend &
Morris, CT
Sediment Analysis
Grid of ~14 Acre Plots
(40 Plots)
Total Fractionization Results:
Organic Phosphorus (mg/L)
Organic P
110 - 190
200 - 270
280 - 350
360 - 430
440 - 510
520 - 600
610 - 680
690 - 760
770 - 840
850 - 920
N
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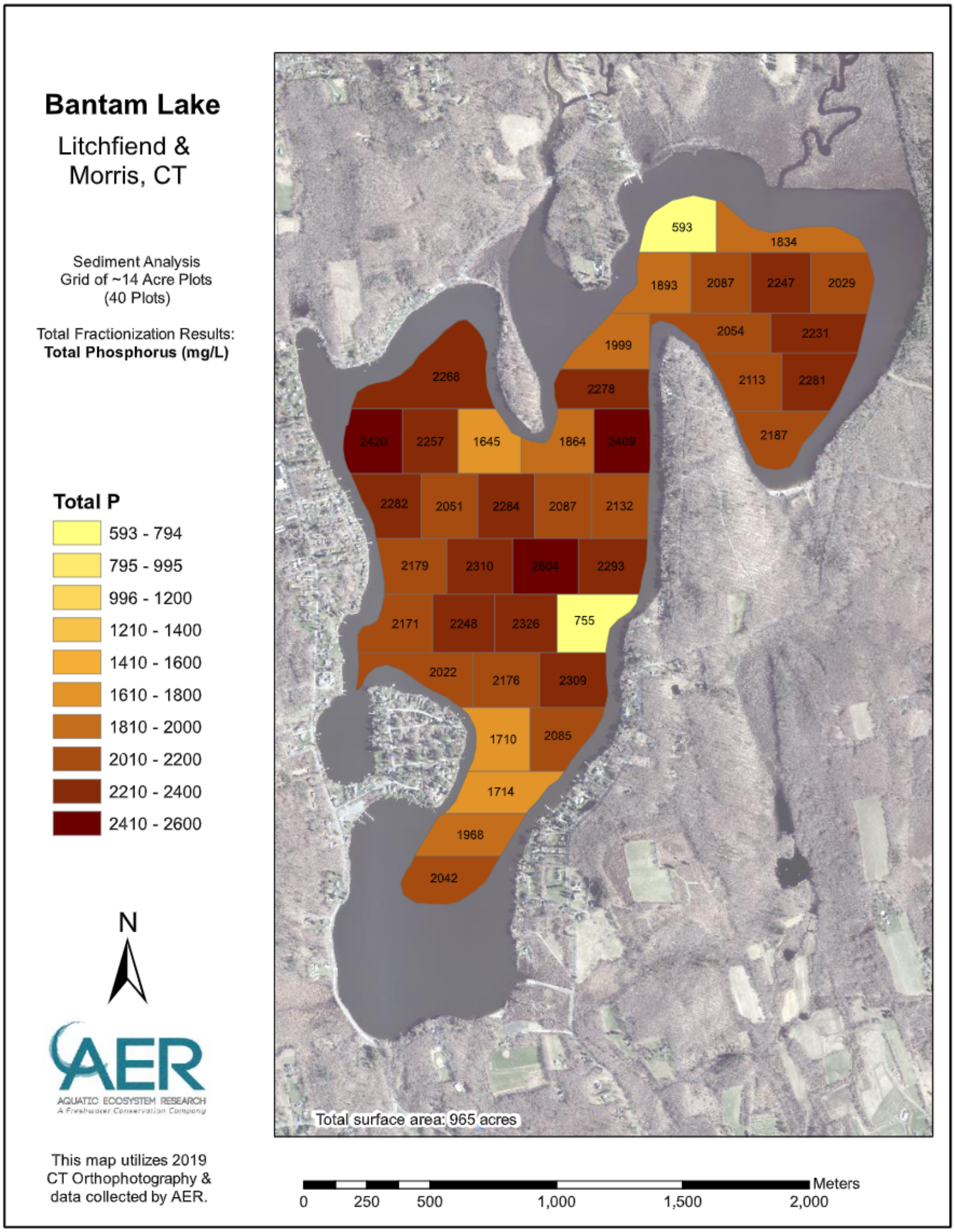
This map utilizes 2019
CT Orthophotography &
data collected by AER.
109
435
696
678
654
656
503
614
604
771
614
663
629
703
761
627
503
919
661
622
556
583
531
644
715
807
865
611
688
814
612
192
532
695
661
490
562
629
541
651
Total surface area: 965 acres
Meters
0
250
500
1,000
1,500
2,000



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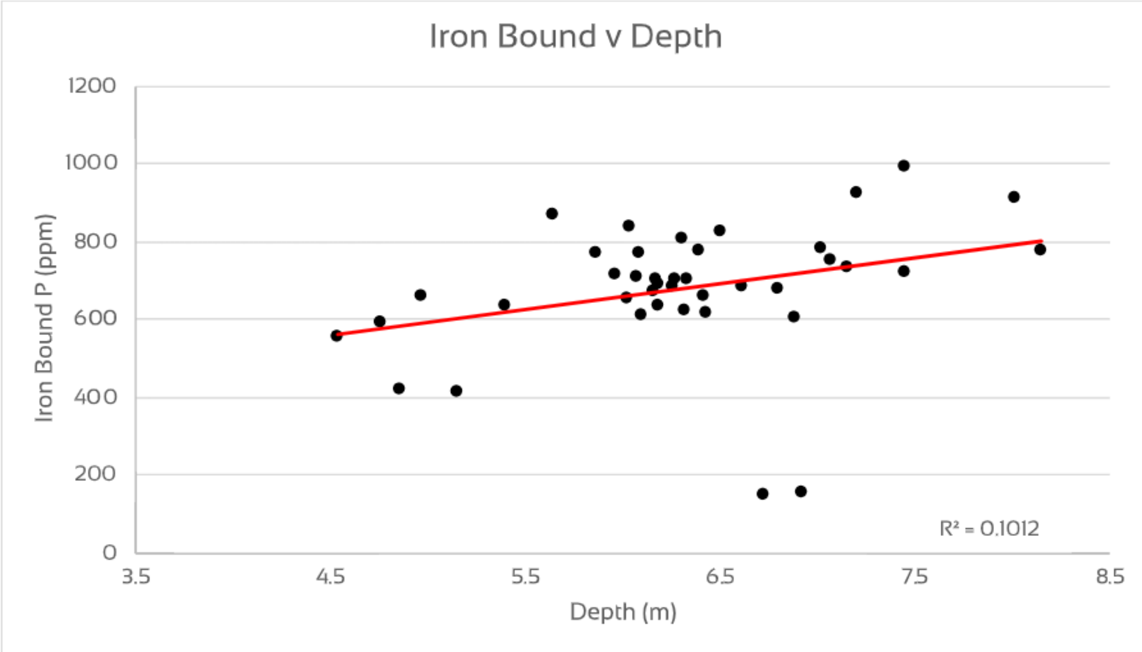

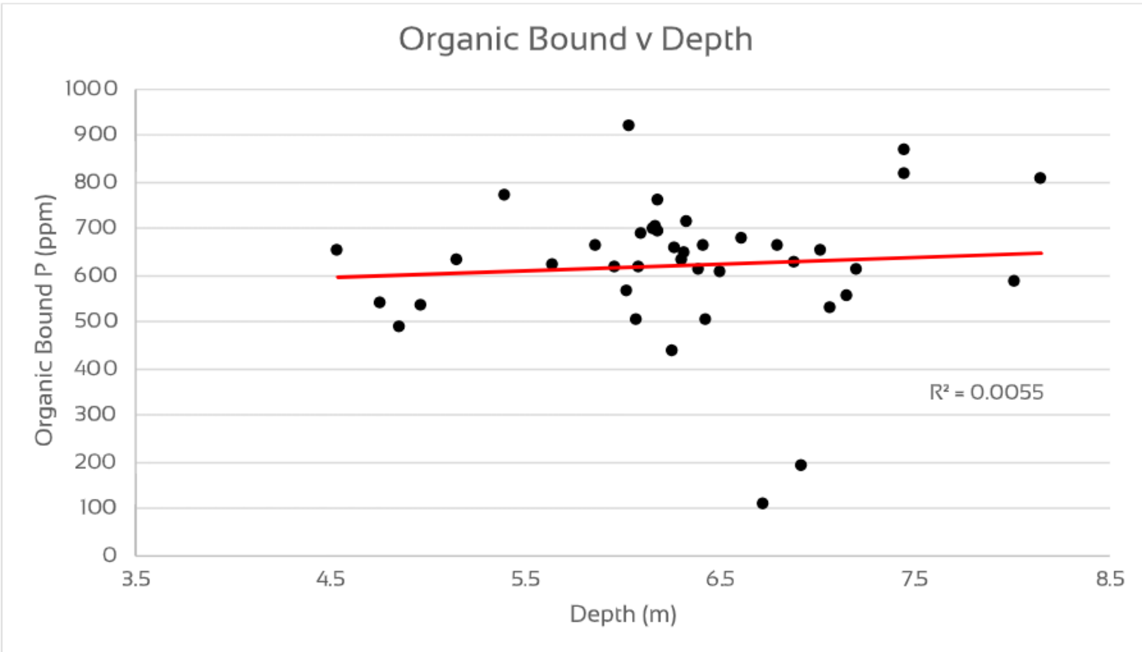

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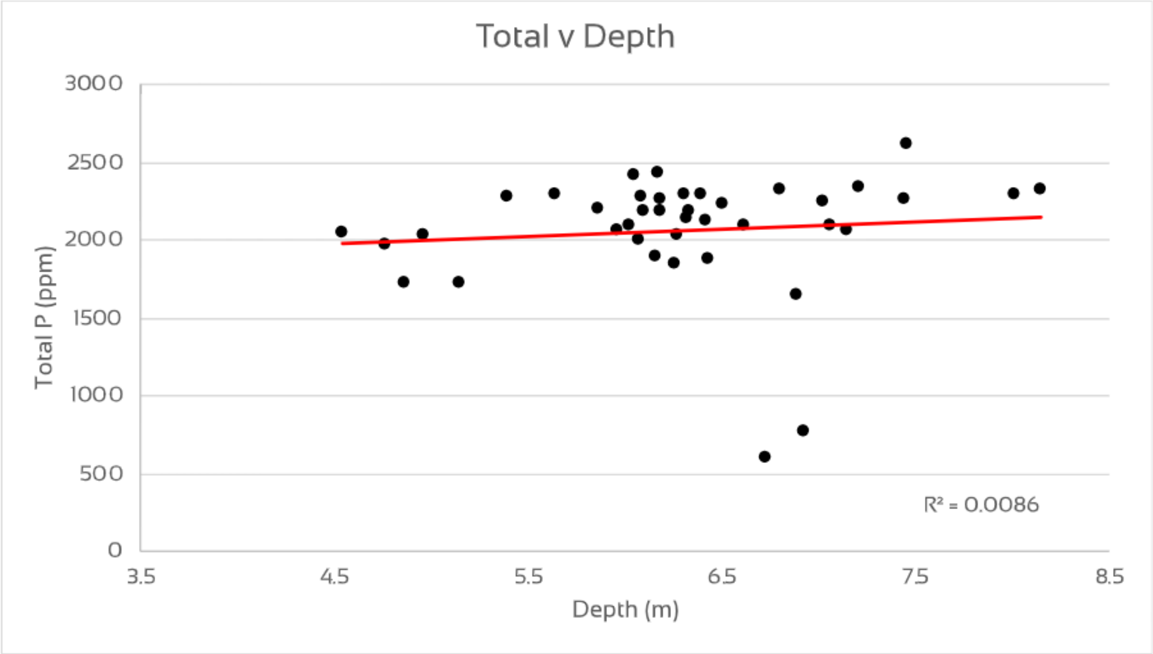

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March 5, 2021

Mark June-Wells and Larry Marsicano
AER
Via email

Dear Mark and Larry:

I am writing to summarize my analysis of the sediment data provided to me and discussed in my recent call with Mark. I was impressed at both the number of samples collected and the data quality. This is very useful information and provides most of what is needed to plan a treatment if so desired.

I will attach a spreadsheet to this email, one that I sent just prior to the call, so you should have it already. It uses the data provided to generate calculations of the aluminum dose necessary in each defined 14-acre cell of the lake. It is my understanding that the total 560 ac area is that portion of the lake with potentially P-rich sediment that is exposed to low oxygen each summer. The values for iron-bound P (Fe-P) are elevated and suggest a high potential for release into the overlying water during exposure to oxygen <2 mg/L, at which redox reactions will allow Fe and P to resolubilize. There is also a substantial biogenic P fraction, about half the Fe-P level on average. This biogenic P is not as available as the Fe-P but is often considered when planning a treatment. When aluminum is added it will definitely replace a lot of Fe in the P binding process, but the relationship with biogenic P is less well understood and the efficiency of binding varies with sediment features, some of which we don't understand yet either. I have therefore provided two worksheets, one with Fe-P only and one with Fe-P and biogenic P added together as the target of inactivation.

Current thinking in aluminum treatments is that once the dose is higher than 50-80 g/m2 there is declining efficiency and splitting the dose over several years yields better results. The Fe-P data suggest doses of between 44 and 83 g/m2 based on stoichiometric calculation, so if the biogenic P fraction was to be considered it would probably result in a split treatment (average for both Fe-P and biogenic P considered together was a dose of 97 g/m2). Considering just the Fe-P at this point is therefore most appropriate, and when the Fe-P is as high as it is in Bantam Lake, the results of a treatment are likely to be very good without worrying about the biogenic P.

What arises from the calculations is a range of doses over the 40 cells of 14 acres each of 44 to 83 g/m2. That assumes a 10:1 ratio of aluminum added to phosphorus in the sediment, a fairly typical number. Sometimes we raise that ratio to 20:1 in planning treatments, but with high Fe-P the binding efficiency is higher and often less aluminum is needed than calculated from even the 10:1 ratio. For a large treatment, there may be value in doing some lab assays that mimic treatment and provide real data on the level of inactivation achieved with each increment of aluminum added. But with the data we have, it is apparent that this will be a substantial treatment; a dose reduction of maybe 25-33% is possible, which would impact cost for sure, but would not make it an inexpensive treatment.

The other important factor is spatial variation in dose. As a general rule, the needed dose increases with water depth. Sediment in shallower areas has less available P and is not exposed to low oxygen for as long as sediment in deeper water. If you graph the doses I have provided on a map of the lake with depth contours, you may find a pattern that allows us to plot variable doses over space. Depending on that pattern, the magnitude of treatment might change. We usually find that less area needs the higher doses, decreasing costs, but it is site specific. The large area of Bantam Lake with a similar depth may minimize this effect, but it is worth examining.

Treatment cost will therefore be determined by a combination of dose and area treated. That dose may be less than what the data suggest based on potentially higher binding efficiency with elevated Fe-P. The combination of area treated and dose might be somewhat different than suggested by simply multiplying average dose by the whole 560 acre target area. The minimum cost that can be expected is $40 per g/m2 per acre treated, so for the average Fe-P dose of 62 g/m2 over an area of 560 acres, the cost would be about $1.4 million. There could be a decrease based on lower dose in some areas, lower dose related to increased binding efficiency, or just economy of scale, but I would not expect a cost of <$1 million, so this is a big project. Large projects with more area and higher doses have been completed, so this is not unusual, but it is a large enough price tag to be worth more investigation to fine tune those costs.

Contact me with any questions.

Sincerely yours,

Kenneth J. Wagner, Ph.D., CLM
Water Resources Manager, WRS Inc.

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