Fixing Lake Whatcom Water Quality

Photo by EJ Ledet   PM Beach Sudden Valley WA

by E.J. Ledet

Are we paying too much to fix Lake Whatcom's water quality? What are the costs, and how long will it take? How effective are the current solutions? Is there a holistic, more cost-effective, timely solution to fix our lake?

Lake Whatcom water users, taxpayers, and new stormwater-district-fee payers are being required to fund major construction projects around Lake Whatcom. These projects are focused on building Best Management Practice

(BMP) stormwater filters to trap/remove phosphorous before it enters the lake.

These projects are part of the Department of Ecology's (DOE) Total Maximum Daily Load (TMDL) on phosphorous and bacteria. The DOE estimates that it will have to remove 3,140 pounds of phosphorous from stormwater runoff to bring the lake back to 2002-3 dissolved oxygen (DO) concentrations.

The DOE has used data from WWU researchers that show phosphorous is the main cause for low DO in the lake. In 1998, the Environmental Protection Agency (EPA) designated Lake Whatcom with its 303(d) impaired waters classification for low DO in basins 1 and 2.

Tax- and fee payers are being assessed a total of $100 million over the next 50 years to pay for implementation and maintenance of these BMP stormwater filters. The new stormwater district fee will collect an estimated $41 million ($820,000 x 50 years) of the total $100 million from Lake Whatcom water users outside the city of Bellingham. City of Bellingham taxpayers have already been assessed a stormwater tax/fee.

If we do the math, $100 million/3,140 lb. phosphorus = $32,000/lb. phosphorus removal from stormwater runoff over a 50-year time period.

This seems to be a very huge sum of money to be spent over a very long time period to remove external phosphorus from stormwater entering Lake Whatcom. How efficient are these BMP stormwater filters at removing external phosphorus? Has the Lake Whatcom data team determined all "external phosphorus pathways" (point source and non-point source pathways) into the lake? Can all external phosphorus pathways be efficiently treated with BMP filters?

Managing Internal, External Phosphorus

What about managing the internal phosphorous, which already exists in the lake over the last 200 years of Lake Whatcom's developmental history? This internal phosphorus recycles annually from anaerobic sediment to cause more phytoplankton/blue green bacteria and more DO depletion.

Will Lake Whatcom water users be assessed additional taxes/fees to capture/bind the internal phosphorus which exists in the water column and sediment? Are there other more cost-effective solutions for treating internal phosphorus, described in scientific literature, which have been shown to remove/bind it? Can these internal phosphorus removal procedures also be applied to remove external and internal phosphorus simultaneously, saving both implementation time and tax-/fee payer money?

What assurance can DOE, the City of Bellingham, and WWU give Lake Whatcom water users/tax/fee payers that their TMDL phosphorus Best Management Practices solutions will remove external phosphorus, restore DO to the lake, and remove the EPA 303(d) impaired waterway designation without addressing internal phosphorus in the lake? Is there a holistic, in-lake, combined solution, which can bind external and internal phosphorus and also supplement DO to satisfy the TMDL phosphorus and remove the 303(d) impaired classification?

A lot of unanswered questions exist for which lake water users, tax- and fee payers need answers.

Let’s see if scientific literature/research/case studies can answer these major questions and provide more cost-effective solutions for removing both external and internal phosphorus, managing phytoplankton, and re-establishing healthy DO levels in Lake Whatcom.

Building stormwater filters, retention ponds, rain gardens, etc. to trap/remove external phosphorus using EPA Best Management Practices (BMPs) have been shown to be inadequate. Best-case BMPs are 50 percent effective at removing stormwater external phosphorus (EP). The majority of BMPs average 25 percent EP removal efficiency. (1,2,3)

In his Inland Waters 2017 research paper on using BMP filters for restoring impaired lakes in the United States (1), Dick Osgood argues that evidence tells us to reconsider the wide-scale use of BMPs in the United States as the primary restoration approach. “To date, the approach has been expensive and has not demonstrated improved water quality at the national scale.” He recommends “using BMPs only as a supplement to an overall mitigation approach as opposed to applying BMPs subjectively and uncritically as the primary strategy while the imperative for effective, outcome-based management of our lakes remains high.”

Functions Like a Forest

In Volume 2 of the “Water Quality Improvement Report and Implementation Strategy, TMDL P and Bacteria (16),” DOE states “When 87 percent of the existing developed area” (i.e., Lake Whatcom watershed) “functions like a forest,” (removing EP from stormwater runoff like an undeveloped forest implied) “the lake will meet water quality standards.”

Contrary to DOE’s above statement, in their book “Lake Management Best Practices, Managing Algae Problems (3),” Dick Osgood and Harry Gibbons state “There is no way to make runoff from developed lands mimic runoff from undeveloped lands.”

The City of Bellingham 2007 Stormwater Management Report (2) shows best-case South Campus BMP filter achieved 50 percent EP removal efficiency. Six other Lake Whatcom BMP filters showed negative efficiencies — i.e., more EP exiting BMP filters than EP entering BMP filters.

Figure 2 photo excerpt 1: 2007 City of Bellingham Stormwater Management Report, 2007.

3.7 PERFORMANCE OF THE CITY'S BMPS

The performance of currently functioning City phosphorus removal BMPs was calculated by comparing the concentrations of phosphorus going into a BMP (termed the influent) with the concentration of phosphorus in the stormwater leaving a BMP (termed the effluent). Percent removal is calculated using the following equation:

$$\text{Percent Reduction} = \left[\frac{\text{Influent Concentration } (\mu\text{g/L}) - \text{Effluent Concentrations } (\mu\text{g/L})}{\text{Influent Concentration } (\mu\text{g/L})}\right] * 100$$

When there is more phosphorus in the effluent (outgo) than in the influent (incoming), then the percent removal is calculated to be a negative value. Review of Table 7 shows that the mean percent reduction of total phosphorus for the Alabama Hill, Brentwood Wet Pond, Park Place Wet Pond, Bloedel Donovan Sand Filter, and Bloedel Donovan Rain Garden are all negative. It is important to note that these measurements were either not significant or calculated from too few measurements to make meaningful comparisons. Given this caution, it is still possible to state that there is not evidence that these facilities are reducing total phosphorus concentrations in the stormwater treated by each.

In contrast, two facilities–South Campus and Park Place WP/Sand Filter–have positive percent reductions of total phosphorus, meaning that for these facilities the measured effluent phosphorus concentrations were less than the measured influent concentrations. This result was significant (meaning less than a 5% probability of error) for South Campus treatment facility. The measured 50% reduction is well within the range of removal values presented in Table 6, with swales, wet ponds, and un-amended sand filters generally showing lower removal efficiencies and most bioretention and amended sand filters generally removing greater percentages of phosphorus.

- **Several of the City's treatment facilities do not appear to be reducing phosphorus levels.**
- **The South Campus and Park Place treatment facilities do appear to reduce phosphorus.**
- **Continued monitoring will be important to establish a statistically significant pattern of removal or addition of phosphorus.**

Overall, findings of this review and evaluation are as follows:

- Phosphorus is difficult to control as evidenced by the City of Bellingham's experience as well as similar experiences documented by other municipalities nationwide.
- Review of the literature and other stormwater programs indicates that the City of Bellingham has, and is, employing the range of available technologies and BMPs for phosphorus control.
- Review of the literature also shows that the City of Bellingham could enhance its current program with additional emphasis on programmatic policies as well as improve existing treatment BMP performance.
- Future source identification and loading analyses may necessitate a re-evaluation and re-prioritization of the City's phosphorus stormwater management program.

Figure 3 photo excerpt 2: Overall findings City of Bellingham Lake Whatcom Stormwater Management Report, 2007.

Figure 4 CoB excerpt 3: City of Bellingham Lake Whatcom Stormwater Management Report, 2007.

- The watershed will have to find opportunities in addition to treatment BMPs to control P in storm water runoff to Lake Whatcom.

Figure 5 CoB excerpt 4: City of Bellingham Lake Whatcom Stormwater Management Report, 2007.

- Future source identification and loading analyses may necessitate a re-evaluation and re-prioritization of the City's phosphorus stormwater management program.

Figure 6 photo excerpt: In-lake measures for phosphorous control.

- **In-Lake measure of P control** : The most feasible and cost effective solution for long-term management of water quality in urban lakes (2015) – "When expressed in terms of dollars spent per unit of P removed, **in lake alum treatment** was on **average 50 times more effective than in-catchment (BMP) measures."** Results from this study indicate that substantial external nutrient reductions may not be adequate to sustainably maintain water water quality in urban lakes and that continued **in lake management of P accumulated in lake sediment** will not only be necessary but will also be **more cost effective relative to in-catchment (BMP) measures.** (**$10s/ lb. P removal vs $1000s/ lb. P removal**)

The 2018 Lake Whatcom Management Progress Report states that to date 436 lbs P out of 3140 lbs P have been prevented from entering the lake.(18) http://www.lakewhatcom.whatcomcounty.org/lwmp_2018_progress_report.pdf.

2015 Lake Whatcom Work Plan Accomplishments data cited from the Lake Whatcom 2010-2014 Lake Management Report Show BMP efficiencies have improved (50-75%, 64% avg for county, and 85% vs 50% best South Campus 2007 Data for CoB).(9)

However all stormwater P pathways (point source plus non point source) into the lake have not been identified and all pathways can not be filtered/treated using BMP filters.

In-lake treatment of internal phosphorus (IP), using alum (aluminum sulfate) is 50 times more effective/efficient than using external BMPs and is one-tenth the cost. (4)

DOE and WWU believe that phosphorus is the main cause for low DO in basins 1 and 2. (5) If this statement is true, then removing phosphorus from Lake Whatcom should correct the 303(d) impaired waters status. The definition of a main or root cause, that cause acted upon by a solution such that the problem does not recur. (6)

However, the TMDL phosphorus solution does not address or recognize the impact of water temperature on oxygen solubility and the importance of destratification of the lake as it relates to temperature and DO solubility, concentration, and distribution to all depths of the lake as another cause/source of low DO in Lake Whatcom. (7)

The DOE WAC 173-201A-200 regulation (https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-200) does not allow man (androgenic) to change water temperature by more than 0.5F, whereas “mother nature” changes water temperature annually by more than 10+F, which, in turn, allows lake water destratification and enables O2/DO solubility concentration, and distribution, via atmospheric exchange/wind stirring, to occur in all levels/depths in the lake.

DOE and the City of Bellingham are implementing a solution that addresses EP only which is projected to remove 3,140 pounds of phosphorus via constructing BMP filters at a cost of $32,000/lb. for external phosphorus. The new stormwater district fee will collect $820,000 per year over the next 50 years for a total of $41 million of the total $100 million, and will only address EP point sources/pathways into the lake.

Problems with addressing EP input only into the lake: 1) all "EP pathways" into the lake (point source streams, creeks, ditches, etc., and non-point sources lawns, land near the lake or undeveloped land near the lake — i.e., undefined/undetermined pathways) have not been identified, and 2) even the best BMP filter efficiency for removing EP can not be used to treat all non point EP pathways into the lake and will not address the internal Phosphorous (IP) already present in the lake sediment.

Central Florida researchers have improved BMP EP removal efficiencies by injecting alum into BMP filters, increasing removal EP efficiencies to 90 percent. (8)

Figure 7 photo excerpt: Conclusions — Alum Treatment of Stormwater — T
The 2007 Lake Whatcom Stormwater Management Report (2) estimates between 2300+ to 2900+ lbs. external phosphorus per year enters Lake Whatcom from undeveloped watershed land ; Another 1400-2600+ lbs. external phosphorus per year from developed land ; Future developed land adds another 800-1,000 lbs. external phosphorus per year.

Figure 8 photo PP Slide Excerpt: Summary of City of Bellingham Lake Whatcom Stormwater Management Report, 2007.

8. In general, removal efficiencies obtained with alum stormwater treatment are superior to removals obtained using a dry retention or wet detention stormwater management facility.

9. Alum treatment of stormwater runoff is often substantially less expensive than other stormwater treatment alternatives with respect to both initial capital construction costs and annual O&M costs.

10. Several innovative designs have recently been developed for collection of alum floc in sump areas and containment areas, with floc disposal to sanitary sewer or adjacent drying beds.

11. Conclusions

Alum treatment of stormwater runoff has emerged as a viable and cost-effective alternative for providing stormwater retrofit in urban areas. Based upon the first 10 years of experience with alum stormwater treatment, the following conclusions have been reached:

1. In lake system where a large percentage of the annual runoff inputs are retrofitted with an alum treatment system, alum treatment has consistently achieved a 90% reduction in total phosphorus, 50-70% reduction in total nitrogen, 50-90% reduction in heavy metals, and >99% reduction in fecal coliforms. However, ultimate water quality improvements in the receiving waterbodies are highly correlated with the percentage of total inputs treated by the system.

2. The observed accumulation rate of alum floc in the sediments of receiving waterbodies appears to be substantially lower than the predicted accumulation rate due to additional floc consolidation over time and incorporation of alum floc into the existing sediment.

3. In all lake systems where phosphorus fractionation has been evaluated, the introduction of alum floc into the sediment has resulted in a reduction in both saloid and iron-bound associations and an increase in aluminum-bound associations, indicating that phosphorus sediment associations have become more stable following introduction of alum floc.

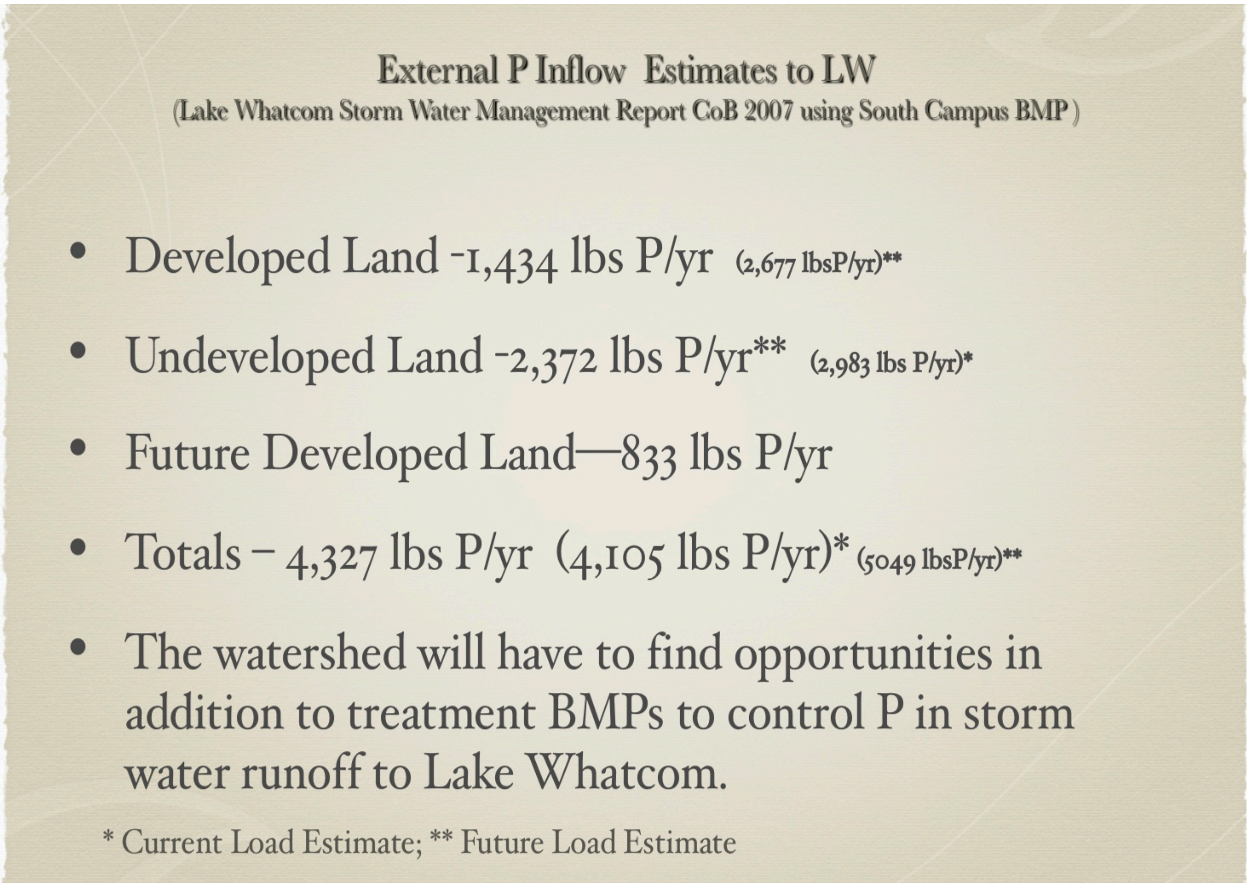
4. Sediment metal associations in post-alum treated sediments appear to be substantially more stable under a wide range of pH conditions and redox potentials than observed in pre-treatment sediment samples. Phosphorus and metal associations, once combined with alum, appear to be virtually inert to changes in pH and redox potential normally observed in a natural lake system.

5. In all lakes tested, introduction of alum floc into the lake sediments has significantly reduced measured pore water concentrations of total nitrogen, total phosphorus and heavy metals, reducing the potential toxicity of in-place sediments.

6. In general, benthic macroinvertebrate monitoring has indicated a reduction in organism density after initiation of alum stormwater treatment which closely follows the observed reduction in system productivity due to nutrient removals. The reduction in organism density is accompanied by a dramatic shift from a community dominated primarily by detritivores to a benthic community composed primarily of carnivores. Clean water indicator species, which were absent in pre-treatment communities, have begun to colonize many lake systems.

7. Construction costs for alum stormwater treatment systems are largely independent of the watershed area to be treated and depend primarily upon the number of outfalls to be retrofitted.

Using above 2007 City of Bellingham data from undeveloped land to estimate how much EP entered lake over the last century: 100 x (2,372 to 2,983)



lbs. EP/year or between around 250-300,000 lbs. EP entered the lake in the last century and over 500,000 lbs. EP entered the lake in the last 200 years of Lake Whatcom history (since development began in the early 1800s). Untreated EP entering the lake becomes IP.

Additional Costs

What additional costs will Lake Whatcom watershed users/tax- and fee payers have to fund to manage IP (water column and sediment) already present in Lake Whatcom?

DOE has indicated that it will have to re-design its lake model to incorporate IP emanating from/in sediment before it can estimate total phosphorus mass balance (IP+ EP) impact on Lake Whatcom. DOE estimates it will take another two years to perform these recalculation using their revised lake model. Recall that the most efficient BMPs can not be used to treat all non point source stormwater pathways into the lake.

What about the effects of extended warmer summer weather temperature patterns and climate change upon lake water temperature and its effect on oxygen supply/DO solubility/DO concentration in all depths/levels of Lake Whatcom?

If lake water temperatures gradually increase and extend over a longer period of time, caused by climate change and/or annual hotter weather patterns then O2/DO supplied via atmospheric exchange will be effected and O2/gas solubility and DO concentration will decrease in all depths of the lake.(17)

Removing/managing total phosphorus (EP + IP) will not replace the DO supplied/ caused by atmospheric oxygen exchange which is impacted by elevated water temperatures.

My causal analysis of low DO in Lake Whatcom and research and correspondence with recognized scientists and lake manager experts over the last 15 years of pro bono research into solutions for DO-impaired lakes, and drinking water reservoirs, have led me to conclude/propose that DOE and the City of Bellingham will have to use a combination of solutions to manage total phosphorus (EP+IP) and phytoplankton, and supplement oxygen. (7)

Proposed Solutions

I have developed the following table of proposed solutions, timing, and estimated costs to address low DO and phosphorus in Lake Whatcom.

Figure 9: Proposed DO and Phosphorus Solutions for Lake Whatcom, EJ Ledet 2019.

The last column, is a proposal to beta test alum addition to Basin 1, with estimated costs to conduct a three-year pilot study for an estimated $280,000. DOE and the City of Bellingham could use results of this beta test/pilot study to assess what combined effect of managing EP (current BMPs for EP) plus

EJ Ledet Proposed Solutions to Low DO and P in Lake Whatcom 5/27/19	Low DO Solution Comparison										
									External+Internal P		
Lake Whatcom Water Quality Property	BMP External P only DOE TMDL P	Pump Basin 3 H20 into Basin 1&2	Clean Flo HAS Ceramic Diffuser		ECO2 HOS (Speece Cone)		Mobley HOS (Line Diffuser)		Alum Addi In Lake (in	Combined HOS + Alum In Lake	Beta Test Alum Addition In Lake
Reduce Algae/Phytoplanton Growth in Lake (Phytoplanton/Algae)	✔	✔ (temp)	✔		✔		✔		✔	✔	✔
a. Decrease Chlorophyl concentrations (Chl)	✔	✔ (temp)	✔		✔		✔		✔	✔	✔
b. Decrease Total Phosporous (TP) inflow into Lake	✔	✘	✔		✔		✔		✔	✔	✔
c. Decrease Total Phosporous (TP) already present in Lake	✘	✘	✔		✔		✔		✔	✔	✔
DO concentration increase via											
a. Reduced Algae Respiration and Bacterial Decay (% CBOD ?)	✔	✔ (temp)	✔		✔		✔		✔	✔	✔
b. Reoxygenation - DO increase hypolimnion	✔ (partial via Algae photosynthetic zone	✔ (temp)	✔		✔		✔		✔	✔	✔
Decrease Anaerobic,Anoxic Sediment Chemistry											
Decrease H2S, NH3, CO2, Methyl Hg, Fe, Mn, Pb	✘	✔	✔		✔		✔		?	✔	✔
TSS, Turbidity Reduction	✔ (inflow)	✔ (temp)	✔)		✔(		✔(		✔)	✔	✔
Reduce Drinking Water Treatment Costs (DBP/THM precursors)	✔	?	✔ (Algae +)		✔ (Algae +)		✔ (Algae +)		✔ (Algae)	✔ (Algae +)	✔ (Algae +)
Improve /enhance Food Chain, Reproductive.Growth Conditions for Fish	?	?	✔		✔		✔		✘	✔	✔
Remove 303d impaired lake on Low DO (Supplement O2 Supply and meet O2 Demand)	X-external P only no internal P	✔ (temp)	✔		✔		✔		?	✔	✔
Warmer Water (Weather) Decreases O2/DO solubility	✘	✘	✔		✔		✔		✘	✔	✔
IncreaseTherml Stratification Duration Inhibits Reaeration of Lake (Temp & Density)	✘	✘	✔		✔		✔		✘	✔	✔
Meets DOE WA 173-201a-200 (0.3 C/0.5F) anthropogenic temperature requirement	✔	?	✘ Destratifies Lake		✔		✔		✔	✔	✔
Other Non Water Quality Considerations											
Implementation Time- Basins	Soil/Rain Garden Filters (50 yrs) Basins 1,2,3	?	(1 yr) 1&2	1 yr 1,2,3	(1 yr) 1&2	1 yr 1,2,3	(1 yr) 1&2	1yr 1,2,3	1yr 1,2,3	1yr 1,2,3	**3 yr Basin 1**
Cost											
Year 1	$10 M)	?	$2.1 M	$8.0 M	$2.0 M	$8.0 M	$2.2M	$8.8M	$2.25 M	$11.05 M	$0.18M
Year 2	$10 M)	?	$0.4 M	$1.2 M	$0.2 M	$1.0M	$0.1 M	$0.75M	$0.25 M	$1.00 M	$0.05M
Year 3	$10 M)	?	$0.4 M	$1.2 M	$0.2 M	$1.0M	$0.1 M	$0.75M	$0.25 M	$1.00 M	$0.05M
Year 4	$10 M)	?	$0.4 M	$1.2 M	$0.2 M	$1.0M	$0.1 M	$0.75M	$0.25 M	$1.00 M	
Year 5	$10 M)	?	$0.4 M	$1.2 M	$0.2 M	$1.0M	$0.1 M	$0.75M	$0.25 M	$1.00 M	
Year 6-50 (44 years)	$50 M)	?	$18M	$52.0M	$9.0 M	$44.0M	$4.5M	$33.0M	$11.0 M	$44.0M	
Total Cost over 50 years	($100M)	?	($22.7M)	$62.8M	$11.8M	$56.0M	$7.1M	$45.0M	$13.25M	$58.0M	
									Beta Test	Total	$0.28M

BMP=Best Management Practice (soil filters); HAS=hypoliminion aeration system; HOS=hypolimnion oxygentation system; ALUm=aluminum sulfate addition to remove internal P

alum addition on IP would have on managing algae and impact on low DO in Basin 1 to develop/assess a forward solution strategy.

I would propose that Bellingham's Public Works Department experiment using the spent alum from their water treatment plant and/or use other aluminum salts to retrofit some of their BMP filters around Basin 1 to improve EP removal performance efficiencies per reference (8).

Spent alum and/or other aluminum salts have reserve capacity to bind/remove EP. Spent alum would normally be disposed of, so this may save money for taxpayers and the city of Bellingham, and help remove more EP from stormwater runoff from exiting point source phosphorus pathways. The most cost-effective and safe way to treat non-point stormwater sources is to add alum via "in-lake" treatment. (9,10,11, 12, 13)

This is my argument: since all non-point source EP pathways into Lake Whatcom cannot be determined, why not treat EP "in lake" rather than continue building external BMPs, which only treat identified point source EP pathways and don't address IP already present in the lake.

Since all EP pathways (point source and non-point source) flow into the lake, and BMPs have to be fortified with alum/aluminum salts to increase BMP filter efficiencies, why not save money (operations and maintenance construction costs), implementation time, and add alum directly to lake waters to bind EP inflow pathways into the lake, as well as bind IP in the water column and sediments already in the lake? "In-lake TP (total phosphorus) treatment" has been successfully performed/demonstrated by Dr. Harry Gibbons and Dick Osgood in several lakes in the United States. (1,3)

My beta test/pilot proposal for Basin 1 treatment: BMPs surrounding Basin 1 will be fortified with alum/aluminum salts to bind EP in stormwater runoff and alum will be added to Basin 1 water to trap/bind IP in the water column and sediment.

A three-year beta test pilot study with analysis by a WWU lab and third party environmental contract lab will be used to test alum-addition effectiveness/efficiencies to bind/remove TP, control/manage phytoplankton growth/reproduction, and verify or refute the DOE/WWU statement that phosphorus is the main cause of low DO in Basin 1. This will determine if removing phosphorus and algae restores enough oxygen to Basin1 to provide a healthy fish habitat and remove DOE's 303(d) impaired waterbody status or not.

The benefits of designing and implementing a combined, "holistic, in-lake phosphorus and oxygen" management system would be less expensive and more cost effective than constructing additional external watershed BMPs alone.This holistic, in-lake proposed solution would also require far less implementation time with lower operation and maintenance costs, would treat total phosphorus (external and internal), and supplement hypolimnion (lower level of water in a stratified lake) DO to prevent recycling phosphorus, ammonia, hydrogen sulfide gas, methane, methyl mercury, and metals (iron, manganese, etc.) caused by sediment anaerobic biochemical reactions.

Figure 10 comparison of Proposed Solutions and Associated Costs

Solutions : **DOE/COB**: Build EPA Best Management Practices (BMP) stormwater runoff filters to trap/bind external P (EP) only from identified point source and some non point sources. Best BMP efficiency is 50% and all EP pathways into lake have not been identified. Meet EPA Total Mass Daily Load (TMDL) P. Remove 3,140 lbs. P to restore DO concentrations to 2002-3 " healthy DO concentrations"

EJL: in lake , holistic TP and DO solutions address TP, phytoplankton, anaerobic reactions

1. Apply Aluminum Sulfate (Alum) to lake to bind TP (EP + IP) EP inflow into lake, plus IP in water column and IP in sediment. Pilot/Beta Test in Basin 1 for 3 yrs, evaluate, determine forward strategy. Does managing TP eliminate Low DO 303d impairment?
2. If 303d is removed apply Alum to all 3 Basins to bind P, manage phytoplankton, and restore DO to all Basin hypolimnion..
3. If 303d is not removed, install Hypolimnion Oxygenation System (HOS) in Basin1 and Basin 2 to remove 303d impaired status and prevent anaerobic reactions . Decide if HOS is needed in Basin 3 at some future date when/if Basin 3 becomes 303d impaired.

Costs : **DOE/CoB** - $100 million over 50 years to address EP only. Best BMP filter efficiency is 50%. All "EP Pathways into lake have not been identified. IP is not managed, anaerobic biochemical reactions in sediment May not be addressed if DO impairment is not removed via current TMDL P solution.

EJL – 1. Alum Beta Pilot in Basin 1 for 3 year study Cost < $ 0.5 million dollars. Evaluate and determine forward strategy for Alum addition to Basin 2 and Basin 3. Total cost for 50 year is $13million for Alum addition to all 3 Basins. Results realized in 3 to 5 years vs 50 years.
2. HOS addition to Basin 1 and 2 for 50 years $14 million. Results realized in 3 to 5 years.
3. HOS addition to Basin 3 if needed for 50 years is $ 31 million. Results realized in 3 to 5 Years.
4. Alum + HOS for all 3 Basins for 50 years $58 million. Results realized in 3 to 5 years

Savings : EJL solutions estimated savings: $50 to $80+ million over 50 years. Results 3 to 5 years vs 50 years.

Results from implementing a "holistic phosphorus and DO management system" could be realized in < 10years vs. the 50-year implementation time for current TMDL phosphorus solution focused on managing EP only with no definitive evidence/case studies for removing the EPA 303(d) impaired low DO classification.

Bind Phosphorus in Sediment

Alum treatment will bind phosphorus in sediment and prevent annual recycling of phosphorus and inhibit/manage phytoplankton growth, reducing carbon biochemical oxygen demand contribution (lowering DO concentration) from bacterial decomposition of dead phytoplankton. Alum is acidic and to assure that its addition to a lake does not cause the water to become acidic (< 7 pH), it is necessary to add a buffer like sodium bicarbonate or equivalent because acidic waters can impact fish reproduction and growth. Alum addition has been shown to be effective, safe, and cost effective. (8)

The Lake Whatcom data team have said that they would prefer not to add any chemicals to the lake because they are concerned about the longterm impact of chemical addition on the ecology of the lake.

Wisconsin studies on alum addition to lakes to control phosphorus and mitigate algae/phytoplankton growth also show that it is both cost effective and safe to use. (9).

Alum is and has been safely used in Drinking water treatment plants , including Bellingham's water treatment plant, all over the United States as well as in Europe.

The Lake Whatcom data team also take the position that the lake is not entirely eutrophic (but is considered mesotrophic, with a fair amount of biological activity) and infer that alum addition is a last resort solution to reverse eutrophic lakes. Lake Whatcom has a 303(d) impaired status for low DO in basins 1 and 2, which contain 4 percent of the lake's 243 billion gallons of water. Basin 3 contains 96 percent of the 243 billion gallons of water and is not impaired for low DO.

I view alum addition to Lake Whatcom as analogous to treating cancer in its earliest stage, which is the most cost-effective approach and achieves the highest success rate.

Is it better to treat first stage cancer and stop/mitigate/prevent progression of this disease, or wait until that cancer is in its third or fourth stage to treat it?

I don't see the logic in waiting 50 years to construct BMPs to treat external phosphorus only, when there are numerous case studies that show treatment of impaired lakes using alum to control total phosphorus and manage phytoplankton has a higher rate/degree of success (50 times more effective than BMPs and one-tenth the cost). (11)

My causal analysis of Lake Whatcom for low DO shows that managing phosphorus alone will not remove the 303(d) impaired DO status because this solution does not address all DO demand causes nor DO supply (atmospheric oxygen exchange) causes. To remove the low DO impaired status, Lake Whatcom watershed users, tax- and fee payers will have to supplement DO using a hypolimnion oxygenation system (HOS) similar to what was done in Newman Lake near Spokane, Wash., which employed both alum and HOS solutions. (14, 15)

Conclusion

DOE/City of Bellingham's Solutions are expensive, inefficient, and don't address total phosphorus in the lake. It will also take 50 years to see if they improve dissolved oxygen in the lake hypolimnions.

My combined total phosphorus and DO solution is less expensive, has an immediate impact, has been demonstrated successfully, and does work.

Why not try my proposed solutions?

E.J. Ledet has over 40 years experience as a chemist, biochemist, and causal analysis investigator/facilitator in the petrochemistry industry. He specialized in ensuring product integrity in both laboratory and field operations management, and in the design and use of laboratory quality assurance systems. In addition, he's done 15 years pro bono research investigating causes of low dissolved oxygen and cost-effective solutions for Lake Whatcom.

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