An Evaluation of Bluegreen Algae (Cyanobacteria) Management Options for Halfmoon Lake, Alberta

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Overview of Talk

- Introduction
- Suitability of Halfmoon Lake for in-lake treatment
- Approach and results of evaluation: what is feasible and what is impractical
- Preliminary costs, regulatory needs, and what needs further study
- Objectives and conclusions

Study Objectives

- Contracted by Halfmoon residents association (HMLRA) to do the following:
  - ✓ Determine options to control cyanobacterial blooms in Halfmoon Lake
  - ✓ Summarize approximate cost of each feasible option
  - ✓ Identify the likelihood of impacts on non-target aquatic species
  - ✓ Determine regulatory requirements

Halfmoon Lake is a Good Candidate for Inlake Treatment

- Few AB lakes are as well-suited
- Small lake area (41 ha); chemical treatments are possible
- Small watershed (2.43 km^2), external nutrient loadings small and already well managed
- Well buffered (can use chemicals affected by pH)
- Active motivated community

Study Approach

- Based entirely on previous sampling and studies
- Only able to obtain provincial monitoring data (most U of Alberta data not available)
- First sorted all the available methods of inlake treatment (e.g. see public document Wagner 2004)
- Serious evaluation of 25 methods; 5 other methods totally impractical, as no practical case studies, or too disruptive

Methods Not Recommended

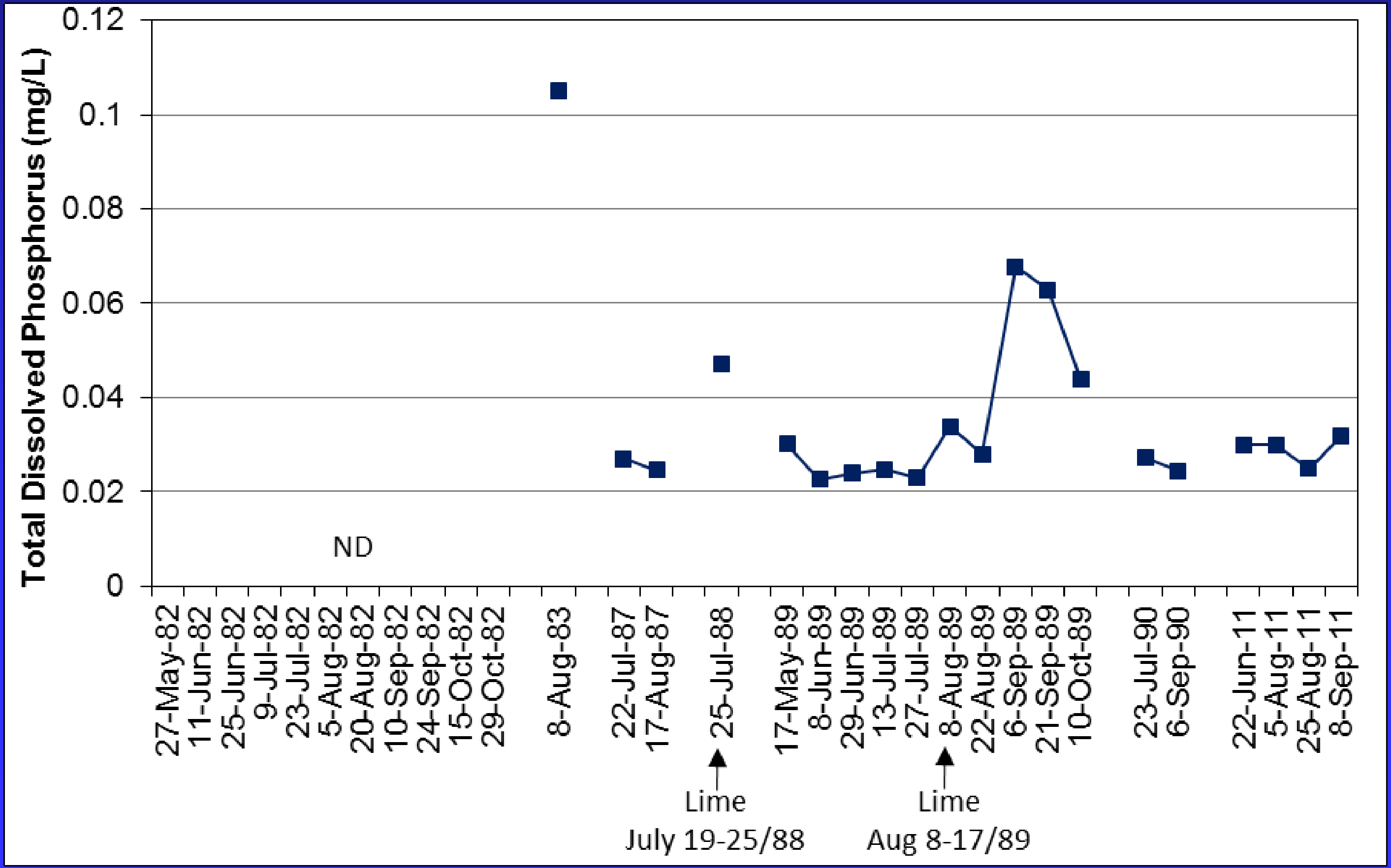
- Of the 25 methods, three tried before on Halfmoon and judged not successful
- Copper sulphate apparently used before 1982
- Has toxic effects on non-target organisms, accumulates sediments, resistance develops in some cyanobacteria
- Algicides do nothing to deplete legacy P
- Aeration of bottom waters tried repeatedly for fisheries enhancement, attempts failed (high sediment DO demand)

Methods Not Recommended (Lime)

- Four experimental treatments of Halfmoon with lime or powdered limestone by U of Alberta scientists in 1988, 1989, 1991, and 1993
- These scientists felt that multiple whole lake treatments needed to obtain purported effects
- Provincial water quality data suggest effects were short-term at best

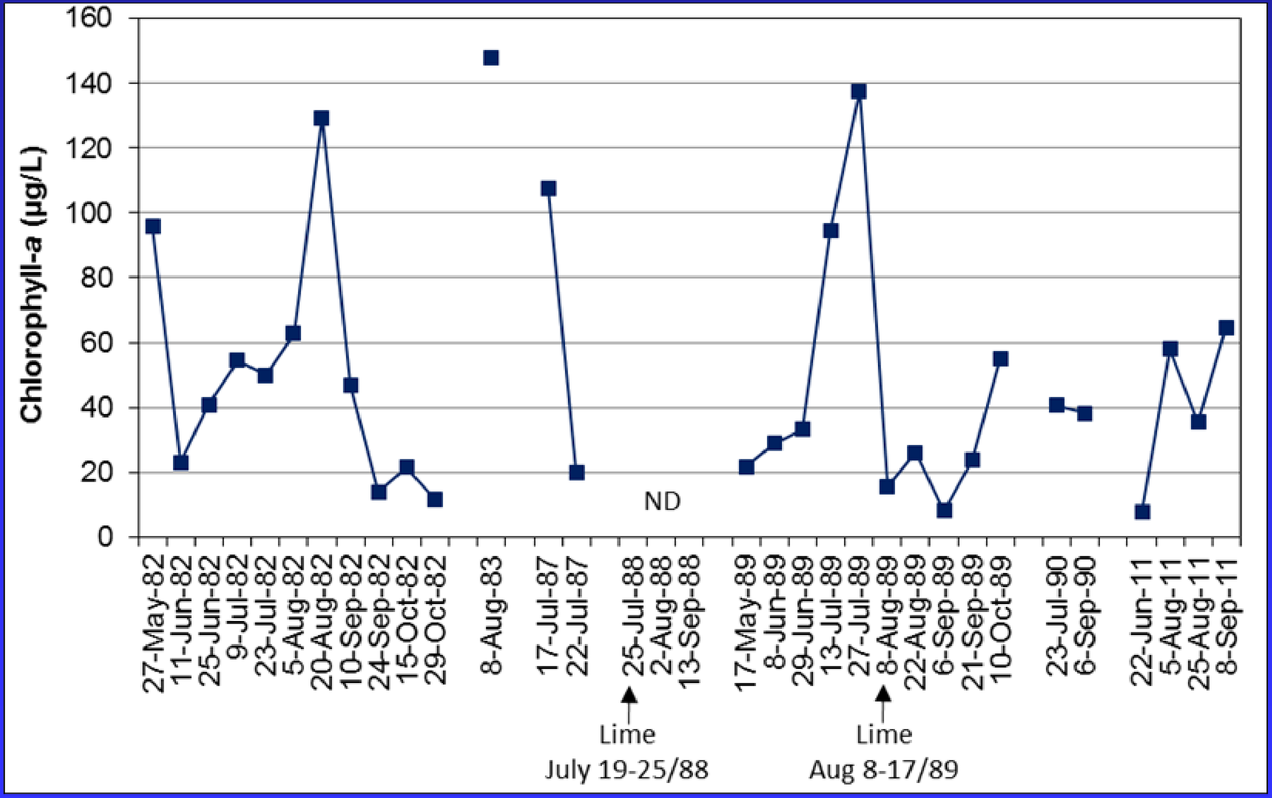
Methods Not Recommended (Lime)

- Total dissolved phosphorus (TDP) increased after at least second application
- Prepas et al. (2001) stated that TP also increased after the third and fourth applications



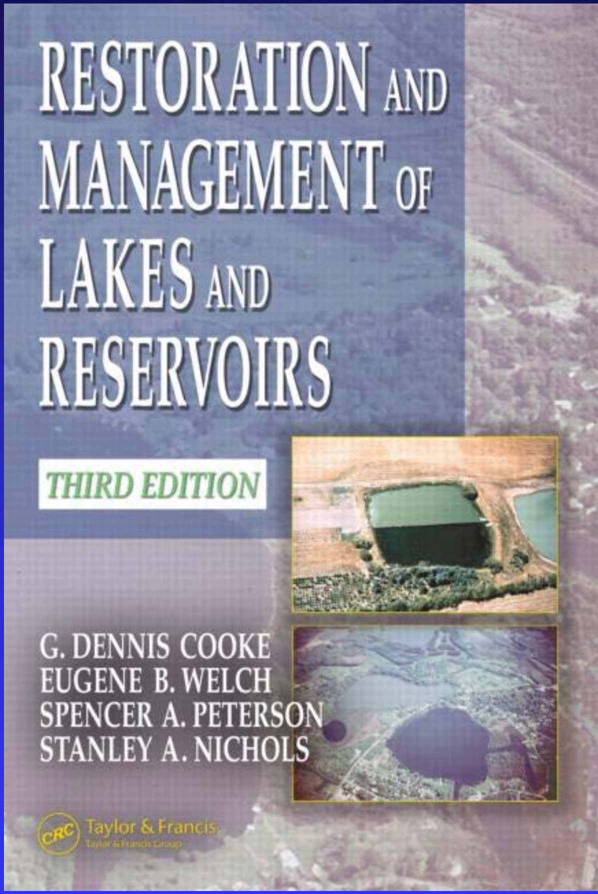
Methods Not Recommended (Lime)

- Provincial data show that chlorophyll *a* increased after the first two lime applications
- Prepas et al. (2001) also reported chlorophyll increased after third and fourth applications



Methods Not Recommended (Lime)

- Cooke et al. (2005) say: “more experimentation (with lime) is needed on questions of dose, application techniques, best seasons for treatment, chemical mechanisms, and treatment longevity”



Methods Not Recommended

- Artificial mixing/circulation has been used to aerate lakes and enhance fish habitat, and reduce P release from anoxic sediments
- "The technique should be most applicable in lakes that are not nutrient-limited" Cooke et al. (2005); Halfmoon is P-limited
- "Algal abundance and cyanobacteria have decreased following circulation in only about half of the cases cited, and increased in others" Cooke et al. (2005)

Artificial mixing: SolarBee deployment in Jordan L., NC

Methods Not Recommended

- Bacterial additives said to out-compete algae for nutrients, and digest sediments
- “There appears to be no evidence from peer-reviewed journals that these products are effective, and caution is suggested” Cooke et al. (2005)

Bacterial Additive

Methods Not Recommended

- Some methods have provided benefits elsewhere, but inappropriate for Halfmoon:
  - Iron salts: should only be used in well-aerated lakes (sediments release P under anoxia)
  - Hypolimnetic withdrawal (used at Pine Lake): too shallow and weak stratification, not enough inflow
  - Enhanced flushing: – no nearby source of low nutrient water that is not already allocated
  - Evaluation of other methods in report

Feasible Treatment Methods

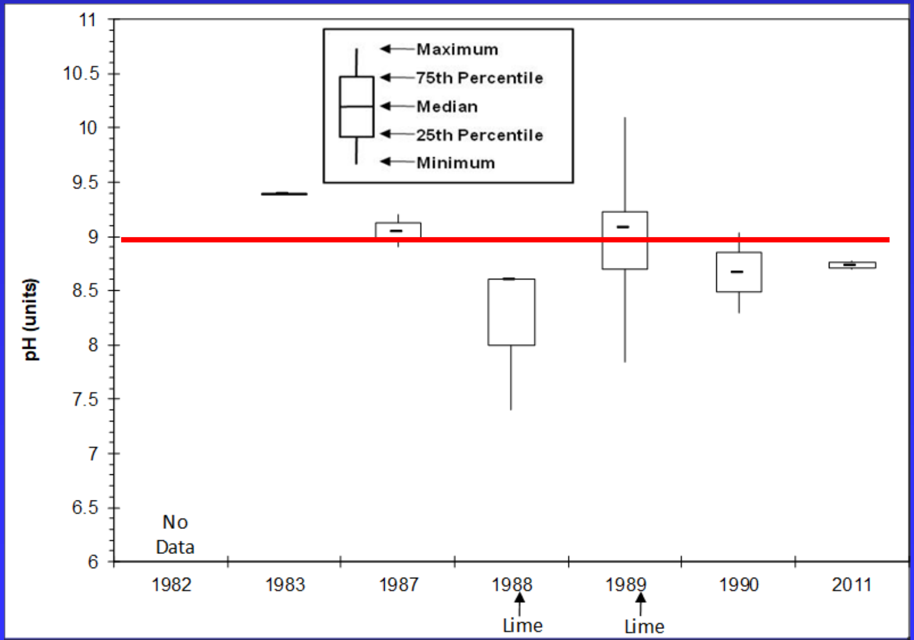
- Four methods have worked elsewhere and should work here
- Three involve P inactivation compounds containing aluminum (Al) or lanthanum (La), and other is hydraulic dredging
- Main goal of the P inactivation compounds is to inactivate P in surficial sediments, and prevent release to overlying water
- Also strip P from the water column

Feasible Treatment Methods – Option 1. Whole Lake Alum Application

- Longest use of any P inactivation agent (200 years in water treatment, over 250 applications world-wide)
- Same active ingredient as Maalox
- Used for many years in water treatment in AB - river discharge of effluent
- One recent application to a lake in northern AB - in 1990’s in combination with lime
- ~10 yr possible duration of effectiveness for Halfmoon - longer in deeper stratified lakes (≤42 yr; less in well-mixed lakes)

Feasible Treatment Methods – Option 1. Whole Lake Alum Application

- Alum can form dissolved and toxic aluminate above pH of 9
- pH should stay in range 6-8 (Cooke et al 2005)
- Can avoid toxic form by slow addition of compound deep in euphotic zone, use of buffering compounds



Feasible Treatment Methods – Option 1. Whole Lake Alum Application

- Requires further sampling and analysis to determine dosage (Dr. Harry Gibbons)
- Typically applied from a barge moving over the target area

Feasible Treatment Methods – Option 2. Whole Lake Phoslock Application

- Phoslock is lanthanum-amended bentonite, developed in Australia
- Extensive use in UK and Europe - in 2016 in Henderson L, AB
- Pros: less pH sensitive, avoids public concerns about aluminum
- Cons: Binds less rapidly than alum, can get increased turbidity if dosage wrong, shorter period of use under narrower range of conditions
- Like alum, should be effective for ~10 yr.

Feasible Treatment Methods – Option 2. Whole Lake Phoslock Application

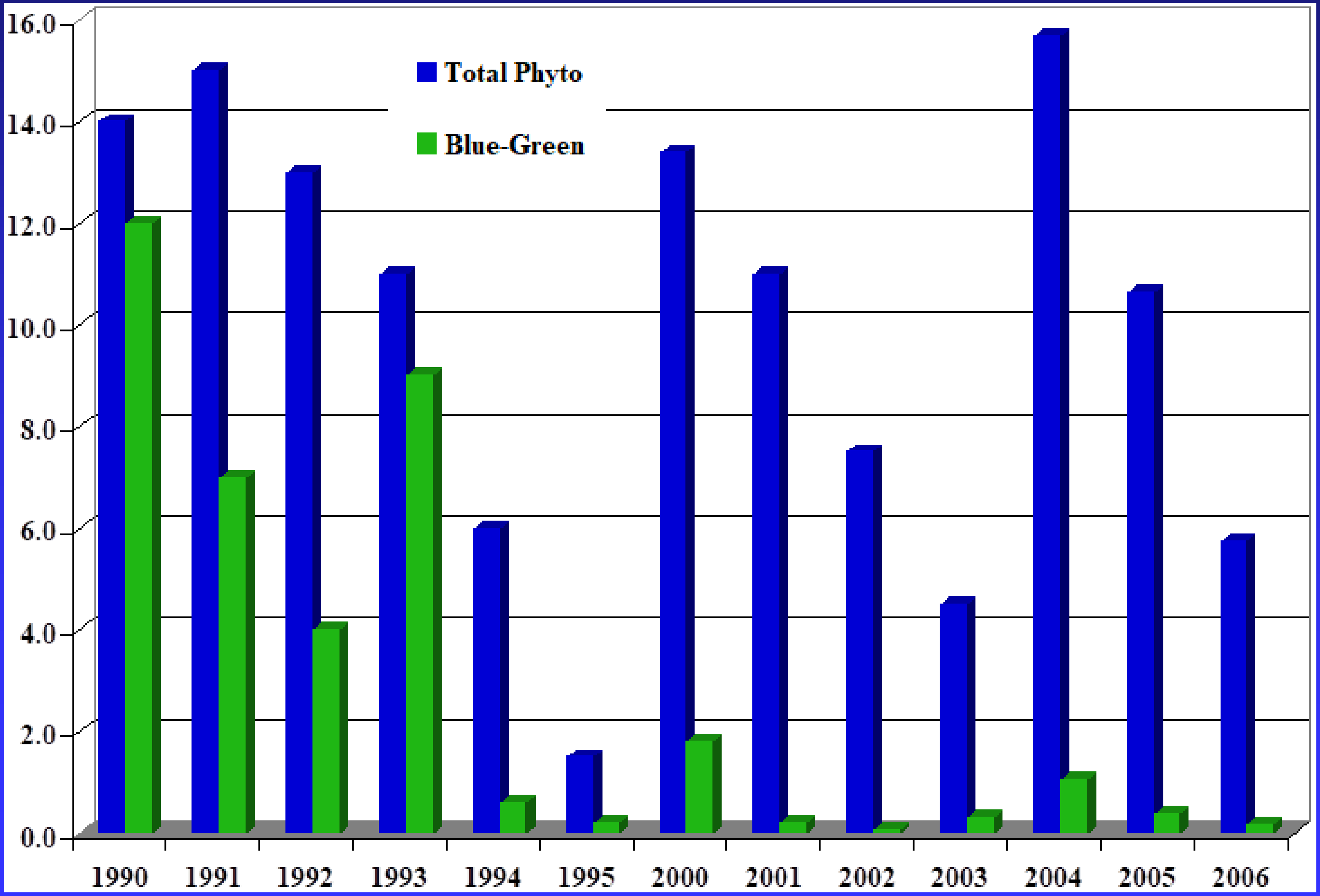
- Requires further sampling and analysis to determine speed of binding at IDN lab in Germany
- Like alum typically applied from a barge moving over the target area (below Henderson L., AB, application by Aquality)

Feasible Treatment Methods – Option 3. Microfloc Alum Injection

- Very low alum levels injected into lake bottom waters
- Intercepts P released from sediments
- Much lower costs, but ongoing process to suppress blooms - costs add up over time
- Costs at Newman Lake, WA over many years thought to be similar to cost of whole lake treatment, but spread out (B. Moore, Washington State U)
- Successful well-documented use at Newman L,WA
- At least seven projects in the US

Feasible Treatment Methods – Option 3. Microfloc Alum Injection

- Below is peak post restoration phytoplankton biovolumes in Newman Lake, WA in mm^3m^3



Feasible Treatment Methods – Option 3. Microfloc Alum Injection

Newman L system consists of:

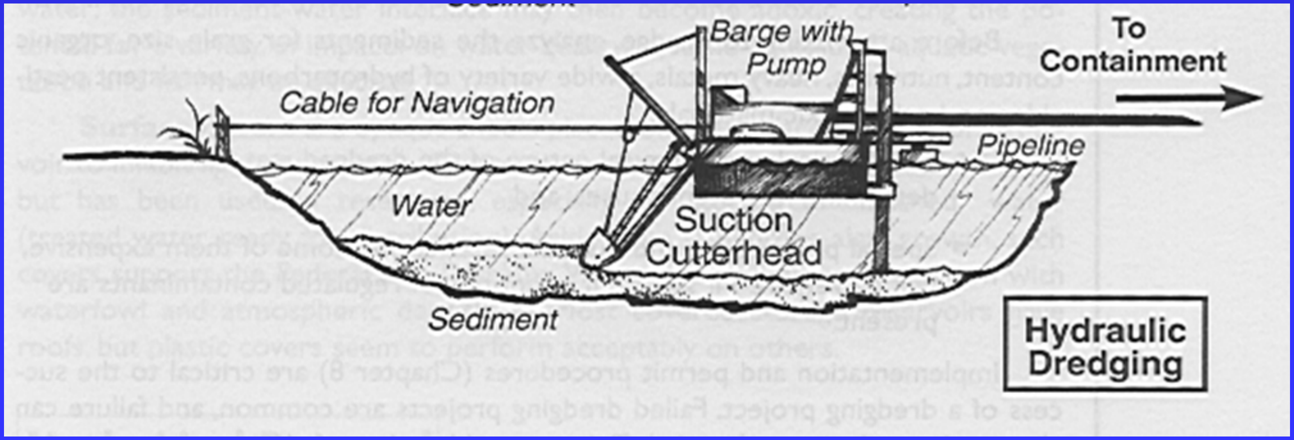
- Storage tank on shore in a spill containment berm
- Peristaltic pump with valves
- Two distribution lines
- Alum injectors on an aeration system

Feasible Treatment Methods – Option 3. Microfloc Alum Injection

- Pros: costs spread out over many years; easier for fundraising, injects deep in lake well away from hi pH induced by photosynthesis.
- Cons: requires permanent site for equipment, lines in lake, ongoing maintenance and operation (volunteer or paid time)
- Requires dosage determination and complete system design for Halfmoon
- Costs should be much less than system for 12.6x larger Newman Lake

Feasible Treatment Methods – Option 4. Hydraulic Dredging

- Mobile cutterhead removes sediments in target area, slurry piped to settling basin or treatment plant on shore
- Commonly used to remove sediment infilling, rarely for control of blooms, but appropriate here because external P loading apparently well controlled

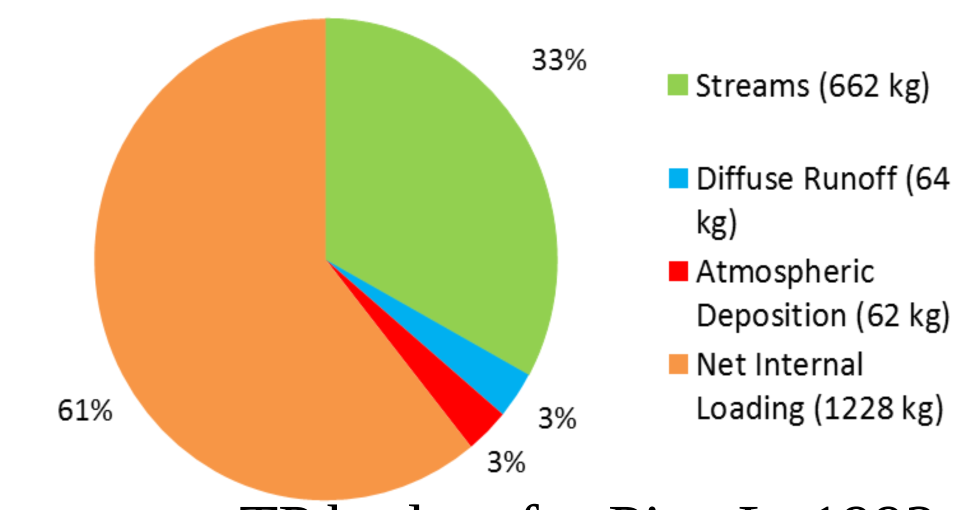


Feasible Treatment Methods – Option 4. Hydraulic Dredging

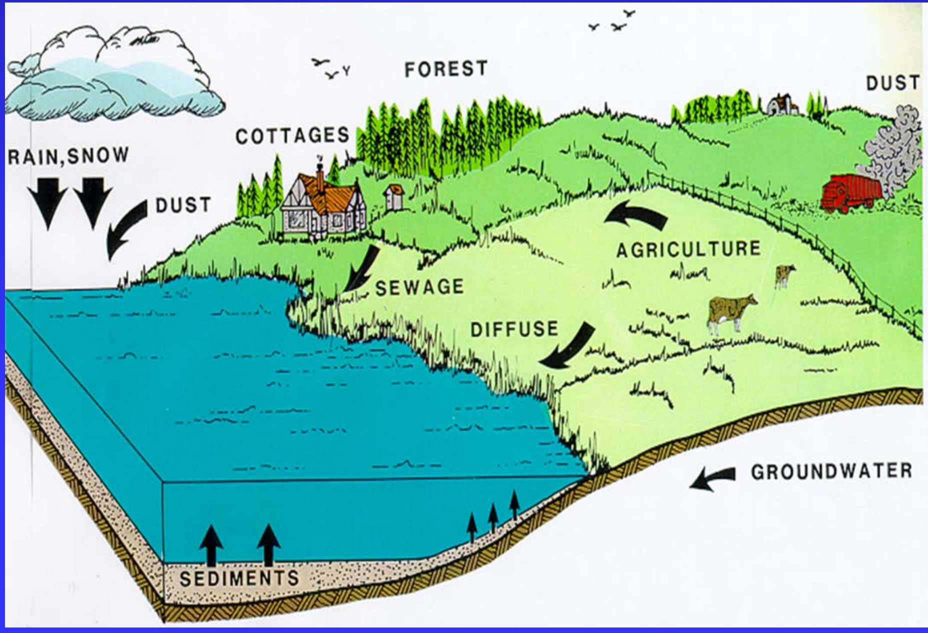
- Used at Arbour Lake, Calgary; Lake Trummen, Sweden
- Permanently removes the legacy P and complete ecosystem rehabilitation
- Could create a valuable sport fishery by deepening lake and removing decomposing material that strips oxygen from water
- Major disruption, aquatic organisms in dredged material are affected
- Most expensive method and ~75% more if centrifuges used to treat effluent.

Option 4 – Hydraulic Dredging

- Requires deep core sediment sampling to determine dredging depth to remove P and oxygen demand
- Also need a good TP budget to confirm previous U of Alberta finding that external P is small



TP budget for Pine L, 1992



Costs

- Approximate costs from applicators, dredging firm, and suppliers
- For method assessment and fundraising

Feasible Methods	Whole Lake Alum Single Treatment	Whole Lake Phoslock Single Treatment	Microfloc Alum Injection	Hydraulic Dredging
Approximate Cost Range	$US325,000 to $525,000 depending on dosage (US applicator)	$390,705 to $401,205 Cdn with Cdn applicator	$US35,000 design and build; $US30,000 annual costs 12x larger Newman L.	$700,000-$1,225,000 Cdn, settling basin northwest end of lake, 75% more for centrifuge treatment of effluent

Regulatory Side

- All feasible methods require licenses and permits from various levels of government (see report for details)
- Whole lake alum or Phoslock treatment will require an AEPEA approval (see sample approval in Appendix III issued for Henderson Lake)
- Under Section 2.1 approval holders have to promptly report any contraventions, do monitoring, submit annual reports for a specified number of years, for specified variables (bioassays, chemistry, etc)

Regulatory Side

- Whole lake treatment alum or Phoslock simplest, dredging most demanding in terms of regulatory requirements, and microfloc alum injection between the two
- Water management is a provincial responsibility - federal involvement triggered if project affects migratory birds, endangered species, sport or commercial fish
- Only sticklebacks in Halfmoon Lake, no sport fishery

Implementation Objectives

- Stakeholders in this community need to decide on objectives, what P levels are realistic, do they want a sport fishery?
- Need to achieve very low dissolved P levels to control cyanobacteria, a little bit is not good enough
- Sas et al. (1989) provide criterion of 10 µg/L soluble reactive phosphorus - well above this at Halfmoon
- Paleolimnology could help by telling what lake was like before European settlement

Control of External Phosphorus (P) Loading

- Control of external P sources alone unlikely to control cyanobacterial blooms (5 kg vs 147 kg from sediments in 1982), but some uncertainty
- HMLRA supports use of P free lawn fertilizers, vegetated buffer strips along watercourses, reduced impervious surfaces, removal of woody debris
- Also need to assess P contribution of birds to P budget

Large flocks of birds congregate some years on Halfmoon Lake

Concluding Remarks

- Any of these four inlake treatment methods should work here
- Inlake treatment tends to be complex, costly, and takes time to get it right
- Alum has the longest track record, methods are well understood, but must control pH, Halfmoon is well-buffered and suitable for either alum or Phoslock
- Phoslock is less sensitive to pH, but newer method and only one treatment in Alberta

Concluding Remarks

- Preliminary costs to apply these two chemicals to the whole lake are similar
- Microfloc alum injection uses far less chemical but requires infrastructure, maintenance, and operation
- Hydraulic dredging could completely and permanently renovate Halfmoon Lake and provide a potentially valuable fishery.

Acknowledgements

- I thank all technical and professional staff of Alberta Environment and Parks (AEP) and Lakewatch (ALMS) who assisted in the sampling of Halfmoon Lake.
- Dörte Köster (Hutchinson Environmental Sciences), Harry Gibbons (Lake Advocates), John Holz (HAB Aquatic Solutions), Nigel Traill and Karin Finsterle (both Phoslock Water Solutions), Jay White (Aquality Environmental Consulting), and Matthew Peyton (CEDA) provided preliminary cost estimates for lake management services at Halfmoon Lake
- Barry Moore (Washington State U.) provided unpublished costs for the Newman Lake microfloc alum injection project.

Lastly thanks to HMLRA! Questions?

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