Province of British Columbia
Ministry of Environment
Fish and Wildlife Branch
4825 Keith, Terrace, B.C.
V8G 1K7 ph: 638-0212
23 February, 1982.

YOUR FILE ....

OUR FILE ....

LAKELSE LAKE DEVELOPMENT CAPACITY

J. JYRKKANEN
HABITAT PROTECTION TECHNICIAN
TERRACE

BACKGROUND

Sinclair (June, 1974) mentions in his summary on the Socioeconomic study of Lakelse Lake that ".......The planning and development of Lakelse Lake must be based on the concept that it has a limited, and identifiable, capacity to accomodate shoreline and water-oriented activities."

Historically, there is a point in the life of developed lakes where pollution, alteration and alienation significantly affect the capability of those lakes to provide quality resource utilization. The sequential changes are often subtle but the net effect is gross.

Pollution isn't just phosphorous. It can be chemical leachates, accidental spills, temperature changes, flow timing alterations, debris influx, changed plant communities or introduction of a predatory species more pollution tolerant. In Canada, the Ontario government recognized that lakes are a finite resource after the collapse of the Great Lakes Fishery, rehabilitation of which may never be complete even with great capital outlay, much to the detriment of all Canadians. They subsequently implimented lake development guidelines to control maximum lake development (MNR Report, March, 1975).

Lakelse Lake and its associated Lakelse River have sufficiently high fisheries values to warrent some form of limiting process to protect these same values. Currently, it has only zoning which is arbitrary and only vaguely based on ecological values. There is no mandatory minimum lot size, established ratio of public access to private waterfront or boat limit.

LAKELSE LAKE CAPACITY

LAKELSE CARRYING CAPACITY ANALYSIS

The Ontario report cites a number of ways to assess the capacity of a lake for development. These methods indirectly consider the effects of total watershed development on water quality and on the ability of the resource to supply certain socioeconomic opportunities. The method is collectively called the 'Lake Alert Study'(Hough, Stansbury and Associates Ltd., 1972). I make a crude application of its methods below.

Boat Limit Method (BLM)

The BLM method recognizes that boats are a reflection of human pressure on a lake. The rule of thumb that is suggested is that there be 3.3 Acres of useable lake surface per motor boat and by inference, per cottage.

Lakelse Lake has 3501.4 Acres of surface area and 250 property owners according to Sinclair in 1974. Assume that (2/3) are useable surface area and additional pressure has added another 50 boats. This yields an A/B ratio of 7.78, still over 2 times as high as the 3.3 A/B limit suggested, possibly indicating an increased capacity for development. This value needs periodic reassessment.

Shoreline Development Method (SDM)

Another check on the safety of the Lake is to compare existing shoreline development with levels suggested to protect total shoreline from intensive development (Regional District of Fraser-Fort George, Lakeshore Guidelines, 1980).

The suggested allowable shoreline development for a lake like Lakelse is 50% (pg.16) with an absolute maximum of 75%. Lakelse currently has 67% in private lands and 27% tied up in Parks. Thus without adding Parks to the shoreline developed, this index is close to the maximum. With Parks, the limit has been exceeded significantly and no additional room exists for development

It is of course reasonable to consider Parks as developments. Thus, according to the SDM, 94% is committed and no more development should be allowed. There exists a 19% over-run.

Chlorophyll-a Limiting Method (CLAM)

mg/m^{-3}

Maximum permissable chlorophyll-a values for protection of cold water fisheries are in the range $2 \leq$ Chlor-a < 5 (Dillon and Rigler, 1975). However, chlorophyll-a levels are related to phosphorous so this method (CLAM) is not independent of another method described below which uses just a few more parameters.

Actual summer average chlor-a was 2.4 micrograms/L^{-1} which translates to 2.4 mg/m^{-3}, ex: (microg/L x10^{3} L/m^{3} x 10^{-3} mg/microg.)= mg/m^{-3}.).

This value is within the maximum permissable level and could even be doubled and still conform. Thus, the CLAM supports more development capacity.

The key question about using this index seems to be...How much additional phosphorous is needed to bring this index over the permissable? It could be computed from a regression curve relating the two variables and this should be done.

Morpheodaphic and Other Parameters Method (MOPM)

This more sophisticated method was developed in Ontario, adapted to suit the Fraser-Fort George Lakeshore Planning Guidelines, but has never been used in British Columbia. The reason, according to Abelson (Abelson, Dennis, 1982, Personal communication), is that the cost of getting parameters is too prohibitive. However, most of the parameters are available for Lakelse Lake since so many studies exist on the system.

LAKELSE LAKE CAPACITY

(1) After selecting 2.06 mg/m^{-3} for a permissable chlorophyll-a concentration, permissable spring phosphorous (2) is computed from P = log ((clor-a + 1.14)/1.45) =.3411. The lake surface area (3) is determined (very crudely) as $A_o = 14.2 \times 10^6 \ m^2$. (4) Mean depth is Z = 7.9 m. (5) Lake volume $V = 1.08 \times 10^8 \ m^3$. (6) Total watershed area $A_d = 2.447223 \times 10^8 \ m^2$. (7) Since A_d is greater than $10 A_o$, total outflow volume is computed (8) as $Q = 6.7932 \times 10^8 \ m^3/yr$. (9) Flush rate is p = Q/V = 6.29 Times /yr while (10) Aerial water load is $q_s = 47.84$. The retention coefficient (11) is computed from:

$$R = 0.426 \ (\exp(-0.271 \ q_s)) + .574 \exp(-0.00949 \ q_s)) = 0.36454.$$

(12) Response time of the lake to an influx of P loading is:

$t_{1/2} = 0.69/ (P + 10/Z) = 0.429392$. The permissable P loading to the (13)
lake or $L_{perm} = PZp/(1-R) = 26.7112 \ mg/m^2 /yr.$. The permissable P supply (14)
to the lake is only $J_{perm} = ((L_{perm})(A_o))/10^6 = 379.3$ kg/yr. (15) The total sypply of P from the land to the lake is the drainage area times the P export coefficient. I chose 10.2 for the export coefficient since it represents igneous bedrock with a forest and farm scenario. Thus, $J_E = A_d \times k_d = 2496.2$ kg/yr.

Even without adding the P from precipitation, the total supply from the land to the lake exceeds the permissable by 6.6 times!

Now, adding the load from precipitation (16) gives $J_r = 75(A_o)/10^6 = 1065$ kg/yr. Thus, the total natural supply to Lakelse Lake is (15) + (16) = 3561.2 kg/yr or 9.4 times the permissable value chosen.

One needs to go no farther to compute the allowable development. There is none according to the computations with the parameters chosen.

But, caution in interpretation is strongly indicated.

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Why hasn't this high apparant P value manifested itself in the Lake? There are a number of possible reasons including the choice of basic paramters. Sources of elimination of P from the actually observed may be:

a) Interception by beaver ponds with a low P export coefficient in the same.

b) Alpine retention in snow longer through the season.

c) Rapid uptake by aquatic macrophytes and plankton.

d) Strong adhesion to Lakelse Lake subsrtates.

e) A converse low Lakelse Lake retention coefficient.

The preliminary conclusion from MOPM is that the precise mechanism should be elucidated prior to any further development. The reason is that if it is either 'c' or 'd', then there are potentially significant ramifications on the lake's fisheries habitat values. This would come about by the alteration of the proportions of various species of plankton and macrophytes with a resulting effect on the anadromous fish food chain and rearing habitat cover values.

Physical Limiting Factors on Biological Systems (PLFBS)

Aquatic plant species have very special ranges of tolerances to concentrations of various nutrients. Some are intolerant to levels where other species thrive. Change of levels of key limiting nutrients can result in a change to undesirable species. Local pockets of nutrient enrichment may produce communities of undesirable plants. This needs study. Aquatic succession and its impact on fish escape habitat is a topic worth looking at in Lakelse Lake. Whether or not the macrophytes function as nutrient buffers (sinks and sources) or serve to create toxic levels in the annual cycle of decay needs to be looked at. If mechanical damage eliminates these plants, it may have far reaching impacts on the fish survival.

BIOLOGICAL CONSIDERATIONS

R. N. Nordin (August 12, 1980) states in a letter to R.J. Buchanen, Director of the Provincial Aquatic Studies Branch, that if the macrophytes enter into any consideration of the lake production, ..." they would certainly increase the estimation of lake production since the phytoplankton is so low." This comment uniquely changes the values in Lakelse Lake if found to be true. Therefore, it should be studied.

When aquatic plants enter the winter, the summer's growth dies back. This decomposes with the help of bacterial action and forms detritus. Detritus in turn forms the basis of a whole food chain for invertbrate production and eventually fish production since they feed on these same invertebrates.

If such a detritus based food chain is present, then fish rearing habitat will hinge on the health of these reed and other macrophyte beds. This should be looked at by a Fisheries Ecologist.

If the beaver swamps are trapping large amounts of drainage P, then when these decline over the roation of the forest as they invariably due because of loss of browse species, then perhaps this phosphorous will damage Lakelse Lake.

CONCLUSION

Various methods of assessing the lake's carrying capacity yield the following summary findings. The BLM = .5(CAPY), SDM = 1.253(CAPY), CLAM = .48(CAPY), MOPM = 9.4(CAPY)(these are read as Method = we are at x% ~~of the~~ times true carrying capacity). If one multiplies all of the factors together, then one finds out the overall prediction of how we rate with carrying capacity. It is briefly, .5(1.235)(.48)(9.4)= 2.78 times the carrying capacity currently, exclusive of biotic factors.

Averaging them yilds a similar conclusion.

MANAGEMENT IMPLICATIONS FOR LAKELSE LAKE

1. Any potentially impacting development should include an impact study of the proposal on water quality, macrophyte community and fish rearing habitat- by all potential impact pathways.

2. Single cottage units and developed foreshore already appear in excess by a number of criteria and thus backfilling should be considered with land disposal systems.

3. In liu of studies of the values of macrophytes, the areas currently undeveloped should have closures to further dock construction.

4. Studies of the value of macrophyte communities as a nutrient source and sink are needed.

5. Fry survival in and out of the reed beds are needed to determine the relative values of these to the fishery.

6. Mechanical impacts on macrophytes and total production studies are needed.

7. The analytical methods used in this article need further testing and refinement.

8. A maximum acres/boat and maximum percent shoreline allowable development should be chosen by the Regional District and then strictly adhered to.

9. Sewage removal by trucking ~~and cottage development by backfilling should be studied as methods of increasing the areas future carrying capacity.~~

Freshwater and Sportfish in Lakelse Lake and Tributaries (Cleugh, et. al. 1978)

Steelhead	Summer Run	200
	Winter Run	700

Cutthroat trout
Rainbow trout
Dolly varden char
Squafish
Whitefish
Peamouth chub
Large-scale suckers
Redside shiners
Threespine sticklebacks
Prickly sculpin
River lamprey eels

Habitat Use

Habitat use by the above species is complex with respect to time of year and types being used.

Potential Impacts of Developments Changing Trophic Regimes

Changes in species abundance relative to each other would be the most likely impact. Predatory anadromous fish would show a numerical response to any changes in prey species abundance. This would have implications to the commercial fishery. It might be possible to model the dynamics of the possible changes to project the general direction of the impact, and possibly crudely approximate its magnitude.

Avian predators like Mergansers and Red necked grebes, would also be affected by any changes in the relative abundance of certain prey species.

Cleugh et. al. reports in his abstract that " ...Relative to a 1946 report the benthic community increased threefold per square meter of substrate in a limnetic zone of nearly twice the depth...". Is this finding indicative of a trend towards a higher trophic status? If so, is the trend
(a) Continuing? (b) Caused by effluent leachates or other watershed developments? (c) Likely to cause a change in fishery population dynamics of a Socio-economic nature?

J. Jyrkkanen
Habitat Protection Technician
Fish and Wildlife Branch
Terrace.

Province of British Columbia
Ministry of Environment
Fish and Wildlife Branch
4825 Keith, Terrace, B.C.
V8G 1K7 ph: 638-0212

YOUR FILE Lakelse Lake
OUR FILE 0959

22 March, 1982

Bob Marcellin
Regional District of Kitimat Stikine
#9-4644 Lazelle Ave.
Terrace, B.C.
V8G 1S6

Mary
Position
Gorman

Bob:

RE: Mailbox Point STP

Total development in the Lakelse Lake system needs some pre-established upper bound to protect fish and fish habitat.

I am not expert enough to determine what criteria could determine that upper bound so I am being asked to comment on a referral outside my area of general knowledge.

Thus, until I receive further direction from my superiors on this complex matter I will have to defer comment. A site inspection with the developer has been tentatively scheduled for this spring and futher clarification of our Branch's position should result.

In short, I suggest putting the Lakelse Lake Mailbox Point Proposal on hold until further Ministry discussions crystalize into firm objectives and policies for their implimentation.

A multi-agency discussion after the site inspection should be fruitful. My Regional Manager has indicated interest in such a meeting. Perhaps the 30th of April, 1300 hours, at the Regional District Office would be a good time, following a morning site inspection.

Would that be acceptable to all?

Yours truly,

JJ
f the reg mgr

CC: AE, RG, JH, BW, BB, HD, Mr. Inselberg-129-9th St.-Prince Rupert, B.C.

For addresses - see over.

Province of British Columbia — Ministry of Environment

MEMORANDUM

To: T. Roberts
Regional Manager
Waste Management Branch
Smithers, B.C.

Date: March 9, 1982

File: 50.6003

Re: Additional Studies at Lakelse Lake

Studies of Lakelse Lake by Ableson (1976) and Cleugh (1978) developed a reasonably good first cut evaluation of the trophic status of the lake. The studies were not directed at developing lake capacity guidelines or management prescriptions in order to protect or enhance the very major fisheries and recreational resources in the lake and system.

It has been six years since the lake was studied, during which time there has been some minor recreational development. However, the issue of the new Mailbox point strata title subdivision (27 lots) plus the attempt to resurrect the Hotsprings Hotel, raises new and important questions of lake capacity.

The subdivision is worrisome in several respects. First, will it cause additional nutrient loading to the lake? Second, are there other land owners awaiting the outcome of this proposal before jumping in with their own? Third, is there a habitat loss situation when cottage owners clear their waterfront of weeds for aesthetic purposes. Fourth, is there nutrient enrichment from boat activity in shallow waters (Yousef, et al 1980)?

It is therefore suggested that additional studies get underway which are more management oriented and ask the ultimate carrying capacity question.

Suggested components of the investigations include:

Item	Reason
1. nutrients in groundwater	changes in the watershed will vary natural & anthropogenic loadings of nutrient
2. nutrient in inlet streams	changes in the watershed will vary natural & anthropogenic loadings of nutrient
3. role of rooted macrophytes as a source or sink of nutrients	to evaluate the impact of macrophyte loss as a result of mechanical removal by cottagers

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Province of
British Columbia

Ministry of
Environment

Fish and Wildlife Branch
4825 Keith Avenue
Terrace, B. C. V8G 1K7

638-0212

YOUR FILE Lakeshore Plannin

OUR FILE 0359/0859

February 5, 1982.

Al Edie,
Regional Habitat Protection Biologist,
Fish and Wildlife Branch,
Bag 5,000
Smithers, B. C. V0J 2N0

Al:

Re: Lakelse Lakeshore Development Planning

I was at a meeting as per our discussion on the phone this P.M. with Hermann Delyea, Conrad Skaalrud, John Hipp and Randy Nelson regarding the status of Lakelse Lake with respect to development and environmental input.

Brought up at the meeting were the following points.

1. Development pressure on the lake is high currently.
2. Fish and Wildlife and Recreational values are enormous.
3. The carrying capacity of the lake is limited and we don't know what that limit is. It is limited for effluent loading and by inference, human days of useage. It also has an upper limit on location and number of different types of developments to protect Public Access etc.
4. The Fraser Fort George Regional District has developed guidelines to handle such contigencies, we haven't (in sufficient detail).
5. We lack sufficient data to approve further development because of these high values and areas of ignorance.
6. Protection of the billion dollar/century fishery etc. demands that a carrying capacity/development type study be done to provide a rational data based method of arriving at development approvals by those agencies entrusted with the care of this resource. The Fraser Fort George Guidelines might serve as a preliminary model.

To properly address these questions, it was agreed by the participants that Regional District should be approached with these concerns and that the successful solution of these questions was essential to ~~approval of~~ proper input for future developments in the Lakelse Lake Area.

This has been done and Bob Marcellin and Earl Hamilton, both with the Regional District, are to address the matter further at a T.P.C. meeting on the 10th of February.

Yours truly,

Jorman Jyrkkanen,
Habitat Protection Technician.

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CHANGES IN PHOSPHORUS CONCENTRATIONS DUE TO MIXING BY MOTORBOATS IN SHALLOW LAKES

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University of Central Florida, Engineering and Industrial Experiment Station, College of Engineering, P.O. Box 25000, Orlando, FL 32816 U.S.A.

(Received November 1979)

Abstract—Recreational motorboats equipped with engines varying from 28 to 165 horsepower were operated at three selected Central Florida lakes. Also, a pair of isolation chambers representing aquatic habitats were placed in each lake for control and mixing studies. Mixing in isolation chambers was performed by small electrical motors connected to two blade propellers.

Agitation of the water column in the lake mixing stations and inside the isolation chambers increased water turbidities and phosphorus concentrations. The increase in turbidity and phosphorus content occurred at a much higher rate than the rate of decline after cessation of mixing. The increase in phosphorus content could result in an increase in lake productivity as noticed from the increase of chlorophyll *a* concentrations in lake mixing stations.

INTRODUCTION

Phosphorus has usually been considered the limiting nutrient in most aquatic systems (Fitzgerald, 1970; Syers, 1973, and USEPA, 1976). The amount of phosphorus present in most aquatic organisms has been found to be only a small percentage of their total weight. However, phytoplankton can absorb more than ten times their normal content of phosphorus and store it for future use. Zooplankton and littoral macrophytes also absorb and store orthophosphate directly from the water column. In environments rich in phosphorus, the luxury phosphorus is usually stored in the form of polyphosphates which have been found to comprise up to 20% of the cell dry weight (Hooper, 1973).

The suspended plankton in a water column settle and become part of the sediment. Sediment phosphorus content has been observed to be generally highest near the sediment–water interface and decreasing with depth as illustrated by sediment phosphorus profiles in several Florida lakes (Stewart, 1976). Phosphorus in the sediment is present in both the soluble and insoluble states (Syers *et al.*, 1973; Williams & Mayer, 1972; Williams *et al.*, 1971).

Mixing of the sediments and the overlying water occurs due to natural and man-made processes. Principal processes of natural mixing have been found to result from thermal gradients, wind and pressure waves, mobility of organisms, such as insect larvae and worms, and the formation of gas bubbles and pockets, either methane, carbon dioxide, or oxygen. Man-made mixing results from recreational activities such as boating and artificial mixing of the lake. Mixing of the sediments and the overlying water would have a number of effects on the phosphorus concentrations and forms present in the sediment. Interstitial water, containing up to fifty times the concentration of soluble ortho-PO_4, would be mixed with the overlying water. After resettling, phosphorus contained in lower sediments and interstitial waters could diffuse upward, replacing the supply of orthophosphate lost to the water column. It has been reported that 19–65% of the inorganic phosphorus absorbed by bottom sediments is exchangeable (Li *et al.*, 1973). Continued mixing would increase the rate of phosphate exchanged (Kuo & Lotse, 1974). Also, contact with aerobic lake water would cause some ortho-PO_4 to be lost to the water column with the conversion of ferrous hydroxide associated with sediments to ferric oxyhydroxide and the resultant decrease in its adsorptive capacity. In addition, bacteria on the now aerobic particles would exhibit a rapid uptake of inorganic phosphorus. Soluble organic phosphorus is released from both phytoplankton and bacteria (Lean, 1973; Hays, 1958). The rapid conversion of sediment orthophosphate to organic phosphorus in a water column is supported by Carter *et al.* (1974) studies.

Little work has been done to determine what role, if any, the increased use of outboard motors has played in the increased rate of eutrophication of many lake systems. Casey *et al.* (1974) and Neilson (1974) were interested in the rate of transfer of oxygen from

Presented to 1979 North American Lake Management Conference, Kellogg Center for Continuing Education, Michigan State University, East Lansing, Michigan, April 16–18, 1979.

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YOUR FILE..............................

OUR FILE 40.8508

1982-02-10

Abelson Letter.

Jorma Jyrkkannen
4825 Keith Avenue
Terrace, British Columbia
V8G IK7

Dear Sir:

Re: Lakeshore Guidelines and Developmental Capacity

Further to your recent telephone inquiry I have taken the liberty of photostating portions of the manual used by the Province of Ontario for assessing lakeshore development. Your attention is respectfully directed towards pages 15-30, where the theory for each step of the management scheme for southern Ontario Lakes is outlined. With specific regard to the calculation of phosphorus leading to the lake, I would stress the following points from Dillon:

1) If a development significantly alters the amount of cleared land in a watershed then an appropriate change in the export value must be made.

2) The total amount of phosphorus supplied to the lake from the land is calculated as the sum of the area of each drainage basin times its phosphorus export co-efficient.

3) A complicating factor arises if any tributaries in the watershed have additional lakes in its course; these lakes will act as nutrient traps, decreasing the actual amount of phosphorus transported from the drainage area to the lake.

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I would stress that the detailed Ontario calculations remain untested in B.C.; many of the variables such as the phosphorus export co-efficient, and the phosphorus retention co-efficient for lake sediments are probably different.

I would also stress, as you have realized, the overwhelming significance of the high flushing rate of Lakelse Lake.

Please contact me if I can be of further assistance. I would also suggest R. Nordien of Aquatic Studies in Victoria as a knowledgeable resource person.

Yours truly,

D.H.G. Ableson
Fisheries Biologist
Omineca Peace Region

DHA/mh

attachments

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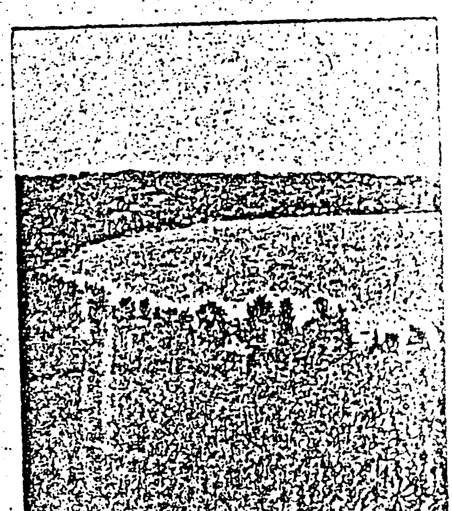
Manuscript Report No. 1472



Cover: At Crystal Lake, Mich., a specially designed survey used a recently developed septic leachate detector, groundwater monitoring, and mathematical models to analyze the performance of shoreline treatment systems. See p. 1717. Photo by William B. Kerfoot.