APPENDIX C

MEMORANDUM - HUTCHINSON TO O'NEILL,

OCTOBER 19, 1992

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Ministry of the Environment
Mı. stère de l'Environnement

Water Resources Branch

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October 19, 1992

MEMORANDUM

TO: Terry O'Neill, MOE, Gravenhurst
Steve Maude, MOE, Central Region
Chris Hodson, Town of Haliburton

FROM: Neil J. Hutchinson
Limnology Section
Dorset Research Centre

RE: Dysart et al. Sewage Treatment Plant Expansion

Background

The Ministry of the Environment has outstanding concerns regarding deterioration of water quality in the Drag River chain of lakes, and how water quality may respond to proposed expansion of the Dysart et al. STP which discharges to Grass Lake in the Town of Haliburton.

In October of 1991, Bernie Neary, at that time with the Limnology Section, Water Resources Branch of MOE, conducted an intensive modelling exercise to predict the responses of that chain of lakes to various alternatives of STP expansion. His results were presented in a memo to Terry O'Neill, which has been circulated to interested parties. The modelling which is presented here should be considered as an addition to Bernie's work, not as a replacement.

In February 1992, Jan Beaver (formerly with Central Region, MOE), Terry O'Neill, Bernie Neary, Chris Hodson and myself, met to discuss plans for further modelling of potential impacts. At that time, it was proposed that the modelling be expanded to include moving the outfall from Grass Lake to North Kashagawigamog Lake, comparing lake responses at TP concentrations of 0.2 and 0.3 $\mu g/L$ in the STP effluent and the implications of extending the sewer network of

Haliburton to service Grass, Head and North Kashagawigamog Lakes. The latter scenario was included to investigate the feasibility of increasing allowable development on those lakes by collecting the sewage and treating it to remove phosphorus.

In the summer of 1992, the Town of Haliburton reviewed its records of shoreline development on Grass, Head and Kashagawigamog Lakes. This exercise produced much higher levels of development than those used in Bernie's modelling exercise. It was therefore considered necessary to repeat the exercise using these revised figures.

Methods and Data Sources

All data, except the revised development figures, were taken from Bernie's original report and is reproduced here for the sake of completeness. Development figures were revised from assessment rolls in the Town of Haliburton, direct observation and reviewing records of electricity usage. Although the Ontario Trophic Status Model used by Bernie has been revised since the last report, I repeated the modelling using the same version used by him (Ver. 1.2.2) to facilitate comparisons.

The workings and theory of the TSM are described fully in Dillon et al. (1986)[1] and its application in a whole watershed context discussed in Hutchinson et al. (1991)[2], which I have appended to this memo.

Comparison with Earlier Modelling Exercises

The Drag River chain of lakes was modelled in 1991 and the results presented in a memo (91.10.31) to Terry O'Neill (MOE, Gravenhurst) from Bernie Neary (MOE, Dorset). Since that time, we have obtained a second set of spring overturn phosphorus measurements and I have remodelled the

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[1] Dillon, P.J., K.H. Nicholls, W.A. Scheider, N.D. Yan and D.S. Jeffries. 1986. Lakeshore Capacity Study, Trophic Status. Research and Special Projects Branch, Ontario Ministry of Municipal Affairs and Housing. Queen's Printer for Ontario. 89 pp.

[2] Hutchinson, N.J., B.P. Neary and P.J. Dillon. 1991. Validation and use of Ontario's Trophic Status Model for establishing lake development guidelines. Lake Res. Mgt. 7: 13-23.

watershed. The results are presented in Table 1. Although I used the same set of data (Table 2) to model these lakes, I obtained slightly higher estimates of total phosphorus concentration, due to a different interpretation of the watershed areas upstream of Head Lake. The new results (Fig. 1) give higher estimates of TP concentrations in Head Lake and all downstream lakes, for both background (no shoreline development) and total phosphorus.

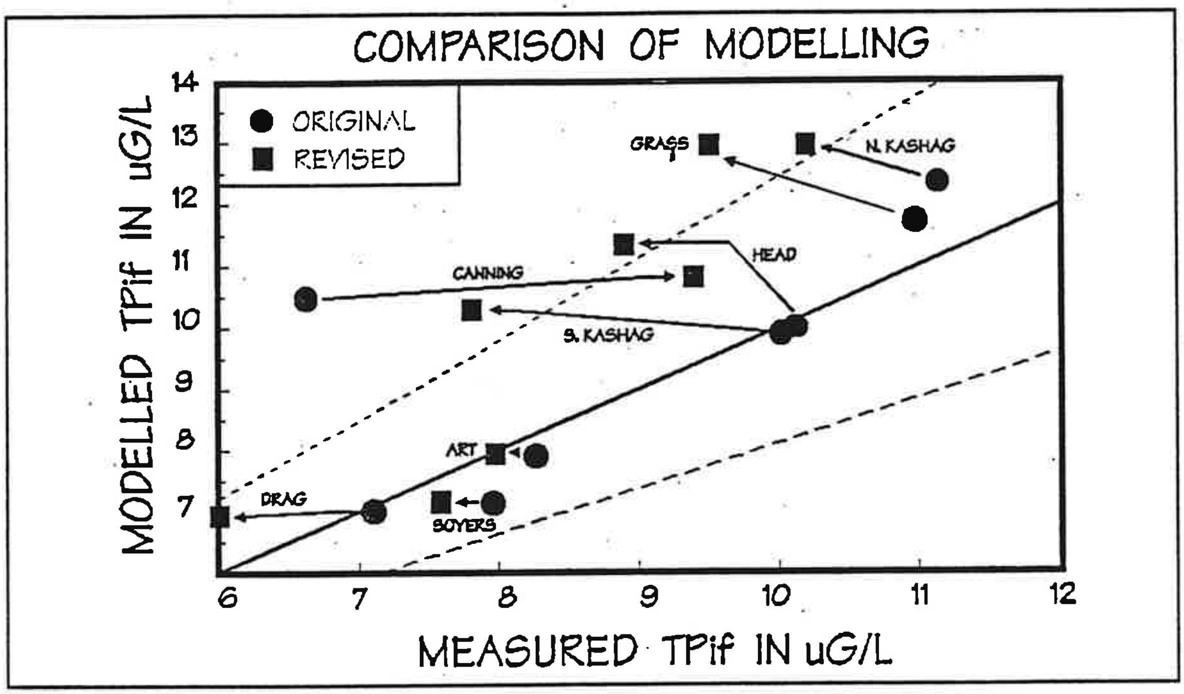

Figure 1

The second year of sampling produced lower measurements of total phosphorus than the first year. The measured values presented in Table 1 and Figure 1 are the mean concentrations from the two years of sampling during spring overturn, which have been converted to mean concentrations for the ice-free period using the relationship:

$$TP_{if} = [0.8 \times TP_{so}] + 2.04^{3}$$

Figure 2 shows the results of my modelling exercise. The top panel shows that for 4 of the 8 lakes, measured and modelled estimates agreed to with ±20% and so are

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[3] Table 48. Dillon et al. 1986. Final Report, Ontario Lakeshore Capacity Study: Trophic Status.

considered equivalent (Hutchinson et al. 1991). Grass was the only lake of the 8 showing an appreciable difference between measured and modelled estimates. The discrepancies between the two modelling exercises likely reflect variability in measurements as the modelled results differed by <14% from Bernie's modelling exercise.

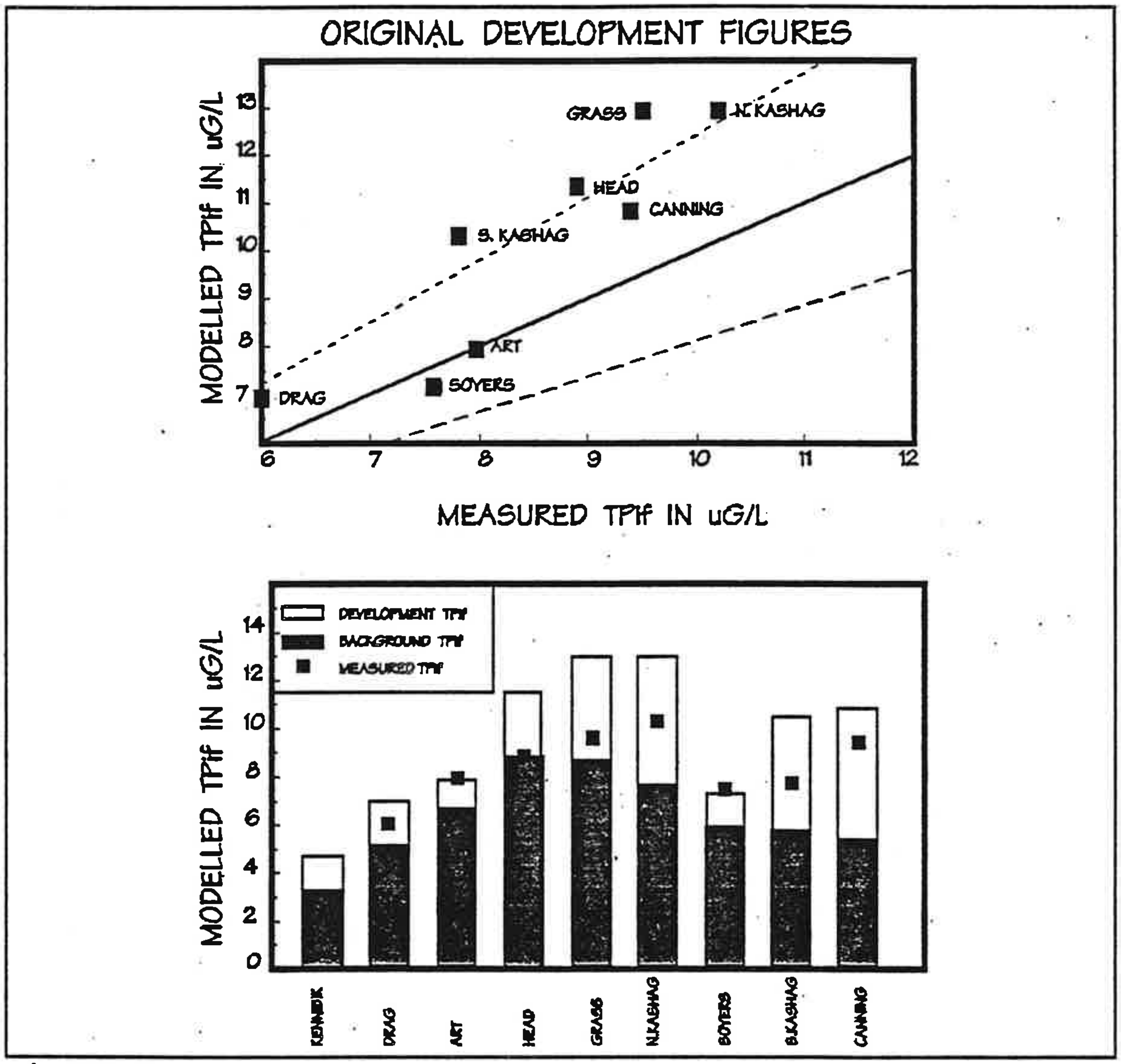

Figure 2

The lower panel in Figure 2 shows that significant portions of the total phosphorus concentrations in Grass, North and South Kashagawigamog and Canning Lakes are attributed to anthropogenic phosphorus inputs as a result of shoreline development, urban runoff and discharge from the existing Haliburton STP.

Revision of Shoreline Development Figures

In the summer of 1992, the Town of Haliburton reviewed existing unserviced shoreline development within 300 m of the shoreline or any stream flowing into Head, Grass and North Kashagawigamog Lakes. Table 3 shows that a substantial amount of development on the shores of these lakes was not included in the original modelling exercise.

The lake chain was remodelled using the revised figures for shoreline development under two scenarios.

Modelling Assuming No Retention of Phosphorus in Septic Fields

The Drag River was modelled using the revised development figures provided by the Town of Haliburton, (C. Hodson, Town Planner, pers. comm.) and the assumption that all phosphorus in shoreline septic systems would eventually migrate to the lakes. This assumption, although conservative, has been validated in Precambrian Shield lakes with thin layers of soil over bedrock (P. Dillon et al. 1992[4]) and forms the basis for current assessment techniques used by the MOE. The results (Figure 3) show that modelled estimates of TP concentration in the Drag River lakes are much greater than the existing measured concentrations and greater than the estimates derived using the original data on shoreline development. Head Lake, and all downstream lakes have higher predicted concentrations than those shown in Figure 2. The lower panel of Figure 3 shoes that, as expected, this increase is a result of anthropogenic inputs of phosphorus from shoreline septic systems.

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[4] Dillon, P.J., W.A. Scheider, R.A. Reid and D.S. Jeffries. 1992. The Lakeshore Capacity Study. Part I: A test of the effects of shoreline development on the trophic status of lakes. Ont. Min. Envir. Tech. Report. 30 pp.

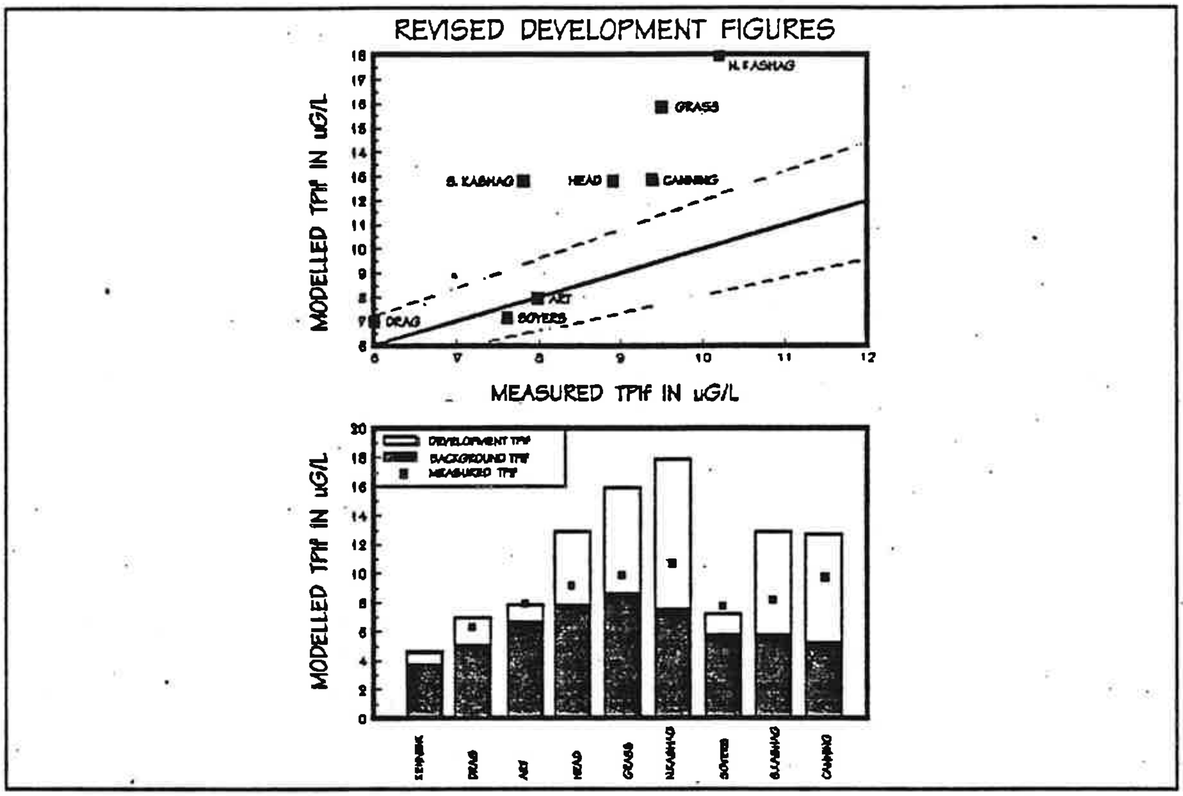


Figure 3

The poor correspondence between measured and modelled estimates suggests that septic system phosphorus has not yet migrated to the lakes. This is not surprising, as the revised figures on shoreline development reflect recent severance and construction in the last 10 years. It is reasonable to conclude that this septic system phosphorus has not yet saturated the soil between the septic systems and the lake, and so the lakes have not yet responded to the added development.

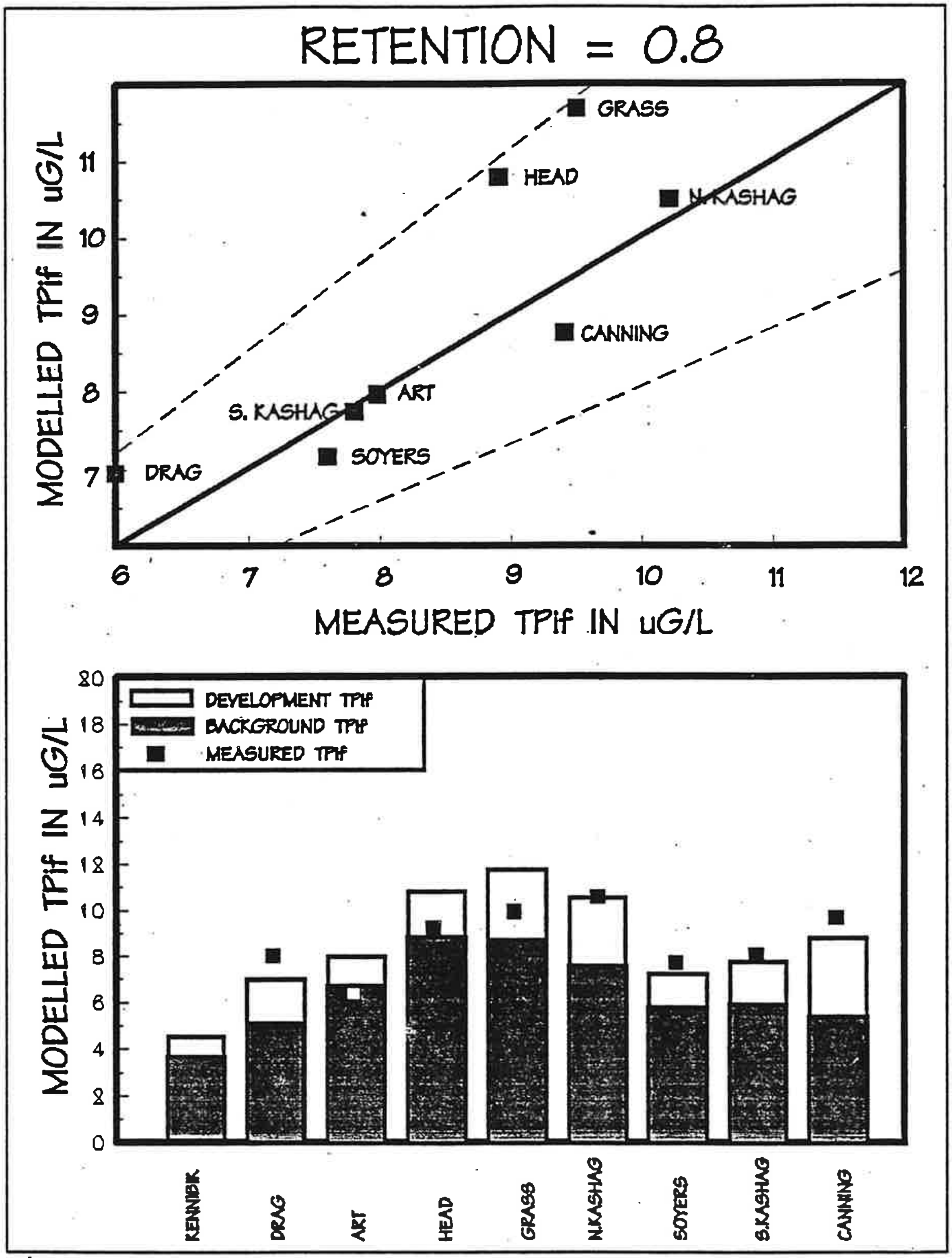
The "no retention" scenario should not, therefore, be interpreted as a valid reflection of existing conditions. Instead, the results are presented as an illustration of the eventual trophic status of the Drag Lake system. If shoreline development on Grass, Head and North Kashagawigamog Lakes remains unserviced, then it is reasonable to conclude that, eventually, all of the phosphorus from this development will impact the lakes unless there is sufficient (>5 m) depth of soil between the septic systems and the lake to retain septic system phosphorus. Past experience suggests that this is a valid assumption for lakes on the Precambrian Shield.

Modelling Assuming 80% Retention of Phosphorus In Septic Fields

In spite of the previous discussion, it was necessary to generate a closer estimate of existing phosphorus concentrations in the Drag River chain of lakes in order to predict the impact of various alternative scenarios for expansion of the Haliburton STP. Any upgrading of the STP which involved servicing development on Head, Grass and North Kashagawigamog Lakes, as proposed, would remove consideration of shoreline development as a source of phosphorus to these lakes. If shoreline lots are serviced before the phosphorus attenuation capacity of shoreline soils is consumed, then it is valid to assume that little of that phosphorus will migrate to the lakes. In addition, it is valid to assume that the revised development figures represent recent development, and so, little of that phosphorus will have reached the lakes yet.

The modelling exercise was thus repeated assuming that 80% of the phosphorus from shoreline development is still retained in the soil, in order to produce closer correspondence between measured and modelled estimates and hence, a more valid reflection of the existing condition in the lakes. Retention of phosphorus from resorts was estimated by reducing the number of resort units by 80%, as the model did not allow explicit calculation of phosphorus retention from resort septic systems.

Figure 4 shows that if 80% of the shoreline development phosphorus is assumed not to have reached the lake yet, that the modelled and measured estimates of TP concentration show close correspondence. Therefore, the trophic status model has reproduced existing conditions in which only 20% of the phosphorus from shoreline development has reached the lake.


RETENTION = 0.8
GRASS
HEAD
N. KASHAG
CANNING
ART
S. KASHAG
SOYERS
DRAG
MODELLED TPif IN uG/L
MEASURED TPif IN uG/L
6
7
8
9
10
11
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DEVELOPMENT TPif
BACKGROUND TPif
MEASURED TPif
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4
6
8
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14
16
18
20
KENNBK
DRAG
ART
HEAD
GRASS
N.KASHAG
SOYERS
S.KASHAG
CANNING

Figure 4

Scenarios of STP Expansion

Discussion with staff of MOE Central Region (T. O'Neill, J. Beaver), the Town of Haliburton (C. Hodson) and Conestoga Rivers and Associates (Ed Roberts) produced many different alternatives to servicing resort expansion, effluent quality and outfall location for the Haliburton STP. Such a large number of scenarios confounds both the modelling process and its interpretation but I have attempted to present results in order to facilitate comparison.

Eight primary scenarios were modelled and numbered as shown below:

STP Diffuser Outfall							
Grass Lake				North Kashagawigamog Lake			
Phosphorus Retention in Septic Fields							
0%		80%		0%		80%	
Resort Capacity							
Existing	Increased	Existing	Increased	Existing	Increased	Existing	Increased
Scenario Number							
1	2	3	4	5	6	7	8

Starting Points for Comparison

The primary point of comparison was the present day level of development and the existing STP design. Each lake was thus modelled using the revised development figures as a baseline; under conditions of no phosphorus retention in shoreline septic fields to represent the possible future with no STP (Scenario 1.1) and under conditions of 80% retention to represent present day conditions or those in the future with shoreline lots serviced by the STP (Scenario 3.1).

Vacant Lots

Presently, a number of severed but vacant, lots exist on each lake. These lots are committed to development but the nature of development in unknown. Vacant lots were therefore committed to either seasonal or permanent residences on the basis of existing land use. That is, if

10% of the existing development on a lake consisted of permanent residences and 90% seasonal, then the vacant lots on that lake were assigned to 10% permanent/90% seasonal residences as well.

Development of all vacant lots on a lake represents the true baseline for comparison of alternative scenarios, because these lots are committed to development. Scenarios 1.2 and 3.2 thus represent existing development + vacant lots developed with 0% and 80% retention of shoreline phosphorus respectively.

Impact of Servicing Shoreline Development via STP

Six secondary scenarios of STP operation were modelled under each of the eight primary scenarios outlined above.

First, all shoreline development on Grass and Head Lakes was connected to the STP and this effluent treated to TP concentrations of 0.2 or 0.3 mg/L.

Second, all shoreline development and resorts on the north shore of North Kashagawigamog Lake, as well as development on Grass and Head Lakes, was connected to the STP. This effluent was treated to TP concentrations of 0.2 or 0.3 mg/L.

Finally, all shoreline development and resorts on both shores of North Kashagawigamog Lake, as well as development on Grass and Head Lakes, was connected to the STP. This effluent was treated to TP concentrations of 0.2 or 0.3 mg/L.

Each secondary scenario was modelled under each of the eight primary scenarios and 4 "baseline" scenarios of existing and vacant development were modelled to generate a total of 52 possible outcomes for each lake downstream of Drag Lake. These are summarized in Table 4.

Estimation of Phosphorus Load from Shoreline Development

All shoreline development serviced by a septic system was modelled using phosphorus loading of 0.8 kg per person per year. This per capita load was developed in the Ontario Lakeshore Capacity Study (Dillon et al. 1986, Final Report of Trophic Status Component) and represents the combined total from human sewage and use of domestic detergents, etc., which contain phosphorus.

Residential usage figures were taken from the final report of the Land Use Component of the Ontario Lakeshore Capacity Study (Downing, J.E. 1986). Cottages were assigned a usage figure of 0.89 capita years/year, corresponding to an average of 3.7 people using the cottage for, on average, 89 days per year. Permanent homes were assigned a usage figure of 2.55 capita years/year, corresponding to an average of 2.6 people residing in a home for 363 days per year.

Campsites on Kennibik lake were included as sources of phosphorus. These were assigned a usage of 0.48 capita years per year, based on estimates used by MOE Central Region for routine assessment (J. Beaver, pers. comm.).

Resorts were assessed on the basis of 1.27 capita years per year for each unit. This is the figure used by MOE Central Region for routine assessment.

Estimation of Phosphorus Load from Haliburton STP

Existing conditions were modelled using an annual loading of 54.4 kg of phosphorus from the STP to Grass Lake (J. Beaver, pers. comm., MOE Central Region, B. Neary, memo to T. O'Neill 91.10.31). The STP operates at an average effluent concentration of 0.5 mg/L of TP.

Urban runoff is another source of phosphorus to urban lakes such as Head Lake. An annual load of 13.1 kg of TP to Head Lake was used, based on previous calculations (B. Neary, 91.10.31).

It is difficult to estimate future loadings from an STP at the design phase, when operating capacity and characteristics are unknown. An effluent concentration of 0.3 mg/L can be designed and achieved reliably, but concentrations of 0.2 or even 0.1 mg/l are attainable. Although most Ontario STPs are routinely limited to 0.5 or 1.0 mg/L of effluent TP, future upgrades or new plants are likely to be limited to 0.3 or even 0.2 mg/L and so the Haliburton STP was modelled at both of these effluent concentrations.

Municipal Service

The future size of Haliburton is difficult to predict. A growth rate of 4% per year has been suggested (J. Beaver, MOE Central Region, pers. comm.) and this would lead to the population doubling in 18 years.

The future load from the STP was thus established on the assumption that the population would double, as follows:

54.4 kg/yr (at present) x 2 = 108.8 kg/yr at 0.5 mg/L TP

$$108.8 \times \frac{0.2}{0.5} = 43.5 \text{ kg/yr at } 0.2 \text{ mg/L TP}$$

$$108.8 \times \frac{0.3}{0.5} = 65.3 \text{ kg/yr at } 0.3 \text{ mg/L TP}$$

These figures were used as the STP loading derived from servicing the Town of Haliburton only (Table 5).

Service to Shoreline Development

The loading of TP resulting from servicing shoreline development on Grass, Head and Kashagawigamog Lakes was derived from estimates of hydraulic loading to the STP at the two proposed effluent concentrations.

Hydraulic loading was estimated from figures in the MOE document "Manual of Policy Procedures and Guidelines for Private Sewage Disposal Systems".

Hydraulic loading from seasonal residences was calculated as 175 L/day x 365 days/yr x 0.89 capita years/yr.

Hydraulic loading from permanent residences was calculated for a 3 bedroom home (1600 L/day) for 365 days per year.

Hydraulic loading from an 80 unit trailer park on the north shore of North Kashagawigamog Lake was calculated assuming 2 bedroom trailers at 1000 L/day for 365 days per year.

Resort units were converted to "Equivalent Residential Units" (ERUs) by multiplying the number of units by 0.75 (B. Neary, memo to T. O'Neill, 91.10.31). Each unit was assumed to accommodate 3 people and hydraulic loading calculated as 180 L/day/person for a non-housekeeping unit and 125 L/person/day for a dining room seat. This produced a figure of 915 L/day for each ERU.

Hydraulic loading figures are summarized in Table 5.

The total hydraulic and phosphorus loading figures from shoreline development on North Kashagawigamog Lake are summarized in Table 6. The figures for shoreline development on Head and Grass Lakes are presented in Table 7.

Resort Expansion

At present, there are 297 resort units on the north shore of North Kashagawigamog Lake and 75 on the south shore, for a total of 372 units (C. Hodson, Town of Haliburton, Table 3). This converts to a total of 279 equivalent residential units. The design of these resorts call for a total of 552 ERUs at full (expanded) capacity (B. Neary, memo to T. O'Neill, 91.10.31). These ERUs were allocated to north and south shore resorts in the same ratio as existing resort units to model the implications of their being connected to the STP. The modelling proceeds from the assumption that <u>all</u> resorts connect to the STP as compliance with this requirement was impossible to predict. Loadings from existing and planned expansion of resorts are summarized in Table 6.

Background Phosphorus and "Suggested Maximum"

At present, Central Region of MOE have recommended against further development on the Drag River chain because of declining water quality in Canning and Kashagawigamog Lakes (B. Neary, memo to T. O'Neill, 91.10.31). Low levels of hypolimnetic oxygen in these lakes have prompted concerns over the future of the lake trout fishery, as lake trout are confined to the hypolimnion because of their strict temperature requirements and prefer >6 mg/L of dissolved oxygen. The implications of development, phosphorus and dissolved oxygen were discussed in the previous memo by B. Neary (91.10.31).

In addition to dissolved oxygen, Central Region of MOE regulate development on the basis of allowable increases in chlorophyll <u>a</u> resulting from increased concentrations of TP. These guidelines are developed for individual lakes and will not be discussed here.

Recent developments in trophic status modelling allow the reliable prediction of TP concentrations in lakes in the absence of anthropogenic inputs from shoreline development. Such "background" concentrations are calculated on the basis of TP loading from the atmosphere and from a lake's watershed. They form a desirable baseline for trophic status assessment because, unlike measurements of present day water quality, they remain constant over time. Future development may alter a lake's trophic status substantially, but it is still possible to calculate the same "pre-development" or "background" trophic status regardless of changes in the measured water quality.

Recent initiatives within MOE suggest that shoreline development be regulated to allow TP concentrations to increase by a fixed amount (i.e., 50%) above the modelled background concentrations. This approach is discussed fully in a paper by Hutchinson et al. (1991) which is appended. Table 8 shows the background or "pre-development" TP concentrations for each lake in the Drag River chain and the suggested maximum of "Background +50%". Figures 5-12 show this suggested maximum as a horizontal bar plotted above each lake, as one alternative to estimating a desirable trophic status for each lake.

Results

Tables 9-16 present the TP concentrations estimated for each lake under each of 52 scenarios. Kennibik, Art and Drag Lakes are not influenced by any of the scenarios of STP expansion, but only by the assumptions regarding phosphorus retention in shoreline septic fields. Figures 5-12, therefore, illustrate the responses of lakes downstream of Drag Lake to various scenarios of STP expansion and operation.

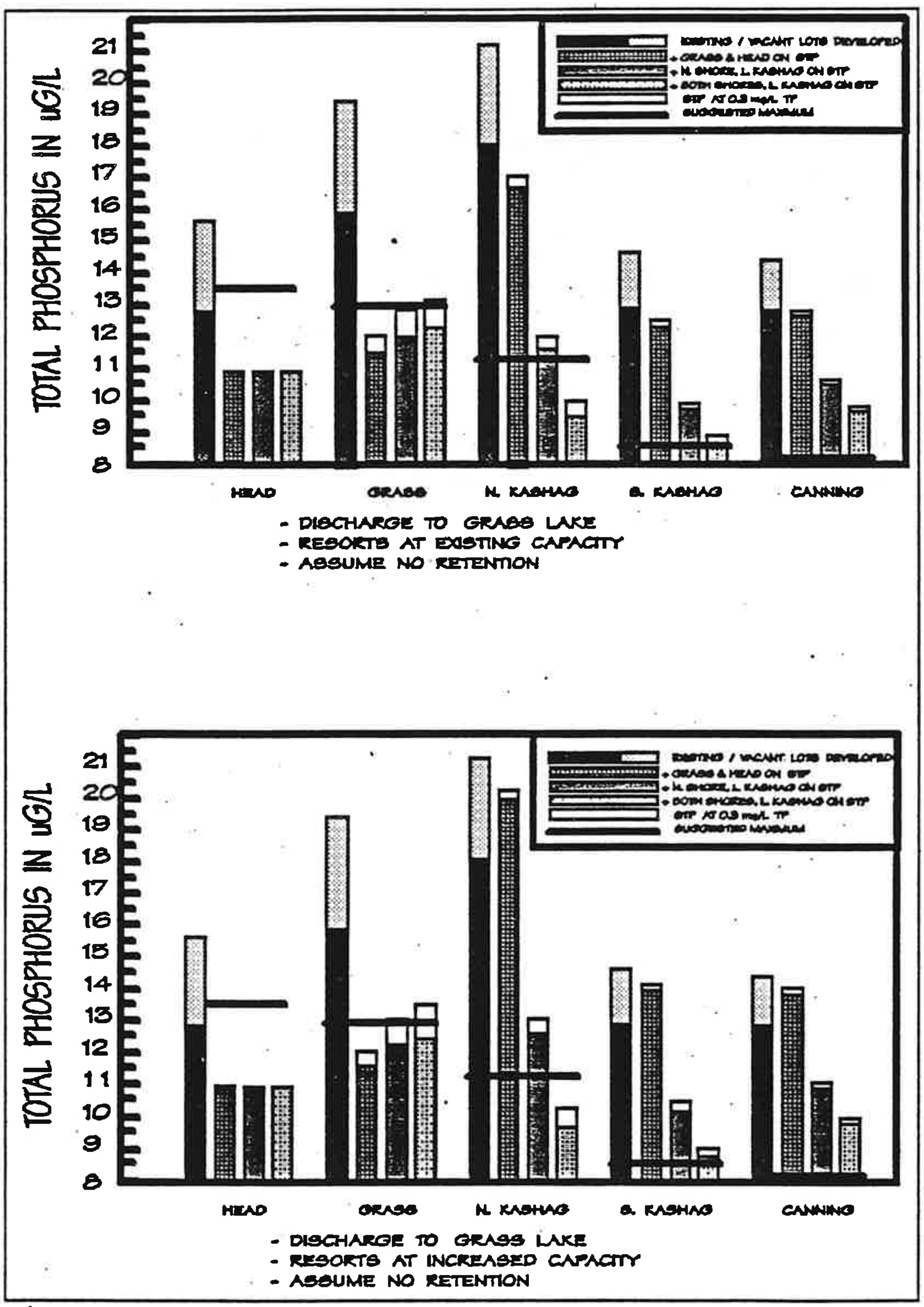
Scenarios Involving No Phosphorus Retention

Figures 5-8 and Tables 9-12 summarize results obtained assuming no phosphorus retention in shoreline septic fields. They show that all lakes are significantly over-developed at existing levels of development or if all vacant lots are developed. They therefore represent possible conditions 20-30 years from now if all development on Grass, Head and Kashagawigamog Lakes remains unserviced and no phosphorus remediation is attempted. These represent a "worst case" scenario.

The modelling predicts that desirable trophic status in Grass and Head Lakes can only be attained by servicing all of their shoreline development via the STP. Kashagawigamog and Canning Lakes show significant impairment of future water quality under all possible scenarios of STP expansion except for that which sees development on Grass, Head and Kashagawigamog Lakes serviced fully by the new STP.

Locating the STP outfall in North Kashagawigamog Lake produces significant improvement to Grass Lake with a marginal decline in water quality in the receiving water, compared to locating the outfall in Grass Lake. Nevertheless, maintaining the outfall in Grass Lake greatly improves water quality there, providing that Head and Grass lakes are serviced by the STP.

Expansion of resorts has little impact on water quality, provided that Lake Kashagawigamog is serviced by the STP. This scenario produces an insignificant change in Grass Lake if the outfall is located there, but a significant improvement in Lake Kashagawigamog. Resort expansion was not modelled on top of the "Existing Vacant Lots Developed" scenario, under the assumption that any expansion is contingent on some form of hook up to the STP. Although connecting Grass and Head Lakes to the STP produces significant improvements in Lake Kashagawigamog (Figure 5), these improvements are essentially nullified if the resorts expand (Figure 6).


TOTAL PHOSPHORUS IN uG/L
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EXISTING / VACANT LOTS DEVELOPED
+ GRASS & HEAD ON STP
+ N. SHORE, L. KASHAG ON STP
+ BOTH SHORES, L. KASHAG ON STP
STP AT 0.3 mg/L TP
SUGGESTED MAXIMUM
HEAD
GRASS
N. KASHAG
S. KASHAG
CANNING
- DISCHARGE TO GRASS LAKE
- RESORTS AT EXISTING CAPACITY
- ASSUME NO RETENTION
TOTAL PHOSPHORUS IN uG/L
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EXISTING / VACANT LOTS DEVELOPED
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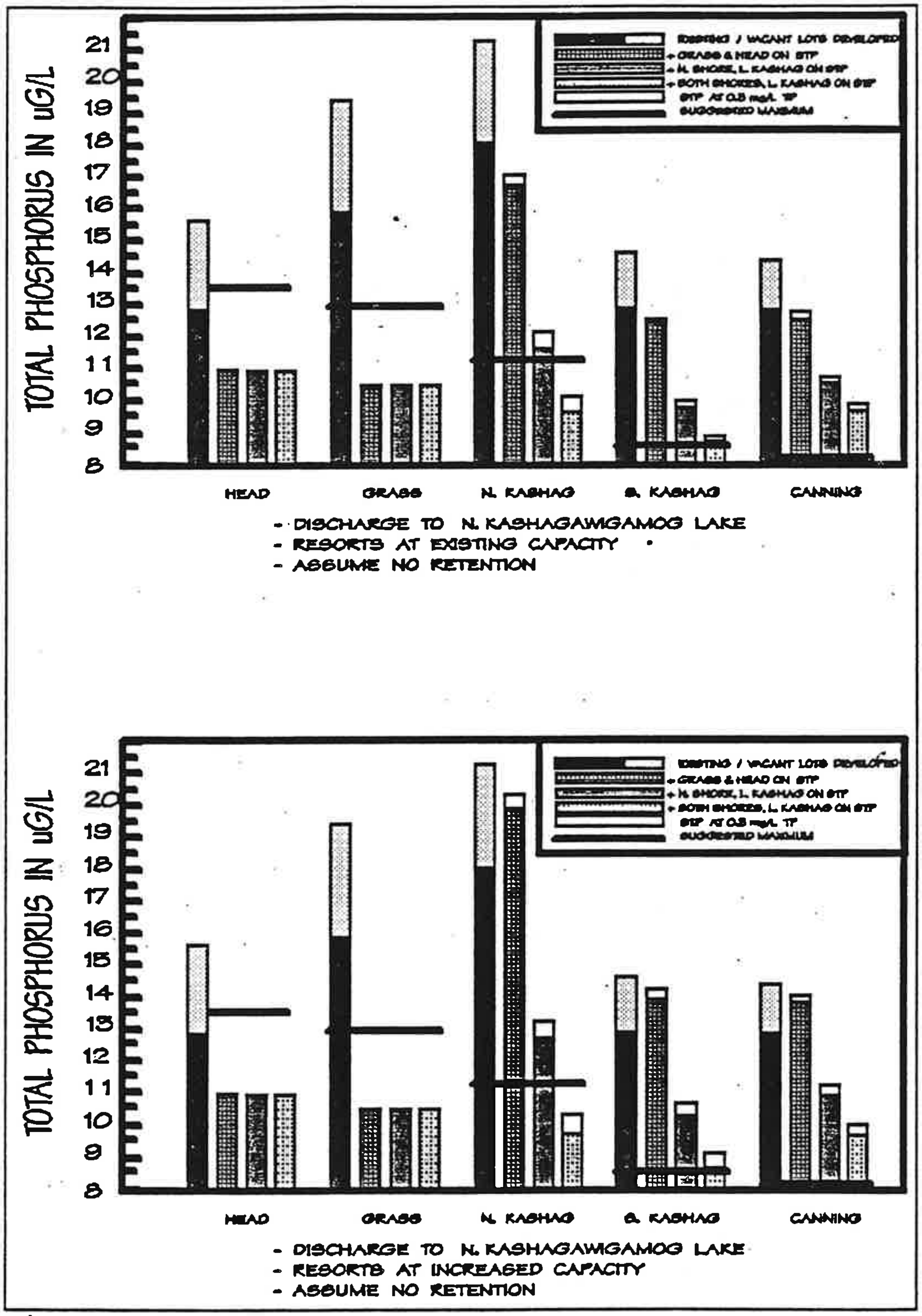
STP AT 0.3 mg/L TP
SUGGESTED MAXIMUM
HEAD
GRASS
N. KASHAG
S. KASHAG
CANNING
- DISCHARGE TO GRASS LAKE
- RESORTS AT INCREASED CAPACITY
- ASSUME NO RETENTION

Figure 5-6


TOTAL PHOSPHORUS IN uG/L
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S. KASHAG
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TOTAL PHOSPHORUS IN uG/L
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- DISCHARGE TO N. KASHAGAWIGAMOG LAKE
- RESORTS AT INCREASED CAPACITY
- ASSUME NO RETENTION

Figure 7-8

Conclusions

The Drag River chain of lakes will show significant deterioration in water quality over the next 30 years if the phosphorus retention capacity of shoreline soils becomes exhausted and all septic system phosphorus from development on existing properties and vacant lots migrates to the lakes. None of the scenarios proposed for the Haliburton STP will address this adequately for all lakes. Servicing all development on Grass and Head Lakes would maintain good water quality on these lakes and significantly improve conditions downstream. Relocating the outfall to North Kashagawigamog improves Grass Lake slightly. Maintaining effluent TP concentration at 0.2 mg/L vs. 0.3 mg/L improves Grass Lake slightly if the outfall is located there, but has an insignificant impact otherwise.

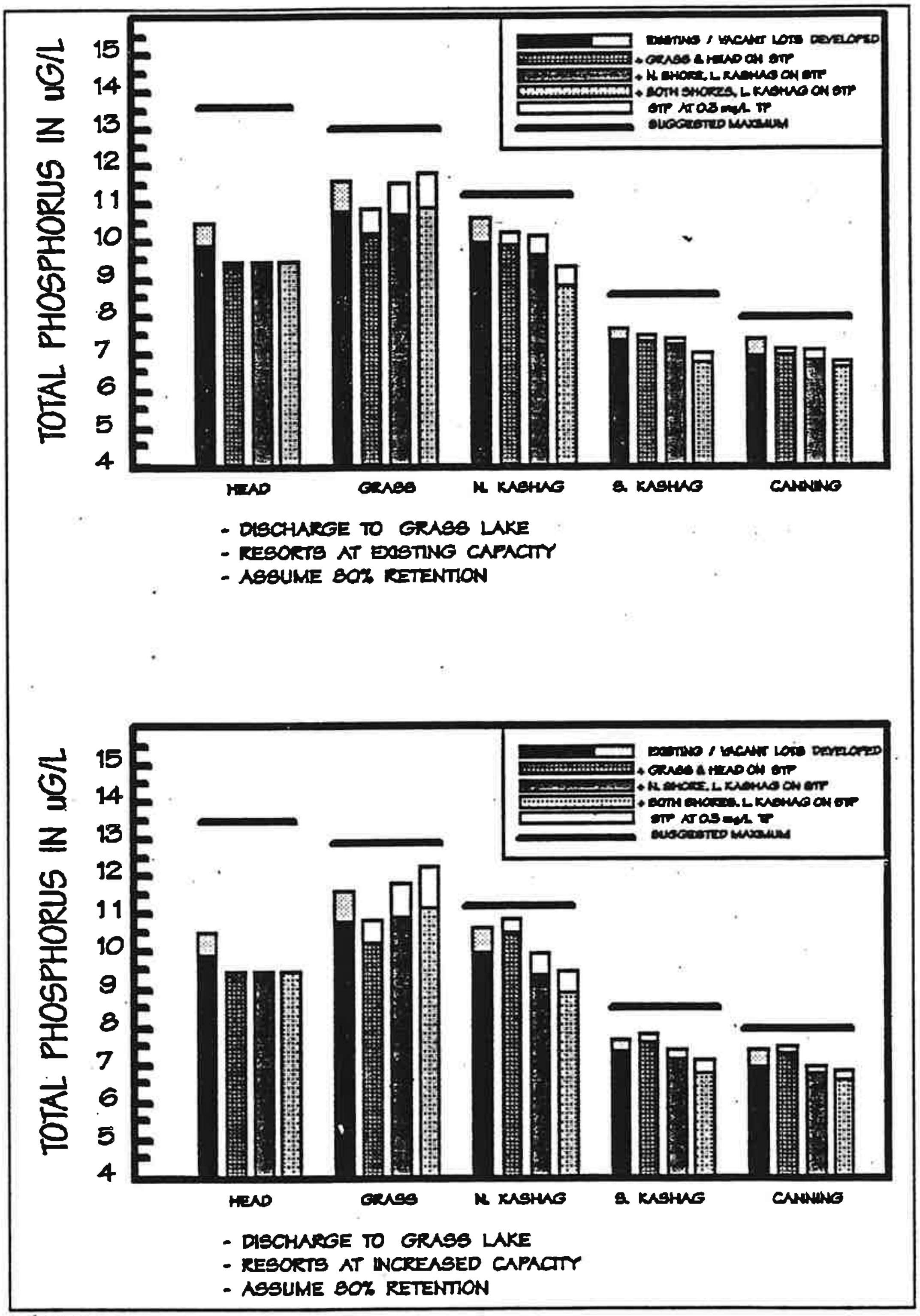
Scenarios Involving 80% Phosphorus Retention

Figures 9-12 and Tables 13-15 summarize results obtained assuming 80% retention of phosphorus from shoreline septic fields. They represent existing conditions in all lakes and lake responses to alternative STP scenarios if they were to take place in the near future. All lakes, under all scenarios, maintain TP concentrations below the suggested maximum of "Background +50%". Note, however, that these maxima are only suggested, are not formalized as MOE policy, and have been set without consideration of either chlorophyll _a_ concentrations or levels of hypolimnetic dissolved oxygen.

Although these results suggest that servicing shoreline lots via the STP is not required to achieve water quality objectives, they must be interpreted in light of the previous results which suggest that, ultimately, no phosphorus will be retained from shoreline development and significant eutrophication of all lakes will result.

Water quality in Head and Grass Lakes improves if these lakes are serviced by the STP, even if the outfall is located in Grass Lake. Water quality in Grass Lake deteriorates as a result of servicing Lake Kashagawigamog unless the effluent is treated to achieve a TP concentration of 0.2 mg/L. Water quality in downstream lakes shows no change or improves slightly under all scenarios at an effluent concentration of 0.2 mg/L, discharged to Grass Lake. Resort expansion has little impact on water quality in Kashagawigamog and Canning Lakes at an effluent quality of 0.3 mg/L and water quality improves slightly at 0.2 mg/L.

Locating the outfall in North Kashagawigamog Lake produces significant improvements to water quality in Grass Lake, as expected, and no significant changes to water quality downstream, even if all resorts connect. Expansion of resorts produces no significant changes in water quality in Kashagawigamog and Canning Lakes, regardless of the location of the outfall.


TOTAL PHOSPHORUS IN uG/L
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EXISTING / VACANT LOTS DEVELOPED
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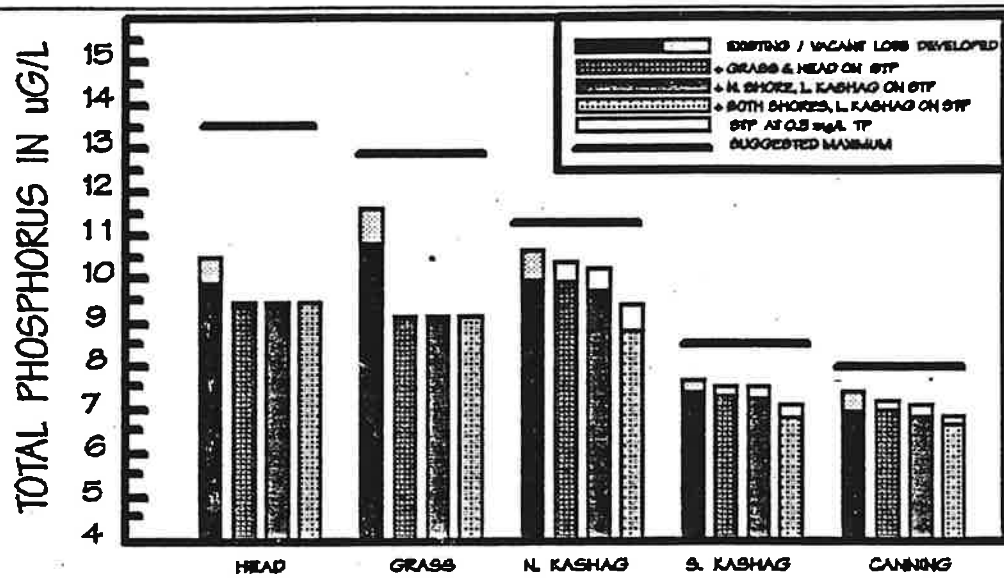
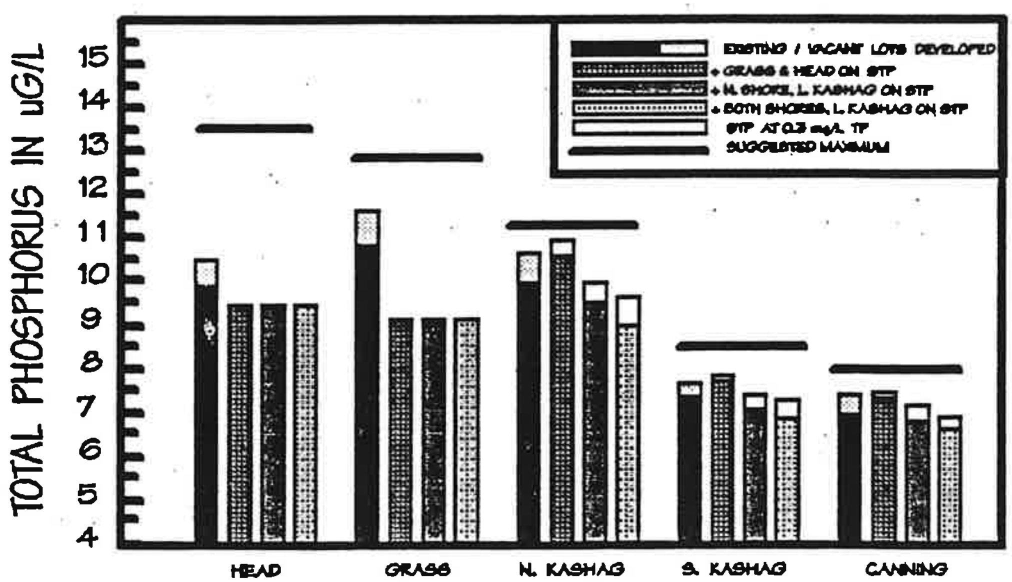
EXISTING / VACANT LOTS DEVELOPED
+ GRASS & HEAD ON STP
+ N. SHORE, L. KASHAG ON STP
+ BOTH SHORES, L. KASHAG ON STP
STP AT 0.3 mg/L TP
SUGGESTED MAXIMUM
HEAD
GRASS
N. KASHAG
S. KASHAG
CANNING
- DISCHARGE TO GRASS LAKE
- RESORTS AT INCREASED CAPACITY
- ASSUME 80% RETENTION

Figure 9-10



- DISCHARGE TO N. KASHAGAWIGAMOG LAKE
- RESORTS AT EXISTING CAPACITY
- ASSUME 80% RETENTION



- DISCHARGE TO N. KASHAGAWIGAMOG LAKE
- RESORTS AT INCREASED CAPACITY
- ASSUME 80% RETENTION

Figure 11-12

Summary

The design of the Haliburton STP should be based on the scenarios in which modelling of existing water quality agrees closely with measured values: that is, under the assumption that present conditions reflect 80% retention of phosphorus in shoreline soils. As long as this phosphorus remains soil bound then improving water quality in Grass and Head lakes appears to be the only advantage to expanding the STP to accommodate shoreline development there. No other scenario offers a significant advantage in terms of water quality. These results suggest that there is room for further development on these lakes, even if it is not serviced by the STP. I would caution, however, that this modelling exercise has not addressed concerns over lake trout habitat and dissolved oxygen. These concerns were well addressed in Bernie Neary's modelling exercise and form the basis for MOE's present concern over impacts of further development on water quality.

The decision on STP design must, however, consider the possibility of further deterioration of water quality which will occur when shoreline soils cease retaining phosphorus from septic fields. If this occurs and this development is not serviced by an STP, then significant environmental deterioration can be expected. Servicing all development by the STP will reduce the extent of deterioration, but will not achieve our suggested maximum TP guideline.

The decision must, ultimately, depend on the confidence placed in the assumptions regarding phosphorus retention. It would appear, however, that servicing development on Head and Grass Lakes would produce a greater improvement in water quality per dollar than would servicing Kashagawigamog Lake. Little would be gained by placing the outfall in North Kashagawigamog Lake under the 80% retention scenario, beyond what would be achieved by servicing Head and Grass Lakes. Moving the outfall would improve water quality in Grass Lake under the 0 retention scenario, but by less than would servicing Grass and Head Lakes development.

I regret that this lengthy modelling exercise has produced few, clear cut conclusions, compared to the work done by

Bernie Neary. Discussion and review of this memo may suggest other approaches. I would be pleased to discuss this at some time.

Neil J. Hutchinson

NJH/rbm
570r.92
attachments

cc: M. Michalski, Michael Michalski Associates
E. Roberts, Conestoga Rovers Ltd.

Table 1 Data used to model the Drag River watershed. All data taken from original modelling exercise (B. Neary 91.10.31).

Lake	Area (ha)	Mean Depth (m)	Max. Depth (m)	Volume ($10^6 m^3$)	Watershed[1] (ha)	Geology % Igneous	Land Use % Forested	Shoreline Development Permanent	Shoreline Development Seasonal	Shoreline Development Resorts
Kennibik	155.4	7.0	25.0	10.87	858	100	95	0	12	0
Drag	1002.6	20.1	55.5	201.52	11338	100	95	22	276	60
Art	126.4	7.6	28.0	9.63	1045	100	85 (945 ha) 90 (100 ha)	2	27	0
Head[2]	62.2	2.6	5.6	1.62	16382	100	85	35	2	0
Grass[3]	63.6	3.4	9.5	2.16	16456	100	10	37	25	0
North Kashagawigamog	315	9.5	22.9	29.90	20986	100	90	20	135	219
Soyers	329.2	19.0	48.8	62.55	4822	100	95	1	97	10
South Kashagawigamog	493	15.2	39.7	74.0	27489	100	95	20	316	0
Canning	244	6.7	22.3	16.35	28653	100	95	30	224	30

1 includes cumulative watershed areas of upstream lakes

2 includes 13.1 kg of TP from urban runoff

3 includes 54.4 kg of TP from Haliburton STP

Table 2 Modelled background, modelled total and concentrations of mean ice-free phosphorus ($\mu g/L$) in lakes on the Drag River system. Left hand side of the table presents results from the original modelling exercise (B. Neary, memo to T. O'Neill, 91.10.31). Right hand side shows results from the present modelling exercise and two years of measurement

	Modelled Background	Modelled Total	Measured	Modelled Background	Modelled Total	Measured
Kennibik	3.68	4.53	-	3.68	4.53	-
Art	6.68	7.94	8.20	6.68	7.94	8.0
Drag	5.03	6.97	7.08	5.03	6.95	6.0
Head	7.61	10.00	10.12	8.97	11.36	8.9
Grass	7.31	11.61	11.00	8.62	12.94	9.5
North Kashagawigamog	6.75	12.21	11.16	7.48	12.95	10.2
Soyers	5.76	7.19	7.88	5.76	7.18	7.6
South Kashagawigamog	5.31	9.96	10.05	5.69	10.29	7.8
Canning	5.03	10.53	6.65	5.33	10.80	9.4

Table 3 Summary of shoreline development upstream of Canning Lake. Existing development from C. Hodson, Town of Haliburton, pers. comm. Vacant lots were developed in same ratio of permanent to seasonal as for existing development.

	Existing Development						Existing & Vacant Lots				
	Perm.	Seas.	Camp	Resort	Point (kg)	Vacant	Perm.	Seas.	Camp	Resort	Point (kg)
Kennibik	0	12	20	0	0	5	0	17	20	0	0
Art	2	27	0	0	0	17	3	43	0	0	0
Drag	22	276	0	60	0	173	36	435	0	60	0
Head	84	5	0	0	13.1	80	159	10	0	0	13.1
Grass	84	45	0	0	54.4	48	110	67	0	0	54.4
North Kashagawigamog	124	198	0	372	0	81	175	228	0	372	0
South Kashagawigamog	20	316	0	0	0	20	21	335	0	0	0
Soyers	1	97	0	10	0	20	1	117	0	10	0
Canning	30	224	0	30	0	20	33	241	0	30	0

Table 4 Total loading of phosphorus from STP for various scenarios. All scenarios assume development of existing vacant lots. Loadings developed from information given in Tables 6 and 7.

Scenario	Serviced Areas	Resorts	Effluent Concentration (mg/L)	Discharge (kg/yr)
1.3, 2.1 3.3, 4.1 5.1, 6.1 7.1, 8.1	Haliburton, Grass Lake, Head Lake	--	0.2	76.2
1.4, 2.2 3.4, 4.2 5.2, 6.2 7.2, 8.2	Haliburton, Grass Lake, Head Lake	--	0.3	114.6
1.5, 5.3 3.5, 7.3	Haliburton, Grass Lake, Head Lake, North shore of Lake Kashagawigamog	Existing	0.2	113.7
2.3, 6.3 4.3, 8.3	"	Expand	0.2	126.4
1.6, 5.4 3.6, 7.4	Haliburton, Grass Lake, Head Lake, North shore of Lake Kashagawigamog	Existing	0.3	170.6
2.4, 6.4 4.4, 8.4	"	Expand	0.3	189.9
1.7, 5.5 3.7, 7.5	Haliburton, Grass Lake Head lake, Both sides of Lake Kashagawigamog	Existing	0.2	125.6
2.5, 6.5 4.5, 8.5	"	Expand	0.2	143.7
1.8, 5.6 3.8, 7.6	Haliburton, Grass Lake Head Lake, Both sides of Lake Kashagawigamog	Existing	0.3	188.6
2.6, 6.6 4.6, 8.6	"	Expand	0.3	216.6
1.1, 3.1 1.2, 3.2	Haliburton	--	0.5 (existing)	54.4

Table 5 Estimation of hydraulic loading to Haliburton STP from shoreline development on Grass, Head and North Kashagawigamog Lakes. Water usage figures were taken from MOE "Manual of Policy Procedures and Guidelines for Private Sewage Disposal Systems", unless noted otherwise.

Seasonal Residence:

275 L/person/day[1] x 365 days/yr x 0.89[2] capita years/yr

= 89.3 m^3/year

Permanent Residence: (assume 3 bedrooms standard)

1600 L/day x 365

= 584 m^3/year

Mobile Home (Trailer Park, assume 2 bedroom home)

1000 L/day x 365

= 365 m^3/trailer/year

Resorts:

No. of ERU[3] x 3 people/unit x (180 L/day[4] + 125 L/day[5])

= 915 L/day/ERU x 365 days

= 334 m^3/yr/ERU

Planned Municipal Service:

Existing = 54.4 kg/yr

Assume population doubles[6] = 108.8 at 0.5 mg/L TP in effluent

= 65.3 at 0.3 mg/L, 43.5 at 0.2 mg/L

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1 275 L/day for single family houses, apartments, condominiums, cottages, etc.

2 Seasonal usage figure ("Summer") from J. Downing (1986). Final Report of Land Use Component and Ontario Lakeshore Capacity Study.

3 ERU = "Equivalent Residential Unit" = No. units x 0.75 (memo B. Neary to T. O'Neill 91.10.31)

4 Hotel: Private room (non-housekeeping) = 180 L/day

5 Hotel: Dining room seat = 125 L/day

6 Ed Roberts, Conestoga Rovers, pers. comm. 92.10.14

Table 6 Summary of hydraulic loading to proposed Haliburton STP and resultant discharge of phosphorus to Grass Lake from development on Kashagawigamog Lake. Loadings are derived for STP phosphorus removal to 0.2 and 0.3 mg/L of effluent. Future expansion of resorts is allocated to north and south shores of Kashagawigamog Lake in same ratio as existing distribution of units. All vacant lots are developed.

Source	No. of Units	Hydraulic Load (m^3/yr)	TP Discharge from STP in kg/yr Effluent Conc. of 0.2 mg/L	Effluent Conc. of 0.3 mg/L
Town of Haliburton	--	217,500	43.5	65.3
Kashagawigamog Lake North Shore				
Permanent	119	69,496	13.9	20.8
Seasonal	133	11,877	2.4	3.6
Resort[1] - existing	223	74,482	14.9	22.3
Resort - expansion	414	138,276	27.7	41.5
Trailer Park	85	31,025	6.2	9.3
Total - existing		186,880	37.4	56.0
Total - Resorts expand		250,674	50.1	75.3
Kashagawigamog Lake South Shore				
Permanent	56	32,704	6.5	9.8
Seasonal	95	8,484	1.7	2.5
Resort[1] - existing	56	18,703	3.7	5.6
Resort - expansion	138	46,089	9.2	13.8
Total - existing		59,891	9.3	13.9
Total - Resorts expand		87,277	14.7	22.1
North and South Shore				
Permanent	175	102,200	20.4	30.6
Seasonal	228	20,361	4.1	6.1
Resort - existing	279	93,185	18.6	28.0
Resort - expansion	552	184,365	36.9	55.3
Trailer Park	85	31,025	6.2	9.3
Total - existing		246,771	49.3	74.0
Total - Resorts expand		337,951	67.4	102

[1] As Equivalent Residential Units (ERU) = # of units x 0.75

Table 7 Summary of hydraulic loading to proposed Haliburton STP and resultant discharge of phosphorus to Grass Lake from development on Grass and Head Lakes. Existing vacant lots allocated to permanent and seasonal residences in ratio of existing development.

Source	No. of Units	Hydraulic Load (m^3/yr)	TP Discharge from STP in kg/yr Effluent Conc. of 0.2 mg/L	Effluent Conc. of 0.3 mg/L
Grass Lake				
Permanent	110	64,240	12.8	19.3
Seasonal	67	5,983	1.2	1.8
Resort	0	0	0	0
Total		70,223	14.0	21.1
Head Lake				
Permanent	159	92,856	18.6	27.9
Seasonal	10	893	0.2	0.3
Resort	0	0	0	0
Total		93,749	18.8	28.2
Total		**163,972**	**32.8**	**49.3**

Table 8 "Background" or "Pre-Development" concentrations of total phosphorus (ice-free mean in μg/L) estimated for the Drag River chain of lakes using the trophic status model. Suggested maxima were calculated as the background concentration +50%.

	Total Phosphorus in μg/L	
	Modelled Background	**Suggested Maximum**
Head	8.97	13.5
Grass	8.62	12.9
North Kashagawigamog	7.48	11.2
South Kashagawigamog	5.69	8.5
Canning	5.33	8.0

Table 9 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (μg/L) and export of phosphorus to next lake downstream (kg).

Scenario 1 - STP discharges to Grass Lake, no phosphorus retention in septic fields, resorts at existing levels.

Scenario	1.1		1.2		1.3		1.4		1.5		1.6		1.7		1.8	
TP	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg
Kennibik	4.5	13.6	4.7	14.1	--	--	--	--	--	--	--	--	--	--	--	--
Art	7.9	29	8.7	32	--	--	--	--	--	--	--	--	--	--	--	--
Drag	7.0	277	7.9	313	--	--	--	--	--	--	--	--	--	--	--	--
Head	12.8	840	15.6	1023	--	--	--	--	--	--	--	--	--	--	--	--
Grass	15.9	1044	19.4	1279	11.5	756	12.0	792	12.0	791	12.8	844	12.2	802	13.1	861
N Kashagawigamog	18.1	1519	21.2	1777	16.7	1403	17.0	1429	11.6	972	12.0	1010	9.5	795	10.0	838
Soyers	7.2	138	7.4	143	7.4	143	--	--	--	--	--	--	--	--	--	--
S Kashagawigamog	12.9	1421	14.6	1609	12.3	1357	12.5	1375	9.7	1067	9.9	1092	8.6	948	8.9	977
Canning	12.9	1477	14.4	1648	12.6	1439	12.7	1454	10.5	1199	10.6	1220	9.6	1101	9.8	1125

1.1 Most recent development figures, C. Hodson, Haliburton Planner, pers. comm.
1.2 1.1 plus all vacant lots developed to maintain existing ratio of permanent to seasonal
1.3 1.2 plus Grass and Head Lakes development on STP - STP effluent = 0.2 mg/L
1.4 1.3; STP at 0.3 mg/L
1.5 1.3 plus north side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
1.6 1.5; STP at 0.3 mg/L
1.7 1.3; both sides of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
1.8 1.5; STP at 0.3 mg/L

Table 10 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (μg/L) and export of phosphorus to next lake downstream (kg).

Scenario 2 - STP discharges to Grass Lake, no phosphorus retention in septic fields, resorts expand

Scenario	2.1		2.2		2.3		2.4		2.5		2.6	
TP	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg
Kennibik, Art, Drag, Head and Soyers Lakes show no changes from Scenario 1.												
Grass	11.5	756	12.0	792	12.2	803	13.1	862	12.4	819	13.5	887
N. Kashagawigamog	19.9	1667	20.2	1693	12.6	1059	13.1	1102	9.6	808	10.2	856
S. Kashagawigamog	14.0	1535	14.1	1552	10.2	1126	10.5	1155	8.7	957	9.0	989
Canning	13.8	1587	14.0	1601	10.9	1248	11.1	1272	9.7	1108	9.9	1135

2.1 Grass and Head Lakes on STP - STP effluent = 0.2 mg/L
2.2 2.1; STP at 0.3 mg/L
2.3 North side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
2.4 2.1; STP at 0.3 mg/L
2.5 Both sides of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
2.6 2.3; STP at 0.3 mg/L

Table 11 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (µg/L) and export of phosphorus to next lake downstream (kg).

Scenario 5 - STP discharges to North Kashagawigamog Lake, no phosphorus retention by septic fields, resorts at existing levels

Scenario	5.1		5.2		5.3		5.4		5.5		5.6	
TP	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg
Kennibik, Art, Drag, Head and Soyers Lakes stay as is.												
Grass	10.4	685	10.4	685	10.4	685	10.4	685	10.4	685	10.4	685
N. Kashagawigamog	16.8	1407	17.1	1434	11.6	977	12.1	1018	9.6	802	10.1	847
S. Kashagawigamog	12.4	1360	12.5	1378	9.7	1071	10.0	1098	8.7	953	8.9	983
Canning	12.6	1442	12.7	1457	10.5	1203	10.7	1225	9.6	1105	9.9	1130

5.1 All vacant lots developed, Grass and Head Lakes development to STP - STP at 0.2 mg/L
5.2 5.1; STP at 0.3 mg/L
5.3 5.1 plus north side of North Kashagawigamog to STP - STP effluent = 0.2 mg/L
5.4 5.3; STP at 0.3 mg/L
5.5 5.1 plus both sides of North Kashagawigamog to STP - STP effluent = 0.2 mg/L
5.6 5.1; STP at 0.3 mg/L

Table 12 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (µg/L) and export of phosphorus to next lake downstream (kg).

Scenario 6 - STP discharges to North Kashagawigamog Lake, no phosphorus retention by septic fields, resorts expand

Scenario	6.1		6.2		6.3		6.4		6.5		6.6	
TP	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg
Kennibik, Art, Drag, Head and Soyers Lakes - no change.												
Grass	10.4	685	10.4	685	10.4	685	10.4	685	10.4	685	10.4	685
N. Kashagawigamog	19.9	1671	20.2	1698	12.7	1065	13.2	1111	9.7	814	10.3	866
S. Kashagawigamog	14.0	1537	14.2	1555	10.3	1130	10.6	1161	8.7	961	9.1	996
Canning	13.9	1588	14.0	1603	10.9	1251	11.1	1277	9.7	1112	10.0	1141

6.1 Grass and Head Lakes on STP - STP at 0.2 mg/L
6.2 6.1; STP at 0.3 mg/L
6.3 6.1 plus north side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
6.4 6.3; STP at 0.3 mg/L
6.5 6.1 plus both sides of North Kashagawigamog to STP - STP effluent = 0.2 mg/L
6.6 6.5; STP at 0.3 mg/L

Table 13 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (μg/L) and export of phosphorus to next lake downstream (kg).

Scenario 3 - STP discharges to Grass Lake, 80% phosphorus retention in septic fields, resorts at existing levels (x 0.2 to account for retention unless connected to STP).

Scenario	3.1		3.2		3.3		3.4		3.5		3.6		3.7		3.8	
TP	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg
Kennibik	4.21	12.6	4.24	12.7	4.24	12.7	--	--	--	--	--	--	--	--	--	--
Art	6.93	25.4	7.1	25.9	7.1	25.9	--	--	--	--	--	--	--	--	--	--
Drag	5.4	215	5.6	222	5.6	222	--	--	--	--	--	--	--	--	--	--
Head	9.9	648	10.5	685	9.5	623	--	--	--	--	--	--	--	--	--	
Grass	10.8	713	11.6	760	10.2	672	10.8	708	10.7	707	11.5	760	10.9	7.8	11.8	777
N Kashagawigamog	10.0	843	10.7	894	9.9	831	10.2	857	9.6	808	10.1	846	8.8	735	9.3	778
Soyers	6.0	117	6.1	118	6.1	118	--	--	--	--	--	--	--	--	--	--
S Kashagawigamog	7.4	810	7.7	847	7.3	804	7.5	822	7.2	789	7.4	814	6.7	740	7.0	769
Canning	7.0	805	7.3	839	7.0	803	7.1	818	6.9	791	7.1	812	6.6	750	6.8	774

3.1 Most recent development figures, C. Hodson, Haliburton Planner, pers. comm.
3.2 3.1 plus all vacant lots developed to maintain existing ratio of permanent to seasonal
3.3 3.2 plus Grass and Head Lakes development on STP - STP effluent = 0.2 mg/L
3.4 3.3; STP at 0.3 mg/L
3.5 3.3 plus north side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
3.6 3.5; STP at 0.3 mg/L
3.7 3.3; both sides of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
3.8 3.3; STP at 0.3 mg/L

Table 14 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (μg/L) and export of phosphorus to next lake downstream (kg).

Scenario 4 - STP discharges to Grass Lake, 80% phosphorus retention in septic fields, resorts expand (x 0.2 to account for retention, unless connected to STP).

Scenario	4.1		4.2		4.3		4.4		4.5		4.6	
TP	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg
Kennibik, Art, Drag, Head and Soyers Lakes show no changes from Scenario 3.												
Grass	10.2	672	10.8	708	10.9	719	11.8	778	11.2	735	12.2	803
N. Kashagawigamog	10.5	883	10.8	909	9.4	789	9.9	831	8.9	748	9.5	796
S. Kashagawigamog	7.6	839	7.8	857	7.1	776	7.3	804	6.8	748	7.1	781
Canning	7.3	832	7.4	847	6.8	780	7.0	803	6.6	757	6.8	784

4.1 Grass and Head Lakes on STP - STP effluent = 0.2 mg/L
4.2 4.1; STP at 0.3 mg/L
4.3 North side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
4.4 4.3; STP at 0.3 mg/L
4.5 Both sides of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
4.6 4.5; STP at 0.3 mg/L

Table 15 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (μg/L) and export of phosphorus to next lake downstream (kg).

Scenario 7 - STP discharges to North Kashagawigamog Lake, 80% phosphorus retention by septic fields, resorts at existing levels

Scenario	7.1		7.2		7.3		7.4		7.5		7.6	
TP	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg	μg/L	kg
Kennibik, Art, Drag, Head and Soyers Lakes stay as is.												
Grass	9.1	601	9.1	601	9.1	601	9.1	601	9.1	601	9.1	601
N. Kashagawigamog	9.9	835	10.3	862	9.7	813	10.2	854	8.8	742	9.4	787
S. Kashagawigamog	7.3	807	7.5	825	7.2	792	7.5	820	6.8	744	7.1	775
Canning	7.0	806	7.2	821	6.9	793	7.1	817	6.6	754	6.8	779

7.1 Grass and Head Lakes on STP - STP at 0.2 mg/L
7.2 7.1; STP at 0.3 mg/L
7.3 7.1 plus north side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
7.4 7.3; STP at 0.3 mg/L
7.5 7.1 plus both sides of North Kashagawigamog to STP - STP effluent = 0.2 mg/L
7.6 7.5; STP at 0.3 mg/L

Table 16 Response of lakes to proposed expansion of Haliburton STP. Values given are total phosphorus concentration in each lake (µg/L) and export of phosphorus to next lake downstream (kg).

Scenario 8 - STP discharges to North Kashagawigamog Lake, 80% phosphorus retention by septic fields, resorts expand

Scenario	8.1		8.2		8.3		8.4		8.5		8.6	
TP	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg	µg/L	kg
Kennibik, Art, Drag, Head and Soyers Lakes stay as is.												
Grass	9.1	601	9.1	601	9.1	601	9.1	601	9.1	601	9.1	601
N. Kashagawigamog	10.6	887	10.9	914	9.5	795	10.0	840	9.0	754	9.6	807
S. Kashagawigamog	7.7	842	7.8	860	7.1	780	7.4	810	6.8	753	7.2	788
Canning	7.3	835	7.4	850	6.8	783	7.1	808	6.6	761	6.9	790

8.1 Grass and Head Lakes on STP - STP at 0.2 mg/L
8.2 8.1; STP at 0.3 mg/L
8.3 8.1 plus north side of North Kashagawigamog on STP - STP effluent = 0.2 mg/L
8.4 8.3; STP at 0.3 mg/L
8.5 8.1 plus both sides of North Kashagawigamog to STP - STP effluent = 0.2 mg/L
8.6 8.5; STP at 0.3 mg/L