Cariboo Regional District

building communities together

Photo by: R. Brundrige

Shoreland Management Policy 2004

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1.0 Introduction

In 1983, the Cariboo Regional District (CRD) established policy with regard to rezoning and possible subsequent subdivision of lakefront properties. It was recognized that lake shoreland is desired for human habitation, yet that lake water quality and wildlife habitat are important resources. The basis for the policy was the Management Strategy for Lake Shoreland Development (Urban Systems Ltd., 1983), and it was believed that development could occur, with the impact mitigated by management policy pertaining to septic system design.

The development of lakeshore properties in British Columbia and North America has expanded rapidly in the last decade. This trend will likely continue due to "baby boomers" continuing to purchase recreational property, as well as an increasing number of retirees in the population. We have seen a trend of increased development and of seasonal to full time occupancy of lakeshore properties. For example, in 1970 Chimney Lake had very few permanent residences and approximately 45 seasonal residences. By 1999, there were 62 permanent and 31 seasonal residences (Hart, 2000).

This activity has resulted in numerous on-going issues with regard to deterioration of lake quality values and uncertainty among local government representatives with regard to decision making. The very values that have attracted lakeshore residents are now in danger of being compromised in the Cariboo by management policies that are too limited in scope to accommodate the variety of users of the lake resource. Many Cariboo lakes are renowned for their fishing, and tourism is an important contributor to the local economy. It is in this context that the CRD decided to review its lakeshore policies. Lakeshore Environmental Ltd. was contracted to conduct this review (Lakeshore Environmental Ltd., 2003).

This review and development of policy concerning lakeshore management involved a review of scientific data and literature and some terminology may not be familiar to some readers, hence a glossary has been included in Appendix I.

After a comprehensive review of lake management planning in selected North American jurisdictions and the problems faced by these jurisdictions in trying to protect the ecological and economic value of their lakes, Lakeshore Environmental Ltd. concluded that a Regional District's Lakeshore Management Policy must be:

- Soundly based on the scientific principles governing lake ecology
- Easy to understand by the public, lakeshore residents, planners, developers, and contractors
- Straight forward to apply both administratively and legally
- Cost effective in terms of data required to put it into effect e.g. water quality sensitivity factors, soil testing requirements, habitat sensitivity factors

It is with these criteria in mind that the following recommendations were developed for the Cariboo Regional District. The view of the public through open houses and questionnaires was also taken into consideration when formulating the recommendations.

1) It was recommended that the Cariboo Regional District ensure that the following management strategies be implemented as a minimum standard for all lakes in the District:

   i. Retain the utilization of the water quality sensitivity ratings from the Lake Evaluation Summaries to determine setbacks for sewage disposal.

   ii. Provide the option to developers to hire a qualified consultant, as per Section 3.5, to collect data and develop a water quality sensitivity rating. The CRD should request that these be reviewed by the Ministry of Environment (formerly the Ministry of Water, Land and Air Protection).

   iii. Ensure that buffer leave strips are required on all new developments within 150m of a low sensitivity lake and 250m of a high sensitivity lake[1] to protect water quality and shoreline habitat. A buffer strip of 15 meters is the recommended width but variation could be allowed down to 5 meters in selected areas. There would be allowance for clearing of up to 25% of the strip to allow for a view, lake access, and the accommodation of the existing 7.5 meter building setbacks. Distances of greater than 15 meters could be required if provincial or federal agencies have identified sensitive habitat that would require a greater setback e.g. shoal spawning areas on Quesnel Lake.

   iv. Continue the Lakeshore Residential zoning minimum parcel size of 0.4 ha (1 acre) and establish a minimum water frontage of 150 ft. (45.7m) for all lakeshore property within the Regional District. This will provide a mechanism to address the issue of overcrowding and help preserve the natural environmental values people attach to the lakeshore living experience. (Note: subsequent to the policy review, in 2007 the CRD established a Lakeshore Residential 2 zoning with a minimum site area of 0.8 ha and a water frontage of 45.5m).

2) It was also recommended that the Cariboo Regional District consider implementation of the following:

   i. Consider a process to allow for individual lake management plans to be undertaken for selected lakes in the District that may be subject to intense development pressure or have a high degree of public or provincial agency concern. The Regional District should consult with the Ministry of Environment, Land & Water BC Inc., and the Department of Fisheries & Oceans on such a process.

   Lakes requiring individual lake management plans will be a judgement call by the Regional District and would be the responsibility of the developer. The following criteria could be used to make this judgement:

[1] This is the same distance requirement that was in the 1983 Management Strategy for Lake Shoreland Development (Urban Systems Ltd., 1983)

- Lakes with known water quality problems associated with development as identified in Section 9.0 of the Lakeshore Management Policy Review (Lakeshore Environmental Ltd., 2003)
- Size of development i.e. large developments would likely trigger this, as opposed to the subdivision of one or a few lots, which would not
- Lakes identified by provincial or federal agencies as having potential environmental concerns
- Lakes identified by the public through public hearings, Official Community Plan development, or by Regional District Directors and their Advisory Planning Committees

ii. The concept of a cluster configuration for development, as opposed to linear, should be considered as part of individual lake management plans (see policies 1,2, 3 – S. 5.3.4 of the 1983 Management Strategy) for areas with high development pressure. This could be accomplished by density bonusing pursuant to Section 904 of the Land Covenant Act where environmentally sensitive areas can be conserved. In turn, local government can permit smaller lots away from the sensitive areas (Brundrige, pers.comm.).

3) It was recommended that the Cariboo Regional District consider the development of an education program to be available to developers and all existing lakeshore owners and users. The purpose of this education program is to assist these stakeholders in:

i. Understanding the value of retaining and planting buffer leave strips to protect lake water quality.
ii. Ensuring existing sewage systems are properly operated and maintained.
iii. Developing subdivisions and lots in a way that minimizes impact on the environment and,
iv. Understanding the economic value inherent in protecting the ecological integrity of Cariboo lakes.

The recommendations from the policy review in 2003 resulted in the CRD adopting a new Shoreland Management Policy in 2004 as found in Section 2.0, following.

Subsequent sections of this document provide supporting information to the new policy. Section 3.0 describes the basis for the water quality sensitivity rating and Section 4.0 gives the rationale for requirements for riparian zone protection. Appendix II contains all the Lake Sensitivity Ratings and Lake Evaluation Summaries available for Cariboo lakes as well as a summary table of the Lake Sensitivity Ratings. Detailed procedures for data collection for the development of Lake Sensitivity Ratings can be found in Appendix III.

2.0 Shoreland Management Policy

2.1 Objectives

The policy statements in this document have been formulated to achieve the following objectives:

1. *To preserve the water quality of lakes and watercourses within the Cariboo Regional District.*
2. *To manage shoreland development in such a manner as to preserve the integrity and capability of existing aquatic and shoreland environmental resources for wildlife habitat (movement and feeding corridor for mammals, waterfowl nesting, spawning grounds, etc.).*
3. *To integrate shoreland developments with their natural surroundings, thereby preserving the aesthetic quality of the natural setting.*
4. *To protect the shoreland from erosion and degradation.*
5. *To provide shoreland access to the general public where appropriate and to reduce conflict with adjacent landowners.*
6. *To determine suitable areas for shoreland development.*

The Cariboo Regional District will strive to meet these objectives through the use of Onsite Effluent Disposal Guidelines, Riparian Buffer Zones Guidelines, Development Guidelines and the ability to create Individual Shoreland Management Plans.

For the purposes of this policy "shoreland" shall be defined as real property (surveyed property or crown lease/ license area) within 150 metres of a lake with low water quality sensitivity, 200 metres of a lake with moderate water quality sensitivity, 250 metres of a lake with high water quality sensitivity, or 100 metres of a watercourse, except when extenuating circumstances exist, in which case, these distances may be increased or decreased, at the discretion of the Cariboo Regional District Board. The definitions of lake, watercourse, and water quality sensitivity are outlined in **Schedule A**.

To aid in determining the existence and location of unique attributes of lakes and watercourses within the Cariboo Regional District, staff will refer to material submitted by the applicant through the application process, in-house mapping as well as material from the provincial government, primarily the Ministry of Environment. Reference materials may include but will not be limited to materials available to the public such as; National Topographic Series (NTS) maps, British Columbia Geographic System (BCGS) maps, Canadian Land Inventory (CLI) information, Critical Fish Habitat maps, Lake Sensitivity Classification information and Environmental Resource Information noted in Appendix III of the 1983 Management Strategy for Lake Shoreland Development.

If the definition of a shoreland property is in dispute or the applicant believes that the proposed development will meet or exceed the objectives noted above without compliance with the policy, the applicant may provide evidence to the Cariboo Regional District Board from an accredited professional in the province of British Columbia i.e., BC Land Surveyor, Registered Onsite Wastewater Practitioner, Professional Agrologist, Professional Forester, Professional Biologist or Professional Engineer for consideration. The Cariboo Regional District Board may allow for exceptions and/or exemptions from the policy, subsequent to consideration of the evidence provided.

All persons involved with the subdivision or development of shoreland property are encouraged to adhere to the policies and guidelines endorsed by the Cariboo Regional District Board.

All persons applying to rezone shoreland property will be required to adhere to the policies as referenced in this document and the Cariboo Regional District will request adherence to this policy during the subdivision referral process.

2.2 Onsite Effluent Disposal Guidelines

Onsite Effluent Disposal Guidelines are intended to contribute towards objective #1 by reducing the amount of nutrient loading, specifically phosphorus loading, from septic systems into any nearby lake or watercourse.

Adoption of a rezoning bylaw for shoreland property will be subject to the applicant offering to enter and entering into a restrictive covenant on the title of the subject property, in accordance with Section 219 of the *Land Title Act*, in favour of the Cariboo Regional District (**Appendix B**) to ensure compliance with the criteria of **Schedule C** for on-site septic systems. All costs associated with the registration of the covenant to be borne by the applicant. In the case of Crown Land, Land and Water, BC Inc. must indicate their commitment to the registration of a covenant when raising title, or offer a lease and/or license over Crown Land.

The Cariboo Regional District will request that the Approving Officer with the Ministry of Transportation require all applications for subdivision of shoreland property be subject to the restrictive covenant as noted above. All costs associated with the registration of the covenant to be borne by the applicant.

As proof of compliance the applicant must submit to the Cariboo Regional District office:

a) a completed *Report Of Soil Investigation Information* signed by an accredited professional in the province of British Columbia i.e., BC Land Surveyor, Professional Agrologist, Professional Forester, Professional Biologist, Professional Engineer or registered practitioner certified in accordance with the provincial regulation under the *Health Act* (i.e. Sewerage System Regulation) indicating that they have determined the soil type(s) on the subject property and confirmed the required "vertical unsaturated distances" at representative locations on the property in accordance with **Schedule C** of this policy; and

b) a map of the property indicating the location of the percolation test pits and the test holes for assessing the "vertical unsaturated distance", and including the percolation rate data and the "vertical unsaturated distance" data.

   The professional conducting the tests will determine the number of soil observation pits and the method of test necessary to obtain sufficient data for determining soil type and percolation rate for each proposed lot. The percolation results may be averaged over the entire lot.

If it is shown that a septic system cannot be accommodated on the property (i.e. percolation rate exceeds 30 minutes) the applicant may choose to amend Section 1 (b) of the covenant to one or both of the following provided they submit written documentation signed by a professional in the province of British

Columbia verifying that the specified system(s) can be accommodated on the subject property :

i) *a disposal system designed on a site specific basis by a qualified professional engineer; or*
ii) *an aerobic treatment unit, which provides oxygenation of sewage and waste water for secondary treatment.*

Exceptions

1. Where the applicant can provide evidence that an existing septic system was approved by the authority administrating the *Health Act* for a permitted use under the relevant Cariboo Regional District bylaw prior to the rezoning application, the septic system may be considered non-conforming with current regulations, but no upgrades will be necessary. However, the covenant noted above must still be registered on title and if a new septic system is constructed and/or the use of the building(s) being serviced by the septic system is changed to a significantly higher level of use the septic system must be made to conform to the specifications of the covenant.

2. All or part of an application may be exempt from compliance with the Onsite Effluent Disposal Guidelines if the rezoning represents:
   i) a consolidation of two or more parcels to create less parcels than previously existed, or
   ii) a minor boundary adjustment, provided that no more lots could be created than existed at the time of application, or
   iii) the property has access to and the applicant provides a letter of intent that they will connect to a community sewer system with a treatment facility removed from the area of concern (i.e. greater then 100m from a watercourse, 150m, 200m or 250m from the natural boundary of a lake).

2.3 Riparian Buffer Zone Guidelines

The Riparian Buffer Zone Guidelines is intended to contribute towards objective #1, 2, 3 and 4. The Cariboo Regional District – Lakeshore Management Policy Review *concluded that riparian leave strips or buffer zones with intact riparian vegetation are important for the protection of water quality, fish and wildlife habitat, maintaining shore stability as well as for reducing the visual impact of development.*

- *The maintenance of a riparian buffer allows riparian vegetation to slow runoff water and subsurface drainage, trapping and settling sediments and causes more infiltration to ground where nutrients can be taken up by plants. This action benefits the overall water quality by*

reducing the amount of sediment and contaminants (effluent) that reach the lake or watercourse.

- *Riparian areas provide valuable habitat as food and cover, as well as travel corridors for numerous wildlife species.*
- *Riparian buffer strips also help maintain shore stability, thereby preventing erosion and loss of sediment and soils to the lake or watercourse.*
- *Retention of riparian areas has the added benefit of reducing the visual impact development.*

It has been documented that riparian buffers for watercourses are important for shade, woody debris and organic input (Bernthal, 1997).

When deemed appropriate, the Cariboo Regional District will incorporate, within its rural land use bylaws, zoning bylaws and/or Official Community Plans, the requirement of a minimum 15 metre riparian buffer zone from the natural boundary of a lake and/or from the natural boundary of a watercourse.

The buffer zone is to remain largely in an undisturbed state with a maximum of 25% vegetation removal at the time of rezoning. The 25% removal may consist of one or more of the following:

- Clearing for a building as approved by zoning
- Clearing for a walkway and beach access
- Clearing for a yard
- Thinning of trees and underbrush

An application for rezoning will require the applicant to register a restrictive covenant on the title of the subject property, in accordance with 219 of the *Land Title Act*, in favour of the Cariboo Regional District, as shown on **Schedule D,** to ensure the above. The width of the buffer zone specified in the covenant may be increased at the discretion of the Regional District Board, due to special habitat considerations.

During the rezoning application process the applicant must provide this office with photographs of the riparian vegetation for each proposed lot for future reference.
The Cariboo Regional District will encourage property owners to submit photographs of clearing and/or thinning to this office to document compliance.

If the applicant can demonstrate that they will enter into a covenant with a provincial agency (i.e. Ministry of Transportation or Land & Water, BC Inc.) for riparian protection of equal or greater restriction then the applicant may be exempt from entering into a covenant with the Cariboo Regional District.

The Cariboo Regional District will request that the Approving Officer with the Ministry of Transportation require all applications for subdivision of shoreland property be subject to a riparian covenant as noted above. All costs associated with the registration of the covenant to be borne by the applicant.

2.4 Development Guidelines

Development Guidelines are intended to contribute towards objectives 1 to 5 of the noted objectives.

The Cariboo Regional District will endeavour to create educational material for Development Guidelines of shoreland property to meet the objectives of this policy. The Cariboo Regional District will encourage the implementation of the Development Guidelines on all shoreland properties and may consider conditional implementation of the guidelines through the rezoning process and development permit process within Official Community Plan areas and Individual Shoreland Management Plan areas.

2.5 Individual Shoreland Management Plans

Development Guidelines are intended to contribute towards all the noted objectives, most notably objectives 5 & 6.

Where the Cariboo Regional District Board believes that a shoreland area warrants special consideration and / or protection to meet the objectives of this policy the Cariboo Regional District Board may endorse an Individual Shoreland Management Plan. The Individual Shoreland Management Plan may be implemented by resolution or through an Official Community Plan, either as a stand-alone document or a secondary document within an Official Community Plan that covers a larger area.

2.6 Schedule A – Lake Sensitivity and Watercourse Sensitivity Ratings

For the purposes of the Shoreland Management Policy the following definitions shall apply:

"Lake" means body of water, typically freshwater, which can be formed by glaciers, river drainage, surface water runoff, or ground water seepage. Lakes can range in size from a small pond to a large reservoir, many miles long.

"Pond" means a body of water encircled by vegetation, and generally shallow enough for sunlight to reach the bottom, i.e. a small lake.

"Watercourse" means any natural or man-made depression with well-defined banks and a bed 0.6 metre or more below the surrounding land serving to give direction to a current of water at least six months of the year or having a drainage area of 2 square kilometers or more upstream of the point of consideration, or as required by a designated official of the Ministry of Water, Land and Air Protection.

"Water Quality Sensitivity" means a rating determined as per the methodology referenced in this document as an indication of the capability of a waterbody to assimilate additional nutrients (principally phosphorus) without a detrimental effect of the water quality of that waterbody.

Lake Sensitivity Rating

Appendix II – Lake Evaluation Summaries of the *Management Strategy for Lake Shoreland Development* will be used to determine the water quality sensitivity rating of a lake. This appendix will be updated periodically as new ratings are made available.

No data available:

If no data is available the water quality sensitivity rating will be considered "High" for purposes of this policy or the applicant may hire a consultant to determine the water quality sensitivity rating of the lake.

The consultant employed to determine the water quality sensitivity rating of the lake must be qualified in the fields of limnology and water quality monitoring and must use the methodology outlined in Section 3.5 and Appendix III of this document and in Section 5.2 and Appendices Section 2.0 of the *Management Strategy for Lake Shoreland Development*, prepared by Urban Systems Ltd. (May 1983). The applicant must provide all data collected, methodology used and credentials of the consultant to this office and consent to relinquishing all ownership claims to the data. The information submitted will be referred to the appropriate Provincial Ministry, currently the Ministry of Environment, for review to ensure consistency. Once the classification has been accepted to be valid by this office, the information will be retained and the new classification incorporated into Appendix II noted above for future reference.

Watercourse Sensitivity Rating

Any watercourse that flows into a lake will be given the water quality sensitivity rating of that lake for the purposes of this policy.

Any watercourse that does not flow into a lake will be given a "High" water quality sensitivity rating for the purposes of this policy. This classification is in recognition that a watercourse that does not flow into a lake will either be a river or tributary (including all orders of streams) of a river located within or adjacent to the Cariboo Regional District. Some of the river systems within or adjacent to the Cariboo Regional District include the following; Baezaeko River, Bella Coola River, Bowron River, Coglistiko River, Clusko River, Canim River, Cariboo River, Chelablie River, Chezko River, Chilanko River, Chilcotin River, Chilko River, Cottonwood River, Dean River, Entiako River, Euchiniko River, Fraser River, Homathko River, Horsefly River, Iltasyuko River, Klinaklini River, Kubhya River, Little River, Little Swift River, Matthew River, Nazko River, Quesnel River, Roaring River, San Jose River, Snaking River, Taseko River, Tchaikazan River, West Road (Blackwater) River, Willow River, Wolverine River, Yalakon River, etc. These rivers support a wide variety of aquatic life that may be adversely affected by effluent contamination. The tributaries and headwaters of these river systems are generally used as spawning grounds and/or nurseries for juvenile fish.

If the applicant does not believe that a watercourse warrants the "High" sensitivity rating, the applicant may provide scientific evidence for the consideration of the Cariboo Regional District Board as noted in the main policy document.

2.7 Schedule B – Restrictive Covenant – Sewage Disposal

TERMS OF INSTRUMENT - PART 2

W H E R E A S:

A. The Grantor is the registered owner in fee simple of:

PID:

(hereinafter called the "Land")

B. The Grantee is the Cariboo Regional District.

C. The Grantor has applied to the Grantee to rezone the Land, as detailed in the Cariboo Regional District Zoning Amendment Bylaw No. , , from to (hereinafter called the "Bylaw").

Or

C. The Grantor has applied to subdivide Land within the Cariboo Regional District boundaries, under section , of the Act.

D. The Land is located within metres of which for the purposes of this covenant the water quality sensitivity has been identified as a in the Cariboo Regional District Shoreland Management Policy.

E. The Grantee has accepted the Grantor's offer to register, at the expense of the Grantor, this agreement as a charge on the title to the Land in the Land Title Office pursuant to Section 219 of the *Land Title Act* as a condition precedent to final adoption of the Bylaw.

Or

E. The Grantee has accepted the Grantor's offer to register, at the expense of the Grantor, this agreement as a charge on the title to the Land in the Land Title Office pursuant to Section 219 of the *Land Title Act* as a condition of final subdivision approval.

NOW THEREFORE, in consideration of the premises and the covenants herein contained and in consideration of the sum of One Dollar ($1.00) now paid by each party to the other and for other valuable consideration (the receipt and sufficiency of which is hereby acknowledged by the parties), the parties hereto covenant and agree with the other as follows:

1. The Grantor, for himself and for his successors and assigns, hereby covenants, promises and agrees, pursuant to Section 219 of the *Land Title Act*, it being the intention of the Grantor that the covenants contained herein shall be annexed to the Land that no building constructed or placed upon the Land, following the date of registration of this covenant in the Land Title Office, shall be occupied until such time as either:
   (a) a sewage lagoon; or

   (d) a septic system, having a minimum metres vertical unsaturated distance, a minimum 35 metre horizontal setback from the natural boundary of the lake or the natural boundary of a watercourse, with a minimum soil depth of 1.6 metre measured form the base of field or mound to an impermeable zone such as clay or bedrock *(Note: soil depth min. not required for Level 1).*

   approved for use by the Authority administering the *Health Act* or the *Waste Management Act* and capable of operating, has been located on the Land.

2. The Grantee will, forthwith upon execution hereof by the Grantee and the Grantor and at the Grantor's expense, do or cause to be done, all acts or things necessary to ensure that this document is registered as a charge on the Land in the Land Title Office.

3. Notwithstanding anything to the contrary contained herein, all the covenants herein shall become null and void and the Grantor shall be entitled to the cancellation of this agreement as a charge on the Land unless, within 120 days after its registration, the Land has been rezoned as detailed in the Bylaw.

4. The Grantee may at any time and without the consent of the Grantor cancel or cause to be cancelled this agreement as a charge on the Land or any portion or portions thereof in the Land Title Office and upon such cancellation this agreement shall be void and of no further force and effect as against the Land or any portion or portions thereof so released.

5. The Grantor and the Grantee agree that the enforcement of this agreement shall be entirely within the discretion of the Grantee and that the execution and registration of this agreement against the title to the Land shall not be interpreted as creating any duty on the part of the Grantee to the Grantor or to any other person to enforce any provision or the breach of any provision of this agreement.

6. Nothing contained or implied herein shall prejudice or affect the rights and powers of the Grantee in the exercise of its functions under any public or private statutes, bylaws, orders and regulations, all of which may be fully and effectively exercised in relation to the Land as if this agreement had not been executed and delivered by the Grantor.

7. The Grantor hereby releases and forever discharges the Grantee of and from any and all claims, causes of action, suits, demands, expenses, costs and legal fees whatsoever which the Grantor can or may have against the said Grantee for any loss or damage or injury that the

Grantor may sustain or suffer arising out of this agreement or the use of the Land as a result of this agreement.

8. The Grantor covenants and agrees to indemnify and save harmless the Grantee from any and all claims, causes of action, suits, demands, expenses, costs and legal fees whatsoever that anyone might have as owner, occupier or user of the Land, or by a person who has an interest in or comes onto the Land, or by anyone who suffers loss of life or injury to his person or property, that arises out of this agreement or the use of the Land as a result of this agreement.

9. It is mutually understood, acknowledged and agreed by the parties hereto that the Grantee has made no representations, covenants, warranties, guarantees, promises or agreements (oral or otherwise) with the Grantor other than those contained in this agreement.

10. The Grantor agrees to execute all other documents and provide all other assurances necessary to give effect to the covenants contained in this agreement.

11. The Grantor shall pay the legal fees of the Grantee in connection with the preparation and registration of this agreement.

12. The Grantor covenants and agrees for itself, its heirs, executors, successors and assigns, that it will at all times perform and observe the requirements and restrictions hereinbefore set out and they shall be binding upon the Grantor as personal covenants only during the period of its respective ownership of any interest in the Land.

13. The restrictions and covenants herein contained shall be covenants running with the Land and shall be perpetual, and shall continue to bind all of the Lands when subdivided, and shall be registered in the Land Title Office pursuant to Section 219 of the *Land Title Act* as covenants in favour of the Grantee against the Land.

14. This agreement shall ensure to the benefit of the Grantee and shall be binding upon the parties hereto and their respective heirs, executors, successors and assigns.

15. Wherever the expressions "Grantor" and "Grantee" are used herein, they shall be construed as meaning the plural, feminine or body corporate or politic where the context or the parties so require.

IN WITNESS WHEREOF the parties hereto hereby acknowledge that this Agreement has been duly executed and delivered by the parties executing Form C and D (pages 1 and 2) attached hereto.

2.8 Schedule C – Information Required for On-Site Effluent Disposal Guidelines

The following information will be used to determine the required Vertical Unsaturated Distance for a septic system under the Onsite Effluent Disposal Guidelines of the Shoreland Management Policy.

The "level" of phosphorus to be removed by a septic system is determined on the basis of proposed development density and water quality sensitivity, as follows.

DEVELOPMENT DENSITY	LOW SENSITIVITY	MODERATE SENSITIVITY	HIGH SENSITIVITY
Very Low (2 ha lots)	Level 1	Level 1	Level 2
Low Density (0.4 ha)	Level 1	Level 1	Level 3
Medium Density (0.2 ha)	Level 1	Level 2	Level 4
High Density (0.07 ha)	Level 2	Level 3	Level 4

Note: For resort, multi-family, or commercial land uses, the development density shall be considered High.

Soil Group Descriptions

Soil Group A - Generally rapidly drained soil types comprising coarse uniform sands and gravel. Percolation Rate: 2 to 5 minutes/inch.

Soil Group B - Moderately drained soil types comprising fine and medium sands and sands with some silt. Percolation Rate: 5 to 15 minutes/inch.

Soil Group C - Slowly drained soil types comprising silts, silty sand, silt with some clay and loams. Percolation Rate: 15 to 30 minutes/inch.

The required vertical unsaturated distance is expressed below as a function of the level of phosphorus to be removed and site soil types.

Level of Phosphorus to be Removed	(Minimum) VERTICAL UNSATURATED DISTANCE		
	SOIL A	SOIL B	SOIL C
Level 1	1.2 m	1.2 m	1.2 m
Level 2	9 m	3 m	1.6 m
Level 3	15 m	5 m	2 m
Level 4	septic disposal not recommended	8 m	3.5 m

Vertical Unsaturated Distance is the vertical soil distance from the base of the disposal field or mound to the groundwater table. When no groundwater table exists, the vertical unsaturated distance shall be

measured as the elevation difference from the base of field or mound to the highwater elevation of the lake or the natural boundary of a watercourse.

The Vertical Unsaturated Distance criteria will be incorporated into the required restrictive covenant (Schedule B) as noted in the Onsite Effluent Disposal Guidelines along with the following criteria:

1. Minimum setback (horizontal) from the highwater mark of a lake or the natural boundary of a watercourse shall be 35 metres.

2. A minimum soil depth of 1.6 m measured from the base of field or mound to an impermeable zone such as clay or bedrock shall be provided for systems designed to meet Level 2, 3 or 4 objectives.

3. If the information provided indicates that a septic disposal system is not recommended or cannot be accommodated on-site then the applicant may amend Section 1 (b) of the covenant (Schedule B) to one or more of the following:
   i) *a disposal system designed on a site specific basis by a qualified professional engineer; or*
   ii) *an aerobic treatment unit, which provides oxygenation of sewage and waste water for secondary treatment.*

   as noted in the Onsite Effluent Disposal Policy.

4. Satisfying the criteria of this policy does not circumvent the landowner from the responsibility to adhere to all legislation and/or decisions of any authority having jurisdiction, which may apply to the land, notably the agency given authority to administer the *Health Act* and *Regulations*.

2.9 Schedule D – Restrictive Covenant – Buffer Strips

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Or

C. The Grantor has applied to subdivide Land within the Cariboo Regional District boundaries, under section , of the Act.

D. The Land is located within metres of which for the purposes of this covenant the water quality sensitivity has been identified as in the Cariboo Regional District Shoreland Management Policy.

E. The Grantee has accepted the Grantor's offer to register, at the expense of the Grantor, this agreement as a charge on the title to the Land in the Land Title Office pursuant to Section 219 of the *Land Title Act* as a condition precedent to final adoption of the Bylaw.

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E. The Grantee has accepted the Grantor's offer to register, at the expense of the Grantor, this agreement as a charge on the title to the Land in the Land Title Office pursuant to Section 219 of the *Land Title Act* as a condition of final subdivision approval.

NOW THEREFORE, in consideration of the premises and the covenants herein contained and in consideration of the sum of One Dollar ($1.00) now paid by each party to the other and for other valuable consideration (the receipt and sufficiency of which is hereby acknowledged by the parties), the parties hereto covenant and agree with the other as follows:

1. The Grantor, for himself and for his successors and assigns, hereby covenants, promises and agrees, pursuant to Section 219 of the *Land Title Act*, it being the intention of the Grantor that the covenants contained herein shall be annexed to the Land that hereafter, no more than 25% of native vegetation from the date of registration of this covenant within a horizontal distance of 15 metres from the natural boundary of a lake and 15 metres from the natural boundary of a watercourse, shall be disturbed, removed or degraded, nor shall any development occur which will preclude growth of native vegetation.

2. The Grantor may apply to vary the requirements of Section 1 by submitting a report to the Cariboo Regional District Board from an accredited professional in the province of British Columbia i.e., BC Land Surveyor, Professional Agrologist, Professional Forester, Professional Biologist or Professional Engineer for consideration. The report must demonstrate that the proposal meets or exceeds the objectives noted within the Cariboo

Regional District Shoreland Management Policy. The Cariboo Regional District Board may allow for exceptions by way of resolution, subsequent to consideration of the report.

3. The area required by a Subdivision Approving Officer for future road dedication pursuant to Section 75(1)(c) of the *Land Title Act* will be exempt from the requirements of Section 1.

4. The Grantee will, forthwith upon execution hereof by the Grantee and the Grantor and at the Grantor's expense, do or cause to be done, all acts or things necessary to ensure that this document is registered as a charge on the Land in the Land Title Office.

5. Notwithstanding anything to the contrary contained herein, all the covenants herein shall become null and void and the Grantor shall be entitled to the cancellation of this agreement as a charge on the Land unless, within 120 days after its registration, the Land has been rezoned as detailed in the Bylaw.

6. The Grantee may at any time and without the consent of the Grantor cancel or cause to be cancelled this agreement as a charge on the Land or any portion or portions thereof in the Land Title Office and upon such cancellation this agreement shall be void and of no further force and effect as against the Land or any portion or portions thereof so released.

7. The Grantor and the Grantee agree that the enforcement of this agreement shall be entirely within the discretion of the Grantee and that the execution and registration of this agreement against the title to the Land shall not be interpreted as creating any duty on the part of the Grantee to the Grantor or to any other person to enforce any provision or the breach of any provision of this agreement.

8. Nothing contained or implied herein shall prejudice or affect the rights and powers of the Grantee in the exercise of its functions under any public or private statutes, bylaws, orders and regulations, all of which may be fully and effectively exercised in relation to the Land as if this agreement had not been executed and delivered by the Grantor.

9. The Grantor hereby releases and forever discharges the Grantee of and from any and all claims, causes of action, suits, demands, expenses, costs and legal fees whatsoever which the Grantor can or may have against the said Grantee for any loss or damage or injury that the Grantor may sustain or suffer arising out of this agreement or the use of the Land as a result of this agreement.

10. The Grantor covenants and agrees to indemnify and save harmless the Grantee from any and all claims, causes of action, suits, demands, expenses, costs and legal fees whatsoever that anyone might have as owner, occupier or user of the Land, or by a person who has an interest in or comes onto the Land, or by anyone who suffers loss of life or injury to his person or property, that arises out of this agreement or the use of the Land as a result of this agreement.

11. It is mutually understood, acknowledged and agreed by the parties hereto that the Grantee has made no representations, covenants, warranties, guarantees, promises or agreements (oral or otherwise) with the Grantor other than those contained in this agreement.

12. The Grantor agrees to execute all other documents and provide all other assurances necessary to give effect to the covenants contained in this agreement.

13. The Grantor shall pay the legal fees of the Grantee in connection with the preparation and registration of this agreement.

14. The Grantor covenants and agrees for itself, its heirs, executors, successors and assigns, that it will at all times perform and observe the requirements and restrictions hereinbefore set out and they shall be binding upon the Grantor as personal covenants only during the period of its respective ownership of any interest in the Land.

15. The restrictions and covenants herein contained shall be covenants running with the Land and shall be perpetual, and shall continue to bind all of the Lands when subdivided, and shall be registered in the Land Title Office pursuant to Section 219 of the *Land Title Act* as covenants in favour of the Grantee against the Land.

16. This agreement shall endure to the benefit of the Grantee and shall be binding upon the parties hereto and their respective heirs, executors, successors and assigns.

17. Wherever the expressions "Grantor" and "Grantee" are used herein, they shall be construed as meaning the plural, feminine or body corporate or politic where the context or the parties so require.

IN WITNESS WHEREOF the parties hereto hereby acknowledge that this Agreement has been duly executed and delivered by the parties executing Form C and D (pages 1 and 2) attached hereto.

3.0 Water Quality Evaluation Methodology[2]

This section explains the basis for the protection measures of Sections 2.2 and 2.7.

3.1 Lake Water Quality

A key factor to be taken into consideration in formulation a management strategy for shoreland development is the water quality of the lake. A basic understanding of the natural processes affecting lake water quality is essential before the water quality management strategies presented in Section 2.0 can be fully appreciated.

[2]Sections 3.1, 3.2 and 3.3 are taken from the 1983 Management Strategy for Lake Shoreland Development (Urban Systems Ltd., 1983)

The water quality of a lake is generally expressed in terms of its *trophic state*. The trophic state of a lake is a measure of its productivity. This is indicated by the extent of algae blooms, aquatic plant growth, and the number and size of the fish. There are three terms used to describe the varying trophic states of lakes.

i. *oligotrophic* lakes are less productive lakes and are characterized by clear water and little algae or plant growth. These lakes are considered desirable by society – they are aesthetically pleasing, they are excellent sources of domestic water, and are desirable for most water oriented recreation activities.
ii. *eutrophic* lakes are characterized by heavy algae blooms (giving them a "pea soup" appearance) and extensive areas of shoreline plants. Although eutrophic lakes produce large fish populations, they are susceptible to fish kills because of oxygen depletion in the water. These lakes are considered to have less desirable or poor water quality.
iii. *mesotrophic* lakes are a general class between oligotrophic and eutrophic lakes.

In summary, the trophic state of a lake is determined by the chlorophyll a concentration as illustrated in the following tabulation. The tabulation also illustrates that the three trophic categories each represent a range on an eutrophic scale rather than a specific point.

Computed Chlorophyll a Concentration	Trophic State
0 – 2 mg/m^3	Oligotrophic
2 – 7 mg/m^3	Mesotrophic
7 + mg/m^3	Eutrophic

The basic water quality consideration is eutrophication, which is caused by the enrichment of surface waters with nutrients. Nutrient poor lakes (oligotrophic) become nutrient rich lakes (eutrophic) as nutrient concentrations increase in the lake water. In effect, the lake becomes fertilized in the transition from oligotrophic to eutrophic, and as a result a significant increase in plant and algae growth results. As the nutrient concentrations increase and more plant growth occurs, the following consequences are observed:

- dissolved oxygen concentrations exhibit diurnal cycles of supersaturation and deficit, and the lake bottom becomes deficient in oxygen.
- loss of diversity and stability in plant life, and blue-green algae becomes more competitive and dominant
- blue-green algae blooms cause problems of taste and odour, and eventually will render water undesirable for domestic consumption without treatment. Blue-green algae is also responsible for the muddy taste of fish.
- recreational and aesthetic values are diminished, skin rashes may be experienced after swimming.
- fish populations change from game fish to coarse fish (if coarse fish are present in a lake), largely due to dissolved oxygen concentrations but also due to changes in the food source.
- aquatic plant growth tends to interfere with recreation and other uses.

3.2 Factors Affecting Lake Water Quality

The transition from an oligotrophic to an eutrophic state in a lake is a natural aging process. Without the influence of human activities, the natural transition process may take thousands or millions of years. Nature fertilizes lakes by the transport of sediments and natural organic debris flowing into the lake. Human activities, including agriculture, forestry, settlements and shoreland habitation increase the natural rate of input of nutrients into a lake. As a result, humans are in effect accelerating the natural aging process of lakes.

The preservation of lake water quality can be achieved by management policies aimed at limiting the nutrient enrichment process. Plant growth requires a variety of nutrients, generally broken into two broad categories – macronutrients and micronutrients. Macronutrients include nitrogen, phosphorus and carbon. Micronutrients include all other elements taken up in minute quantities, including iron, manganese and molybdenum. Before plant growth can occur, all these nutrients, particularly the macronutrients, must be present in specific concentration ratios. The absence of one of the required nutrients essentially negates plant growth. In terms of a typical lake in the Cariboo, phosphorus is the limiting nutrient. Management policies for lakes in the Cariboo are therefore directed to limiting the contribution of phosphorus to lakes as a result of human activities.

Watershed Characteristics – Potential Sources of Phosphorus

Although shoreland development and individual on-site sewerage systems are often perceived to be the primary "offender" affecting lake water quality, this is often not the case. It is important to recognize that these systems are only one of several potential sources of phosphorus nutrients. Phosphorus sources may be in the immediate vicinity of the lake or may be removed from the lake but within the contributing watershed. Other potential sources include:

- storm drainage from higher density developments.
- natural runoff
- phosphorus contributions increase as a result of clearing (by clear cut logging or clearing for agriculture)
- agricultural sources – animal wastes and agricultural land runoff are the most probable agriculture related phosphorus sources in the Cariboo. Although the degree of phosphorus contribution from agricultural sources is unpredictable, specific studies of certain lakes in the Cariboo (Williams Lake Study and Dragon Lake Study by the Ministry of Environment) have identified agricultural operations as major nutrient contributors – much higher than contributions from shoreland development even if it were assumed that all septic tank effluent discharged directly into the lake with no phosphorus removal.[3]

[3] In the Williams Lake Study, agriculture was shown to be a much higher nutrient contributor than shoreland development, which is relatively extensive around Williams Lake. It was estimated that only 3% of the total phosphorus loading of Williams Lake could be attributed to shoreland development, even under the worst case assumption that all septic tank effluent discharged directly into the lake with no phosphorus removal. In the Dragon Lake Study, a similar estimate attributed some 13% of total phosphorus loading under the same worst case assumptions to residential development.

In the case of individual on-site sewerage systems serving shoreland developments, the amount of phosphorus entering a lake is highly variable and depends on a number of factors including:

- soil types and disposal system standards
- seasonal or permanent residency
- total number of units both in the watershed and along the lakeshore

3.3 Trophic Status Change Rating

The capability of a lake to assimilate additional phosphorus without a detrimental affect on water quality is a function of how "fast" the trophic status of that lake may change. A more descriptive term which can be applied to this concept is the "sensitivity" rating. A lake with a high sensitivity rating has a low capability to assimilate additional phosphorus without a detrimental effect on water quality. Conversely, a lake with a low sensitivity rating has a high capability to assimilate additional phosphorus.

The sensitivity of a lake to change in trophic status is a function of a number of physical characteristics, described as follows:

i. flushing period – flushing period, or residence time, is a measure of the time (expressed in years) that natural inflow actually replaces the lake water volume. Lakes with a short retention time have a higher capacity to assimilate additional phosphorus without a change in trophic state because a large percentage of the added phosphorus is flushed out of the lake each year. Lakes with a long flushing period have a higher sensitivity because of the potential for accumulation of added nutrients.

ii. mean depth/volume – as the mean depth of a lake increases in relation to its volume, the assimilation capacity of the lake increases and the sensitivity rating decreases. This is attributable to a greater nutrient dilution and a reduction in shallow or littoral areas where biological activity generally is most pronounced.

iii. physical/chemical indicators – the knowledge of various chemical parameters (eg. total dissolved solids, pH levels, etc.) and lake temperature or oxygen profile, can provide further insight into the assimilation capacity of the lake. For example, the presence of a high pH level and salt content can create a buffering capability in the lake.

iv. watershed characteristics – the watershed and the activities which occur within it can be considered the single most important factor in terms of the eventual disposition of a lake. Lakes which may experience any significant change in land use in the watershed are likely to respond more rapidly in terms of trophic state change (higher sensitivity) than a comparable lake for which the watershed will remain in its natural state.

For general evaluation purposes, three sensitivity ratings are used – high, moderate and low. Typical examples of the application of these three ratings are described as follows:

i. high water quality sensitivity – generally lakes with a combination of all or several of the following characteristics:
   - range of the trophic scale from oligotrophic to slightly eutrophic
   - long flushing period – generally greater than 8 years.
   - relatively shallow lake – low mean depth – generally less than 5m.
   - small watershed or watershed with a significant degree of activity – agriculture, logging, or other development.[4]

   In summary, lakes with a high water quality sensitivity rating have a low capability to assimilate additional phosphorus without a detrimental effect on water quality. Lakes having a high sensitivity classification require the most stringent standards in terms of nutrient management.

ii. moderate water quality sensitivity – generally lakes with a combination of all or several of the following characteristics:
   - range on the trophic scale similar to high sensitivity lakes, although somewhat further into the eutrophic range
   - average flushing period – generally 2 – 8 years.
   - average mean depth – generally 5 – 15 m.
   - possible physical and chemical parameters which may retard quantity and composition of plant growth.
   - larger watersheds or watersheds with less activity.

   Lakes with a moderate water quality sensitivity have a moderate capability to assimilate additional phosphorus without a detrimental effect on water quality. Eutrophic lakes in this category may be slightly into the eutrophic state, again accompanied by factors suggesting the trophic state is reasonably stable.

iii. low water quality sensitivity – generally lakes at either extreme of the trophic scale.
   - highly oligotrophic lakes.
     - short flushing periods – generally 0 – 2 years.
     - higher mean depth – greater than 15 m.
     - probable natural state of watershed or large watershed.
   - highly eutrophic lakes – lakes which are sufficiently advanced into a eutrophic state that only large amounts of additional nutrients will result in a noticeable further deterioration in water quality.

   Lakes with these characteristics have a relatively high capability to assimilate additional phosphorus without a detrimental effect on water quality. Low sensitivity lakes are considered to be the most capable of accommodating additional recreational or permanent residential development.

[4]In some situations, the Ministry of Environment will classify a lake as high sensitivity where management of phosphorus input is critical. A good example is Williams Lake which is very eutrophic and not likely to change as result of small nutrient additions, however lake management dictates that a reduction in phosphorus is crucial.

A further consideration in evaluating water quality sensitivity is the potential for localized portions of a given lake to have a higher sensitivity rating than the general rating for the lake as a whole. Lakes with the following characteristics are likely to be the most susceptible to localized problems, even though the lake as a whole may have a low sensitivity rating:

a) Lakes with an irregular shoreline, and which are characterized by numerous embayments. Embayments are likely to be more sensitive than the lake as a whole because nutrients are more likely to be retained in them, and the average depth of bays is usually less than that for the main lake.

b) Lakes with shallow littoral zones. The shallow littoral zones, or areas of light penetration to the bottom, are the most productive areas of a lake and are therefore the most susceptible to the introduction of added nutrients. Many lakes in the Cariboo are fed by groundwater aquifers which may pick up nutrients from the shorelands (e.g. ground disposal sewage effluent systems) and discharge them up through the lake bottom in much higher concentrations than are found in the overlying water. If this takes place in the potentially productive littoral zone of a lake, the results will predictably be enhanced plant growth in a localized area. The result can be a healthy oligotrophic lake dotted with a strip of developed shoreline with excessive plant growth, particularly those shallow gently sloping beaches most favourable for swimming and other shore oriented activities, and also the spawning habitat of fish. On lakes where the above conditions occur, portions of the lake may be assigned a higher sensitivity rating than the overall rating for the lake.

Water quality tests that are performed include total and total dissolved phosphorus, forms of nitrogen, total dissolved solids, pH and dissolved oxygen. The sampling is scheduled to coincide with spring "turnover" in each of the lakes. A dissolved oxygen-temperature profile is undertaken at each sample point to confirm that the lake is in a turnover condition. Secchi disk measurements are also undertaken at the time of sampling.

The spring phosphorus concentration as measured by the field sampling is directly proportional to the summer chlorophyll a concentration by a relationship established originally by Dillon and Rigler (1975) and adapted by Nordin (1982) for B.C. lakes:

$\log_{10}[\text{chl}\underline{a}] - 0.9873 \log_{10}[P] - 0.6231$

where [chl$\underline{a}$] = summer chlorophyll a concentration in mg/cubic metre

[P] = phosphorus concentration at spring overturn in mg/cubic metre

The chlorophyll a concentration corresponding to the different trophic states is tabulated in Section 3.1.

In summary, the sampling program enables definition of the present actual trophic state of the sample lakes. The defined trophic states for the lakes considered in the sampling program may in many cases be generally applicable to other lakes in the same geographic region.

Once the trophic state or status of the lake is determined, the capability of the lake to accommodate additional development from a water quality point of view is a function of how "fast" the trophic

status may change. The Ontario model (Dillon and Rigler, 1975) using physical parameters for the lake and watershed results in a numerical calculation of this parameter.

In the Cariboo Lake Management Strategy, a subjective estimation of the probable rate of response of any particular lake was made considering the following factors:

- flushing period: Flushing period is expressed in years and is a measure of the time that natural runoff (inflow) actually replaces the lake water volume. Lakes with a short retention time have a higher capacity to assimilate additional phosphorus without a change in trophic state because a large percentage of the added phosphorus is flushed out of the lake each year. On the other hand, lakes with a long flushing period have a higher sensitivity to added nutrients because of the typical retention and accumulation of added nutrients.

  Flushing period values in relation to the capability of a lake to assimilate additional phosphorus are given in the following table:

Flushing Period	Additional Nutrient Assimilation Rating
0 – 2 years	High
2 – 8 years	Average
> 8 years	Low

  Several of the lakes in the Cariboo have flushing periods in excess of 50 years, for example, Sheridan Lake, which represents a major factor affecting the lakes ability to assimilate nutrients. This factor alone may determine a high sensitivity rating.

- mean depth/volume – As the mean depth of a lake increases in relation to its volume, the assimilation capacity of the lake increases. This increase is attributable to a greater nutrient dilution and a reduction in shallow or littoral areas where biological activity generally is most pronounced.

  Mean depth values, expressed as a function of a lake's ability to assimilate additional phosphorus, are given in the following table:

Mean Depth	Additional Nutrient Assimilation Rating
< 5 m	Low
5 – 15 m	Moderate
> 15 m	High

- water quality indicators – This consideration involves data compiled for total dissolved solids, dissolved oxygen profiles and Secchi disk visibility. In general, lakes having low dissolved solids (less than 100 mg/L) or some indication of oxygen deficiencies are considered more likely to respond poorly to changes in phosphorus loading. The poor response basically involves a rapid deterioration in trophic state.

- watershed characteristics – This consideration is a subjective conclusion on possible additional sources of nutrients other than residential development within the contributing watershed of the

lake. Factors such as agricultural potential, forestry activities and residential development in the watershed were considered. Lakes which may experience any significant change in land use in the watershed are likely to responds more rapidly in terms of trophic state change than a comparable lake for which the watershed will remain in its natural state. The watershed characteristics are a subjective assessment of possible additional phosphorus loading from sources other than residential development.

Classification of Lakes

i. The compilation of the trophic state and factors affecting the rate of change of the trophic state results in a Lake Evaluation Summary and Lake Sensitivity Rating for each lake (Appendix II). The sensitivity classification is strictly a measure of the sensitivity of the lake (in terms of deterioration of water quality) to accept additional nutrients from any source e.g. residential development, agricultural operations, natural runoff, etc. As stated in Section 3.3, the three water quality sensitivity ratings utilized are high, moderate, and low. The Lake Sensitivity Rating in turn dictates the degree of protection the lake needs for on-site sewage disposal systems as described in Section 2.8.

3.4 Evaluation of Lake Water Quality Sensitivity Ratings

As explained in Section 3.3, a cornerstone of the 1983 Management Strategy for Lake Shoreland Development was the Lake Sensitivity Rating for each lake which determines the sewage disposal requirements based on a lake's sensitivity to phosphorus inputs. In simple terms, the greater the sensitivity of the lake to phosphorus and the greater the lot density, the more stringent are the guidelines for sewage disposal. For example, a subdivision with a 0.4 ha (1 acre) lot size on a high sensitivity lake will require a phosphorus removal objective of 60-90%. In rapidly drained soils that will effectively transport phosphorus to the lake, the CRD's sewage disposal guidelines require a 15m depth to water table for a sewage disposal system. More details for other lot densities, soil types, and sensitivity ratings can be found in Section 3.3.

The 2003 Lakeshore Management Policy Review evaluated the use of the Lake Sensitivity Ratings in lake management in the context of the CRD's Management Strategy.

Lake Ecology

An extensive review of the scientific literature on lake ecology and the processes that control lake water quality has recently been completed by Robert G. Wetzel, a respected limnologist and scientific researcher (Wetzel, 2001). The book represents an updating of previous versions of it which have become classic references for university limnology classes, as well as for lake ecologists and managers.

A crucial aspect of evaluating the 1983 Management Strategy in 2002, twenty years after it was written, was a review of the scientific aspects of it to ensure they are current and valid. The fundamental elements of the water quality sensitivity rating are lake trophic state, mean depth, volume, water quality indicators, and watershed characteristics. The 1983 Management Strategy

specified criteria to be applied to these in a step-wise assessment of the susceptibility of a lake to a change in trophic state as a result of the addition of nutrients from septic systems.

An assessment of the scientific principles on which the Lake Sensitivity Ratings are based was carried out by Lakeshore Environmental Ltd. in light of recently published scientific reviews in the field of limnology (Wetzel, 2001; North American Lake Management Society, 2001). The Management Strategy was largely based on scientific research done in Ontario in the early 1970's by Dillon and Rigler (1975) and this methodology has, with some refinements, been applied to lake management issues in that province (Hutchinson et. al., 1991; Dorset Environmental Science Centre, 1999).

The result of this assessment by Lakeshore Environmental was that these are essentially still valid and there is no need to change the methodology found in Section 3.2 of the 1983 Management Strategy.

Policy of Defaulting to High Sensitivity

The CRD has requested Water Quality Sensitivity Ratings from the Ministry of Environment (formerly MELP and MWLAP) since the implementation of the 1983 Management Strategy. Shortly after the implementation, the CRD collaborated with MELP on obtaining data and sensitivity ratings for lakes. As a result of these activities, approximately 84 lakes have been rated (see Appendix II). Many of these have been updated from time to time by the MoE (see for example O'Keefe et. al., 2000; Zirnhelt and Petch, 1997).

In spite of these efforts, lakes come before the CRD for subdivision that do not have sensitivity ratings. The CRD does not have the resources to do this work and the MoE often cannot provide it (Brundrige, pers. comm.).

The policy of the CRD in the absence of a rating is to default to a high sensitivity rating. This approach is conservative with respect to the environment because it results in application of the most stringent sewage disposal guidelines. This could possibly unfairly penalize a developer by increasing the lot size requirement and reducing the number of potential lots unnecessarily because if data were available, a lower lake sensitivity rating may have resulted. Another potentially negative result of this is the reduced availability of lots for the public, when these lots may have made available without impact on water quality. Recognizing this, the CRD would like to see an option for a developer to hire a qualified consultant to develop a Water Quality Sensitivity Rating for a particular lake where there is none available. A procedure for this is therefore outlined in the next section.

The sensitivity rating developed is circulated to the Ministry of Environment for review. This helps ensure consistency and as well provides an opportunity for any special water quality or other resource management concerns to be taken into account.

3.5 Procedure for the Development of Water Quality Sensitivity Ratings

The development of Water Quality Sensitivity Ratings has a number of essential components:

- Map of lake basin morphometry to identify optimal monitoring locations and obtain data on lake volume, depth, surface area, perimeter

- Chemical sampling of the Lake at Spring Overturn (just following ice-out), with an adequate Quality Assurance/Quality Control Program to ensure data integrity
- Calculation of a mean phosphorus concentration taking into consideration oxygen/temperature profiles; as well as lake basin morphometry and any chemical stratification that is evident
- Calculation of Flushing Rate (see Appendix III)
- Watershed boundaries and information on land uses within the watershed
- Compilation and interpretation of the information into a summary format
- Determination of the Water Quality Sensitivity Rating

Monitoring of a lake should be done just following ice-out because this is the optimal time to get a representative sample that will best reflect average lake concentrations for the parameters of interest (O'Keeffe et. al., 2000). For the purposes of developing a Water Quality Sensitivity Rating (i.e. the primary objective being to determine trophic state), a single sampling is adequate, providing there is a proper QA/QC program associated with it.

Lake Morphometry

Maps of lake basin morphometry are available for a large number of lakes on line from MoE (Environmental Stewardship Program) at http://pisces.env.gov.bc.ca/index.asp. If unavailable from MoE, a consultant would have to be retained to carry out a bathymetric survey which would add to the cost of the sensitivity rating (see below).

Monitoring & Quality Assurance/Quality Control (QA/QC)

For cost effective lake monitoring, a consultant qualified in the field of limnology needs to determine optimal sampling location(s) and depths, and as well carry it out with an adequate QA/QC program for both the field and lab portions of the program. This is essential in order to ensure that data meets defined standards of quality. QA/QC programs cover collection, preservation, filtration, and shipping of samples as well as laboratory analytical procedures. A recommended lake QA/QC program can be found in Appendix III.

Chemical sampling of a lake must include temperature/dissolved oxygen profiles and takes into account potential chemical differences both with depth and throughout the lake. The sampling program should then be adjusted accordingly.

Calculation of Mean Phosphorus Concentration & Flushing Rate

Once laboratory results are received, a mean lake phosphorus value is calculated (most lakes are phosphorus limited), which takes into account all of the limnological factors that contribute to obtaining a representative average value for the lake.

Flushing rate is calculated according to the procedure in Appendix III. As noted in the appendix, if flow data is available on the inlet or outlet, flushing rate is a straight forward calculation of lake volume divided by outflow volume. However, if there is no flow data available, extrapolation of flows from watersheds of similar hydrology are required as outlined.

Determination of the Water Quality Sensitivity Rating

Considerable error can result if the forgoing steps are not properly executed, potentially resulting in either unfair limits to development or unacceptable risk to the lake. A detailed procedure is given in Section 3.3, however consultants qualified in the field of lake assessment must be retained for the above data compilation and interpretation.

The draft Lake Sensitivity Ratings, are circulated to the Ministry of Environment for review, to help ensure consistency as discussed in Section 3.4.

Estimated Costs for Water Quality Sensitivity Ratings (based on prices in 2002)

Costs will of course vary somewhat depending on such things as consultant fees, travel distance required, and variation in lab charges. The intent here is to give the CRD ***typical costs,*** to allow a judgment as to whether or not this is a feasible option, and to provide to developers to assist them in meeting their obligations to the CRD for a rezoning application.

Typical lake sampling costs are as follows:

1. Lake sampling at Spring Overturn
   - Field sampling: 2 person days $800 (1 biologist, 1 technician)
   - Preparation of equipment, shipment of samples: 0.5 person days $100 (technician)
   - Lab analysis: $500 including QA/QC
2. Calculation of flushing rate and mean phosphorus: 1 day $600 (biologist)
3. Compile and interpret data; determine Water Quality Sensitivity Rating: 1 day $600 (biologist)
4. Expenses for 1 field day $75-$100

   Cost = $2,700.

Typical basin morphometry (if not available from MoE):

Cost = $1,000-2,000 (depending on lake size)

The total cost for a Water Quality Sensitivity Rating could therefore be approximately $4,700 (based on prices in 2002).

4.0 Rationale for Riparian Zone Protection

This section explains the basis for the protection measures of Sections 2.3 and 2.8.

4.1 Definition of Riparian Zones

The term riparian zone describes land adjacent streams and lakes where vegetation is strongly influenced by water. They usually contain native grasses, flowers, shrubs, and trees. A riparian buffer strip refers to a strip of this native vegetation, generally 15m in width (Nener et. al., 1997), between land development and a water body. While much of the available literature is about the benefits of riparian buffers along streams (Department of Fisheries and Oceans and Province of BC, 1994; Agriculture and Agri-Food Canada. 2002), many of the fundamental principles relating to water quality and habitat protection are applicable to lakes as well.

4.2 Importance of Riparian Zones to Water Quality

Riparian vegetation slows runoff water, trapping and settling sediments that might otherwise reach the lake, reducing the clarity of the water, and resulting in negative impacts to fish and their habitat. In addition, fine sediments (particularly soil) can be a source of nutrients such as phosphorus and nitrogen, which can promote the growth of weeds and algae and advance eutrophication (aging of a lake).

Runoff water from residential development also often contains nitrogen and phosphorus from lawn fertilizers as well as other contaminants such as herbicides. A riparian buffer strip can filter this water and impede the flow, causing more infiltration to ground where nutrients can be taken up by plants rather than going directly to the lake.

Riparian buffer strips also help with shore stability thereby preventing erosion and loss of sediment and soils to the lake, which could result in detrimental effects on water quality. As well, riparian vegetation between a septic system and a lake can take up nutrients from septic effluents, thereby helping reduce the amount reaching the lake.

4.3 Importance of Riparian Zones to Fish and Wildlife Habitat

Runoff water containing sediments can have detrimental effects on fish and habitat. Typical effects of sediments include smothering of aquatic organisms (fish food) and spawning gravels, as well as abrasion of fish gills. As noted above, riparian buffer strips can help prevent sediments from getting into lakes. Shading provided by trees in riparian areas can help keep water at more suitable temperatures for fish, and as well provide a source of food for fish as habitat for terrestrial insects which fall into the water. Leaves and other organic matter from riparian vegetation fall into the water and provide a food source for aquatic organisms, which in turn provide food for fish.

Riparian areas provide valuable habitat as food and cover for numerous wildlife species as well as travel corridors. Many small furbearers inhabit these areas. Riparian areas provide nesting habitat for waterfowl and songbirds.

Many of the values of living on a lake depend on maintenance of riparian habitat: fishing, bird watching, wildlife viewing, and good quality water for recreation and drinking.

To fully reap the benefits of riparian zone protection, a rigorous application of appropriate riparian leave strips to all subdivision development is required.

4.4 Riparian Zone Size

The appropriate size for a riparian buffer strip is dependant on the purpose of it, and much larger buffer widths are needed for wildlife habitat than for the protection of water quality.

For example, a buffer strip of between 5 and 10 meters may be adequate for water quality protection on low to moderate slopes, but greater widths are necessary for steeper slopes (Wisconsin Department of Natural Resources, 2002). A literature review by Fischer and Fischenich (2000) makes a clear distinction between buffer strips and wildlife corridors. While a riparian buffer strip refers to a strip of native vegetation between land development and a water body, corridors are strips of vegetation that connect two or more larger patches of vegetation (habitat), through which organisms will move. While a narrow strip may be adequate for small wildlife, large mammals will likely require something wider.

The value of riparian buffer strips for a variety of purposes is widely recognized. However, Fischer and Fischenich (2000) point out that criteria for determining proper dimensions is not well established and designs are highly variable. This was found in their survey of recommended widths for protection of water quality, vegetation, reptiles, amphibians, mammals, fish, invertebrates, and birds.

Many factors come into play in designing an adequate buffer size such as slope, erosion potential, soil type, animal species present, and vegetation present. After a review of a considerable amount of scientific literature on the topic, Fischer and Fischenich (2000) make a number of conclusions:

- In all cases, buffers wider than 10 meters should be promoted for optimizing a range of multiple objectives for water quality, stability, and habitat functions
- Up to 30 meters may be required to adequately protect water quality for steeper slopes and other site-specific factors
- Greater than 30 meters may be required to provide food and shelter for a wide variety of riparian and aquatic wildlife
- Widths of 100 meters or more are usually needed to ensure use as wildlife migration corridors
- Wider strips are better than narrow strips to maximize protection of the environment overall

In BC, the Department of Fisheries and Oceans and the Ministry of Environment recommend a minimum of 15 meters of riparian protection along all water bodies, and greater if there are special habitat considerations. In the 2003 Policy Review by Lakeshore Environmental Ltd., it was noted that lake classification processes under the Cariboo Forest Region establish a minimum 10 meter Riparian Reserve Zone on all lakes.

Given the forgoing discussion, a minimum riparian buffer strip of 15 meters is recommended, but should be greater if it is sensitive habitat.

4.5 Riparian Vegetation

A comprehensive review of the use of riparian leave strips has shown that riparian vegetation is important for the protection of water quality as well as fish and wildlife habitat.

Riparian vegetation slows runoff water, trapping and settling sediments that might otherwise reach the lake, reducing the clarity of the water, and resulting in negative impacts to fish and their habitat. A riparian buffer strip can filter runoff water and impede the flow, causing more infiltration to ground where nutrients can be taken up by plants rather than going directly to the lake. Riparian buffer strips also help maintain shore stability, thereby preventing erosion and loss of sediment and soils to the lake. As well, riparian vegetation between a septic system and a lake can take up nutrients from septic effluents, thereby helping reduce the amount reaching the lake.

Shading provided by trees in riparian areas can help keep water at more suitable temperatures for fish, and as well provide a source of food for fish as habitat for terrestrial insects that fall into the water. Riparian areas provide valuable habitat as food and cover, as well as travel corridors for numerous wildlife species.

Retention of riparian areas has the added benefit of reducing the visual impact of lakeshore subdivisions.

4.6 Recommendations for Riparian Leave Strips

The 2002 Policy Review recommended that the CRD ensure that buffer leave strips are required on all new developments within 150m of a low sensitivity lake and 250m of a high sensitivity lake to protect water quality and shoreline habitat. A buffer strip of 15 meters is the recommended width but variation could be allowed down to 5 meters in selected areas. There would be allowance for clearing of up to 25% of the strip to allow for a view, lake access, and the accommodation of the existing 7.5 meter building setbacks. Distances of greater than 15 meters could be required if provincial or federal agencies have identified sensitive habitat that would require a greater setback e.g. shoal spawning areas on Quesnel Lake.

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Appendix I – Glossary[5]

Algae – small aquatic plants that occur as single cells, colonies, or filaments

Bathymetric survey - process of obtaining data for a bathymetric map of a lake

Bathymetric map - a map showing the bottom contours and depth of a lake; can be used to calculate lake volume

Eutrophic - describes a lake of high nutrients (nitrogen and phosphorus), high photosynthetic activity and low transparency (Secchi depth). See also Trophic State

Eutrophication - the process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment /sedimentation of a lake or reservoir that causes a waterbody to age. If the process is accelerated b human influences, it is termed cultural eutrophication

Flushing rate - the rate at which water enters and leaves a lake relative to lake volume, usually expressed as time needed to replace the lake volume with inflowing water

Limnology - the scientific study of the physical, chemical, geological and biological factors that affect aquatic productivity and water quality in freshwater ecosystems – lakes, reservoirs, rivers or streams

Loading - the total amount of material (sediment, nutrients) brought into a lake by inflowing streams, runoff, direct discharge through pipes, groundwater, the air, and other sources over a specific period of time (often annually)

Mean depth - average depth of a lake; important for determining a lake's sensitivity to further nutrient input

Mesotrophic - the medium range of eutrophication. See also Trophic State

Morphometry - relating to a lake's physical structure (e.g. depth, shoreline length)

Oligotrophic – describes a lake of low nutrients (nitrogen, phosphorus), low plant productivity, and high transparency (Secchi depth). See also Trophic State

Quality Control/Quality Assurance - the field quality assurance program is a systematic process which, together with the laboratory and data storage quality assurance programs, ensures a specified degree of confidence in the data collected. The field quality assurance program involves a series of steps, procedures and practices designed to ensure the data collected meets appropriate standards.

Secchi depth - a measure of transparency of water (the ability of light to penetrate water) obtained by lowering a 20 cm diameter black and white disk (Secchi disk) into water until it is no longer visible.

Soil retention capacity - the ability of a given soil type to adsorb substances such as phosphorus, thus retarding their movement to the water

Spring Overturn – the spring mixing by wind, of lake water, top to bottom, caused by warming to uniform temperatures. An ideal time to obtain representative samples due to uniform concentrations of lake constituents, such as phosphorus

Trophic state - the degree of eutrophication of a lake. Transparency, amount of algae, and phosphorus concentrations can be used to assess trophic state

[5]Largely taken from North American Lake Management Society (2001)

Appendix II

Summary of Lake Water Quality Sensitivity Ratings/Individual Lake Evaluation Summaries

Photo by: R. Brundrige

Appendix II-A Summary of Lake Sensitivity Ratings for Cariboo Lakes

Lake	General Area[2]	Lake Sensitivity Rating
Alexis Lake	152 km W of Williams Lake	N/A (1982)
Anahim Lake	5 km NW of town of Anahim Lake	Moderate (1988)
Antoine Lake	75 km E of Williams Lake	Low (1984)
Big Lake	54 km NE of Williams Lake	Moderate (1983)
Big Rutherford	56 km E of 100 Mile House	High (2000)
Blue Lake	40 km N of Williams Lake	High (1984)
Bouchie Lake	13 km W of Quesnel	High (2000)
Bowers Lake	64 km E of 100 Mile House	Low (1984)
Bowron Lake	32 km E of Wells	Low (1995)
Bridge Lake	56 km E of 100 Mile House	High (1998)
Burn Lake	60 km E of 100 Mile House	Moderate (1998)
Canim Lake	40 km NE of 100 Mile House	Low (1983)
Cariboo Lake	128 km NE of Williams Lake	Low (1983)
Charlotte Lake	320 km W of Williams Lake	Low (1983)
Chaunigan Lake	186 km SW of Williams Lake	Low (1983)
Chilko Lake	203 km SE of Williams Lake	Low (1983)
Chimney Lake	35 km SE of Williams Lake	High (2000)
Choelquoit Lake	257 km W of Williams Lake	High (1984)
Crooked Lake	138 km E of Williams Lake	Low (1983)
Deka Lake (northern basin)	48 km E of 100 Mile House	High (1998)
Deka Lake (southern basin)	48 km E of 100 Mile House	High (1998)
Dewar Lake	15 km E of 150 Mile House	High (1984)
Dragon Lake	8 km SE of Quesnel	High (1983)
Drewry Lake	64 km E of 100 Mile House	Moderate (1984)
Eagle Lake	226 km SW of Williams Lake	Low (1983)
Elkin Lake	179 km SW of Williams Lake	Moderate (1984)
Eugene Lake	60 km E of 100 Mile House	Moderate (1998)
Fawn Lake	44 km E of 100 Mile House	Moderate (1998)
Felker Lake	35 km SE of Williams Lake	Moderate (under review)
Fletcher Lake	106 km SW of Williams Lake	Moderate (1984)
Green Lake	40 km S of 100 Mile House	Moderate (1983)
Hathaway Lake	56 km E of 100 Mile House	High (2000)
Hawkins Lake	37 km NE of 100 Mile House	Moderate (1984)
Henley Lake	60 km E of 100 Mile House	High (1998)
Higgins Lake	48 km E of 100 Mile House	Moderate (2000)
Horse Lake	8 km E of 100 Mile House	High (2000)
Horsefly Lake	74 km NE of Williams Lake	Low (1983)
Keno Lake	99 km NE of Williams Lake	Moderate (1984)
Knight Lake	60 km E of 100 Mile House	Moderate (1998)
Konni Lake	176 km SW of Williams Lake	Low (1983)

[2] Distances are approximate

Lac des Roches	60 km SE of 100 Mile House	High (1984)
Lac La Hache	25 km NW of 100 Mile House	High (1984)
Lang Lake	70 km NE of 100 Mile House	Moderate (1984)
Lesser Fish Lake	50 km E of 100 Mile House	Low (1983)
McIntosh Lake North	64 km E of Williams Lake	High (1983)
McLeese Lake	45 km N of Williams Lake	High (2000)
Milburn Lake	16 km W of Quesnel	High (2000)
Mons Lake	100 km W of Williams Lake	Moderate (2000)
Morehead Lake	83 km NE of Williams Lake	Moderate (1984)
Murphy Lake	67 km E of Williams Lake	Low (1984)
Nimpo Lake	10 km SE of community of Anahim Lake	High (2000)
One-Eye Lake	261 km W of Williams Lake	Low (1983)
108 Mile Lake	13 km N of 100 Mile House	High (2000)
Otter Lake	60 km E of 100 Mile House	High (1998)
Puntchesakut Lake	40 km W of Quesnel	High (1983)
Puntzi Lake	178 km W of Williams Lake	High (1984)
Quesnel Lake	95 km E of Williams Lake	Low (1983)
Rail Lake	40 km NW of 100 Mile House	High (1983)
Roe Lake	50 km E of 100 Mile House	Moderate (1998)
Rose Lake	37 km E of Williams Lake	High (2000)
Ruth Lake	32 km NE of 100 Mile House	High (1983)
Sapeye Lake	265 km W of Williams Lake	High (1984)
Sepa Lake	13 km N of 100 Mile House	High (2000)
Sheridan Lake	50 km E of 100 Mile House	High (1998)
Spanish Lake	115 km NE of Williams Lake	Moderate (1984)
Spout Lake	54 km N of 100 Mile Lake	High (1984)
Lower Stack Lake	58 km E of 100 Mile House	Moderate (1998)
Middle Stack Lake	58 km E of 100 Mile House	Moderate (1998)
Stum Lake	149 km NW of Williams Lake	N/A (Provincial Park)
Sulphurous Lake	48 km E of 100 Mile House	High (1998)
Taseko Lakes	181 km SW of Williams Lake	Low (1983)
Tatla Lake	205 km W of Williams Lake	High (2000)
Tatlayoko Lake	274 km SW of Williams Lake	Low (1983)
Ten Mile Lake	11 km N of Quesnel	Moderate (2000)
Till Lake	32 km W of Williams Lake	Moderate (1998)
Timothy Lake	45 km N of 100 Mile House	High (1984)
Tyee Lake	43 km N of Williams Lake	High (1984)
Watch Lake	35 km SE of 100 Mile House	High (1984)
Watson Lake	8 km N of 100 Mile House	Low (1984)
Wavey Lake	66 km E of 100 Mile House	Moderate (1998)
Webb Lake	56 km E of 100 Mile House	Moderate (1998)
West Twin Lake	60 km E of 100 Mile House	Moderate (2000)
Whitley Lake	64 km E of 100 Mile House	Moderate (2000)
Williams Lake	2 km E of Williams Lake	High (1998)

Appendix II–B Lake Water Quality Sensitivity Ratings

Alexis Lake

Location: 152 km W of Williams Lake
Size: 110 ha
Perimeter: 10.7 km
Elevation: 1,036 m
Ownership: Private – 15%; Crown – 85%
Other: long irregular lakeshore, land slopes gently to lake, light cottage development on east and west shores of lake

Lake Evaluation Summary

Trophic State:	survey data inconclusive – wide variance in readings	
Flushing Period:	4.5 years	
Mean Depth:	5.7 m	
Volume:	6.27 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	
	pH	
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = 272 km^2 Low-lying forests of interior douglas fir; some logging activity, but not extensive – light cabin development	
Summary:	Brownwater lake – application of water quality analysis not reliable	
Lake Sensitivity Rating:	N/A	

Date prepared: 1982

Anahim Lake

Location: 5 km NW of town of Anahim Lake
Size: 590 ha
Perimeter: 26.5 km
Elevation: 1,083 m
Ownership: Private - 50%, Crown – 40%, Reserve - 10%
Other: Irregular shoreline, relatively flat surrounding lands, forest to the lakeshore with considerably marshy areas.

Lake Evaluation Summary

Trophic State:	Eutrophic (computed chlorophyll *a* 12 = mg/m^3, WMB samples May 1987)	
Flushing Period:	0.03 year or approximately every 11 days	
Mean Depth:	1.7 m	
Volume:	10.1 million m^3	
Water Quality Indicators:		
	TDS	57 mg/L
	Dissolved Oxygen	
	pH	7.7
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	7.9:1 (possibly N limiting)
	Water Clarity	Secchi = 1.125m
Watershed Characteristics:		
	Watershed Area = Low lying forests or sub-boreal spruce Poorly drained surrounding lands Agriculture/ranching, considerable cottage/resort development scattered around lake, logging began in 1987	
Summary:	Due to already eutrophic condition and rapid flushing rate, but low mean depth, classified as moderate sensitivity.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1988

Antoine Lake

Location: 75 km E of Williams Lake
Size: 220 ha
Perimeter: 14.6 km
Elevation: 807 m
Ownership: Private – 15%, Crown – 85%
Other:

Lake Evaluation Summary		
Trophic State:	eutrophic (computed chlorophyll *a* = 19.6 mg/m^3, outlet sample Aug 1984)	
Flushing Period:	6 years (based on limited flow data)	
Mean Depth:	7.2 m	
Volume:	16.1 million m^3	
Water Quality Indicators:		
	TDS	257 mg/L
	Dissolved Oxygen	
	pH	8.5
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	9.4:1
	Water Clarity	5.5 m
Watershed Characteristics:		
	Watershed Area = 3 inlets and 1 outlet Biogeoclimatic zone – interior cedar and hemlock	
Summary:	Small lake, eutrophic state, moderate flushing period, moderate depth, possible short circuiting at east end	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1984

Big Lake

Location: 54 km NE of Williams Lake
Size: 580 ha
Perimeter: 17.5 km
Elevation: 820 m
Ownership: Private - 60%, Crown – 40%
Other: Elongated lake with irregular shoreline, gently sloping terrain to the lake. Inlets – Tyee Lake – Big Lake Creek. Outlets – Big Lake Creek.

Lake Evaluation Summary

Trophic State:	mesotrophic to slightly eutrophic (computed chlorophyll *a* = 14.5 mg/m^3)	
Flushing Period:	likely greater than 5 years	
Mean Depth:	13.4 m	
Volume:	78.0 million m^3	
Water Quality Indicators:		
	TDS	145 mg/L
	Dissolved Oxygen	
	pH	8.0
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = 145 km^2	
Summary:	Relatively large lake, moderate depth, mesotrophic and slightly eutrophic, likely moderate flushing period; therefore moderate sensitivity.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1983

Big Rutherford Lake

Location: 56 km E of 100 Mile House
Size: 68.17 ha
Perimeter: 5.03 km
Elevation: 1,125 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 4.6 mg/m^3)	
Flushing Period:	9.0 years (low additional nutrient assimilation rating)	
Mean Depth:	3.1 m (low additional nutrient assimilation rating)	
Volume:	2.17 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	8.21 (1997 mean)
	$[Nitrogen]_{Total}$	1.2 mg/L
	$[Phosphorus]_{Total}$	0.020 mg/L
	Nitrogen:Phosphorus	59.5 :1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.3 m (1997 mean)
Watershed Characteristics:		
	Watershed Area = 400 ha	
Summary:	Water quality of this mesotrophic basin does not appear to have changed for the period 1997 - 2000. Low mean depth and long flushing period indicate a limited capacity to assimilate additional nutrients. Consequently, Big Rutherford Lake remains classified as highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Blue Lake

Location: 40 km N of Williams Lake
Size: 50 ha
Perimeter: 4.3 km
Elevation: 823 m
Ownership: Private – 20%, Crown – 80%
Other: 2 Forest Service recreation sites, 1 resort, 6 lots, 2 cottages

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 4.6 mg/m^3)	
Flushing Period:	indefinite, due to no outlet	
Mean Depth:	10 m	
Volume:	5 million m^3	
Water Quality Indicators:		
	TDS	261 mg/L
	Dissolved Oxygen	
	pH	8.3
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	27:1
	Water Clarity	Secchi depth = 4.9 m
Watershed Characteristics:		
	Watershed Area = No inlet and no outlet Forested – 90%, residential – 10% Small watershed collecting runoff and a few springs Biogeoclimatic zone – interior douglas fir	
Summary:	Small lake, mesotrophic state, no outlet, moderate depth, small watershed.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Bouchie Lake

Location: 13 km W of Quesnel
Size: 129 ha
Perimeter: 3.7 km
Elevation: 762 m
Ownership: 100 % Private
Other: Mixture of farming and residential development around the lake, except at south tip marshy area. Gentle terrain sloping to lakeshore**.**

Lake Evaluation Summary		
Trophic State:	eutrophic	
Flushing Period:	3-4 years (limited data) (average additional nutrient assimilation rating)	
Mean Depth:	4.2 m (low additional nutrient assimilation rating)	
Volume:	5.40 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	very well mixed
	pH	8.82 (2000 mean)
	$[Nitrogen]_{Total}$	0.78 mg/L
	$[Phosphorus]_{Total}$	0.024 mg/L
	Nitrogen:Phosphorus	32.5:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.59 m (1999), 2.50 m (2000) (summer means)
Watershed Characteristics:		
	Watershed Area = 4,134.5 ha Low-lying forest with considerable clearing, thinning and logging; several agricultural operations.	
Summary:	With a relatively small lake size and a low mean depth, the lake's ability to assimilate additional nutrient inputs is limited. Extensive blue green algae blooms occur, usually in late summer. Due to concerns with respect to elevated nutrients, the lake is classified as high sensitivity.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Bowers Lake

Location: 64 km E of 100 Mile House
Size: 600 ha
Perimeter: 18.1 km
Elevation: 1,116 m
Ownership: Private – 10%, Crown – 90%
Other: 12 cottages, 3 undeveloped UREP's

Lake Evaluation Summary		
Trophic State:	oligotrophic (computed chlorophyll *a* = 2.5 mg/m^3 – survey May 1984 – MoE)	
Flushing Period:	1.6 years (based on limited flow data)	
Mean Depth:	19.0 m	
Volume:	114.5 million m^3	
Water Quality Indicators:		
	TDS	118 mg/L
	Dissolved Oxygen	
	pH	7.8
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	16:1
	Water Clarity	Secchi depth = 5.0 m
Watershed Characteristics:		
	Watershed Area = 1 major inlet, several smaller inlets and 1 outlet Forested – 90%, residential/recreational – 10% Biogeoclimatic zone – sub-boreal spruce	
Summary:	oligotrophic state, short flushing period, relatively deep	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1984

Bowron Lake

Location: 32 km E of Wells
Size: 1,011 ha
Perimeter: 18.5 km
Elevation: 3,100 m
Ownership: Private – 20 – 25%, Crown – 75 – 80%
Other: several lodges, stores and a government campsite are part of the privately owned, developed shoreline at the accessible north end; the remainder of the lake is a Class A Provincial Park. Lake fairly heavily used by canoers and boaters.

Lake Evaluation Summary

Trophic State:	oligotrophic (computed chlorophyll *a* = 1.34 mg/m^3 – survey May 1995 by MELP)	
Flushing Period:	0.6 years (based on outflow from Bowron River)	
Mean Depth:	16.2 m	
Volume:	165 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	10.6 mg/l (surface) (1995) 13.9 mg/l (29m) (1995)
	pH	7.6
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	24:1
	Water Clarity	Secchi depth = 5.16 m
Watershed Characteristics:		
	Watershed Area = 45,800 ha Drainage system – Bowron River to Fraser River Small drainage inlet at northeast side of lake (from Kibble Lake), just a trickle Bowron River inlet at south end has good flow (1.42 – 1.98 cms), outlet is a large river with gravel bottom (2.12 – 3.54 cms) discharge Biogeoclimatic zone – primarily coniferous forest (mostly spruce)	
Summary:	A relatively deep oligotrophic lake with a high turnover rate (short flushing period) which helps to decrease the lake sensitivity. These factors may help prevent the build-up of the limiting nutrient phosphorus; the N:P ratio is high and indicates P limitation; the watershed is in the natural state (i.e. protected as a park).	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1995

Bridge Lake

Location: 56 km E of 100 Mile House
Size: 1,376 ha
Perimeter: 47 km
Elevation: 1,128 m
Ownership: Private - 95 %, Crown - 5 %
Other: very irregular shoreline, heavily utilized for fishing

Lake Evaluation Summary

Trophic State:	borderline mesotrophic to slightly eutrophic (chlorophyll *a* = 7.1 mg/m^3)	
Flushing Period:	62.2 years (low additional nutrient assimilation rating)	
Mean Depth:	17.0 m (high additional nutrient assimilation rating)	
Volume:	595 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	well mixed at spring overturn. winter profile - anoxic in some areas.
	pH	8.18
	[Nitrogen]$_{Total}$	0.543 mg/L (eutrophic)
	[Phosphorus]$_{Total}$	0.031 mg/L
	Nitrogen:Phosphorus	17.5:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 7.17 m
Watershed Characteristics:		
	Watershed Area = 15,900 ha Low lying, poorly drained forests of interior douglas-fir have been subject to logging and clearing. South and west shores contain most of the housing development. New development occurring along south shore. Agricultural activity on north and west shores.	
Summary:	Borderline mesotrophic to slightly eutrophic state, but water clarity relatively high. Has relatively long flushing period, but mean depth is quite high allowing for moderate assimilation of additional nutrients. High sensitivity, particularly in localized areas along the shoreline, such as in isolated bays.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Burn Lake

Location: 60 km E of 100 Mile House
Size: 24.4 ha
Perimeter: 2.67 km
Elevation: 1,160 m
Ownership:
Other: 1 resort, 1 residence

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.2 mg/m^3)	
Flushing Period:	4.7 years (average additional nutrient assimilation rating)	
Mean Depth:	3.6 m (low additional nutrient assimilation rating)	
Volume:	0.874 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	7.99
	$[Nitrogen]_{Total}$	0.638 mg/L
	$[Phosphorus]_{Total}$	0.023 mg/L
	Nitrogen:Phosphorus	28.0:1 (P limiting)
	Water Clarity	Secchi depth = 4.43 m
Watershed Characteristics:		
	Watershed Area = 310 ha	
Summary:	Small mesotrophic lake. Rates fair in ability to assimilate additional nutrients.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Canim Lake

Location: 40 km NE of 100 Mile House
Size: 5,600 ha
Perimeter: 67 km
Elevation: 770 m
Ownership: Private – 58%, Crown – 42%
Other: 200 cottages, 1 Class A and 1 Class C Provincial Park, 11 undeveloped UREP's, 12 commercial resorts, 14 government campsites, 174 camper sites.

Lake Evaluation Summary

Trophic State:	oligotrophic	
Flushing Period:	large inflow – 17 inlets – likely less than 5 years	
Mean Depth:	unknown – max. depth 208 m	
Volume:		
Water Quality Indicators:		
	TDS	215 mg/L
	Dissolved Oxygen	
	pH	8.5
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 3.7 m
Watershed Characteristics:		
	Watershed Area = Shoreline: forested – 85%, agriculture – 5%, residential/recreational – 10% Biogeoclimatic zone – interior western hemlock	
Summary:	Large, deep lake – likely oligotrophic state; large inflow, likely short flushing period. Overall low sensitivity but potential for localized problems.	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Cariboo Lake

Location: 128 km NE of Williams Lake
Size: 1,100 ha
Perimeter: 34.1 km
Elevation: 688 m
Ownership: Private – 15%, Crown – 85%
Other: 6 recreational sites

Lake Evaluation Summary		
Trophic State:	likely oligotrophic	
Flushing Period:	less than 1 year	
Mean Depth:	18.0 m	
Volume:	198 million m^3	
Water Quality Indicators:		
	TDS	108 mg/L
	Dissolved Oxygen	
	pH	7.6
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = 15 inlets and 1 outlet Forested – 6o%, logged – 40% Biogeoclimatic zone – sub-boreal spruce, interior west hemlock	
Summary:		
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Charlotte Lake

Location: 320 km W of Williams Lake, W of Anahim Lake
Size: 65,100 ha
Perimeter: 46.3 km
Elevation: 1,169 m
Ownership: Private – 20%, Crown – 80%
Other: commercial resort/lodge, 2 Forest Service recreational sites, a number of cottages around lake

Lake Evaluation Summary		
Trophic State:	highly oligotrophic (chlorophyll *a* = 0.94 mg/m^3, survey June 1982 – Aquatic Studies Branch)	
Flushing Period:	Short, 2.7 years – however lake could be subject to "short circuiting"	
Mean Depth:	40.5 m	
Volume:	2,670 million m^3	
Water Quality Indicators:		
	TDS	32 mg/L
	Dissolved Oxygen	
	pH	6.7
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	22.5:1
	Water Clarity	Secchi depth = 7.3 m
Watershed Characteristics:		
	Watershed Area = 27 inlets and 1 outlet Biogeoclimatic zone – sub-boreal spruce	
Summary:	Highly oligotrophic, short flushing period, deep, could be subject to localized problems however overall lake is low sensitivity.	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Chaunigan Lake

Location: 186 km SW of Williams Lake
Size: 5,600 ha
Perimeter: 11.4 km
Elevation: 1,494 m
Ownership: Private – 14%, Crown – 86%
Other: 6 resort cabins/lodge, 5 camper sites

Lake Evaluation Summary		
Trophic State:	likely oligotrophic	
Flushing Period:	1.35 years	
Mean Depth:	15.8 m	
Volume:	88.5 million m^3	
Water Quality Indicators:		
	TDS	150 mg/L
	Dissolved Oxygen	
	pH	8.4
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 8.6 m
Watershed Characteristics:		
	Watershed Area = 2 inlets and 1 outlet Forested 92%, residential/recreation 8% Biogeoclimatic zone – interior douglas fir	
Summary:		
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Chilko Lake

Location: 203 km SE of Williams Lake
Size: 19,800 ha
Perimeter:
Elevation: 1,172 m
Ownership: Crown – 100%
Other: 2 recreation sites, 1 commercial lodge, some cottage development

Lake Evaluation Summary

Trophic State:	Large, deep, oligotrophic	
Flushing Period:		
Mean Depth:	108 m	
Volume:	21,384 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	
	pH	7.3
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 5.2 m
Watershed Characteristics:		
	Watershed Area = 91 inlets and 1 outlet Forested – 97% and residential – 3% Biogeoclimatic zone – interior douglas fir, some alpine present in forest – approximately 5%	
Summary:		
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Chimney Lake

Location: 35 km SE of Williams Lake
Size: 431 ha
Perimeter: 13.4 km
Elevation: 915 m
Ownership: Private - 50 %, Crown - 50 %
Other: Considerable residential development and high recreation use

Lake Evaluation Summary

Trophic State:	borderline mesotrophic/eutrophic (chlorophyll *a* =4.59 mg/m^3)	
Flushing Period:	16.8 years (low additional nutrient assimilation rating)	
Mean Depth:	8.7 m (moderate additional nutrient assimilation rating)	
Volume:	37.5 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	fairly well mixed
	pH	8.70 (1998 mean)
	[Nitrogen]$_{Total}$	1.20 mg/L
	[Phosphorus]$_{Total}$	0.020 mg/L
	Nitrogen:Phosphorus	60:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.76 m (1998), 3.23 m (1999), 2.42 m (2000) (summer means)
Watershed Characteristics:		
	Watershed Area = 6,080.9 ha 2 inlets, 1 outlet Forested - 50 % and rangeland – 50% Biogeoclimatic zone - interior douglas fir	
Summary:	The borderline mesotrophic/eutrophic status is indicative of a transition state between the two trophic states. Mean depth shows only a moderate ability for the lake to assimilate additional nutrients without changing trophic status. This factor combined with a long flushing rate and a high level of development within the watershed predicts a low additional nutrient assimilation capability; therefore Chimney Lake is classified as highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Choelquoit Lake

Location: 257 km W of Williams Lake
Size: 14,700 ha
Perimeter:
Elevation: 1,170 m
Ownership: Crown – 100%
Other: 1 Forest Service recreation site

Lake Evaluation Summary

Trophic State:	mesotrophic, computed chlorophyll *a* = 3.9 mg/ml^3	
Flushing Period:	Indefinite due to no outlet	
Mean Depth:	18.0 m	
Volume:	265 million m^3	
Water Quality Indicators:		
	TDS	462 mg/L
	Dissolved Oxygen	
	pH	8.6
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	36:1
	Water Clarity	Secchi depth = 4.3 m
Watershed Characteristics:		
	Watershed Area = 8 inlets and no outlet rangeland 50%, forested 48%, residential 2% Biogeoclimatic zone – interior douglas fir, small drainage area	
Summary:	Mesotrophic state, indefinite flushing period, relatively deep, no outlet, small watershed, rangeland.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Crooked Lake

Location: 138 km E of Williams Lake
Size: 1,120 ha
Perimeter:
Elevation: 933 m
Ownership: Crown – 100%
Other: 1 commercial resort with cabins, boat launch and campgrounds, 1 recreation site with 10 campsites

Lake Evaluation Summary

Trophic State:	oligotrophic (computed chlorophyll *a* = 1.9 mg/m^3, survey 1984 – MoE)	
Flushing Period:	> 10 years	
Mean Depth:	35.1 m	
Volume:	390 million m^3	
Water Quality Indicators:		
	TDS	33 mg/L
	Dissolved Oxygen	
	pH	7.6
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	14:1
	Water Clarity	Secchi depth = 7.0 m
Watershed Characteristics:		
	Watershed Area = 13 inlets and 1 outlet Biogeoclimatic zone – interior cedar and hemlock	
Summary:	Oligotrophic state, long flushing period, deep lake, low TDS	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Deka Lake (northern basin)

Location: 48 km E of 100 Mile House
Size: 766 ha
Perimeter: 19.5 km
Elevation: 1,113 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 3.9 mg/m^3)	
Flushing Period:	under review	
Mean Depth:	41.42 m (high additional nutrient assimilation rating)	
Volume:	230 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	Very well mixed at both sites
	pH	8.12
	$[Nitrogen]_{Total}$	0.256 mg/L
	$[Phosphorus]_{Total}$	0.017 mg/L
	Nitrogen:Phosphorus	15.2:1 (P limiting)
	Water Clarity	Secchi depth = 8.86 m
Watershed Characteristics:		
	Watershed Area = 5,980 ha Shoreline almost completely undeveloped, but logging pressures exist (Liebe and Zirnhelt, 1996)	
Summary:	Mesotrophic basin. Assumed to have poor capacity to assimilate additional nutrients because of uncertainty over flushing rate.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Deka Lake (southern basin)

Location: 48 km E of 100 Mile House
Size: 362 ha
Perimeter: 14.3 km
Elevation: 1,113 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 4.9 mg/m^3)	
Flushing Period:	under review	
Mean Depth:	13.88 m (moderate additional assimilation rating)	
Volume:	20.5 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified
	pH	7.92
	[Nitrogen]$_{Total}$	0.39 mg/L
	[Phosphorus]$_{Total}$	0.021 mg/L
	Nitrogen:Phosphorus	18.3:1 (P limiting)
	Water Clarity	Secchi depth = 5.68 m
Watershed Characteristics:		
	Watershed Area = 6,060 ha Largely developed with significant recreational use. Pressure from logging also present (Liebe and Zirnhelt, 1996)	
Summary:	Mesotrophic basin that rates moderate in its ability to buffer nutrient loading. However, a great amount of pressure, primarily from development of the surrounding watershed, makes this basin more vulnerable. There is presently uncertainty over the flushing rate.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Dewar Lake

Location: 15 km E of 100 Mile House
Size: 410 ha
Perimeter: 3.1 km
Elevation: 984 m
Ownership: Private – 30%, Crown – 70%
Other:

Lake Evaluation Summary		
Trophic State:	eutrophic (computed chlorophyll *a* = 21 mg/m^3, sampled Nov 1984 – MoE)	
Flushing Period:	indefinite, due to no outlet	
Mean Depth:	4 m	
Volume:	1.68 million m^3	
Water Quality Indicators:		
	TDS	628 mg/L
	Dissolved Oxygen	
	pH	8.9
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	27:1
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = No inlet, no outlet, small watershed.	
Summary:	Small lake, eutrophic state, no outlet, shallow, small watershed, water quality important to tentative fisheries management plans.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Dragon Lake

Location: 8 km SE from Quesnel
Size: 225 ha
Perimeter: 16.4 km
Elevation: 579 m
Ownership: Private – 98%, Crown – 2%
Other: 108 lakefront lots, 64 cottages (70% permanent residences), 1 commercial resort, 1 Forest Service recreation site

Lake Evaluation Summary

Trophic State:	slightly eutrophic (computed chlorophyll *a* = 8.9 mg/m^3)
Flushing Period:	17 years (WMB)
Mean Depth:	6.04 m
Volume:	13.56 million m^3
Water Quality Indicators:	
	Dissolved Oxygen
	pH
	$[Nitrogen]_{Total}$
	$[Phosphorus]_{Total}$
	Nitrogen:Phosphorus
	Water Clarity
Watershed Characteristics:	
	Watershed Area = 1 inlet and 1 outlet Biogeoclimatic zone – sub-boreal spruce Extensive residential development around lake; extensive agriculture in watershed, also extensive logging planned.
Summary:	Low flushing rate, relatively shallow depth, slightly eutrophic, small watershed with a great deal of activity, therefore highly sensitive.
Lake Sensitivity Rating:	High sensitivity

Date prepared: 1983

Drewry Lake

Location: 51 km E of 100 Mile House
Size: 560 ha
Perimeter: 24.1 km
Elevation: 1,067 m
Ownership: Private – 90%, Crown – 10%
Other: High recreation use, several cabins on lake shore, 3 Forest Service recreation sites. Long narrow lake, 80% shoreland rocky, 20% swampy, forest down to lakeshore.

Lake Evaluation Summary

Trophic State:	eutrophic (computed chlorophyll *a* = 12.7 mg/m^3)	
Flushing Period:	11 years (based on limited flow data)	
Mean Depth:	12.9 m	
Volume:	73.1 million m^3	
Water Quality Indicators:		
	TDS	66-111 mg/L
	Dissolved Oxygen	oxygen deficient with depth (variable readings in different parts of the lake).
	pH	7.2
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 1.25-2 m
Watershed Characteristics:		
	Watershed Area = 11 inlets and 1 outlet Interior douglas fir forests on steep terrain into the lakeshore Heavy logging activity on the N slopes almost down to the lakeshore. Biogeoclimatic zone – sub-boreal spruce	
Summary:	eutrophic state, long flushing period, moderate depth, logging activity	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Eagle Lake

Location: 226 km SW of Williams Lake
Size: 11,700 ha
Perimeter: 28 km
Elevation: 1,044 m
Ownership: Private - 5%, Crown - 95%
Other:

Lake Evaluation Summary		
Trophic State:	highly oligotrophic – based on limited data	
Flushing Period:		
Mean Depth:	18 m	
Volume:	211.2 million m^3	
Water Quality Indicators:		
	TDS	486 mg/L mg/L
	Dissolved Oxygen	
	pH	8.3
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 13.4 m
Watershed Characteristics:		
	Watershed Area = 6 inlets and 1 outlet Biogeoclimatic zone – sub-boreal spruce, dry	
Summary:	Likely low sensitivity based on likely oligotrophic state, high TDS rating.	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Elkin Lake

Location: 179 km SW of Williams Lake
Size: 2,400 ha
Perimeter: 12.4 km
Elevation: 1,216 m
Ownership: Crown – 100%
Other: commercial resort (lodge and 14 resort cabins) on inlet stream between Vedan Lake and Elkin Lake

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 4.1 mg/m^3, survey: May 9, 1984 – MoE)	
Flushing Period:	1.3 years (based on limited flow data)	
Mean Depth:	14.4 m	
Volume:	34.7 million m^3	
Water Quality Indicators:		
	TDS	50 mg/L
	Dissolved Oxygen	
	pH	7.8
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	7:1 (possible N limited)
	Water Clarity	Secchi depth = 4.6 m
Watershed Characteristics:		
	Watershed Area = 7 inlets and 1 outlet Rangeland 20%, forested 80% Biogeoclimatic zone – interior douglas fir	
Summary:	mesotrophic state, short flushing period, moderate depth, low TDS, N:P ratio indicates possible N limitation, agricultural land use along major inlet stream.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Eugene Lake

Location: 60 km E of 100 Mile House
Size: 129 ha
Perimeter: 7.23 km
Elevation: 1,166 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	under review	
Flushing Period:	22.4 years (low additional nutrient assimilation rating)	
Mean Depth:	6.8 m (moderate additional nutrient assimilation rating)	
Volume:	8.77 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	profile showing stratification and low levels in the bottom half
	pH	8.15
	$[Nitrogen]_{Total}$	0.507 mg/L
	$[Phosphorus]_{Total}$	0.079 mg/L (particulate contamination suspected)
	Nitrogen:Phosphorus	6.4:1 (co-limitation or no limitation)
	Water Clarity	Secchi depth = 7.21 m
Watershed Characteristics:		
	Watershed Area = 650 ha Little recreational use and low development pressure (Liebe and Zirnhelt, 1996).	
Summary:	Total phosphorus was 0.079 mg/L, however total dissolved phosphorus was only 0.004 mg/L. The lake's high transparency suggests an oligotrophic state. Rates fair in its ability to assimilate additional nutrients. Little development pressure.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Fawn Lake

Location: 44 km E of 100 Mile House
Size: 32 ha
Perimeter: 3.60 km
Elevation: 1,067 m
Ownership:
Other: 1 resort, 5 residences

Lake Evaluation Summary		
Trophic State:	mesotrophic (chlorophyll *a* = 6.4 mg/m^3)	
Flushing Period:	4.6 years (average additional nutrient assimilation rating)	
Mean Depth:	4.8 m (low additional nutrient assimilation rating)	
Volume:	1.53 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified
	pH	8.54
	[Nitrogen]$_{Total}$	0.827 mg/L
	[Phosphorus]$_{Total}$	0.028 mg/L
	Nitrogen:Phosphorus	29.3:1 (P limiting)
	Water Clarity	Secchi depth = 3.45 m
Watershed Characteristics:		
	Watershed Area = 550 ha	
Summary:	Mesotrophic state with fair ability to buffer nutrient loading. Not much developmental pressure.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Felker Lake

Location: 35 km SE of Williams Lake
Size: 227 ha
Perimeter: 8.80 km
Elevation: 884 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.49 mg/m^3)	
Flushing Period:	5.3 years (average additional nutrient assimilating rating)	
Mean Depth:	5.06 m (moderate additional nutrient assimilation rating)	
Volume:	11.6 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	fairly well mixed
	pH	8.84 (1998 mean)
	[Nitrogen]$_{Total}$	1.04 mg/L
	[Phosphorus]$_{Total}$	0.024 mg/L
	Nitrogen:Phosphorus	43.3:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.95 (1998), 2.70 m (1999), 2.47 m (2000) (summer means)
Watershed Characteristics:		
	Watershed Area = 1,930.9 ha 2 inlets and 1 outlet Some forest, recreational area, grazing and agricultural land, as well as permanent and summer residences Biogeoclimatic zone - interior douglas fir	
Summary:	This is a small and moderately shallow lake with average flushing rate. Its condition is mesotrophic. Chimney Lake upstream provides some buffering effect on incoming nutrients, therefore we assume a moderate water quality sensitivity rating and an overall high sensitivity lake rating.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 2000

Fletcher Lake

Location: 106 km SW of Williams Lake
Size: 2,000 ha
Perimeter: 7.6 km
Elevation: 1,128 m
Ownership: Private – 30%, Crown – 70%
Other: 10 recreation sites, 1 fishing resort

Lake Evaluation Summary

Trophic State:	eutrophic (computed chlorophyll *a* = 10.7 mg/m^3 – survey May 1984 – MoE)	
Flushing Period:	4 years (based on limited flow data)	
Mean Depth:	5.8 m	
Volume:	11.4 million m^3	
Water Quality Indicators:		
	TDS	178 mg/L
	Dissolved Oxygen	
	pH	8.7
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	14:1
	Water Clarity	Secchi depth = 1.1 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Rangeland 10%, forested 90% Biogeoclimatic zone – interior douglas fir Large diversion from Big Creek	
Summary:	Small lake, eutrophic state, moderate flushing period, relatively shallow, small watershed.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Green Lake

Location: 40 km S of 100 Mile House
Size: 2,310 ha
Perimeter: 65.3 km
Elevation: 1,069 m
Ownership: Private – 36%, Crown – 64 %
Other: 505 lots, 350 cottages, 1 Class A Provincial Park, 4 undeveloped UREP's, 5 Forest Service recreation sites, 6 commercial resorts. High recreation use, long, narrow lake – north side in CRD, south side in TNRD.

Lake Evaluation Summary

Trophic State:	oligotrophic (computed chlorophyll *a* = 2.77 mg/m^3 – survey 1983)	
Flushing Period:	unknown, but very long – often has no outflow	
Mean Depth:	10.3 m	
Volume:	283 million m^3	
Water Quality Indicators:		
	TDS	954 mg/L
	Dissolved Oxygen	
	pH	9.1
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = Biogeoclimatic zone – interior douglas fir Shoreline: agriculture – 15%, rangeland – 15%, forested – 60%, residential/recreational – 10%	
Summary:	Low flushing rate, moderate mean depth, probably has a good open water assimilative capacity due to chemical processes within the lake, however could be subject to localized problems.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1983

Hathaway Lake

Location: 56 km E of 100 Mile House
Size: 152 ha
Perimeter: 8.73 km
Elevation: 1,152 m
Ownership:
Other: 1 resort, 9 residences

Lake Evaluation Summary

Trophic State:	borderline mesotrophic/eutrophic (chlorophyll *a* = 7.52 mg/m^3)	
Flushing Period:	45.2 years (low additional nutrient assimilation rating)	
Mean Depth:	19.7 m (high additional nutrient assimilation rating)	
Volume:	29.95 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	stratified
	pH	7.99 (1998 mean)
	$[Nitrogen]_{Total}$	0.385 mg/L
	$[Phosphorus]_{Total}$	0.033 mg/L
	Nitrogen:Phosphorus	11.5:1 (co-limitation or no limitation)
	Water Clarity	Secchi depth = 7.04 m (1996), 7.25 m (1997), 8.57 m (1998), 7.79 m (1999), 8.15 m (2000) (summer means)
Watershed Characteristics:		
	Watershed Area = 1,100 ha Outlet of Hathaway Lake flows into Sulphurous Lake	
Summary:	This borderline mesotrophic/ eutrophic basin has a very long flushing period. Although the lake is relatively deep, in light of all of these factors, the lake's ability to assimilate additional nutrients is low. Therefore, Hathaway Lake is classified as highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Hawkins Lake

Location: 37 km NE of 100 Mile House
Size: 180 ha
Perimeter: 10.6 km
Elevation: 915 m
Ownership: Private – 70%, Crown – 30%
Other: Downstream from Ruth Lake

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 5.5 mg/m^3 – survey 1984 – MoE)	
Flushing Period:	< 1 year (based on limited flow data)	
Mean Depth:	7.2 m	
Volume:	13.2 million m^3	
Water Quality Indicators:		
	TDS	135 mg/L
	Dissolved Oxygen	
	pH	8.0
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	18:1
	Water Clarity	Secchi depth = 2.3 m
Watershed Characteristics:		
	Watershed Area = 4 inlets and 1 outlet, rolling hill terrain Shoreline : forested – 70%, rangeland – 30% Biogeoclimatic zone – sub-boreal spruce	
Summary:	Small lake, mesotrophic state, short flushing period, moderate depth, agriculture land use along major inlet stream.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Henley Lake

Location: 60 km E of 100 Mile House
Size: 33.9 ha
Perimeter: 2.70 km
Elevation: 1,160 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.6 mg/m^3)	
Flushing Period:	11.4 years (low additional nutrient assimilation rating)	
Mean Depth:	3.8 m (low additional nutrient assimilation rating)	
Volume:	1.298 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified
	pH	8.19
	$[Nitrogen]_{Total}$	0.632 mg/L
	$[Phosphorus]_{Total}$	0.024 mg/L
	Nitrogen:Phosphorus	26.0:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.92 m
Watershed Characteristics:		
	Watershed Area = 190 ha	
Summary:	Small, mesotrophic lake with little ability to buffer nutrient loading.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Higgins Lake

Location: 48 km E of 100 Mile House
Size: 21.8 ha
Perimeter: 2.24 km
Elevation: 1,143 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	eutrophic (chlorophyll *a* = 7.52 mg/m^3)	
Flushing Period:	1.6 years (high additional nutrient assimilation rating)	
Mean Depth:	5.0 m (moderate additional nutrient assimilation rating)	
Volume:	1.083 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	well mixed
	pH	7.91 (1997 mean)
	$[Nitrogen]_{Total}$	0.46 mg/L
	$[Phosphorus]_{Total}$	0.033 mg/L
	Nitrogen:Phosphorus	13.9:1 (nitrogen and phosphorus limiting)
	Water Clarity	Secchi depth = 2.75 m (1997 summer mean)
Watershed Characteristics:		
	Watershed Area = 1,150 ha	
Summary:	Higgins is a small, eutrophic lake. A short flushing period and a moderate mean depth suggest a fairly good capacity to assimilate additional nutrients without a rapid change in trophic state. Historically, Higgins Lake has reached an anoxic state during winter months. Aerators are currently operated in winter by the Fisheries Branch to prevent oxygen deficiency.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 2000

Horse Lake

Location: 8 km E of 100 Mile House
Size: 1,160 ha
Perimeter: 31 km
Elevation: 991 m
Ownership: Private - 79 %, Crown - 21 %
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 8.4 mg/m^3)	
Flushing Period:	3.5 years (average additional nutrient assimilation rating)	
Mean Depth:	15.2 m (high additional nutrient assimilation rating)	
Volume:	174.6 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	well mixed
	pH	8.09 (1998 mean)
	$[Nitrogen]_{Total}$	0.414 mg/L
	$[Phosphorus]_{Total}$	0.037 mg/L
	Nitrogen:Phosphorus	11.2:1 (borderline between phosphorus limitation and co-limitation)
	Water Clarity	Secchi depth = 6.66 m (1996), 5.90 m (1997)
Watershed Characteristics:		
	Watershed Area = 83,000 ha Horse Lake is quite close to 100 Mile House and approximately 88 % of the residents are permanent (Petch and Zirnhelt, 1996). There are six inflow creeks and one major outflow, Bridge Creek. The south shore contains most of the housing development, and except for at the west end, the north shore has little development.	
Summary:	Mesotrophic state, but water clarity is relatively high. Has an average flushing period, a high mean depth, and a moderate ability to assimilate additional nutrients. The lake is rated as high priority for further monitoring largely because of its high recreational value and the large degree of permanent residents. As well, due to its downstream position in the watershed, Horse Lake receives runoff from many land uses upstream. These factors combined with data indicating phosphorus levels may be increasing, gives the lake a rating of high sensitivity.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Horsefly Lake

Location: 74 km NE of Williams Lake
Size: 5,800 ha
Perimeter:
Elevation: 785 m
Ownership: Private – 5%, Crown – 95%
Other: 51 resort cabins, 12 government campsites, 93 camper sites

Lake Evaluation Summary		
Trophic State:	likely oligotrophic state	
Flushing Period:		
Mean Depth:	66.2 m	
Volume:	3839 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	
	pH	8.5
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = 1 outlet Forested – 100% Biogeoclimatic zone – interior western hemlock	
Summary:	Large, deep lake, likely oligotrophic state, overall low sensitivity but potential for localized problems in littoral zone.	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Keno Lake

Location: 99 km NE of Williams Lake
Size: 230 ha
Perimeter: 14.1 km
Elevation: 810 m
Ownership: Crown – 100%
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (computed chlorophyll *a* = 6.6 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	limited flushing due to "short circuiting" of inlet – outlet flows	
Mean Depth:	11.2 m	
Volume:	25.5 million m^3	
Water Quality Indicators:		
	TDS	84 mg/L
	Dissolved Oxygen	
	pH	7.9
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	11:1
	Water Clarity	Secchi depth = 2.8 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Forested – 95%, residential – 5% Biogeoclimatic zone – interior cedar and hemlock Rolling hill terrain: 50% deciduous, 50% coniferous	
Summary:	Mesotrophic state (possibly dystrophic), small lake, limited flushing, moderate depth, low TDS, low N:P ratio.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Knight Lake

Location: 60 km E of 100 Mile House
Size: 14.92 ha
Perimeter: 1.61 km
Elevation: 1,184 m
Ownership:
Other:

Lake Evaluation Summary		
Trophic State:	eutrophic (chlorophyll *a* = 8.3 mg/m^3)	
Flushing Period:	4.8 years (average additional nutrient assimilation rating)	
Mean Depth:	4.4 m (low additional nutrient assimilation rating)	
Volume:	0.663 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	profile showing stratification and sharp decline to low levels near the bottom
	pH	8.07
	$[Nitrogen]_{Total}$	0.915 mg/L
	$[Phosphorus]_{Total}$	0.037 mg/L
	Nitrogen:Phosphorus	25.0:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 4.19 m
Watershed Characteristics:		
	Watershed Area = 230 ha	
Summary:	Small, eutrophic lake that has a fair ability to buffer nutrient loading. Pressure from development is minimal.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Konni Lake

Location: 76 km SW of Williams Lake
Size: 5,600 ha
Perimeter: 15.0 km
Elevation: 1,247 m
Ownership: Reserve – 20%, Crown – 80%
Other:

Lake Evaluation Summary		
Trophic State:	likely oligotrophic, based on limited data	
Flushing Period:		
Mean Depth:	17.1 m	
Volume:	95.6 million m^3	
Water Quality Indicators:		
	TDS	422 mg/L
	Dissolved Oxygen	
	pH	8.5
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 3.4 m
Watershed Characteristics:		
	Watershed Area = 10 inlets and 1 outlet Rangeland – 50%, forested – 50% Biogeoclimatic zone – interior douglas fir	
Summary:		
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Lac des Roches

Location: 60 km SE of 100 Mile House
Size: 1,830 ha
Perimeter: 43.5 km
Elevation: 1,134 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (computed chlorophyll *a* = 5.0 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	97.6 years	
Mean Depth:	17.1 m	
Volume:	312.2 million m^3	
Water Quality Indicators:		
	TDS	152 mg/L
	Dissolved Oxygen	
	pH	8.3
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	13:1
	Water Clarity	Secchi depth = 5.0 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Biogeoclimatic zone – sub-boreal spruce	
Summary:	mesotrophic state, long flushing period, relatively deep, small watershed	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Lac La Hache

Location: 25 km NW of 100 Mile House
Size: 2,300 ha
Perimeter: 42.6 km
Elevation: 808 m
Ownership: Private – 78%, Crown – 20%, Reserve – 2%
Other: 354 lots, 124 cottages, 12 commercial resorts, 2 Provincial Parks (Class II), 7 undeveloped UREP sites

Lake Evaluation Summary

Trophic State:	mesotrophic (average computed chlorophyll *a* = 3.8 mg/m^3, survey 1978-84 – MoE)	
Flushing Period:	17 years (based on limited flow data)	
Mean Depth:	14.6 m	
Volume:	336.6 million m^3	
Water Quality Indicators: There appears to be an increasing trend in overturn phosphorus and summer algal growth (chlorophyll *a*).		
	TDS	365 mg/L
	Dissolved Oxygen	
	pH	8.5
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	23:1
	Water Clarity	Secchi depth = 4.9 m
Watershed Characteristics:		
	Watershed Area = 3 inlets and 1 outlet Biogeoclimatic zone – interior douglas fir	
Summary:	mesotrophic state, long flushing period, moderate depth, agricultural land use along major inlet stream, heavily developed as residential and summer cottages, overturn phosphorus should be closely monitored on an annual basis due to an apparent increasing trend.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Lang Lake

Location: 70 km NE of 100 Mile House
Size: 680 ha
Perimeter: 18.8 km
Elevation: 819 m
Ownership: Crown – 100%
Other:

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 3.7 mg/m^3, survey 1984 – MoE)	
Flushing Period:	4.3 years (based on limited flow data)	
Mean Depth:	35.2 m	
Volume:	238 million m^3	
Water Quality Indicators:		
	TDS	78 mg/L
	Dissolved Oxygen	
	pH	7.9
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	20:1
	Water Clarity	Secchi depth = 3.2 m
Watershed Characteristics:		
	Watershed Area = 1 major inlet and several smaller tributaries and 1 outlet Biogeoclimatic zone – sub-boreal spruce	
Summary:	mesotrophic state (possibly dystrophic), moderate flushing rate, deep lake, low TDS.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Lesser Fish Lake

Location: 50 km E of 100 Mile House
Size: 78.71 ha
Perimeter: 4.023 km
Elevation:
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	oligotrophic (measured chlorophyll *a* = 1.3 mg/m^3)	
Flushing Period:	estimated at less than 2 years	
Mean Depth:	<12 m (max. depth 12 m)	
Volume:	4.3 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	
	pH	8.7
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = Stable phosphorus loading from Bridge Lake, therefore not likely to change.	
Summary:	shallow, high flushing rate, stable watershed	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

McIntosh Lake North

Location: 64 km E of Williams Lake
Size: 250 ha
Perimeter: 9.8 km
Elevation: 914 m
Ownership: Crown – 100%
Other:

Lake Evaluation Summary		
Trophic State:	slightly eutrophic (computed chlorophyll *a* = 7.5 mg/m^3, WMB 1981)	
Flushing Period:	no data but likely relatively long because close to headwater	
Mean Depth:	7 m	
Volume:	17.5 million m^3	
Water Quality Indicators:		
	TDS	120 mg/L
	Dissolved Oxygen	
	pH	8.3
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 2.4 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Wilderness lake, biogeoclimatic zone – interior douglas fir, heavily forested watershed	
Summary:		
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1983

McLeese Lake

Location: 45 km N of Williams Lake
Size: 340.5 ha
Perimeter: 13.2 km
Elevation: 731.7 m
Ownership: 70% Private, 30% Crown
Other: North shore - community of McLeese Lake, South shore - agriculture, East Shore - agriculture, homes/cabins, West shore - homes/cabins

Lake Evaluation Summary

Trophic State:	borderline eutrophic/mesotrophic (chlorophyll *a* = 7.07 mg/m^3)	
Flushing Period:	15.7 years (low additional nutrient assimilation rating)	
Mean Depth:	16.3 m (high additional nutrient assimilation rating)	
Volume:	129.7 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	profile showing gradient and anoxia near the bottom
	pH	8.01 (2000 mean)
	[Nitrogen]$_{Total}$	0.48 mg/L
	[Phosphorus]$_{Total}$	0.031 mg/L
	Nitrogen:Phosphorus	15.5:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 4.10 m (year 2000 summer mean)
Watershed Characteristics:		
	Watershed Area = 10,830 ha Dam present on the South end of the lake at the stream outlet. Used for irrigation downstream of McLeese Lake Some logging and agricultural activity as well as lakeshore development	
Summary:	A borderline eutrophic/mesotrophic status is indicative of a transition period between the two trophic states. Combined with a long-flushing period and substantial development within the watershed, McLeese Lake shows only a low ability to assimilate additional nutrients; consequently, it is classified as highly sensitive to future land development.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Milburn Lake

Location: 16 km W of Quesnel
Size: 33.9 ha
Perimeter: 6.16 km
Elevation: 762.2 m
Ownership: 100% Private
Other: approximately 78% forested, 6.5% recently logged, 7% agricultural, 6% urban and 2% mining land

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.04 mg/m^3)	
Flushing Period:	0.7 years - numerous bays could result in shorter flushing period for the central waterbody and longer flushing periods for protected bays (high additional nutrient assimilation)	
Mean Depth:	7.6 m (moderate additional nutrient assimilation rating)	
Volume:	0.89 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	profile showing gradient and deficiency near the bottom
	pH	7.78 (2000 mean)
	$[Nitrogen]_{Total}$	0.48 mg/L
	$[Phosphorus]_{Total}$	0.022 mg/L
	Nitrogen:Phosphorus	24.0:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 3.61 m (summer mean 2000)
Watershed Characteristics:		
	Watershed Area = 2,413 ha 1 inlet and 2 outlets Biogeoclimatic zone - sub-boreal spruce	
Summary:	This mesotrophic basin has a moderate mean depth and appears to have a high flushing rate. However, longer retention of water within protected bays is possible and the overall basin would a experience greater assimilation of nutrients than that predicted by the flushing rate provided. Because of this factor and the high level of development on the surrounding lakeshore, Milburn Lake is vulnerable to additional nutrient inputs and rated as highly sensitive to future land development.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Mons Lake

Location: 100 km W of Williams Lake
Size: 134.8 ha
Perimeter: 8.961 km
Elevation: 1,128 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 4.13 mg/m^3)	
Flushing Period:	8.64 years (moderate additional nutrient assimilation rating)	
Mean Depth:	5.0 m (moderate additional nutrient assimilation rating)	
Volume:	6.74 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	well mixed @ SE Bay but stratified @ deepest Pt.
	pH	8.04 (1998 mean)
	[Nitrogen]$_{Total}$	0.46 mg/L
	[Phosphorus]$_{Total}$	0.018 mg/L
	Nitrogen:Phosphorus	25.6:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 4.53 m (1998 mean)
Watershed Characteristics:		
	Watershed Area = 8,053 ha	
Summary:	This mesotrophic basin has a moderate flushing period and a moderate mean depth. These characteristics predict some ability to assimilate additional nutrients without changing trophic state. Consequently, Mons is assigned a moderate sensitivity rating.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 2000

Morehead Lake

Location: 83 km NE of Williams Lake
Size: 240 ha
Perimeter: 10.9 km
Elevation: 916 m
Ownership: Private – 25%, Crown – 75%
Other: 8 resort cabins, 4 camper sites

Lake Evaluation Summary

Trophic State:	mesotrophic (computed chlorophyll *a* = 6.4 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	1 year (based on limited flow data)	
Mean Depth:	6.0 m	
Volume:	14.2 million m^3	
Water Quality Indicators:		
	TDS	76 mg/L
	Dissolved Oxygen	
	pH	7.8
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	16:1
	Water Clarity	Secchi depth = 1.3 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Forested – 100% Biogeoclimatic zone – sub-boreal spruce and interior cedar and hemlock	
Summary:	Mesotrophic state (possibly dystrophic), small lake, short flushing period, relatively shallow, low TDS.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Murphy Lake

Location: 67 km E of Williams Lake
Size: 1,000 ha
Perimeter: 30.5 km
Elevation: 865 m
Ownership: Private – 10%, Crown – 90%
Other:

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 5.0 mg/m^3, survey 1984 – MoE)	
Flushing Period:	5 years (based on limited flow data)	
Mean Depth:		
Volume:		
Water Quality Indicators:		
	TDS	113 mg/L
	Dissolved Oxygen	
	pH	8.2
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	22:1
	Water Clarity	Secchi depth = 2.5 m
Watershed Characteristics:		
	Watershed Area = Several inlets and 1 outlet Forested 100% Biogeoclimatic zone – sub-boreal spruce	
Summary:	mesotrophic state, moderate flushing period	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1984

Nimpo Lake

Location: 10 km SE of community of Anahim Lake
Size: 990 ha
Perimeter: 38.6 km
Elevation: 1,097 m
Ownership: 58.5% surveyed (either crown or private) and 41.5% crown
Other: 90% forested and remaining 10% is agricultural land, rangeland and land that has been logged

Lake Evaluation Summary

Trophic State:	slightly eutrophic - eutrophic (chlorophyll *a* = 9.09 mg/m^3)	
Flushing Period:	14.6 years (limited data) (low additional nutrient assimilation rating)	
Mean Depth:	11.9 m (moderate additional nutrient assimilation rating)	
Volume:	117.1 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	profile showing gradient and deficiency near the bottom
	pH	8.24 (2000 mean)
	$[Nitrogen]_{Total}$	0.44 mg/L
	$[Phosphorus]_{Total}$	0.040 mg/L
	Nitrogen:Phosphorus	11:1 (nitrogen and phosphorus limiting)
	Water Clarity	Secchi depth = 5.03 m (2000 mean)
Watershed Characteristics:		
	Watershed Area = 62,950 ha Heavily forested; gently sloping with some agriculture on surrounding lands Biogeoclimatic zone - Sub-boreal Spruce 6 major inlets and 1 outlet	
Summary:	Long flushing rate and moderate mean depth combined with agricultural activity along stream inlets indicate a low additional nutrient assimilation capability. As a result, the lake is classified as highly sensitive. Approximately 33% of shoreline has been has been developed for homes/cabins. Most dwellings have retained the natural shoreline and are situated approximately 50 - 150 m from shore.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

One-Eye Lake

Location: 261 km W of Williams Lake
Size: 4,800 ha
Perimeter: 15.7 km
Elevation: 914 m
Ownership: Private – 35%, Crown – 65%
Other:

Lake Evaluation Summary		
Trophic State:	likely oligotrophic	
Flushing Period:	likely relatively short	
Mean Depth:	7.6 m	
Volume:	36.6 million m^3	
Water Quality Indicators:		
	TDS	85 mg/L
	Dissolved Oxygen	
	pH	7.5
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 4.3 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet largely forested, some logging Biogeoclimatic zone – sub-boreal spruce	
Summary:		
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

108 Mile Lake

Location: 13 km N of 100 Mile House
Size: 119.4 ha
Perimeter: 6.949 km
Elevation: 1,006 m
Ownership: Not available - probably 100% private
Other: Golf course on East side of lake; 108 Mile Ranch on South end of lake. Approximately 44% forested, 37% logged, 16% urban and 3% recreational land

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 4.36 mg/m^3)	
Flushing Period:	greater than 25 years (may never be completely flushed) (low additional nutrient assimilation rating)	
Mean Depth:	7.3 m (moderate additional nutrient assimilation rating)	
Volume:	8.765 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	profile showing gradient and deficiency near the bottom
	pH	8.62 (2000 mean)
	$[Nitrogen]_{Total}$	1.41 mg/L
	$[Phosphorus]_{Total}$	0.019 mg/L
	Nitrogen:Phosphorus	74.2:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 4.69 m (2000 summer mean)
Watershed Characteristics:		
	Watershed Area = 3,323 ha Heavy residential and agricultural development 1 inlet and 1 outlet Biogeoclimatic zone - interior douglas fir Channel connecting to Sepa Lake	
Summary:	Although this mesotrophic basin has a moderate mean depth, its subsequent ability to assimilate additional nutrients without changing trophic status is counterbalanced by a long flushing period. This factor combined with heavy development within the watershed makes 108 Mile Lake vulnerable to additional nutrient inputs. As a result, this lake is considered highly sensitive to future land development.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Otter Lake

Location: 60 km E of 100 Mile House
Size: 53.18 ha
Perimeter: 5.029 km
Elevation: 1,158 m
Ownership:
Other: relatively little development on lake at present

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.9 mg/m^3)	
Flushing Period:	4.5 years (average additional nutrient assimilation rating)	
Mean Depth:	4.30 m (low additional nutrient assimilation rating)	
Volume:	2.278 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	spring overturn - stratification and considerable oxygen depletion at deep end, well mixed at west end. winter profile - major oxygen deficit at deep end, well mixed and moderate oxygen depletion at west end.
	pH	7.8
	$[Nitrogen]_{Total}$	0.436 mg/L (mesotrophic)
	$[Phosphorus]_{Total}$	0.026 mg/L
	Nitrogen:Phosphorus	16.8:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 3.9 m
Watershed Characteristics:		
	Watershed Area = 850 ha Small, gently sloping watershed with surrounding forests of interior douglas-fir. Lake is small and sheltered with large swamp at one end.	
Summary:	Small mesotrophic lake. West end of lake is very shallow with aquatic plant growth, especially along the shoreline.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Puntchesakut Lake

Location: 40 km W of Quesnel
Size: 2,200 ha
Perimeter: 7.5 km
Elevation: 914 m
Ownership: Private – 75%, Crown – 25%
Other: sparse cabins located around the lake, gently rolling terrain to lakeshore

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 3.9, measured Secchi = 4-4.25 m)	
Flushing Period:	likely quite long	
Mean Depth:	7.3 m	
Volume:	16.1 million m^3	
Water Quality Indicators:		
	TDS	108 mg/L
	Dissolved Oxygen	
	pH	7.75
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi = 2 m
Watershed Characteristics:		
	Watershed Area = 11,100 ha Considerable areas of rangeland/agriculture land – extensive logging in the surrounding forests Low-lying forests of sub-boreal spruce	
Summary:	Mesotrophic state, probable long flushing period, oxygen deficit, lower level, relatively small lake – therefore high sensitivity	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1983

Puntzi Lake

Location: 178 km W of Williams Lake
Size: 17,100 ha
Perimeter: 16.9 km
Elevation: 955 m
Ownership: Private – 35%, Crown – 65%
Other: 1 recreation site, several resorts, some cottages

Lake Evaluation Summary

Trophic State:	eutrophic (computed chlorophyll *a* = 15.1 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	156 years (based on limited flow data), outlet frequently has no flow	
Mean Depth:	22.8 m	
Volume:	389.5 million m^3	
Water Quality Indicators:		
	TDS	291 mg/L
	Dissolved Oxygen	
	pH	8.6
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	10:1
	Water Clarity	Secchi depth = 5.4 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Rangeland – 20%, forested – 80% Biogeoclimatic zone – interior douglas fir	
Summary:	Eutrophic state, extremely long flushing period, relatively deep, N:P ratio low, agricultural land use along inlet stream.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Quesnel Lake

Location: 95 km E of Williams Lake
Size:
Perimeter:
Elevation:
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	likely oligotrophic	
Flushing Period:		
Mean Depth:		
Volume:		
Water Quality Indicators:		
	Dissolved Oxygen	
	pH	
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area =	
Summary:	Large, deep lake, likely oligotrophic state, overall low sensitivity but potential for localized problems in littoral zone.	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Rail Lake

Location: 40 km NW of 100 Mile House
Size: 230 ha
Perimeter: 9.1 km
Elevation: 1,073 m
Ownership: Private – 40%, Crown – 60%
Other: Lake heavily utilized for fishing; north shore – cabins, forest; south shore – cabins, forest; east shore – forest; west shore –cabins, forest. Regular shoreline, surrounding lands slope gently to lake.

Lake Evaluation Summary

Trophic State:	oligotrophic (computed chlorophyll *a* = 1.4 mg/m^3)	
Flushing Period:	7.9 years	
Mean Depth:	6.1 m	
Volume:	14 million m^3	
Water Quality Indicators:		
	TDS	99 mg/L
	Dissolved Oxygen	
	pH	8.0
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 3.5 m
Watershed Characteristics:		
	Watershed Area = 2,020 ha Some logging activity – considerable lakeshore cabin development, some boggy areas on east and northeast shores of the lake, surrounded by thick forest of interior douglas fir.	
Summary:	Small lake, shallow, moderate flushing rate, oligotrophic state, small watershed with significant activity therefore high sensitivity	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1983

Roe Lake

Location: 50 km E of 100 Mile House
Size: 51.7 ha
Perimeter: 3.4 km
Elevation: 1,112 m
Ownership: Private – 100%
Other: 15 residences

Lake Evaluation Summary		
Trophic State:	mesotrophic (chlorophyll *a* = 5.2 mg/m^3)	
Flushing Period:	0.4 years (high additional nutrient assimilation rating)	
Mean Depth:	7.6 m (moderate additional nutrient assimilation rating)	
Volume:	3.943 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	8.17
	$[Nitrogen]_{Total}$	0.383 mg/L
	$[Phosphorus]_{Total}$	0.023 mg/L
	Nitrogen:Phosphorus	17.0:1
	Water Clarity	Secchi depth = 4.95 m
Watershed Characteristics:		
	Watershed Area = 16,030 ha	
Summary:	Mesotrophic state with relatively good capacity to assimilate additional nutrient. Developmental pressure fairly high.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Rose Lake

Location: 37 km E of Williams Lake
Size: 230 ha
Perimeter: 11.3 km
Elevation: 994 m
Ownership: Private – 80%, Crown – 20%
Other: very irregular shoreline, forest or grasslands down to lakeshore, some swampy shorelands. North shore – cottages; south shore – cottages and farming; east shore – forest; west shore – cottages and farming.

Lake Evaluation Summary

Trophic State:	slightly eutrophic (computed chlorophyll *a* = 7.5 mg/m^3)	
Flushing Period:	likely long flushing period	
Mean Depth:	6.1 m	
Volume:	14 million m^3	
Water Quality Indicators:		
	TDS	94-123 mg/L
	Dissolved Oxygen	Rapid oxygen deficit, stratified
	pH	7.4 – 7.9
	$[Nitrogen]_{Total}$	0.73 (1998)
	$[Phosphorus]_{Total}$	0.021 (1998)
	Nitrogen:Phosphorus	34.8:1 (P limiting)
	Water Clarity	Secchi depth = 2.25 m
Watershed Characteristics:		
	Watershed Area = 1,220 ha Intermittent spruce forests and grassland, considerable agricultural activity in immediate vicinity of the lake, cabins located mainly on west and north shores	
Summary:	Slightly eutrophic, small watershed with significant activity, shallow, likely long flushing period, therefore highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Ruth Lake

Location: 32 km NE of 100 Mile House
Size: 280 ha
Perimeter: 20.8 km
Elevation: 792 m
Ownership: Private – 50%, Crown – 50%
Other: very irregular shoreline

Lake Evaluation Summary		
Trophic State:	slightly eutrophic (computed chlorophyll *a* = 11.3 mg/m^3 – not into advanced trophic state)	
Flushing Period:	15.4 years	
Mean Depth:	7.3 m	
Volume:	20.7 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	oxygen deficient
	pH	
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = 4,070 ha Some logging and agricultural activity, extensive shoreland development	
Summary:	Long flushing period, eutrophic state, small watershed, shallow depth, therefore highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1983

Sapeye Lake

Location: 265 km W of Williams Lake
Size: 2,700 ha
Perimeter: 11.2 km
Elevation: 762 m
Ownership: Private – 10%, Crown – 90%
Other: Forest Service recreation site

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 5.5 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	> 3 years (based on limited flow data)	
Mean Depth:	9.3 m	
Volume:	25.4 million m^3	
Water Quality Indicators:		
	TDS	106 mg/L
	Dissolved Oxygen	
	pH	8.3
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	7:1
	Water Clarity	Secchi depth = 6.0 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Forested – 90%, residential - 10% Biogeoclimatic zone – interior douglas fir Small drainage area	
Summary:	Small lake, mesotrophic state, moderate flushing period, moderate depth, low TDS, N:P ratio indicates possible N limiting, small watershed	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Sepa Lake

Location: 13 km N of 100 Mile House
Size: 12.4 ha
Perimeter: 1.646 km
Elevation: 1,006 m
Ownership: 100% Private
Other: Golf course on East side; 108 Mile Ranch on West side of lake

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.04 mg/m^3)	
Flushing Period:	unknown because no outlet exists (low additional nutrient assimilation rating)	
Mean Depth:	2.3 m (low additional nutrient assimilation rating)	
Volume:	0.278 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	deficiency near the bottom at spring overturn 2000
	pH	8.5 (2000 mean)
	$[Nitrogen]_{Total}$	0.98 mg/L
	$[Phosphorus]_{Total}$	0.022 mg/L
	Nitrogen:Phosphorus	44.5:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 3.89 m (year 2000 summer mean)
Watershed Characteristics:		
	Watershed Area = 3,323 ha Extensive residential development including a resort and golf course Heavy agricultural development No inlets or outlets Biogeoclimatic zone - Interior Douglas Fir Channel connecting to 108 Mile Lake	
Summary:	Extensive development within the watershed makes Sepa Lake vulnerable to additional nutrient inputs. Lacking both an inlet and an outlet, this mesotrophic basin likely assimilates a very high proportion of nutrients added because of its inability to flush nutrients out. Compounded by a low mean depth, Sepa Lake's ability to assimilate additional nutrients without changing trophic is minimal and thus, this lake is highly sensitive to future land development.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Sheridan Lake

Location: 50 km E of 100 Mile House
Size: 1,659 ha
Perimeter: 39.6 km
Elevation: 1,115 m
Ownership: Private – 68%, Crown – 32%
Other: very irregular shoreline, heavily utilized for fishing

Lake Evaluation Summary		
Trophic State:	mesotrophic (chlorophyll *a* = 5.7 mg/m^3)	
Flushing Period:	24.9 years (low additional nutrient assimilation rating)	
Mean Depth:	7.32 m (moderate additional nutrient assimilation rating)	
Volume:	121 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	well mixed at spring overturn
	pH	8.5 (1992)
	$[Nitrogen]_{Total}$	0.754 mg/L (eutrophic)
	$[Phosphorus]_{Total}$	0.025 mg/L
	Nitrogen:Phosphorus	30.2:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 9.66 m
Watershed Characteristics:		
	Watershed Area = 8,100 ha Gentle rolling terrain with low levels of water entering and leaving the lake. Considerable logging and clearing, some agriculture, scattered lakeshore development – potential high impact on water quality.	
Summary:	Mesotrophic lake with very long flushing period. Relatively shallow depth. High sensitivity, particularly in localized areas.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Spanish Lake

Location: 115 km NE of Williams Lake
Size: 450 ha
Perimeter: 19.7 km
Elevation: 919 m
Ownership: Private – 5%, Crown – 95%
Other: 1 recreation site, 3 cottages

Lake Evaluation Summary		
Trophic State:	oligotrophic (computed chlorophyll *a* = 1.4 mg/m^3, survey 1984 – MoE)	
Flushing Period:	3 years (based on limited flow data)	
Mean Depth:	29.6 m	
Volume:	134.3 million m^3	
Water Quality Indicators:		
	TDS	65 mg/L
	Dissolved Oxygen	
	pH	7.7
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	35:1
	Water Clarity	Secchi depth = 4.1 m
Watershed Characteristics:		
	Watershed Area = 3 inlets and 1 outlet Extensive logging in surrounding area Biogeoclimatic zone – interior cedar and hemlock	
Summary:	Oligotrophic state, moderate flushing period, deep lake, low TDS, extensive logging activity.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1984

Spout Lake

Location: 54 km N of 100 Mile House
Size: 690 ha
Perimeter: 21.1 km
Elevation: 1,077 m
Ownership: Crown – 100%
Other: 1 commercial resort

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 4.4 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	6.8 years (based on limited flow data)	
Mean Depth:	5.5 m	
Volume:	37.2 million m^3	
Water Quality Indicators:		
	TDS	148 mg/L
	Dissolved Oxygen	
	pH	8.4
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	28:1
	Water Clarity	Secchi depth = 3.2 m
Watershed Characteristics:		
	Watershed Area = No inlets and 1 outlet Forested 100%, biogeoclimatic zone – sub-boreal spruce	
Summary:	mesotrophic state, moderate flushing period, shallow, small watershed	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Lower Stack Lake

Location: 58 km E of 100 Mile House
Size: 17.3 ha
Perimeter: 2.37 km
Elevation: 1,140 m
Ownership:
Other:

Lake Evaluation Summary		
Trophic State:	mesotrophic (chlorophyll *a* = 4.8 mg/m^3)	
Flushing Period:	0.2 years (high additional nutrient assimilation rating)	
Mean Depth:	5.1 m (moderate additional nutrient assimilation rating)	
Volume:	0.889 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	7.99
	$[Nitrogen]_{Total}$	0.312 mg/L
	$[Phosphorus]_{Total}$	0.021 mg/L
	Nitrogen:Phosphorus	14.7:1 (co-limitation or no limitation)
	Water Clarity	no Secchi depth readings taken
Watershed Characteristics:		
	Watershed Area = 8,590 ha	
Summary:	Small, mesotrophic lake that rates relatively good in its ability to buffer nutrient loading.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Middle Stack Lake

Location: 58 km E of 100 Mile House
Size: 13.1 ha
Perimeter: 1.92 km
Elevation: 1,140 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	borderline mesotrophic/eutrophic (chlorophyll *a* = 6.7 mg/m^3)	
Flushing Period:	0.1 years (high additional nutrient assimilation rating)	
Mean Depth:	4.2 m (low additional nutrient assimilation rating)	
Volume:	0.555 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	7.85
	$[Nitrogen]_{Total}$	0.355 mg/L
	$[Phosphorus]_{Total}$	0.029 mg/L
	Nitrogen:Phosphorus	12.2:1 (co-limitation or no limitation)
	Water Clarity	no Secchi depth readings taken
Watershed Characteristics:		
	Watershed Area = 8,490 ha	
Summary:	Small lake that is borderline mesotrophic/eutrophic. Very short flushing period allows for quick removal of nutrients. However the mean depth is quite low and partially counters the effect of the short flushing period. No significant pressure from development.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Stum Lake

Location: 149 km NW of Williams Lake
Size: 824.4 ha
Perimeter: 20.2 km
Elevation: 1,189 m
Ownership: Private 8%, Crown – 92%
Other: Designated as Provincial Park in 1971 to protect endangered population of pelicans.

Lake Evaluation Summary		
Trophic State:		
Flushing Period:		
Mean Depth:		
Volume:		
Water Quality Indicators:		
	TDS	205 mg/L
	Dissolved Oxygen	
	pH	8.6
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 1.5 m
Watershed Characteristics:		
	Watershed Area = 5 inlets and 1 outlet Forested 100% Biogeoclimatic zone – sub-boreal spruce	
Summary:	inadequate data	
Lake Sensitivity Rating:	N/A (protected)	

Date prepared: 1983

Sulphurous Lake

Location: 48 km E of 100 Mile House
Size: 380.8 ha
Perimeter: 14.2 km
Elevation: 2,944 m
Ownership: private - 38 %, crown - 62 %
Other: heavily concentrated development on north shore, one commercial resort.

Lake Evaluation Summary		
Trophic State:	oligotrophic (chlorophyll *a* = 2.8 mg/m^3)	
Flushing Period:	38.4 years (low additional nutrient assimilation rating)	
Mean Depth:	15.36 m (high additional nutrient assimilation rating)	
Volume:	58.4 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	spring overturn –stratification winter profile - slight oxygen depletion at greater depths
	pH	8.12
	$[Nitrogen]_{Total}$	0.339 mg/L (mesotrophic)
	$[Phosphorus]_{Total}$	0.012 mg/L
	Nitrogen:Phosphorus	28.2:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 8.66 m
Watershed Characteristics:		
	Watershed Area = 2,530 ha Small watershed with surrounding forests of interior douglas-fir. Outlet flows into Deka Lake. Concentrated development on north shore of lake.	
Summary:	Medium-sized, oligotrophic lake. Relatively high Secchi disk readings with low estimated chlorophyll *a* concentration. Potential for localized problems in concentrated development area.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Taseko Lakes

Location: 181 km SW of Williams Lake
Size: 30,700 ha
Perimeter:
Elevation: 1,368 m
Ownership: Crown – 100%
Other:

Lake Evaluation Summary		
Trophic State:		
Flushing Period:		
Mean Depth:	43.3 m	
Volume:	1330 million m^3	
Water Quality Indicators:		
	TDS	54 mg/L
	Dissolved Oxygen	
	pH	7.0
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	
Watershed Characteristics:		
	Watershed Area = 44 inlets and 1 outlet rangeland – 3%, forested – 97% biogeoclimatic zone – sub-boreal spruce	
Summary:	Probably low sensitivity – based on limited data	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Tatla Lake

Location: 205 km W of Williams Lake
Size: 1,770 ha
Perimeter: 56 km
Elevation: 999.7 m
Ownership: 49% surveyed (either private or crown) and 51% crown
Other: 94% forested and remaining 16% comprised of agricultural land, range land and land that has been logged.

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 5.49 mg/m^3)	
Flushing Period:	20.3 yr (limited data) (low additional nutrient assimilation rating)	
Mean Depth:	10.4 m (moderate additional nutrient assimilation rating)	
Volume:	186.7 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	well mixed at Spring overturn 2000
	pH	8.61 (2000 mean)
	$[Nitrogen]_{Total}$	0.77 mg/L
	$[Phosphorus]_{Total}$	0.024 mg/L
	Nitrogen:Phosphorus	32.1:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 4.81 m (Spring overturn 2000)
Watershed Characteristics:		
	Watershed Area = 58,300 ha 1 outlet and approximately 10 inlets 150 ac ft (185,022 m^3) is licensed and approximately 650 ac ft (801,763 m^3) is in the application process to be diverted from the Klinaklini River for irrigation. Diverted water may be backflooded onto the land and then flow into Tatla Lake. Biogeoclimatic zone - interior douglas fir	
Summary:	Water quality conditions do not appear to have changed for the period 1987 - 2000. High volume allows for increased dilution of nutrients but is counterbalanced by a long flushing period and moderate mean depth. Consequently, this mesotrophic basin rates moderate in its ability to buffer nutrient loading. Additional nutrient loading may result from diversion of water from the Klinaklini River into Tatla Lake. This factor increases the basin's vulnerability, and therefore the lake is classified as highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 2000

Tatlayoko Lake

Location: 274 km SW of Williams Lake
Size: 39,500 ha
Perimeter: 53.3 km
Elevation: 827 m
Ownership: Private – 10%, Crown – 90%
Other: 20 recreational sites

Lake Evaluation Summary		
Trophic State:	oligotrophic	
Flushing Period:		
Mean Depth:	106 m	
Volume:	4,189 million m^3	
Water Quality Indicators:		
	TDS	220 mg/L
	Dissolved Oxygen	
	pH	7.9
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 4.9 m
Watershed Characteristics:		
	Watershed Area = 3 inlets and 1 outlet Forested – 95%, residential – 5% Biogeoclimatic zone – interior douglas fir	
Summary:	Large, deep, cold, non-productive lake	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1983

Ten Mile Lake

Location: 11 km N of Quesnel
Size: 242.9 ha
Perimeter: 7.35 km
Elevation: 762 m
Ownership: 51% crown (26% provincial park) and 49% private
Other: heavy residential development on Northwest and Southeast ends; provincial parks on Northwest and Southwest ends; approximately 142 campsites

Lake Evaluation Summary

Trophic State:	mesotrophic (chlorophyll *a* = 4.59 mg/m^3)	
Flushing Period:	3.0 years (average additional nutrient assimilation rating)	
Mean Depth:	8.0 m (moderate additional nutrient assimilation rating)	
Volume:	19.5 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	very well mixed
	pH	7.68 (2000 mean)
	$[Nitrogen]_{Total}$	0.53 mg/L
	$[Phosphorus]_{Total}$	0.020 mg/L
	Nitrogen:Phosphorus	26.5:1 (phosphorus limiting)
	Water Clarity	Secchi 5.30 m (summer mean 2000)
Watershed Characteristics:		
	Watershed Area = 4,920 ha No inlets and 1 outlet Spruce forest Extensive land clearing - several farming operations, minimal logging and extensive residential development	
Summary:	The watershed of 10 Mile Lake has undergone considerable development. This mesotrophic basin is therefore vulnerable to additional nutrient inputs. 10 Mile Lake has some ability to assimilate additional nutrients without changing trophic status because of the basin's reasonable flushing rate and moderate mean depth. With these factors considered, 10 Mile Lake is rated as having moderate sensitivity to future land development.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 2000

Till Lake

Location: 32 km W of Williams Lake
Size: 78.5 ha
Perimeter: 7.096 km
Elevation: 963.2 m
Ownership:
Other:

Lake Evaluation Summary		
Trophic State:	mesotrophic (chlorophyll *a* = 4.59 mg/m^3)	
Flushing Period:	EXTREMELY LONG (low additional nutrient assimilation rating)	
Mean Depth:	7.8 m (moderate additional nutrient assimilation rating)	
Volume:	61.49 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified
	pH	8.99
	[Nitrogen]$_{Total}$	1.09 mg/L
	[Phosphorus]$_{Total}$	0.020 mg/L
	Nitrogen:Phosphorus	54.5: 1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.54
Watershed Characteristics:		
	Watershed Area = 2,353 ha	
Summary:	Mesotrophic state, very infrequent outflow	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Timothy Lake

Location: 45 km N of 100 Mile House
Size: 440 ha
Perimeter: 17.7 km
Elevation: 905 m
Ownership: Private – 40%, Crown – 60%
Other: 52 lots, 14 cottages, 3 commercial resorts

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 4.1 mg/m^3 – survey May 1984 – MoE)	
Flushing Period:	10.3 years (from USL report)	
Mean Depth:	13.5 m	
Volume:	59.9 million m^3	
Water Quality Indicators:		
	TDS	147 mg/L
	Dissolved Oxygen	
	pH	8.1
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	17:1
	Water Clarity	Secchi depth = 2.6 m
Watershed Characteristics:		
	Watershed Area = 4 inlets and 1 outlet Biogeoclimatic zone – sub-boreal spruce Shoreline: forested – 75%, residential – 20%, agricultural – 5%	
Summary:	Mesotrophic state, long flushing period, moderate depth, agricultural land use along major inlet stream	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Tyee Lake

Location: 43 km N of Williams Lake
Size: 410 ha
Perimeter: 17.6 km
Elevation: 914 m
Ownership: Private – 30%, Crown – 70%
Other: 6 resort cabins, 26 camper sites, 8 recreation sites

Lake Evaluation Summary		
Trophic State:	mesotrophic (computed chlorophyll *a* = 5.3 mg/m^3, survey Apr 1984 – MoE)	
Flushing Period:	13.2 years (from limited flow data)	
Mean Depth:	19.5 m	
Volume:	80 million m^3	
Water Quality Indicators:		
	TDS	184 mg/L
	Dissolved Oxygen	
	pH	8.3
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	13:1
	Water Clarity	Secchi depth = 4.8 m
Watershed Characteristics:		
	Watershed Area = small 2 inlets and 1 outlet Shoreline: forested – 95%, residential – 5% Biogeoclimatic zone – sub-boreal spruce	
Summary:	Mesotrophic state, long flushing period, relatively deep, small watershed.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Watch Lake

Location: 35 km SE of 100 Mile House
Size: 260 ha
Perimeter: 14.6 km
Elevation: 1,128 m
Ownership: Private – 70%, Crown – 30%
Other:

Lake Evaluation Summary		
Trophic State:	eutrophic (computed chlorophyll *a* = 13.6 mg/m^3)	
Flushing Period:	>7 years (based on limited flow data)	
Mean Depth:	4.3 m	
Volume:	11.2 million m^3	
Water Quality Indicators:		
	TDS	85 mg/L
	Dissolved Oxygen	
	pH	7.9
	[Nitrogen]$_{Total}$	
	[Phosphorus]$_{Total}$	
	Nitrogen:Phosphorus	
	Water Clarity	Secchi depth = 4.5 – 6.25 m
Watershed Characteristics:		
	Watershed Area = 5,180 ha Gently rising hills of interior douglas fir from the lakeshore; considerable agricultural activity; considerable agricultural activity; extensive cottage development; west 1/3 of lake: moderate logging/clearing; some poorly drained surrounding land.	
Summary:	Low TDS, moderate flushing period. Shallow, small watershed with activity, and slightly eutrophic, therefore considered to be highly sensitive.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1984

Watson Lake

Location: 8 km N of 100 Mile House
Size: 130 ha
Perimeter: 6.6 km
Elevation: 975 m
Ownership: not available (probably 100% private)
Other:

Lake Evaluation Summary

Trophic State:	mesotrophic (computed chlorophyll *a* = 6.2 mg/m^3, survey May 1984 – MoE)	
Flushing Period:	8 years (based on limited flow data)	
Mean Depth:		
Volume:		
Water Quality Indicators:		
	TDS	972 mg/L
	Dissolved Oxygen	
	pH	9.2
	$[Nitrogen]_{Total}$	
	$[Phosphorus]_{Total}$	
	Nitrogen:Phosphorus	62:1
	Water Clarity	Secchi depth = > 3.5 m
Watershed Characteristics:		
	Watershed Area = 1 inlet and 1 outlet Heavy residential and some agricultural activity Biogeoclimatic zone – interior douglas fir	
Summary:	Small lake, mesotrophic state, moderate flushing period with possible short-circuiting, probably shallow, very high TDS, heavy residential and agricultural activity, small watershed	
Lake Sensitivity Rating:	Low sensitivity	

Date prepared: 1984

Wavey Lake

Location: 66 km E of 100 Mile House
Size: 86.6 ha
Perimeter: 5.42 km
Elevation: 1,200 m
Ownership:
Other:

Lake Evaluation Summary

Trophic State:	strongly eutrophic (chlorophyll *a* = 11.1 mg/m^3)	
Flushing Period:	7.8 years (average additional nutrient assimilation rating)	
Mean Depth:	10.8 m (moderate additional nutrient assimilation rating)	
Volume:	9.37 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	7.92
	[Nitrogen]$_{Total}$	0.403 mg/L
	[Phosphorus]$_{Total}$	0.049 mg/L
	Nitrogen:Phosphorus	8.3:1 (co-limitation or no limitation)
	Water Clarity	no Secchi depth readings taken
Watershed Characteristics:		
	Watershed Area = 1,990 ha	
Summary:	Strongly eutrophic lake with slightly above average capacity to assimilate additional nutrients	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

Webb Lake

Location: 56 km E of 100 Mile House
Size: 80.4 ha
Perimeter: 8.7 km
Elevation: 1,150 m
Ownership:
Other: 8 residences

Lake Evaluation Summary

Trophic State:	strongly eutrophic (chlorophyll *a* = 11.1 mg/m^3)	
Flushing Period:	4.4 years (average additional nutrient assimilation rating)	
Mean Depth:	1.8 m (low additional nutrient assimilation rating)	
Volume:	1.485 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	well mixed
	pH	8.12
	[Nitrogen]$_{Total}$	0.69 mg/L
	[Phosphorus]$_{Total}$	0.049 mg/L
	Nitrogen:Phosphorus	14.1:1 (co-limitation or no limitation)
	Water Clarity	Secchi depth = 2.49 m
Watershed Characteristics:		
	Watershed Area = 560 ha	
Summary:	Small, strongly eutrophic lake that rates fair in its ability to assimilate additional nutrients. Exhibits some marsh-like characteristics and has a large number of macrophytes. Low clarity consistent with trophic state.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 1998

West Twin Lake

Location: 60 km E of 100 Mile House
Size: 19.34 ha
Perimeter: 2.28 km
Elevation: 1,193 m
Ownership:
Other:

Lake Evaluation Summary		
Trophic State:	strongly eutrophic (chlorophyll *a* = 12.4 mg/m^3)	
Flushing Period:	4.5 years (average additional nutrient assimilation rating)	
Mean Depth:	2.4 m (low additional nutrient assimilation rating)	
Volume:	0.464 million m^3	
Water Quality Indicators:		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom.
	pH	8.48
	$[Nitrogen]_{Total}$	1.4 mg/L
	$[Phosphorus]_{Total}$	0.055 mg/L
	Nitrogen:Phosphorus	25.6:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.10 m
Watershed Characteristics:		
	Watershed Area = 170 ha	
Summary:	Small, eutrophic lake that rates fair in its ability to buffer nutrient loading. Low clarity coincides with trophic state.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 2000

Whitley Lake

Location: 64 km E of 100 Mile House
Size: 34.3 ha
Perimeter: 4.25 km
Elevation: 1,187 m
Ownership:
Other:

Lake Evaluation Summary		
Trophic State:	strongly eutrophic (chlorophyll *a* = 12.0 mg/m^3)	
Flushing Period:	3.2 years (average additional nutrient assimilation rating)	
Mean Depth:	3.1 m (low additional nutrient assimilation rating)	
Volume:	1.077 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	stratified profile showing deficiency near the bottom
	pH	8.71 (1997 mean)
	$[Nitrogen]_{Total}$	1.1 mg/L
	$[Phosphorus]_{Total}$	0.053 mg/L
	Nitrogen:Phosphorus	20.8:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 1.17 m (1997), 2.26 m (1998), 1.73 m (1999) & 2.34 m (2000) (summer means)
Watershed Characteristics:		
	Watershed Area = 630 ha	
Summary:	Small, eutrophic lake with some ability to assimilate additional nutrients. Clarity very low and coincides with trophic state.	
Lake Sensitivity Rating:	Moderate sensitivity	

Date prepared: 2000

Williams Lake

Location: 2 km E of Williams Lake
Size: 723 ha
Perimeter: 19.1 km
Elevation: 562 m
Ownership: Private - 90%, Reserve - 10%
Other: extensive development on perimeter of lake

Lake Evaluation Summary

Trophic State:	highly eutrophic (chlorophyll *a* = 9.9 mg/m^3; Summer, 1998)	
Flushing Period:	1.5 years (high additional nutrient assimilation rating)	
Mean Depth:	12.2 m (moderate additional nutrient assimilation rating)	
Volume:	88.2 million m^3	
Water Quality Indicators: data is from spring overturn unless otherwise stated		
	Dissolved Oxygen	fairly well mixed but very bottom is oxygen deficient
	pH	8.31 (1998 mean)
	$[Nitrogen]_{Total}$	0.82 mg/L
	$[Phosphorus]_{Total}$	0.044 mg/L
	Nitrogen:Phosphorus	18.6:1 (phosphorus limiting)
	Water Clarity	Secchi depth = 2.29 m (1998), 2.58 m (1999)
Watershed Characteristics:		
	Watershed Area = 224,000 ha 1 outlet and inlet Biogeoclimatic zone - interior douglas fir Watershed activities include cattle ranching, some logging There is extensive residential development on the north and south slopes of the lake.	
Summary:	Due to severe water quality problems, the MOE Lake Classification Committee (Cariboo) considers this lake highly sensitive, requiring stringent nutrient management to reverse its trophic status from eutrophic to mesotrophic in keeping with MOE Water Quality Objectives set for this lake in December of 1987.	
Lake Sensitivity Rating:	High sensitivity	

Date prepared: 1998

Appendix III – Lake Monitoring and Flushing Rate Procedures

A. Lake Monitoring

The following procedure has been adapted from the *Ambient Fresh Water and Effluent Sampling Manual* (Province of BC, 1997). These protocols are designed to complement the overall procedure outlined in Section 6.3 with specific, detailed steps. They are specific to sampling a lake for the development of a Water Quality Sensitivity Rating for the CRD Lakeshore Management Policy, and may not be adequate for other purposes.

Sampling from a Boat

The collection of deep water samples requires that at least one member of the sampling group be very familiar with boat operation and safety. If the sampling trip involves the use of a boat, then the weather forecast should be obtained prior to departure from home. If conditions are poor, then the sampling trip should be postponed**. In the early spring in the Cariboo, lake water temperatures are very cold, and gusting winds are common.**

Site Identification

Deep water sampling sites should be referenced by easily identifiable features (preferably two) on shore. Reference points should be described (both in writing and with photographs) in a site identification log book and if possible a GPS used. Once at the site, and if it is not too deep, anchor the boat (or tie it to the buoy) and wait until it settles with the bow (front) facing into the wind before collecting the sample. If the water is too deep to anchor, then one person will have to maintain the location (with either the motor or with paddles) while the other person collects the samples and takes the field measurements.

Surface Water Sampling Protocol

a) The person at the bow (front) should always collect the samples. This is because the bow is the anchor point and this precaution reduces the potential for contamination from the boat or motor. The person in the stern (rear) can be responsible for holding the boat's position (when not anchored), taking the field measurements and field notes. Contamination is not as much of a concern for field measurements.
b) Obtain a labelled sample bottle and remove the lid without touching the inside of the lid (or bottle!). If rinsing is required for the type of bottle, fill and rinse three times.
c) Reach out an arm length from the boat to take the sample. Ensure that the person in the stern is providing counterbalance (working over the opposite side of the boat).
d) Plunge the bottle under the surface and move it slowly towards the direction the boat is facing. This should be done at a depth of approximately 0.5 meters.
e) Recap the bottle immediately and proceed with the next sample.

Deep Water Sampling

Lake water samples may be collected from any desired depth through the use of a Van Dorn (or similar) sampler (Figure 1). The Van Dorn bottle is designed for sampling at a depth of 2 metres or greater. A drain valve is provided for sample removal. Note that Van Dorn samplers are available in both horizontal and vertical configurations. The advantage of the vertical configuration is that the water within the open bottle is flushed out as the bottle is lowered, so one can be guaranteed the water collected was collected from the indicated depth. The advantage of the horizontal configuration is that a very narrow depth range is sampled. Vertical configurations are most commonly used. The horizontal configuration should be used when samples are taken near bottom at the sediment-water interface, or when samples are required from a narrow band of the depth profile (i.e., chemocline, thermocline).

The sampling sequence recommended is to obtain the field measurements first (temperature, DO, conductivity). These are often necessary prerequisite for locating the locations and depths from which the water samples should be taken (i.e. if three deep samples are required at a site then it might be necessary to know the depths of potential temperature and dissolved oxygen concentrations.

Although operation of the Van Dorn bottle varies slightly depending on its size and style, the basic procedure is the same.

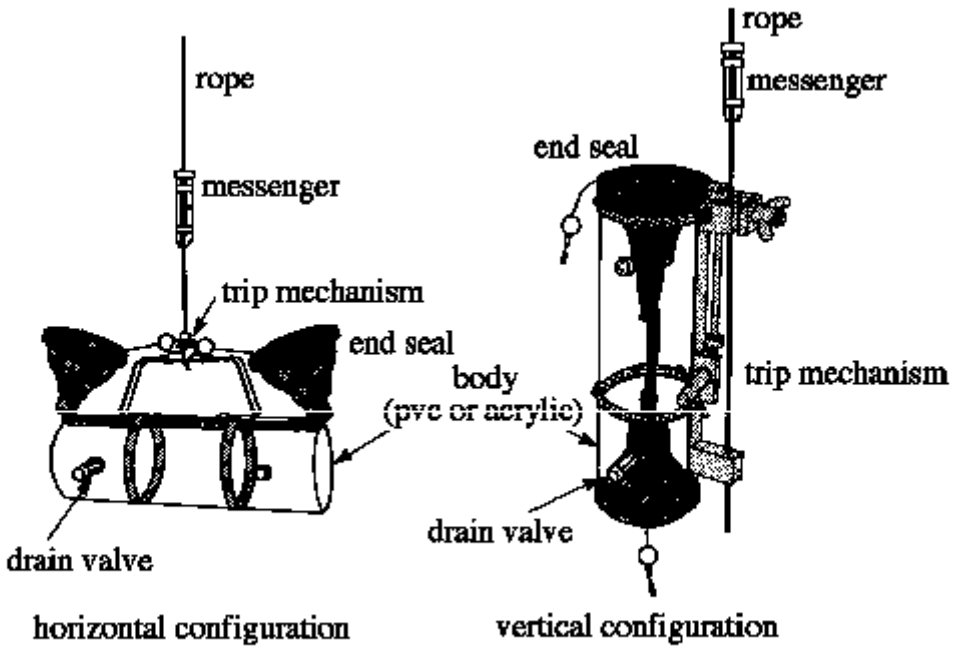

Figure 1. Van Dorn sampler

Deep Water Sampling Protocol

a) Ensure the sampling bottle is clean.
b) Open the sampler by raising the end seals.
c) Set the trip mechanism.
d) Lower the sampler to the desired depth.
e) Send the messenger down to "trip" the mechanism that closes the end seals.
f) Raise the sampler to the surface.
g) Transfer the water sample from the Van Dorn bottle to individual sample containers via the drain valve. Take care to avoid contact with the drain spout as contamination at this stage often occurs.
h) Rinse bottles 3 times **(if not pre-cleaned by the laboratory)**

Field Quality Assurance

The field quality assurance program is a systematic process which, together with the laboratory and data storage quality assurance programs, ensures a specified degree of confidence in the data collected. The field quality assurance program involves a series of steps, procedures and practices which are described below.

The quality of data generated in a laboratory depends, to a large degree, on the integrity of the samples that arrive at the laboratory. Consequently, the field investigator must take the necessary precautions to protect samples from contamination and deterioration. There are many sources of contamination, and following are some basic precautions.

- Field measurements should always be made using a separate sub-sample which is then discarded once the measurements have been made. They should never be made on a water sample which is returned to the analytical laboratory for further chemical analyses. For example, specific conductance should never be measured in sample water that was first used for pH measurements. Potassium chloride diffusing from the pH probe alters the conductivity of the sample. Similarly, pH should not be measured from a sample that will be analyzed for phosphorus, as some pH buffers contain phosphorus. Use a separate bottle for water temperature if not in-situ. Dissolved oxygen measurements (by DO probe) should be made in-situ rather than in a separate container.

- Sample bottles, including bottle caps, must be cleaned according to the recommended methods and certified by the issuing laboratory as `contamination free' (if pre-cleaned by the laboratory), for the intended analysis. Sample bottles which are pre-cleaned by the laboratory must not be rinsed with the sample water being collected. Bottles must be supplied with cap in place. Use only the recommended type of sample bottle for each analysis. Pre-cleaned bottles are recommended.

- The inner portion of sample bottles and caps must not be touched with anything (e.g., bare hands, gloves, thermometers, probes, preservative dispensers, etc.) other than the sample water. Remove caps only just before sampling and re-cap right away.

- Keep sample bottles in a clean environment, away from dust, dirt, fumes and grime. Bottles must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample. Vehicle cleanliness is an important factor in eliminating contamination problems. During sample collection, store bottle caps in a clean, resealable plastic bag, not in pockets, etc.

- Petroleum products (gasoline, oil, exhaust fumes) are prime sources of contamination. Spills or drippings (which are apt to occur in boats) must be removed immediately.

- Samples must never be permitted to get warm; they should be stored in a cool, dark place. Coolers packed with ice packs are recommended (most samples must be cooled to 4°C during transit to the laboratory). Conversely, samples must not be permitted to freeze. Cool samples as quickly as possible. A common mistake is to forget that a large volume of warm water soon melts a small amount of ice.

- Samples must be shipped to the laboratory without delay so that they arrive within 24 hours of sampling. Nitrogen and phosphorus analyses must be conducted within 72 hours.

- Sample collectors should keep their hands clean and refrain from eating or smoking while working with water samples.

Quality Control

Quality control is an essential element of a field quality assurance program. In addition to standardized field procedures, field quality control requires the submission of blank samples to test: 1) to check for contamination of sample containers, or any other equipment that is used in sample collection, handling or transportation; and 2) to detect other systematic and random errors occurring from the time of the sampling to the time of analysis. Replicate samples must also be collected to check that the sample is reproducible. Replicate samples allow the precision of the sampling and measurement process to be estimated, and are an additional check on sample contamination.

Blanks

Blanks are samples that do not contain the variable to be analyzed and are used to assess and control sample contamination. They are most often used to assess contamination of the trace measurements (metals and nutrients) but should also be used on occasion to test potential contamination of the other analyses (such as general ions). Most blanks are carried through the entire sample collection and handling process so that the blank is exposed to the same potential sources of contamination as actual samples. Ideally, blanks should be prepared by the analytical laboratory in the appropriate sample bottles under clean conditions. Some of the blanks remain in the laboratory for analysis (laboratory blanks), while the remainder travel to the field for use as trip, field, equipment, and filtration blanks. Alternatively, blanks may be prepared in the field as outlined below.

Trip Blank Protocol

Trip blanks are meant to detect any widespread contamination resulting from the container (including caps) and preservative during transport and storage.

a) Prior to a field sampling trip, one or more sample bottles being used during the trip are selected at random, filled with de-ionized water that is provided by an analytical lab and handled in the field in the same manner as field samples.

b) These bottles are capped and remain unopened throughout the sampling trip. They are transported to the field with the regular sample bottles and submitted with the field samples for the analysis of interest.

Field Blank Protocol

Field blanks mimic the extra sampling and preservative process but do not come in contact with ambient water. Field blanks are exposed to the sampling environment at the sample site. Consequently, they provide information on contamination resulting from the handling technique and through exposure to the atmosphere. They are processed in the same manner as the associate samples (i.e., they are exposed to all the same potential sources of contamination as the sample). This includes handling and, in some cases, filtration and/or preservation.

a) If the blank was prepared by the lab, then open the bottle to expose the de-ionized water to the air for as long as the sample was exposed when it was collected. Otherwise, when the blank is prepared in the field, pour de-ionized water into the pre-labelled field blank bottle and recap it (this simulates sample collection). Document whether it was a lab prepared or a field prepared blank.

b) Ship to the lab with the remaining samples.

Equipment Blank Protocol (prepared prior to the field trip)

A field equipment blank is a sample of de-ionized water that has been used to rinse sampling equipment. This blank (perhaps more properly described as a rinsate) is useful in documenting adequate decontamination of equipment. It is collected after completion of the decontamination process (washing) and prior to sampling.

a) Pour the rinse (de-ionized) water that was used for the last rinsing into a pre-labelled bottle that identifies the piece of equipment that was cleaned.

b) Submit the blank with the regular samples for analysis.

Replicate Samples

Co-located samples i.e. same depth for lakes, are independent samples collected as close as possible to the same point in space and time and are intended to be identical. These samples are essential in documenting the precision of the entire sampling and analytical (laboratory) process.

For this procedure, simply follow (and repeat) the sample collection protocol.

Samples/Laboratory Analyses

For the purpose of developing a Water Quality Sensitivity Rating, the following analyses are required: Total Nitrogen, Total Phosphorus, Total Dissolved Phosphorus. It is recommended that the following be done; 1 lake replicate, 1 equipment blank, 1 trip blank.

The number of locations and depths sampled will vary according to lake size and depth, and will have to be ascertained by the consultant.

Shipping

The day's sampling schedule must be designed to ensure that the samples arrive at the shipping agency's terminal well before the end of business hours. Since some variables have very limited hold times so every effort must be made to avoid delays in shipping. The following is the procedure to be followed to maintain the integrity of the samples during transit.

Note: Ice packs should be used as opposed to loose ice or bagged ice. When loose ice melts, the contents of the cooler are free to shift, potentially allowing contamination of samples with melted ice water and/or breakage of glass bottles.

a) Pack the samples upright in the cooler with at least 1 (winter) to 2 (spring, summer, fall) times as much ice as the total volume of the samples. Ensure that the samples that are most likely to deteriorate are closest to the ice packs (i.e., those that are not chemically preserved). Also, ensure that the glass bottles are separated from each other by ice packs, plastic bottles, or clean packing material to prevent them from shifting, falling over and/or breaking.

b) Complete the laboratory requisition forms, enclose them in a sealed plastic bag, and then tape them to the inside lid of the cooler or place them in the cooler on top of the samples. The recommended minimum information that should accompany samples to the laboratory (on each requisition form) includes:
   - Name of the source
   - Site name
   - Date and time of collection
   - Name of collector
   - Field measurements
   - Comments on sample appearance, weather conditions, and any other observations that may assist in interpreting water quality data

Additionally, a request should be made to the laboratory that they record the time and temperature of the samples at arrival (whenever samples requiring preservation by cooling to 4°C are shipped).

c) Seal the cooler with heavy duty packing tape to reduce the possibility of it accidentally opening and to prevent tampering with the samples. Coolers arriving at the laboratory with torn or absent tape alert the lab staff that tampering might have occurred during transit.

d) Attach a label prominently displaying the destination.

Note: If data on temperature on arrival is requested (to document that samples arrived at the laboratory at proper temperatures), a separate labelled bottle with water in it should be shipped in each cooler.

Field Check List

Field measurements required are: Temperature and Dissolved Oxygen Profiles and Secchi Disk depth; Conductivity and pH are optional.

Labelled Sample Bottles____

Log Books____ Pencils____

Cooler (with ice packs)____ Felt Markers (waterproof)____

Rope____ Tape____

Camera (film)____ Requisition forms____

Way bills____ Shipping labels____

De-ionized water (4L)____ Squirt bottle ____ maps____

Thermometer____ DO/Temperature meter with long probe____

pH meter____ Conductivity meter____(optional)

Secchi disc____

Van Dorn, rope____

Boat Equipment:

Boat/ Paddles____

Motor____ Fuel____

Life jackets____ Rope____

Map (topographical and bathymetric___

Lake Field Form

Date _____

Time _____

Weather _____

Air temperature _____

Field Measurements:

Secchi depth _____

Depth (m)	Temp		D.O.		pH	Conductivity
	down	up	down	up		
0						
2						
4						
6						
8						
10						
12						
14						
16						
18						
20						
22						
24						
26						
28						
30						

B. Flushing Rate Calculations

Needs precipitation data or hydrologic zone data.

Flushing Period is defined as Lake Volume ÷ Outflow Volume and can be obtained a number of ways. The most straight forward method is when there is flow data available on the inlet or outlet stream as is the case with Horse Lake. The following examples are taken from the Ministry of Water, Land, and Air Protection report *Cariboo Region Lake Water Quality 1998-99 (* O'Keeffe et.al., 2000). Flow data may be obtained from Ministry of Sustainable Resource Management.

Example 1) Flow data available on lake inlet or outlet

Horse Lake Flushing Period Calculations:

The flushing period for Horse Lake is given by

$F = (V_L - V_P) / D$

where F, V_L, V_P, and D represent flushing period, lake volume, volume of permitted withdrawals, and volume discharged per year, respectively.

D = 1.584 $m^3 s^{-1}$ 5 (60 s / 1 min) 5 (60 min / 1 hr) 5 (24 hr / 1 day)
5 (365 days / 1 yr)
= 4.995 510^7 $m^3 yr^{-1}$

F = (174,600,000 m^3 - 284,454 m^3) / 4.995 510^7 $m^3 yr^{-1}$
= 3.490 yr
≅ 3.5 yr

Example 2) Flow station available in immediate vicinity i.e. same hydrologic zone

Burn Lake Flushing Period Calculations:

This lake was arbitrarily chosen to illustrate how flushing periods can be calculated for lakes that do not have a flow station as does Horse Lake. Since Horse Lake is close to Burn Lake and therefore is in a similar geographical area and experiences similar precipitation, it is reasonable to use its flow rate to predict flow rates for other lakes in the area. This is done by dividing the flow rate of Horse Lake by its watershed area and then by multiplying by the watershed area of the lake who's flow rate is in question.

$\text{flow rate}_{\text{Horse Lake}}$ / $\text{watershed area}_{\text{Horse Lake}}$
= 4.995 510^7 $m^3 yr^{-1}$ / 83,000 ha
= 601.8 $m^3 yr^{-1} ha^{-1}$

flow rate$_{\text{Burn Lake}}$
= (flow rate$_{\text{Horse Lake}}$ / watershed area$_{\text{Horse Lake}}$) 5 watershed area$_{\text{Burn Lake}}$
= 601.8 $m^3yr^{-1}ha^{-1}$ 5 310 ha
= 1.866 5 10^5 m^3yr^{-1}

The flushing period for Burn Lake is given by

$F = V_L / D$

where F, V_L, and D represent flushing period, lake volume, and volume discharged per year (flow rate), respectively.

F = 874,543 m^3 / 1.866 5 10^5 m^3yr^{-1}
= 4.687 yr
≅ 4.7 yr

Example 3) Lakes without flow stations in the immediate vicinity i.e. same hydrologic zone

Mons Lake Flushing rate Calculation

Flow rates were obtained for the nearest hydrometric station to the lake in question and, correcting for differences in drainage area or watershed area, the approximate flow rate for the lake was determined.

A representative hydrometric station with similar precipitation and mean annual temperatures was used. (08MB011: Puntzi Cr. above Puntzi Lake) near Mons Lake had a mean annual flow rate of *0.156 m^3/sec (1988-1997). The drainage area for this hydrometric station is 508 km^2, and the watershed area for Mons Lake is 80.529 km^2.

0.156m^3/s * 365 days/yr * 24hr/day * 3600 sec/hr = 4,919,616 m^3/yr

4,919,616 m^3/yr ÷ 508 km^2 = 9684.28 m^3/km^2•yr

The approximate flow rate of Mons Lake is therefore:
9684.28 m^3/km^2 * 80.528 km^2 = 779,855.98 m^3/yr

And the flushing period of the lake is:
6,740,000 m^3 (volume of Mons Lake) ÷779,855.95 m^3/yr = 8.64 years.

These calculations can be done by the consultant retained to develop the Water Quality Sensitivity Rating.

*These numbers were taken from Dong, C. 1998. *Cariboo Region Streamflow Estimation (Draft)* Minstry of Environment, Lands and Parks. Williams Lake, B.C.