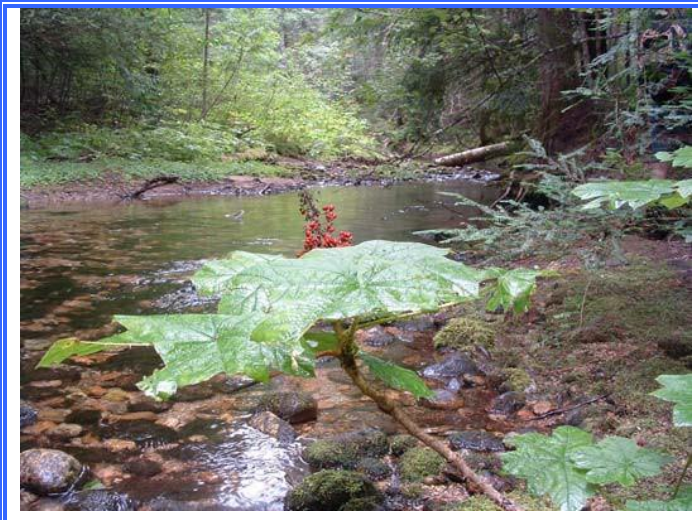
CHRISTINA LAKE MANAGEMENT PLAN

"A Community Watershed-Based Plan"




Prepared for:
The Christina Lake Stewardship Society

Prepared by:
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and
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Christina Lake, British Columbia
August 2005

AUTHORS' BIOGRAPHIES

Brenda LaCroix

Prior to moving to the Christina Lake area in 1994, Brenda LaCroix worked for the Federal Department of Fisheries and Oceans, at the Institute of Ocean Sciences in the Ocean Environment and Fisheries section as Office Manager. This research team focused on the "Base of the Food Web" benthic and pelagic communities including marine biotoxins.

After a brief trip to the Boundary region in 1993, on her way to the Yukon and Alaska, Brenda fell in love with the Christina Lake area and immediately purchased property in the community. She left her position with the Federal Department of Fisheries and Oceans in 1994 after almost a decade of public service and with great anticipation and excitement embarked on a new path in her life and career.

Once settled into the region, Brenda was employed by the Provincial Ministry of Forests as a Forestry Technician in the Timber and Road Engineering Divisions (1995-1996) and as the Boundary Woodlot Technician during the regional woodlot expansion program in 1996-1997.

Brenda returned to University in 1997. She completed the Forest Technology diploma program at Selkirk College in 1999. This course of study solidified her belief that environmental stewardship and education are the keys to sustaining the environment for future generations through preventative actions, not corrective actions.

Since graduation, Brenda has worked and volunteered as an Environmental Consultant as well as the Stewardship Coordinator and Project Manager for several environmental projects undertaken by the Christina Lake Stewardship Society. Her initiatives have included pilot projects for the Christina Lake area with many being considered as cutting edge examples of community based environmental management. These projects include the development of the Community Stewardship Resource Centre, the Sutherland Creek Restoration Project, the Young Stewards of the Boundary Educational Program, and the Christina Lake Management Plan and Implementation Strategy.

Brenda has been pivotal in developing and delivering these programs and projects by writing proposals and obtaining grants and funds in order for them to come to fruition. She has also been very successful acting as a liaison and developing partnerships with First Nations, universities, federal, provincial, and regional government agencies, local businesses, other non-profit organizations, and individuals in order to obtain their involvement and participation in Christina Lake stewardship initiatives.

To date Brenda has been successful in acquiring grants pertaining to environmental stewardship projects, research, educational initiatives, and core funding for the Stewardship Centre and Society (including capital purchases) for the Christina Lake area in the amount of $368,500.00 and $649,941.00 for inkind services and contributions. Brenda's initiatives have provided several job opportunities within the local community as well as educational awareness on topics such as

water quality, conservation, fisheries and wildlife. Her workshops contain local content and reach all age groups.

Brenda's current endeavors include continuing with the stewardship initiatives defined in the Christina Lake Management Plan and Implementation Strategy with a focus on issues of concern identified by the local community. This will also include professional consultation with other communities who have expressed an interest in using this watershed plan as a template for their own community watershed.

Brenda's future plans are to pursue a university degree that will build on her existing diverse qualifications in environmental field work, technical writing, budget and staff management, natural resource management and community education and liaison.

Brenda looks forward to seeing the Christina Lake Management Plan and Implementation Strategy evolve and anticipates positive results. She expects that a key result of the plan will be to foster a viable local economy based on sustainable resource management, local business initiatives and tourism. Community support and involvement is the foundation for this success.

Rebecca McLean

Rebecca McLean completed the Integrated Environmental Planning Technology diploma program at Selkirk College in Castlegar in 1999 and from there went on to earn a Bachelor of Science degree in Environmental Science at Royal Roads University in Victoria. Since graduation she has gained experience working for a First Nations group, a municipal government, and in the environmental consulting field. As a fisheries biologist she worked in the state of Nevada, and the provinces of Alberta, and British Columbia. She also worked as a Project Scientist in the environmental consulting field while living in Calgary from 2000-2002. Prior to accepting the Science/Technical Assistant position with the Christina Lake Stewardship Society, she worked as an Engineering Assistant for the Town of Canmore.

In 2002, the Canadian Environmental Certification Approvals Board (CECAB) granted her the designation of Certified Environmental Practitioner-in-Training (CEPIT). Her future plans are to continue her education in the field of Geographic Information Systems and complete the remaining 6 months of work experience required to earn the designation of Certified Environmental Practitioner (CEP).

Acknowledgements

This edition of the Christina Lake Management Plan (CLMP) was prepared by Brenda LaCroix (CLMP Project Manager) and Rebecca McLean (CLMP Science/Technical Assistant); under the guidance of the CLMP Community Advisory Committee and Science/ Technical Committee as well as the many partner organizations as listed below and individuals that were kind enough to share their expertise.

I would like to extend a special thank you to Julia Kokelj, Shauna Bennett (formerly Shauna Rysavy), and Ian Sharpe. Their plans were used extensively in the initial research and preparation of this document. Also, sections of this plan were taken directly from the Lakelse (Kokelj, 2003), Lake Kathlyn (Rysavy and Sharpe, 1995) and the Tyhee Lake (Rysavy and Sharpe, 1999) Management Plans, and in particular Section 2.0 (Lake Management Planning – Methodology).

A very special thank you goes out to Geneen Russo (an Environmental Consultant based out of Victoria), who conducted much of the water quality data analysis and in collaboration with Vic Jensen drafted water quality sections 7.2, 7.3.1, 7.3.2, 7.3.3 and associated recommendations which have been incorporated into the CLMP Implementation Strategy Manual.

Members of the Christina Lake Stewardship Society (CLSS) have volunteered many hours of their time attending and facilitating meetings, performing required field work, reviewing materials for the plan, and liaisoning with Community members, as well as media outreach for the plan. In particular, I would like to acknowledge the contributions of Dave Beattie, James Derby, Mike Stephenson (boat usage), and Paul Beattie for the time and effort they contributed towards water sampling, kokanee enumerations and monitoring of Christina Lake, Sandner Creek, McRae Creek, and Sutherland Creek. I would also like to thank the Directors of the CLSS including Marion Beattie, Grace McGregor, David Durand, Carlo Crema, Barb Stewart, Roland Krueger, Roy Ronaghan, Pat Palmer, Dan Wolkosky, Peter Bowen, and Gail Russell (former Director) for their dedication and commitment towards this plan and their community.

A special thank you goes out to Christina Lake resident Ron Walker (Naturalist), Lesley Anderton (Geologist) who produced the Geology section of this plan, Jim Lewall (Webmaster), Mark Jennings (Practicum Student – Selkirk College) who compiled the maps for this plan, attended meetings and provided input towards the GIS component of the plan, and to Brad Mason (Community Mapping Network) who produced the map sets for the plan. Also, Frank Fowler, Rob Macrae, and Louise Porto (School of Renewable Resources – Selkirk College) and their students who participated in the early stages of plan implementation by conducting field surveys within the Christina Lake watershed.

And last but not least a very special thank you goes out to the individuals on the Community Advisory Committee and the Science Technical Committee as well as all of the Community Volunteers and Stakeholders who contributed valuable information for segments of this document. Without your support and guidance the completion of this plan would not have been possible.

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- Brad Mason (Department of Fisheries and Oceans – CMN)
- Lesley Shelley (Interior Health)
- Serge Zibin (Interior Health)
- Doug Noren (Pope and Talbot Ltd.)
- Andrew Wilson and Jerry Mitchell (Ministry of Water Land and Air Protection - Fisheries)
- Barb Stewart (CLSS CLMP Director) (Boundary Weed Program)
- Ted Evans (Ministry of Forests)
- Vic Jensen (Ministry of Water Land and Air Protection – EIA Biologist)
- Virginia Stanford (Ministry of Water Land and Air Protection – EI Biologist)
- Donna Dean (RDKB – Planning)
- Gail Russell (Former CLSS Director)
- Dan Wolkosky (Local Businessperson – Wastewater Treatment Systems)
- Frank Wilmer (Ministry of Sustainable Resource Management)

Community Advisory Committee:

- Joey Tatangelo (Director Area C – RDKB)
- Mike Ladd (BC Parks)
- Roland Krueger (CLSS Director)
- Grace McGregor (CLSS Director)
- Paul Beattie (Christina Lake Nature Park Committee)
- David Durand (CLSS Director)
- Marion Beattie (CLSS President)
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- Margaret Maximenko (Community Futures)
- Gord and Al Nichols (Boundary Mapping and Design)
- Grant Furness (Ministry of Water Land and Air Protection – Ecosystem Officer)
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- Orville Dyer and Brian Harris ((Ministry of Water Land and Air Protection – Wildlife)
- Dawn Roumieu (BC Lake Stewardship Society)
- Deana Machin and Jillian Tamblyn (Okanagan Nations Alliance)
- Gretchen Harlow and Greg Brunette (Environment Canada – EcoAction)
- Bob Black and Peter Darbyshire (Sutherland Creek Water District)
- Carl Withler (Ministry of Agriculture)
- Sarah Kipp and Clive Calloway (Living by Water)

This project is funded through a grant from Environment Canada's EcoAction Community Funding Program, awarded to the Christina Lake Stewardship

Society, in partnership with the Regional District of Kootenay Boundary, Ministry of Water Land and Air Protection, Ministry of Sustainable Resource Management, Ministry of Forests, BC Parks, Land and Water BC Inc., Ministry of Agriculture, Okanagan Nations Alliance, Boundary Weed Management Society, Italy Sutherland Planning Team, Fife Water Users Group, BC Lake Stewardship Society, Department of Fisheries and Oceans, Interior Health, Pope and Talbot Ltd., Christina Lake Chamber of Commerce, Christina Lake Park Committee, Christina Waterworks District, Sutherland Water District, Boundary Mapping and Design, Selkirk College, Living by Water Project, Community Futures Development Corporation, Phoenix Foundation of the Boundary Communities, BC Gaming Commission (Direct Access), and Sunshine Communications.

Brenda LaCroix
Christina Lake Management Plan – Project Manager

Executive Summary

The Christina Lake Watershed is located in south-central British Columbia within the Monashee Mountain Range of the Columbia Mountains physiographic province. Environmental health is the foundation of economic prosperity in the Boundary Region, and is of particular importance to the Christina Lake area. The long term stability of this environmentally based economy depends on maintaining and restoring the environmental health of the lake and surrounding watershed. All this said, with human settlement and higher tourism levels, community concerns have risen over the last two decades on issues such as, water quality, habitat degradation, protection of native fish stocks and wildlife stocks, lake access and capacity, and Eurasian watermilfoil and the impact that this species can have on recreational values. The citizens of this community want to maintain the quality of life, which originally attracted them to this area while realizing that the very environment they want to conserve and protect is the major economic force within this region.

The overall mission of the Christina Lake Management Plan (CLMP) planning process and implementation strategy is to devise methods "**to preserve and protect the quality and health of the Christina Lake Watershed"**. This CLMP and accompanying Implementation Strategy Manual is intended to provide long-term direction to the Christina Lake Stewardship Society (CLSS) and Project Partners in the undertaking of projects to improve the quality of the watershed.

Due to the magnitude of information presented within this planning document, watershed level and lake level characteristics have been divided into two sections as follows:

- Section 5.0 "Watershed Characteristics" – deals with all aspects of the watershed including geology, hydrology, streams and fish species present within these systems, wildlife, and current land usage information (excluding lake level characteristics).

- Section 7.0 "Christina Lake Characteristics" – deals with lake level characteristics such as morphometric data, water quality, and biological characteristics.

► Summary of Priority Issues in the Watershed

The following summary of priority issues within the Christina Lake Watershed was compiled using the results of the surveys delivered to the community as well as input from the Science Technical Committee and Community Advisory Committee. A comprehensive search, compilation of all available literature and data, and research review was undertaken. This helped to identify research gaps with many of these gaps coinciding with the issues.

At the beginning of the lake management process, all involved stakeholders identified 6 priority issues in the Christina Lake Watershed:

ISSUE	REASON FOR CONCERN
1. Water Quality ⇔	• Drinking water quality, public health, recreational values at risk
2. Non-Native Plant species⇔	• Spread of Eurasian watermilfoil and other noxious

	weeds
3. Fisheries Sustainability⇔	• Lack of knowledge about the status of fish populations, impacts of introduced species on native species
4. Forestry Practices⇔	• Wildfire hazard, logging practices
5. Wildlife Values⇔	• Lack of knowledge about the status of local wildlife
6. Shoreline and Streambank Modifications⇔	• Destruction of fish habitat, removal of riparian vegetation

► Goal Statements and Management Objectives

To address the priority issues within the watershed, a series of goal statements and potential management objectives were identified.

Goal 1:	Identify current and potential sources of water quality degradation.

Objective 1.1: Continue with and expand upon current water quality monitoring program(s).
Objective 1.2: Investigate the potential sediment inputs to the lake.
Objective 1.3: Investigate the potential fecal contaminant inputs to the lake.
Objective 1.4: Estimate the potential nutrient inputs to the lake.

Goal 2:	Monitor, protect, and restore fisheries and wildlife values within the Christina Lake watershed.

Objective 2.1: Identify the need for restoring native fish habitat.
Objective 2.2: Promote fisheries research and data collection to address population knowledge gaps.
Objective 2.3: Improve wildlife habitat
Objective 2.4: Promote wildlife research and data collection.

Goal 3:	Increase public awareness of lake management issues and provide workable options for watershed users.

Objective 3.1: Develop and deliver workshops for residents and lake users.
Objective 3.2: Produce informative material and signage
Objective 3.3: Coordinate community involvement activities.
Objective 3.4: Develop and deliver school programs

Goal 4:	Create and maintain a locally based resource library that will be accessible to the public.

Objective 4.1: Establish a data retrieval system

Goal 5:	Sustain the Christina Lake community and local economy within the context of a healthy watershed.

Objective 5.1: Sustain the CLMP through volunteerism and an annual review process

► Plan Highlights

For each management objective, a comprehensive list of potential actions was compiled. The advantages and disadvantages of each action were summarized and the CLMP Science Technical Committee and Community Advisory Committee reviewed and discussed the overall merits of each action. The Committee's determined which actions were realistic and likely to be effective in the watershed. The Committee recommended which actions where to go forward in the plan and prioritized each action into short and long term implementation strategies. The recommended short-term actions were then incorporated into the companion document the "Implementation Strategy Manual". The actions within the manual were placed under broad categories to reflect the type of work that the action would entail. For example: some actions have a public education component while another action is field research oriented. The actions set out in this manual will be undertaken in 2005 and 2006 and the initiation of further project developments will continue into the future as the plan and strategy evolves. The long term recommended actions will be reviewed for implementation potential on an annual basis by the CLMP Committee. It must be noted here that the phrase short term does not mean that the action will be short in duration. For an example one short-term action item for immediate implementation is to continue and expand the water quality monitoring program. To establish trends, comprehensive data sets must be established over a long duration of time.

Some highlights of the recommended actions set for immediate implementation are summarized below.

Recommendations

Category – Core operation initiatives:

- Secure core funding to keep the Community Stewardship Resource Centre (CSRC) open (project nucleus)
- Build and maintain a constituency of involved citizens
- Form an agreement with project participants to ensure future participation in CLMP revision and implementation
- Produce an annual CLMP progress report

Category – Public education and community involvement initiatives:

- Update/install informative signage
- Develop and distribute a water conservation brochure
- Coordinate local "Lake Clean-Up Day" event
- Coordinate a "Fire Preparedness" informational display
- Develop a "Wildfire and Property Protection" video
- Continue media releases
- Improve distribution of water quality and other data to the public
- Determine community's interest in applying for a Community Forest license
- Promote acquisition and conservation of District Lot 498
- Develop and deliver school programs
- Develop and deliver an Internet-based habitat atlas for the Christina Lake watershed

- Develop and deliver a map-based pamphlet about natural resources in the Christina Lake watershed

Category – Continue and expand upon current monitoring programs:

- Support recommendations in Cavanagh *et al*. (1994) to expand the current MWLAP water quality monitoring program
- Establish a volunteer biological water quality monitoring program for major lake tributaries and Christina Creek
- Establish a volunteer hydrometric data collection program
- Conduct shoreline and tributary surveys to identify potential restoration sites *(Also see Category – Fisheries and wildlife initiatives below)*
  - ► Habitat degradation: if the stock assessment shows there are problems with recruitment (more for kokanee and rainbow trout), what is the current state of the habitat (in particular where do rainbow trout spawn) and what benefits could possibly accrue to the lake if restoration is undertaken?
- Conduct sediment core sample collection and analysis
- Promote a survey of Eurasian watermilfoil infestation sites and conduct inventories of terrestrial noxious and invasive weeds

Category – Fisheries and wildlife initiatives:

- Assess potential fish habitat gains/losses associated with barrier removal on McRae Creek
- Provide support for a hydroacoustic kokanee population assessment
- Conduct kokanee shore spawner enumeration
- Conduct kokanee stream spawner enumeration
- Conduct research about exotic species interactions with native species in aquatic ecosystems
- Conduct creel surveys

  Rationale:
  - ► A need for basic stock assessment information on kokanee, rainbow trout, and burbot; methods could include spawner surveys for each species, more creel data, in-lake population assessments, and fry assessments.
  - ► Exotic species interactions – What is the status of these species? What are the possible impacts of all of the warm water species in the lake? Are *mysis relicta* a problem? What can be done about any of the exotics if they are a problem?
  - ► Over fishing: New regulations are in place for Christina Lake; they need to be followed up with creel surveys and aerial boat counts to determine if they are being effective or if they need to be changed (made more or less stringent).

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1.0 LAKE MANAGEMENT PLANNING – INTRODUCTION

1.0 IMPETUS FOR THE PLAN

Environmental health is the foundation of economic prosperity in the Boundary Region, and is of particular importance to the Christina Lake area. The long term stability of this environmentally based economy depends on maintaining and restoring the environmental health of the lake and surrounding watershed. All this said, with human settlement and higher tourism levels, community concerns have risen over the last two decades on issues such as, water quality, habitat degradation, protection of native fish stocks and wildlife stocks, lake access and capacity, and Eurasian watermilfoil. The citizens of this community want to maintain the quality of life, which originally attracted them to this area while realizing that the very environment they want to conserve and protect is the major economic force within this region.

1.1 MISSION

The mission of this lake management planning process is to devise methods:

"To preserve and protect the quality and health of the Christina Lake Watershed"

1.2 GOAL STATEMENTS

Based on the priority issues identified in the Christina Lake Watershed, five goal statements were established by the Christina Lake Management Plan Community Advisory Committee and the Science/Technical Committee to provide direction for their overall mission "to preserve and protect the quality and health of the Christina Lake watershed". The Christina Lake Management Plan goal statements were important to provide context and direction throughout the management planning process. They helped the CLMP Project Manager and Science/Technical Assistant and all participants translate the priority issues into management objectives with potential short and long-term actions. The short-term actions will become part of the Implementation Strategy for the Christina Lake Management Plan and the long-term actions will be evaluated by the Committees on an ongoing basis with a review and update on an annual basis. The goal statements used in the planning process are as follows:

Goal 1: Identify current and potential sources of water quality degradation.

Goal 2: Monitor, protect, and restore fisheries and wildlife values within the Christina Lake watershed.

Goal 3: Increase public awareness of lake management issues and provide workable options for watershed users.

Goal 4: Create and maintain a locally based resource library that will be accessible to the public.

Goal 5: Sustain the Christina Lake community and local economy within the context of a healthy watershed.

1.3 PRIORITY ISSUES IN THE WATERSHED

Priority issues in the Christina Lake watershed were discussed at length during the first committee meeting on July 22, 2004. Both the Science/Technical Committee and the Community Advisory Committee identified several issues they felt were of particular concern and should be addressed in the CLMP. Following that meeting, as part of the public participation process, a group survey was composed and distributed to local user groups and business owners to get a sense of which issues the community felt were paramount. Approximately 88 surveys were distributed and 40 were completed and returned. The survey results confirmed that the groups surveyed also considered many of the issues identified by the committees to be of concern. A second, slightly more detailed survey was distributed to lake residents and property owners that also confirmed the identified issues were of concern to the public although the ranked order was slightly different (refer to Appendix A. for sample survey forms and summarized survey results). Other issues raised through the committee and surveys included concern over vandalism and lake access. Because these types of issues are not considered to be within the scope of the CLMP, comments were sent to the appropriate jurisdictional authority and follow up to ensure these concerns will be addressed will be ongoing.

Based on the committees input and the compiled survey results the following six priority issues were identified:

1) Water Quality
2) Non-Native Plant Species (terrestrial and aquatic)
3) Fisheries Sustainability
4) Forestry Practices
5) Wildlife Values
6) Shoreline and Stream Bank Development and Modification

A literature review of all available reports pertaining to the Christina Lake area was conducted and identified many research gaps that are partially reflected in the priority issues listed above.

1.4.0 Water Quality

Many residents draw drinking water from Christina Lake either directly through small intakes or via the Christina Waterworks District system. The lake also has high recreational and fisheries values and draws thousands of tourists to the region each year (Christina Lake Chamber of Commerce, 2005). Both sets of survey results indicate that there is a general concern over water quality. Although no scientific data exists to suggest that water quality is degrading, long-time local residents and visitors insist that there has been a noticeable decline (Freeman, 2004). Septic systems located close to shore, increased algae/sludge, odor problems and decreased clarity, especially during summer months, were noted in the survey responses as being areas of concern.

1.4.1 Non-Native Invasive Plant Species (Terrestrial and Aquatic)

The presence of non-native invasive plant species, primarily Eurasian watermilfoil (*Myriophyllum spicatum)*, as well as terrestrial invasive plants were raised as an issue of concern both in survey responses and through identified research gaps. Haberstock (2004) states that Eurasian watermilfoil continues to increase in Christina Lake despite management efforts and many survey

respondents indicated a concern over the impacts it has on recreational quality and habitat for native species.

1.4.2 Fisheries Sustainability

Survey respondents indicated a concern regarding small fish size and lack of knowledge about the status of fish populations. Data gaps identified through the literature review also raised concerns over the lack of existing information regarding Christina Lake fish stocks. Introduced species, over fishing, and habitat destruction are all possible impacts that have affected Christina Lake fish populations (Mitchell and LaCroix, 2004). Although stream and shore spawning kokanee enumerations have been conducted annually in recent years, the status of these two distinct kokanee populations is not well understood (Wilson, 2004). There have been a few creel surveys undertaken at Christina Lake over the years. From the limited information available, angler's comments indicate a level of dissatisfaction with catch levels and size. Bass and rainbow trout seem to be caught on a regular basis while burbot has not been noted on any recent creel surveys documented to date. From a creel census completed in 2004, kokanee represented the species caught most frequently with angler species preference evenly divided between kokanee and rainbow trout (Webster and Wilson, 2005).

1.4.3 Forestry Practices

Sedimentation, visual quality, habitat fragmentation and water quality were some of the issues raised in regards to forestry practices in the Christina Lake watershed. Survey respondents indicated that sustainable forestry practices are crucial to maintaining both the local economy and the quality of the local environment. Other concerns included forest fire hazards, forest health, and long-term viability of the local forest industry.

1.4.4 Wildlife Values

Research gaps identified during the literature review suggested that little has been done in terms of studying wildlife species in the Christina Lake watershed. A report prepared by the BC Conservation Data Centre (Ramsay, 2000) lists wildlife species identified in the Christina Creek area. Another draft report, Proposal to Establish the Sandner Creek Wildlife Management Area (Bryan, 1995), lists wildlife species that "occur or may occur" in the Sandner Creek drainage although there is no indication of how many of those species have been confirmed. Bryan (1995) also states "no species inventory or study of population status or distribution has been carried out." As of 2005, 10 years later, no further wildlife studies have been initiated.

Species at risk data is also very limited (see Table 19). These species at risk are discussed in detail in section 5.3.5.1 of this document. Survey respondents indicated a concern over the lack of information available about the area's wildlife and expressed concern about the status of many local wildlife species including grizzly bears, elk, cougars, and other large mammals.

1.4.5 Shoreline and Streambank Development and Modification

As indicated by survey respondents and through direct observation, increasing shoreline development has become a major issue of concern. Removal of riparian vegetation and loss of fish habitat were identified as contributing factors to shoreline and stream bank degradation and subsequent habitat loss. Direct observations have recently been made of retaining walls constructed below the high water mark, clearing of riparian vegetation, and placement of docks in shore spawning kokanee habitat. The lack of public knowledge about the jurisdictional roles of local, provincial, and federal governments in terms of shoreline development, permitting, and

enforcement were also raised. There were also several comments on the length of time the permit process takes before approvals and permits are obtained and the lack of field personnel to do site inspections to ensure that compliance of the permit is maintained. With increasing development pressures in the Christina Lake watershed, the use of guidelines and enforcement procedures are essential to ensure that development is carried out in a sustainable manner protecting resources for future generations by maintaining ecosystem health and water quality.

Shoreline and stream bank development and modification occurs in conjunction with many human activities and overlaps with many of the other issues discussed above. Logging operations, residential development, road building, and many other modifying actions can cause irreparable damage to lakes and streams by increasing the risk of contamination or decreasing the amount or density of riparian vegetation. Increased sediment input can encourage the spread of unfavorable vegetation such as Eurasian watermilfoil. When sediment is deposited on a lake bottom or over bottom barrier, it creates the perfect substrate for Eurasian watermilfoil to become established (University of Winnipeg, 2004).

SECTION 2.0

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2.0 LAKE MANAGEMENT PLANNING – METHODOLOGY

2.1 PURPOSE OF THE PLANNING PROCESS

This document will provide the long-term direction necessary to achieve the overall mission -**"To preserve and protect the quality and health of the Christina Lake Watershed"**. This version of the plan is intended to act as a handbook and reference guide for both resource managers and the Christina Lake Stewardship Society (CLSS). It identifies priority issues in the watershed, and describes the concerns of natural resource managers and local stakeholders regarding water quality and ecosystem protection. In order to plan at this scale or magnitude, all existing reports and documentation that could be found were reviewed to group the existing information and identify research gaps within the watershed area. All pertinent information is discussed within the plan. The plan then outlines in detail, the logistics and resources required to implement desirable management objectives for the watershed. It is intended that the Society will refer to the document on an ongoing basis, to identify projects that will prevent further degradation to the lake and its watershed, and improve lake quality.

It is important to remember that this document does not indicate completion of the lake management planning process. As recommended actions in the plan are implemented, the planning process will continue in a cyclical nature with assessments and revisions occurring on an ongoing basis.

2.2 STRATEGIC PLANNING

Developing management objectives, actions, and implementation strategies for environmental protection is not a simple task. Ecological systems are complex, and there are many relationships and interactions that we still do not understand (Kokelj, 2003). For example, signs that indicate a potential decrease in lake water quality should be regarded seriously and efforts to lessen impacts need to be investigated. Postponing corrective actions may result in forgoing relatively low-cost means of problem solving. Now is the time to determine a long-term plan of action to protect environmental, economic, and social values associated with Christina Lake and its watershed.

Problem solving can be approached using short -term tactical thinking or long-term strategic thinking (Spitzer, 1991). In general, tactical approaches treat only the symptoms of the problem, and are *relatively* simple and appear to be the least expensive. Strategic approaches tend to require long-term commitment, treat the causes of the problem and may be expensive. For solving complex problems, however, they are often the most practical and efficient approach that can be used (Kokelj, 2003).

Lake Management planning is complex because solutions cannot simply be generated by applying technical and scientific reasoning. There are many economic and social considerations and consequences associated with any proposed technical solution. For example, eutrophication (nutrient enrichment) concerns will not likely go away by employing tactical solutions that treat the symptoms of the problem. While in-lake treatment methods may form an important part of the overall solution, a long-term sustainable solution needs to look beyond the symptoms and treat the underlying causes: nutrient inputs from the surrounding watershed (Kokelj, 2003).

2.3 CONSENSUS BUILDING

Due to the complexity of the concerns and the variety of the stakeholders, consensus building is an important part of the lake management planning process. A successful lake management program begins with a Lake Management Plan that has widespread support from stakeholders and involves all interested groups and regulatory agencies throughout the planning process (Gibbons et al., 1994). There is no substitute for local knowledge of the lake's problems and/or lifetime of observations of a lake (Rast and Holland, 1988). For an example of a consensus-building model see section 2.5 Project Methodology.

2.4 PROJECT PARTNERS

Project Partners and Guidance Stakeholders identified in the Christina Lake Management Plan project include all levels of government, (Department of Fisheries and Oceans Canada, Ministry of Water, Land, and Air Protection, BC Parks, Ministry of Sustainable Resource Management, Land and Water BC, and the Regional District of Kootenay Boundary), lakeshore and watershed residents, local businesses and college, lake user groups, and environmental organizations. To establish priority issues, public input was sought through the Christina Lake Stewardship Society (CLSS). A Science Technical Committee and Community Advisory Committee was established prior to the commencement of the initial plan start-up. A terms of reference (TOR) for the project was circulated to all members of the CLMP committees. A list of contacts, project partners, and guidance stakeholders involved with the Christina Lake Management Plan is included in Section 10.1.2.

The CLMP committees and guidance stakeholders were involved from the formative stages and throughout the planning and implementation process to discuss the issues and work towards achieving widespread support. Regular meetings were held so that all stakeholders could provide input; during the prioritizing of issues, creation of plan goals, when management objectives were identified and evaluated, identifying potential actions, and developing implementation strategies for recommended short term action items. Various stakeholders will be involved in the implementation of each action, including monitoring and evaluation, and also review the success of the plan and identify changes where required. Figure 1 in Section 2.5 illustrates the opportunities for input at critical stages in the lake management planning process.

2.5 PROJECT METHODOLOGY

To implement a strategic approach for the Christina Lake Management Plan, a framework similar to the one outlined by Rast and Holland (1988) was used. It has been modified from its original form, to reflect the actual process of creating the Christina Lake Management Plan.

Incorporated into this method is the [1]K-T "Situation Appraisal" procedure that can help to identify and prioritize concerns, make decisions and identify possible actions. This procedure provides a logical, common sense approach to clarifying concerns and making them manageable. The results of this analysis can form the basis of the planning process (Kokolj, 2003).

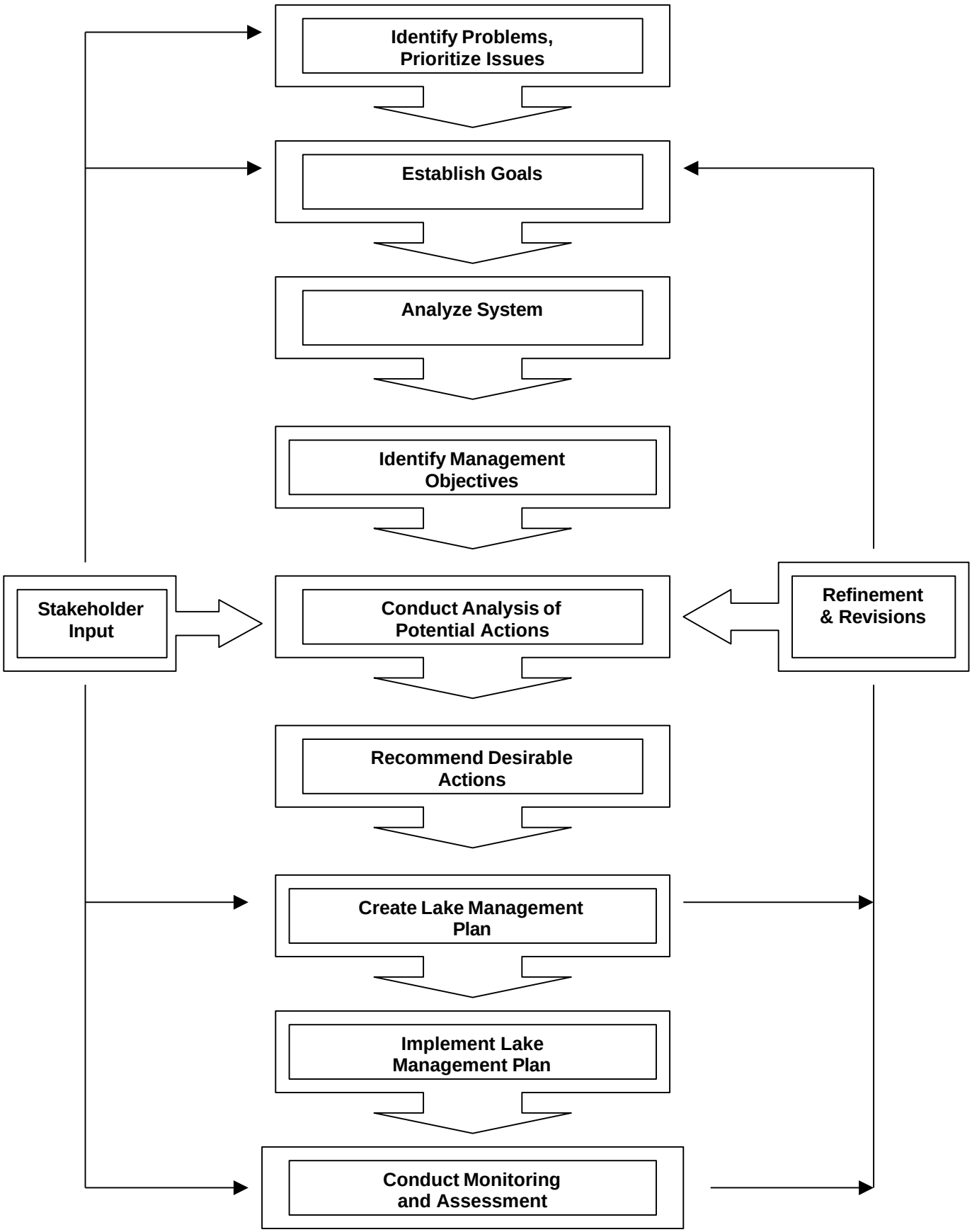
Situation Appraisal:

- Identify concerns
- Break issues down into workable pieces

[1] *Kepner-Tregoe (K-T) Rational Process – to build consensus and to clarify what issues require action. Kepner-Tregoe is a management consulting and training company that specializes in the areas of strategy formulation and implementation.*

- Set priorities
- Plan next steps
- Select appropriate people to resolve issues

Figure 1. The Lake Management Planning Process (Modified from Rast and Holland, 1988)



The management-planning framework consists of the following steps:

Step 1: Identify local problems and prioritize issues of concern

Step 2: Define lake management goals – issues outlined in step 1 are considered and general goals are devised to encompass the issues

Step 3: Analyze the Christina Lake system – background information on the physical and chemical/biological systems – all components of the system are interrelated

Step 4: Identify possible management objectives to achieve goals – management objectives are defined for each of the issues based on the general goals. To identify possible objectives a comprehensive search is to be conducted and experts consulted. Descriptions of each approved management objective along with consideration for potential actions must be included

Step 5: Conduct an analysis of potential actions – the costs and benefits of each action taking into account the values of various stakeholders and is based on judgments made by experts and key stakeholders

Step 6: Provide recommendations – that best address the priority issues – include information on possible resources and other implementation considerations

The management plan represents completion of Step 6 in the management planning process. The framework includes two additional steps, which form an important part of the ongoing process. The management planning for Christina Lake watershed will continue through Steps 7 and 8 and become an ongoing and cyclical process

Sept 7: Plan implementation – generate support and gather resources to undertake the activities recommended in the plan

Step 8: Assessment and revisions – as the plan is implemented, arrangements are made to monitor the success of the plan, and to make changes as necessary – schedule meetings for once a year to review and update the management plan

SECTION 3.0

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3.0 FIRST NATIONS TRADITIONAL LAND USE IN THE CHRISTINA LAKE WATERSHED

Prior to European settlement, the area we now call the Boundary region was used by several First Nations groups such as the [2]Colville, Okanagan, Lakes, Nespelem, Sanpoil, Methow, and Shuswap as a travel route between the Okanagan and Kettle Falls, Washington (Boundary Museum, 2005).

Christina Lake was part of the region inhabited by the Lakes People First Nations group. Also known as the Arrow Lakes People or Sinixt. For the purpose of this report, Sinixt will be used. The Sinixt did not appear to have lived in the Grand Forks area itself, but rather moved through it en route to and from hunting and fishing grounds. Many of the other First Nations also passed through this area (Boundary Museum Society, 1996).

The Sinixt were an Interior Salish people whose territory stretched roughly from the Monashees to Kootenay Lake, and from Revelstoke to northeast Washington. Christina Lake was an important fishing ground, as was the Kettle River around Cascade (Christina Lake Chamber of Commerce, 2005). Neighboring first Nations included the Kalispel, Colville, and Sanpoil to the south, the Okanagan and Shuswap to the west, and the Kutenai to the east (Boundary Museum Society, 1996).

For the most part, peaceful trade relations existed among the Interior Salish; dried salmon, preserved roots, and berries, and other foodstuffs were common items of trade. The Lillooet Salish were the chief intermediaries in trade with the Coastal Salish and it was largely through them that such coastal goods as dentalium and other valuable shells entered the interior. In the east, the Lakes Salish traded dried salmon to the Kutenai for bison-hide bags and robes. Major fisheries or root collecting areas brought large numbers of people together each bringing regional specialties to these large “trade fairs” (Boundary Museum Society, 1996). Therefore, trading occurred from all routes (north, south, east, and west) as is further evidenced in a display at the Boundary Museum in Grand Forks. The display is comprised of two different types of beads that do not come from this region. According to Boundary Museum Curator William Adams, the beads were excavated from a local gravel quarry in Grand Forks. The beads are made of dentalium (shells) from the Pacific Northwest coast area and turquoise (semi-precious stones) found in the Arizona/New Mexico area. This provides insight to the vast distances traveled for trading purposes (Adams, 2005).

According to the Boundary Museum (2005), the Sinixt used this area for thousands of years for hunting and fishing during the summer months due to the abundance of fish in the Nehoialpitkwu river (now called the Kettle), and the wild game that roamed the valley and mountainsides. The Sinixt were a peaceful and nomadic people that moved throughout what is now the Boundary Kootenay area as the seasons changed. At that time the lake was called En-Chalm or Nichelaam (english translation unknown). At one time numbering in the thousands, these people were plagued with disease brought to North America by the Europeans. First, in the 1780’s when smallpox killed approximately 50 percent of the population - this was the first of several epidemics

[2] The term Colville-Okanagan has been used by several ethnographers as a reference to larger tribal groupings with a common language (with different dialects) and territory (Reserve Management Inc., 2002)

that plagued and decimated many First Nations People over the next century (Boundary Museum, 2005).

By 1811 renowned explorer David Thompson had forged his way into the southern interior of British Columbia, making him the first documented European to enter the region. He met with the Sinixt and several other tribes along his way (Boundary Museum, 2005).

In 1956 the Sinixt were considered extinct by the federal and provincial governments (Duff, W. 1964). According to Duff (1964), this was due to introduced epidemics decimating the tribe and the few surviving members were driven from the area and/or assimilated into other tribes such as the Colville, Okanagan or Shuswap. Annie Joseph was considered the last surviving member of the Sinixt (Lakes Band) in Canada. She died on October 1, 1953. Recently there have been many people who have come forward, both from the United States and Canada to claim that they are Sinixt (Boundary Museum, 2005). Further research into various archaeological records indicated that representatives from the Sinixt (Arrow Lakes Band) signed [3]repatriation forms from the Royal British Columbia Museum, the Boundary Museum located in Grand Forks, and the University of British Columbia for ancestral remains in the 1990's. Although, as stated above the federal government does not legally recognize the Sinixt as a native band as specified under the *Indian Act,* these documents were signed by duly authorized representatives of the Okanagan Tribal Council – Sinixt/Arrow Lakes Band Council of Elders and ancestral descendents.

In 1977 an archaeological investigation within the Boundary region was performed. It involved locating all first nations campsites, habitation sites, fishing sites, pictographs, resource utilization sites (sites where raw materials were obtained such as stone for the manufacture of stone tools or red ochre for an important ingredient used in painting on rocks), and housepit sites. The archaeological survey was conducted along the Kettle River from Cascade to just outside of Grand Forks. Christina Lake was also surveyed in certain areas. A total of 34 sites were found. Most of the sites found were campsites where at one time in the past the Snoxielpituk (the people of the Kettle River) camped temporarily on their seasonal journeys. There were five sites located which indicate permanent residences and storage sites. These sites are all located within the Christina Lake and Cascade area. The sites at Christina Lake represent several different types such as housepit sites, pictograph sites, campsites, and fishing sites; each expressing their antiquity within this diverse area. Pictographs can still be seen today on Christina Lake east of where Texas Creek flows into the lake (Boundary Museum, 2005). All of the sites found are from 100 years old to as much as 6,000 years old, allowing for a wide range of cultural history within the valley of the Nehoialpitkwu (Kettle River). The method used for the dating of archaeological remains recovered so far in the Boundary area is by comparing artifacts and cultural traits with other nearby areas that possess similar artifacts and traits that have been radiocarbon dated. One site, which is located along the Kettle River near Cascade, lies in the range of 4,000 to 6,000 years in antiquity. This site represents the oldest known site found in the Boundary area and puts the age of the first people here at approximately 4,000 B.C (Freisinger, 1979). In most sites the dominant types of evidence found were stone tools (scrapers, arrowheads, knives, and chopping implements). Another site located above the Cascade Canyon yielded a wooden dugout canoe, which was submerged and imbedded in the Kettle River. This site is unique, as it is the first and only dugout canoe to have been discovered in the Interior of British Columbia in an archaeological situation (Freisinger, 1979). It is believed that the canoe was manufactured around 1850 A.D. The main purpose of the study of earlier inhabitants of the land is to discover the many diverse

[3] Copies of these signed documents are located in the Christina Lake Stewardship Society office.

aspects of humans and their relationship with the earth and to protect these valuable archaeological and historical resources (Freisinger, 1979).

3.1 FIRST NATIONS REFERRALS FOR CLMP INPUT

As part of the Christina Lake Management Plan (CLMP), a very important component of the entire planning process is to include all stakeholders throughout all phases of the planning and implementation strategy. In order to ascertain First Nation requirements within the watershed, a First Nation's referral package was sent to Bands that may have a historical insight and/or territorial interest in the area. A listing of Bands was provided by Okanagan Nations Alliance and Pope and Talbot Ltd. who both undertake First Nation's referrals for land management initiatives including environmental planning purposes.

The following Bands were contacted by telephone, email, and regular mail:

- Okanagan Nations Alliance: 3255 C Shannon Lake Road, Westbank, BC V4T 1V4 Attn: Deana Machin
- Osoyoos Indian Band: Natural Resource Department, RR3 S25 Comp 1, Oliver, BC V0H 1T0
- Penticton Indian Band: Lands Department, RR2 S80 Comp 19, Penticton, BC V2A 6J7 Attn: Joan Phillip
- Lower Similkameen Indian Band: Lands Department, PO Box 100, Keremeos, BC V0X 1N0
- Westbank First Nation: Natural Resource Department, #301-515 Hwy. 97S, Kelowna, BC V1Z 3J2
- Okanagan Indian Band: Natural Resource Department, RR7, Site 8, Comp 20, Vernon, BC V1T 7Z3 Attn: Keith Louis
- Spallumcheen Indian Band: Lands Department, PO Box 301C, Enderby, BC V0E 1V0
- Sinixt: Selkirk College, Castlegar Campus, 301 Frank Beinder Way, Castlegar, BC V1N 3J1 Attn: Marilyn James, Aboriginal Advisor
- Confederated Tribes of Colville Reservation: PO Box 150, Nespelem, WA 99155 Attn: Joe Peone
- Canadian Columbia River Inter-Tribal Fisheries Commission: Bill Green, 7468 Mission Road, Cranbrook, BC V1C 7E5

3.2 FIRST NATIONS TREATY NEGOTIATIONS – BC TREATY COMMISSION

Land has spiritual, economic and political significance for First Nation's peoples. First Nation's traditional territory—land occupied and used historically—is integral to their identity and survival as a distinct nation (BC Treaty Commission, 2005).

In 1997, the Supreme Court of Canada ruled in the Delgamuukw case that aboriginal title is a right to the land itself—not just the right to hunt, fish and gather. Crown title refers to the provincial or the federal government's interest in land. Almost all Crown land in BC is held by the province. Delgamuukw confirmed that aboriginal title still exists in BC and that when dealing with Crown lands the government must consult with and may have to compensate First Nations whose rights are affected (BC Treaty Commission, 2005).

When a First Nation enters the BC treaty process they submit a statement of intent outlining their traditional territory. This establishes the parameters for land to be included in a final treaty. For most First Nations, treaty settlement lands—area of land that will be owned and managed by First Nations pursuant to a treaty—will likely comprise only a percentage of their traditional territory. For example, land included within the Nisga'a Treaty comprises approximately eight per cent of the nation's traditional territory (BC Treaty Commission, 2005).

As discussed above in Section 3.0 “First Nations Traditional Land Use”, sensitive archaeological areas and areas with spiritual significance to First Nations have been identified within the Christina Lake Watershed. Therefore, ensuring protection of these areas and continued liaison with all stakeholders is imperative.

The results of a search on the on-line BC Treaty Commission website and personal communications with Okanagan Nations Alliance (ONA) Program Manager Deana Machin (2005) revealed that at this time the Okanagan Nations are not involved with the BC Treaty process and have not submitted a statement of intent outlining their traditional territory.

The ONA commissioned Urban Systems Ltd. in 1998 to prepare a map showing Syilx territory, which is referred to, as “Okanagan Nation Territory” on the map. This map was submitted to the CLMP in a digital format as shown in Figure 2. The map does not depict individual tribal territories but is a combination of territories: Northern Okanagan, Southern Okanagan, Colville, Lakes, Methow, Nespelem, and Sanpoil (Reserve Management Inc., 2002).

As Figure 2 below indicates, the Christina Lake watershed is within the Okanagan Nation Territory.

Personal communications with Bill Green (2005), representative from the Canadian Columbia River Inter-Tribal Fisheries Commission, stated that the Christina Lake watershed in not within the traditional territories of either the Secwepemc (Shuswap) and Ktunaxa (Kutenai).

Figure 2: Okanagan Nation Territory

SECTION 4.0

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4.0 HISTORY (EUROPEAN SETTLEMENT)

In the early history of the Boundary region, Christina Lake played an important role as being part of the waterway system that was used for transportation before the trails and roads of our time were built (Sandner, 1967). The first written record of its existence appeared in David Thompson's journals (1811) (Boundary Museum, 2005). He did not visit its shores, but acquired his information from the First Nations People in the south as he traveled along the Columbia River. To these people, the lake was known as En-Chalm (Sandner, 1967).

One of the first uses of Lake En-Chalm for the first European settlers was the abundance of wild game, which had obvious values to the fur trade industry. In 1825 the Hudson Bay Company (HBC) had built a trading post just south of Lake En-Chalm named Fort Colville (Boundary Museum, 2005). Trading took place at Fort Colville on almost every day of the year. From 1826 to 1871, the same fifteen species were traded from the First Nations People; beaver, black bear, grizzly bear, muskrat, fish, fox, lynx, marten, mink, otter, raccoon, wolverine, badger, wolf, and coyote. Many other products harvested or made by the First Nations People other than furs were purchased by the traders of the Colville district. These included deer and elk hides, pine pitch for boats, leather wear, dried salmon, roots and berries, dried meat, horses, canoes, baskets, rope, snowshoes, and fresh game was traded as well. Everything was entered on ledgers and summarized in annual statistics (Boundary Museum Society, 2005). Today, the Hudson Bay Company Archives in Winnipeg Manitoba houses these documents (Post journals, reports on districts, incoming and outgoing mail etc.) and has copied them onto microfilm tape. This invaluable information is used by universities, museums, historians and researchers. The CLMP Staff applied to the Hudson Bay Company Archives in Winnipeg for an inter-library loan for microfilm tapes for Fort Colville, Washington, Post number B.45 that has records for years covered 1826-1856. The rolls that were applied for were Roll #'s B.45/a/1 post journals (a) and B.45/e/1-3 reports on districts (e) (Hudson Bay Company Archives, 2005).

The microfilm tapes were reviewed by the CLMP Staff to verify existing information and to see if we could find new information for the CLMP. Many of the documents contained on the microfilm were hard to decipher. The documents contained information on the different First Nations groupings that frequented the Post and some of the Chief Traders did keep journals that held information such as population estimates, common language with different dialects within the groups etc. As well, Chief Trader John Work (Post Report 1929) did keep ledgers with the names of the tribes as described by the traders in one column, and the names of the tribes in their spoken language (translated and spelled as it sounded) in another column, and columns with population estimates for each grouping; broken down to how many men, women, and children (further broken down to boys and girls). John Work also wrote extensively on his interpretation on native life, including an extensive journal (15 pages) that consisted of two columns – one column being english words and the other column being the native translation for the english word (example: stone – shanish). Unfortunately, he did not mention which tribal groupings language he was documenting.

Trading records were also reviewed to try and ascertain wildlife species type and harvesting rates for the Christina Lake area for the period that the Colville Trading Post existed. Unfortunately, the records did not indicate a specific enough area in which the harvesting took place. It was

interesting to note that the post records indicated that between 1824 and 1829 the number of species recorded in the trading ledgers for the district were as follows:

	TOTAL FROM 1824 TO 1829
Beaver	20,599
Otter	978
Fisher	801
Fox	340
Marten	856
Mink	1842
Muskrat	35,733
Bear	105
Wolf	13
Wolverine	9

In 1852 Angus [4]MacDonald became a [5]Fur Trader for Fort Colville bringing with him his family which included his eldest daughter Christina MacDonald (as spelled on the Fort Colville Cenotaph – St Paul's Mission Site near Roosevelt Dam) who would accompany her father as his bookkeeper while he conducted his business on behalf of the HBC. On one of his trips through the area, Angus MacDonald and his riding party (which included Christina MacDonald) were crossing En-Chalm Creek via a raft used for ferrying people across. The raft broke apart mid-stream sending Christina and the years worth of HBC accounts into the water, as her father and the native guide pulled her to safety, the books that she had been carrying were still in her arms. Upon seeing this, her father and the local native chief named the creek and the lake that it flowed from Christina, in recognition of her bravery. Fort Colville was established in 1825 and until its closure in 1871 remained a central fixture of the area (Boundary Museum, 2005).

[4] In other reviewed documentation, spelling was both McDonald and MacDonald

[5] Various reports and historical records varied as to what position Angus MacDonald held for the HBC Colville Post (Clerk/Chief Factor, Chief Trader). For the purpose of this report Fur Trader will be used.

Photograph 1: Christina MacDonald – Courtesy of the Boundary Museum

According to Boundary Museum records (2005), the peaceful co-existence between local First Nations and the European settlers that had gone on since 1825 ended sometime in the 1850's when "gold fever" struck the area and miners started to flood in hoping to become rich. The Sinixt were not supportive of the increase of goldseekers, having just gotten over yet another smallpox epidemic and they had no idea of what was yet to come. As the rush of people came, the seemingly endless supply of fish and wildlife was being diminished. As of yet no European settlers lived in the Christina Lake valley, until Edgar Dewdney blazed his trail through the valley to Wild Horse Creek in the Kootenays (Boundary Museum, 2005). This provided early pioneers with the first route into the Christina Lake region that did not require traveling through American territory (Christina Lake Chamber of Commerce, 2005). The Dewdney Trail was completed in September of 1865 at a cost of $74,000.00 dollars (Fort Steele, 2005). The first European settler was a man named John Lawless who settled at En-Chalm by himself in a small cabin on the east shore of the lake. According to the Boundary Museum (2005), he was apparently aptly named as he spent much of his time stirring up the natives to oppose the HBC and it's trading policies. He was disliked by the natives as much as the traders for they eventually found him building a canoe at English Point and chased him with the apparent intent to end his life. His only route for an escape was by taking to the water and swimming across to what is now known as Chase's Point. John Lawless left the lake shortly afterwards never to return (Boundary Museum, 2005). Settlement however of the Boundary did not really begin until the late 1880s and early 1890s (Christina Lake Chamber of Commerce, 2005).

By the early 1890s prospecting had spilled over from Rossland into the Christina Lake region. The Lake's original European settlers (residents) were prospectors, trappers, or both. McRae Creek and Sutherland Creek are among the many local landmarks named for these pioneer prospectors. In 1896, around the time settlement began at Cascade, F.A. Heinze, owner of the Trail smelter, chartered the Columbia & Western Railway. In 1898 the CPR bought out the C&W and began

construction in Castlegar. The C&W railway was completed as far as Grand Forks by September of 1899, and reached Midway the following year. The rail lines were crucial to the success of the mining, smelting and lumber industries that were propelling the region's economic growth. The arrival of the railroad brought more permanent settlement to the region, and by the turn of the century Christina Lake had multiple townsites, with a total of at least five hotels. Christina Lake first became a recreational area for day-trippers from Grand Forks and Phoenix, who were able to make use of the new railroad to visit the lake. Dominion Day was a favorite holiday, with special excursion trains running from Grand Forks to Christina Lake (Christina Lake Chamber of Commerce, 2005).

Beginning in the first decades of the twentieth century, Christina Lake provided summer cottages, fishing (including a commercial fishery), swimming and other entertainment to residents of Grand Forks and the Boundary region. The 1920s saw further growth of Christina Lake as a recreational community and tourism destination. The completion of the Cascade-Rossland highway in 1922 provided vacationers from Rossland and Trail with a direct route to the Boundary for the first time. In the 1920s, Prohibition in the United States encouraged an influx of visitors from northeast Washington, who were attracted by the Lake's saloons and dance halls. Even during the depression of the 1930s Christina Lake attracted a number of tourists, mostly vacationers from Rossland, Trail and the Grand Forks area. A summer resort hotel was built on English Point in 1928-9 and was run by George Brown and subsequent owners until 1942, when the hotel and its surrounding cabins were used to house Japanese families interred away from the coast for the duration of WWII. A few families remained in the area after the last of the restrictions were lifted in 1949, others settled elsewhere (Christina Lake Chamber of Commerce, 2005).

The years following WWII saw Christina Lake become well established as a recreational community. In the early 1960s the highway connecting Castlegar to Christina Lake was completed, saving vacationers from the Kootenays and Alberta hours of travel time, as they no longer had to follow the old Cascade-Rossland highway to reach the lake. As you drive through on the highway today, Christina Lake appears quiet and secluded. The frenzied energy of the prospecting era and the expansive optimism of the years surrounding the turn of the century may be hidden behind today's laid-back community (Christina Lake Chamber of Commerce, 2005). However, the legacy of the lake's early residents lives on as evidenced by the pictographs on “Painted Rock” on Christina Lake, our lakes namesake itself and in the names of our creeks, trails and roads systems.

SECTION 5.0

WATERSHED CHARACTERISTICS

5.0 WATERSHED CHARACTERISTICS

The Christina Lake Watershed is located in south-central British Columbia within the Monashee Mountain Range of the Columbia Mountains physiographic province. The climatic conditions of the area are generally that of cool winters with moderate to heavy snowfall, and warm, dry to relatively moist summers (Cavanagh et al., 1994). The watershed is located within the Kootenay Boundary Forest District and the Ministry Water, Land, and Air Protection, Fish and Wildlife Management Unit 8-15. The rural community system is unincorporated therefore, land development processes and taxation for community services is administered by the Regional District of Kootenay Boundary (RDKB).

The Christina Lake Watershed covers approximately 51,900 hectares or 519 km^2 (Jennings, 2005). The lake itself is 18.7 km long with the watershed extending another 14.5 km beyond the north end of the lake. The watershed is 22.5 km wide at an east-west point 3.2 km north of Texas Point. Beyond this watershed, land to the north drains into Lower Arrow Lake; land to the west drains into the Granby River, and land to the east drains into Big Sheep Creek (CL Study 1975). The lake drains through Christina Creek, at its south end, into the Kettle River, which flows into the Roosevelt Reservoir on the Columbia River in Washington State (Sigma Engineering, 1991).

Watershed Group:	Kettle River (KETL)
Watershed Code:	320-160600
Waterbody Identifier:	01206KETL
UTM at Lake Outlet:11.5432962.411678	Number
of Tributaries:	41
Drainage Basin Area:	519 km2 (includes Christina Creek outflow)
Elevation at Lake Outlet:	446.7 m (Hare, 2005) (as per Water Survey of Canada Gauge)
NTS Map:	82E/01
TRIM Maps:	82E009, 82E010, 82E019, 82E020, 82E029, 82E030, 82E039
Air Photos:	30BCC93060 0-22, 51, 52, 70, 71
	30BCC93019 24, 25, 50-52, 98-100, 126, 127, 166, 167
	30BCC93018 149, 150
BEC Zones:	[6]Interior Cedar Hemlock (ICH), Interior Douglas Fir (IDF), Ponderosa Pine (PP), Engelmann Spruce, Subalpine Fir (ESSF)

See Appendix E Map 1 - Land base map for the watershed boundary.
See Appendix E Map 2 - Biogeoclimatic ecosystem classification (BEC) for forest type (zone) locations.
See Appendix E Map 12 – Landsat 7 satellite imagery of the Christina Lake watershed.

5.1 GEOLOGY OF THE CHRISTINA LAKE WATERSHED BY LESLEY ANDERTON (GEOLOGIST)

A glance at the Geology map of Grand Forks (figure 3a and 3b below) shows that the 67 to 50 million year old Kettle River Fault is the most significant geologic feature of the Christina Lake watershed. The fault trends north-south beneath the lake separating the ancient Precambrian rocks of the Grand Forks Complex on the west from the younger downfaulted plutonic, volcanic

[6] Interior Cedar Hemlock is the primary forest type within the Christina Lake watershed.

and sedimentary rocks on the east. Christina Lake developed along the fault line, as the rocks there were so severely crushed and broken that they were easily eroded by river action to create an impressive valley that was later overdeepened by south flowing glacier ice. The unusual warmth of the waters of Christina Lake may be due to hot springs in the lake bottom, as the fault would provide a passageway for superheated water to rise through the rocks to add heat to the lake water.

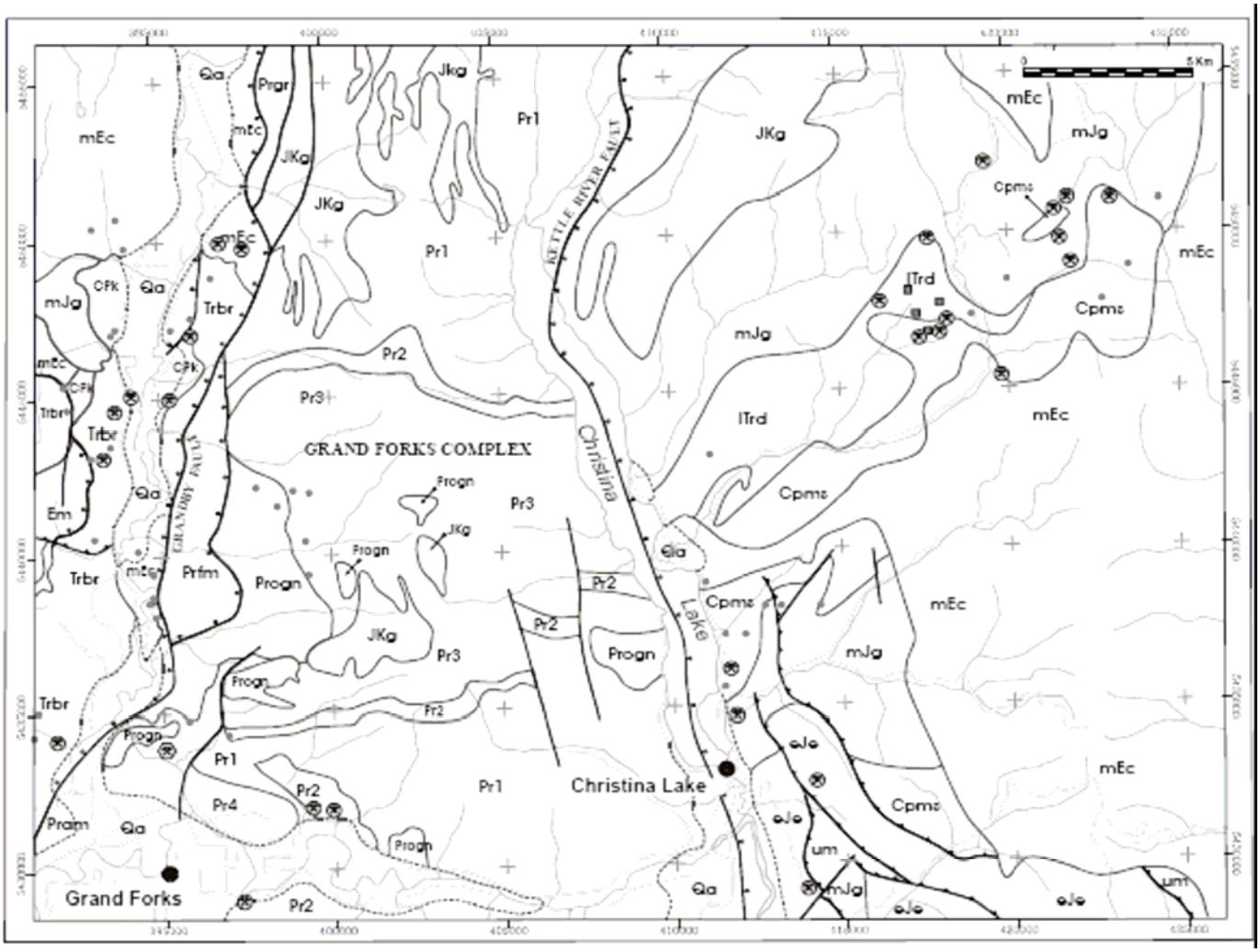


Figure 3a: Geological Map of the Grand Forks Area (Hoy and Jackaman, 2004)

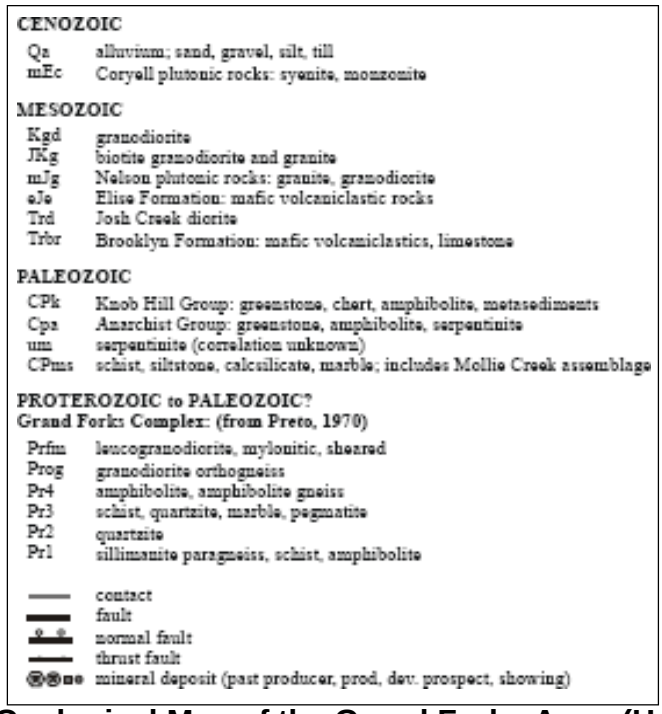


Figure 3b: Legend for Geological Map of the Grand Forks Area (Hoy and Jackaman, 2004)

The rocks of the Grand Forks Complex consist of 1.6 to 2.0 billion year old gneisses (Pr1) that probably represent the eroded remnants of ancient mountains of ancestral North America. Gneiss, a metamorphic rock formed by heat and pressure, consists of alternating bands of light coloured minerals such as feldspar and quartz and darker bands of biotite and hornblend. In composition it is similar to granitic rock, but the minerals are parallel instead of randomly arranged, and like granite it breaks down to a rather sandy and not particularly fertile soil. Younger rocks of the Grand Forks Complex include hard and resistant quartzite (Pr2), which may once have been a sandy beach on the edge of ancient North America, and marble (Pr3), which was once limestone formed in fairly shallow water just offshore.

The younger metasedimentary and metavolcanic rocks, now seen on the east side of Christina Lake, originated as ocean floor sediments and volcanic islands to the west of ancestral North America. These rocks amalgamated offshore to form the Intermontane Superterrane, which collided with North America about 170 million years ago. The force of the plate collision caused these younger rocks to be metamorphosed and intensely folded and to be thrust inland as much as 150 to 200 kms over the top of the gneisses, quartzites and marbles of ancient North America, as can be seen in the cross section. These younger rocks include the schists, siltstones, marbles and limestones of the Mountain Roberts Formation (cPms), once ocean floor sediments, and the volcanics of the Elise Formation (eJe), formed in an island arc about 190 million years ago. The schists, siltstones and volcanic rocks weather to give a fine-textured nutrient rich soil. The marbles and limestones, being composed of calcite, give rise to very thin soils with a high pH favoured by alkaline tolerant plants. The Mount Roberts limestone at Fife supplied 1.6 million tones of limestone for flux at the Trail Smelter.

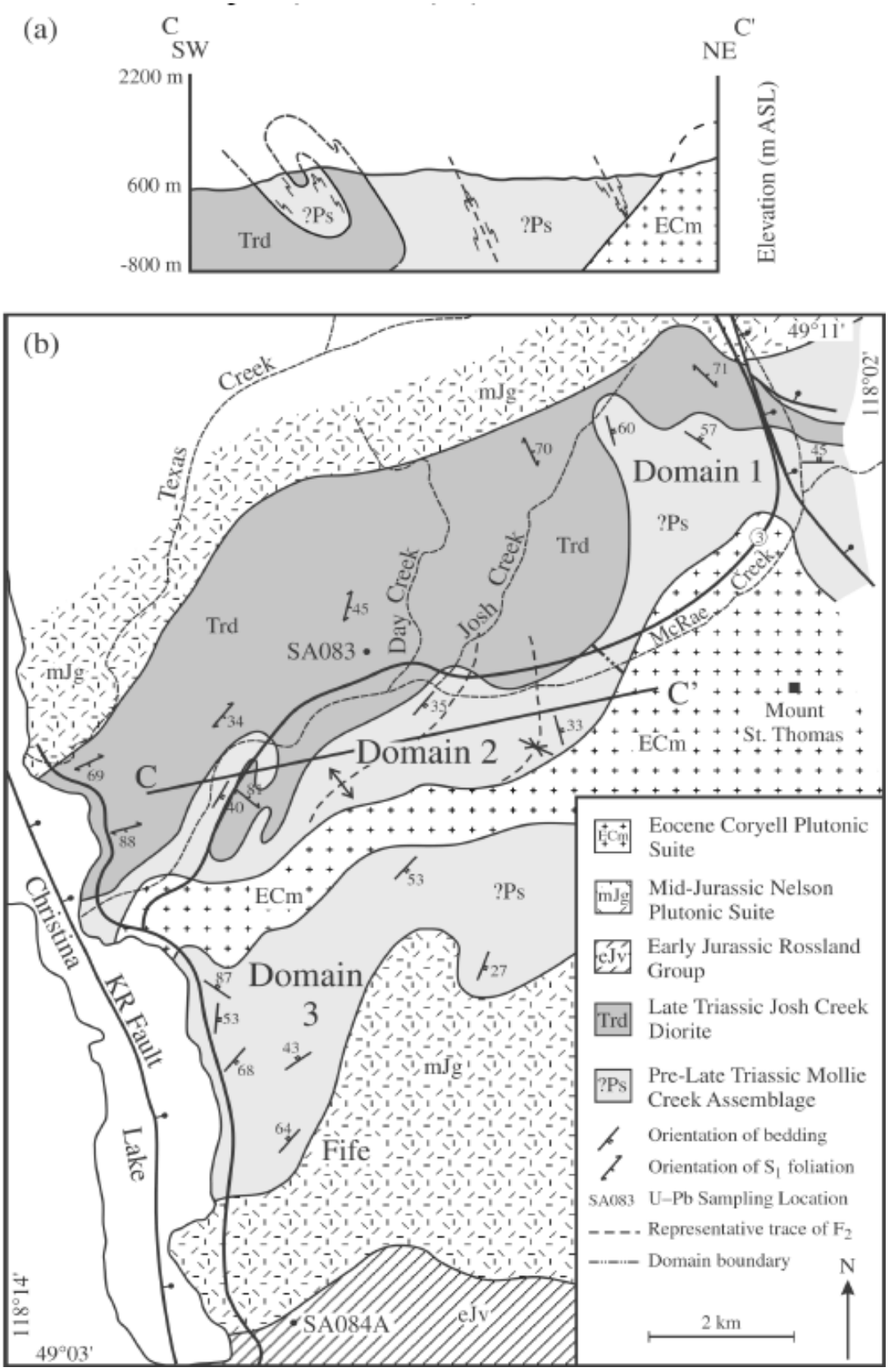


Figure 4 (a) Cross-section C-C' and (b) Simplified geologic map of the Christina Lake area showing the location of structural domains 1,2, and 3 of the Mollie Creek assemblage. ASL, above sea level; Kettle River. (Acton, Simony, and Heaman, 2002)

Plutonic rocks, that originated as magma cooled slowly deep within the crust, occupy a large portion of the eastern side of the Christina Lake Watershed. The Josh Creek Diorite (lTrd) may represent the feeder magma to the Rossland Group volcanics. The 170 to 165 million year old granites and granodiorites of the Nelson Plutonics (mJg) formed as a result of intense heating and melting of the base of the crust during plate collision. The last plutonic event was the development of the syenites and monzonites of the Coryell Plutonics (mEc). The coarse grained plutonic rocks, composed primarily of feldspar with small quantities of dark minerals and some quartz, generally weather to give somewhat nutrient deficient sandy soils, although the higher percentage of dark minerals in the diorite will form a somewhat richer soil.

A small patch of fault-bounded serpentinite (um) occurs in the south and outcrops on the old Cascade Highway. This represents a sliver of ocean mantle rock broken off during plate collision. Serpentinite is usually rich in iron and magnesium and can have unusual flora. The serpentinite is also the site of an old nickel and chromium mine (Castle Mountain Nickel), but the nickel ore is quite low grade.

All the mineral prospects in the Christina Lake area are located in the younger rocks east of the Kettle River Fault and are primarily small gold-copper skarn deposits adjacent to plutonic intrusions and polymetallic silver-lead-zinc veins, sometimes with gold. None have been major producers, unlike the Rossland mines to the east and the Phoenix mines to the west. However Hoy and Jackaman (2005) suggest that “there is considerable potential for discovery of new gold occurrences in the Grand Forks and Christina Lake areas.” The volcanic Elise Formation rocks of the Rossland Group have potential for Rossland-type gold-copper veins, and there is the possibility of gold mineralization in the Coryell rocks.

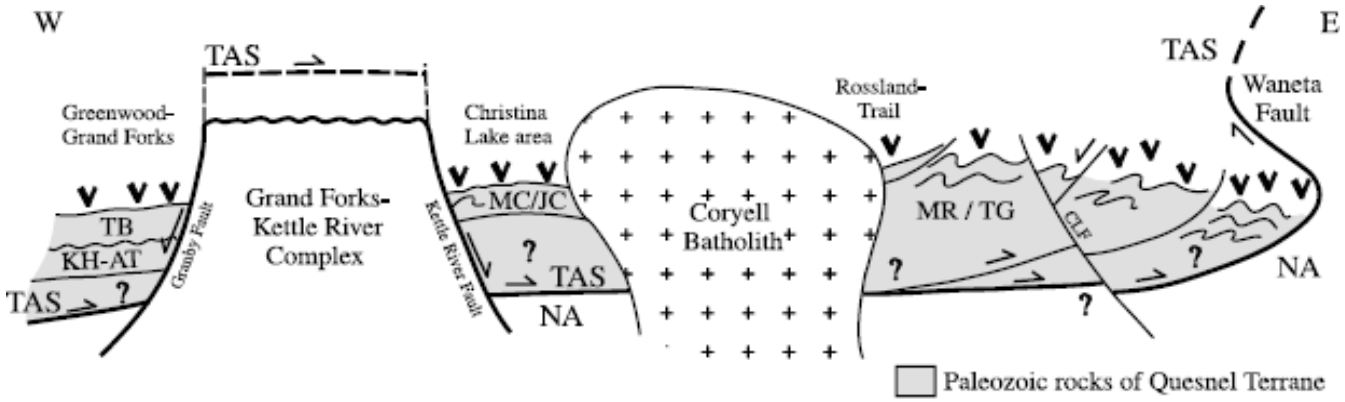


Figure 5: Simplified cross-section from the Greenwood – Grand Forks area to the Waneta Fault, immediately north of the 49th parallel, showing the relationship of Quesnel Terrane rocks in the Christina Lake area to adjacent regions CLF, champion Lake Fault; KH-AT, Knob Hill and Attwood Groups; MC/JC, Mollie Creek assemblage and Josh Creek diorite; MR, Mount Roberts Formation; NA, North American margin and cratonic basement rocks; TAS, terrane accretion surface; TB, Brooklyn Formation; TG Trail Gneiss; V, Rossland Group. (Acton, Simony, and Heaman, 2002)

The Kettle River Fault is an east dipping normal fault that along with the west dipping Granby Fault was formed in stages from 67 to 50 million years ago. The faults formed as the crust was stretched and the Precambrian rocks domed up and the younger rocks dropped down on either side of the gneiss as seen in the cross-section. The uplifted block of rock between the faults is known as the Grand Forks Horst. The younger metasediments and volcanics were eroded off on

the horst to reveal the gneiss beneath, whereas they were preserved by downdropping on either side of the horst. As mentioned earlier movement on the Kettle River Fault caused the rocks to be broken and crushed so that they were easily eroded by river action to create the present valley.

The present scenery is the result of fifty million years of weathering, river erosion, mass-wasting and glaciation. Following the uplift of the Grand Forks Horst there was a period of relative stability during which erosion formed a low relief landscape with gentle slopes and low hills. About 10 million years ago the area was reuplifted causing streams to cut into the old erosion surface forming steep narrow valleys separated by gently sloping upland areas (Ryder 1996). The whole area was completely buried by ice during the glaciations of the last two million years, but the ice caused only minor modifications of the landscape.

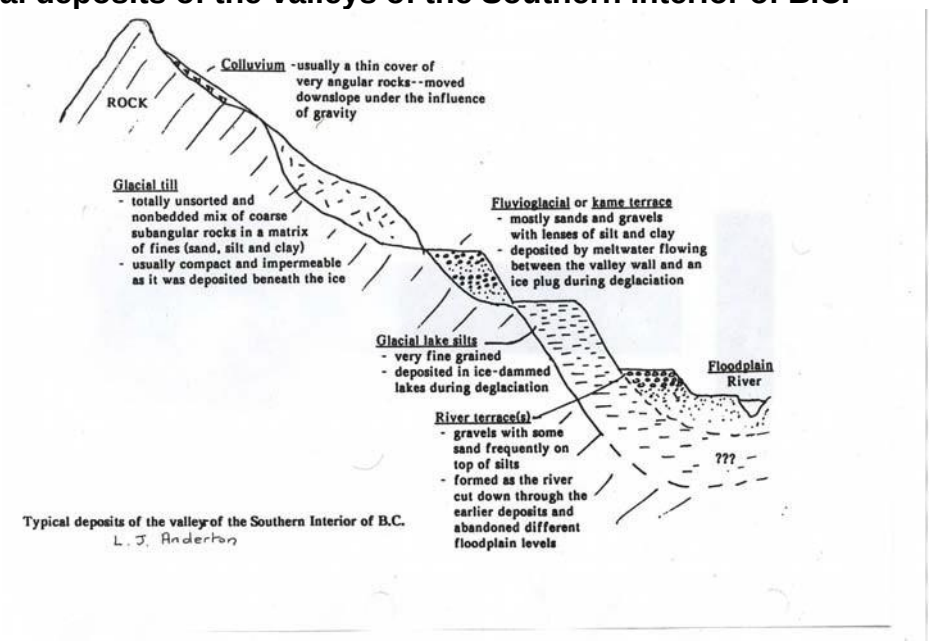
5.1.0 Surficial Geology of the Christina Lake Watershed

By two to three million years ago the main landscape features would have been carved out by weathering and erosion, and the land would have had a thick covering of soil and weathered rock. During the Ice Age there must have been several periods of glaciation interspersed with warm interglacials. Each glacial advance generally removed the evidence for the previous one. South moving glacial ice, that overrode the whole region and reached to heights of 2,050 m above sea level, caused overdeepening of the main valley to create the Christina Lake Basin. The ice evidently overrode all the ridges, even Mt. St. Thomas, and as a result they were protected from frost action and have a rounded appearance. At higher elevations some of the ridges were scraped bare.

Perhaps the most significant impact of the last major glacial episode (Fraser Glaciation) was the deposition of surficial materials as the ice melted down. During ice advance the ice would have picked up soil, weathered rock and earlier glacial and fluvial (river) deposits, and as the ice cover melted the landscape would have been plastered with till. This till was then reworked by mass wasting (down slope movement) and streams and deposited as fluvioglacial sand and gravel kame terraces against ice plugs in the valleys. In some cases drainage was blocked by ice and silts were deposited in glacial lakes. These deposits in their turn were later dissected by streams and redeposited to form river terraces, alluvial fans and deltas. As a result of all this activity much of the landscape is blanketed by surficial materials, ranging in thickness from less than a metre to more than 50m, that have a profound influence on land use and stability.

SURFICIAL MATERIALS

Figure 6: Typical deposits of the valleys of the Southern Interior of B.C.



TILL

Till is material that was deposited directly from glacier ice and characteristically consists of coarse subangular rocks in a matrix of fines. Basal till was deposited beneath the ice and as a result is compact and impermeable, except when loosened by weathering. Ablation till, which is less common, melted off the top and sides of the ice and is much looser, has fewer fines and is permeable. Basal till is widespread and forms a blanket (> 1m. thick) or veneer (< 1m.) on most gentle and moderate slopes above 800 metres and is extensive on the broad gently sloping uplands.

Weathered basal till forms an excellent forest soil as the fines retain moisture and nutrients. Seepage and stability problems exist where sites are disturbed by road building and permeable ablation till or weathered till overlie compact basal till. Usually the problems are fairly minor and result in small slumps of road banks. However, if drainage is not managed well, major failures can occur when the overlying till becomes saturated. This happened on the Lower Arrow Lake near Allandale Creek when drainage spilled off a new road saturating the weathered till and causing a major debris flow on a relatively gentle tree-covered slope (< 45%).

FLUVIOGLACIAL SANDS AND GRAVELS.

Beginning about 12,000 years ago the climate warmed and the ice melted down leaving plugs of ice blocking the major valleys. Streams drained down the mountainsides eroding the till and then flowed between the ice and the valley wall depositing extensive tracts of sand and gravel forming relatively flat kame terraces as at Lafferty above McRae Creek and above English Point, near the mouth of McRae Creek. These deposits are usually highly permeable and relatively stable. They are often a good source of well washed sand and gravel (e.g. Lafferty Pit) and make good railbed and road sites. Problems can arise where lenses of finer material (e.g. silt) lead to seepage and instability.

GLACIOLACUSTRINE MATERIALS.
Sometimes the ice plugs formed temporary dams so that short-lived lakes were formed in which fine sand, silt and clay were deposited (glacial lake or glaciolacustrine sediments). These have poor permeability and cause impeded drainage, perched watertables, surface seepage and instability. “It is likely that glaciolacustrine sediments are a significant component of the valley fill that extends along the floors of the main valleys, and that they are common along the stream-side scarps” (Ryder, 1996).

COLLUVIUM.
Colluvium refers to deposits that are primarily the result of mass movement under the influence of gravity, which covers rock falls, landslides, slumps, avalanches, debris flows and less dramatic soil creep. “Downslope from steep rock outcrops, discontinuous colluvial veneers commonly overlie till. Colluvium covered slopes are widespread on the relatively steep valleysides of the main creeks and their tributaries, and colluvial veneers are probably extensive on the uplands in the alpine zone.” (Ryder, 1996). Talus slopes, composed of fairly loose angular rocks, occur beneath steep rock bluffs and colluvial fans occur where debris flows deposited material at the base of steep gullies.

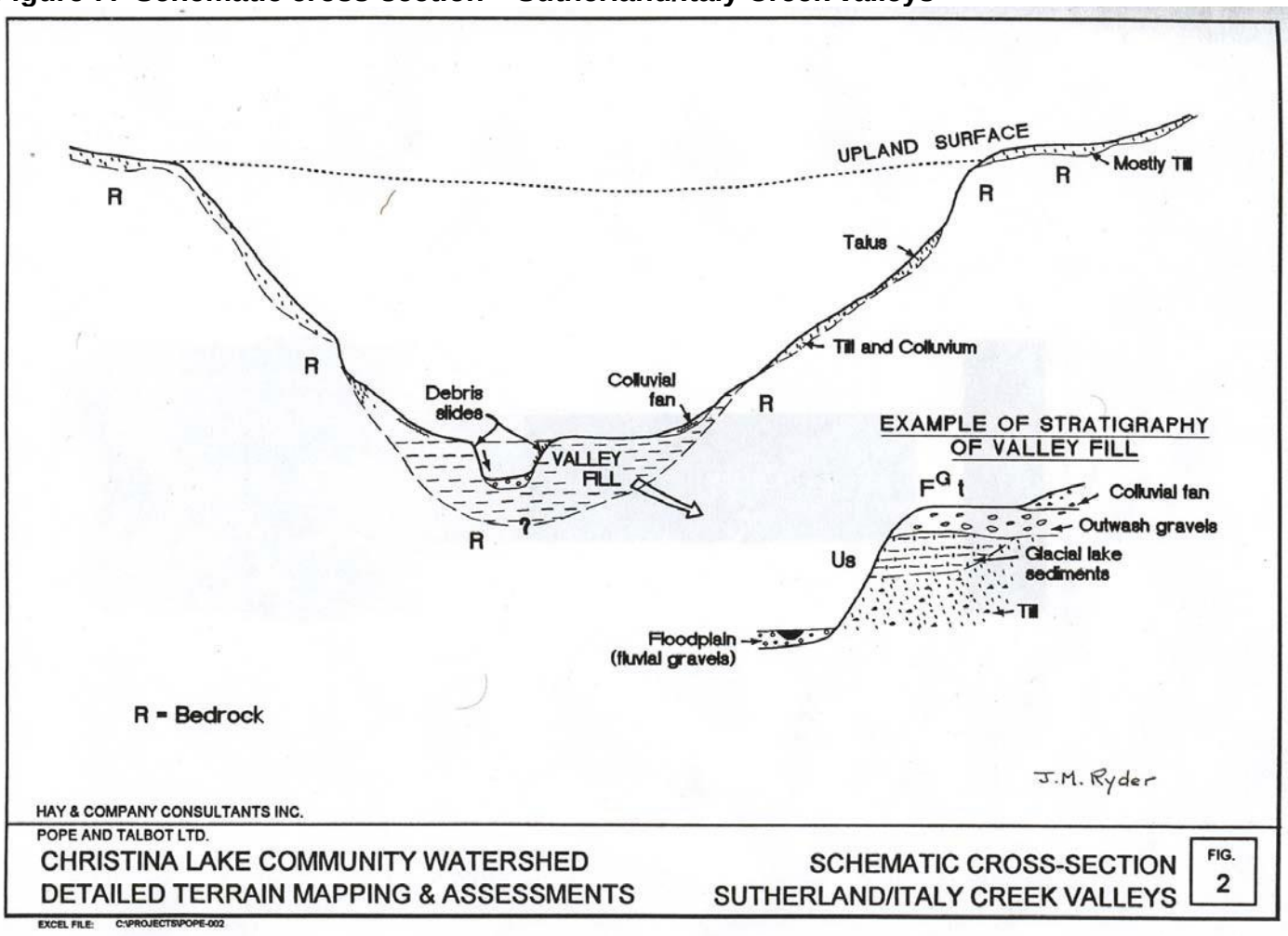
FLUVIAL MATERIALS
Fluvial deposits have been transported and deposited by flowing water and as a result the sands and gravels are moderately well sorted and rounded, unless they represent flood deposits. Narrow floodplains and river terraces occur along most creeks, and there is an extensive floodplain, occupied by Christina Creek and the Kettle River, to the south of Christina Lake. The most significant fluvial features in the watershed are the large fan-deltas built into Christina Lake by Sandner, Texas, McRae and Sutherland Creeks on the east side of the lake, where the streams drain much larger basins than on the west side. The fan-deltas were built as heavily sediment-laden streams deposited their load into Christina Lake and had such an excess of material that fans were built above lake level on top of the deltas.

The fan-deltas make good settlement sites, as they are gently sloping and well drained. They appear to be fairly stable sites, but if there is severe disturbance in their drainage basins the fans could be flooded by sheet wash or impacted by debris flows. Good management practices where road building and logging are concerned should prevent this from happening, particularly if attention is paid to good drainage. If lake levels rise the toes of the fans may be flooded and high water tables could be a problem. With increasing settlement on the fans, care needs to be taken with sewage disposal and study of the grain size of sediment is important. If the material is gravel and coarse sand filtration will be inadequate and this can lead to groundwater contamination and pollution of the lake. If the material is too fine (silt and very fine sand) leachate will not drain sufficiently well. Similar care has to be taken with settlement sites on the floodplain and here high watertables can pose additional problems.

TERRAIN MAPPING
Detailed terrain mapping is invaluable for proper land management including forestry, road building, mining and settlement, as it provides information on surficial materials and their properties and pinpoints possible areas of concern. Detailed terrain mapping of Sutherland and Italy Creeks was done by J.M. Ryder and Associates for Pope and Talbot. This produced six terrain maps at a scale of 1:20,000 and a very useful report with descriptions of the surficial materials and recommendations for maintaining stable slopes and minimizing erosion. Ryder

(1996) in referring to the Sutherland and Italy watersheds states that “in general, slopes appear relatively stable, and there are extensive uplands with relatively gentle slopes where logging can proceed with few physical constraints, although careful management and planning will be required.”

Figure 7: Schematic cross-section – Sutherland/Italy Creek valleys



See Appendix E Map 6 – Soils – for soil types in the Christina Lake watershed.
See Appendix E Map 8 – Terrain – for terrain types in the Christina Lake watershed.

5.2 WATERSHED HYDROLOGY

Water that flows through the watershed via stream corridors and through the ground carries nutrients, pollutants and sediments into and out of lakes; therefore an understanding of lake hydrology is required to analyze water quality.

The hydrological characteristics of Christina Lake and its watershed is summarized in Table 1 on the following page.

Table 1: List of Hydrologic Data for Christina Lake (Cavanagh *et al*., 1994.)

Evaporation Rate (assume 75 cm evaporated from surface/yr)		18825 dam^3/yr
Outflow Volume		208000 dam^3/yr
Inflow Volume (evaporation rate + outflow volume)		226825 dam^3/yr
Drainage Basin Water Yield		461 dam^3/km^2
Flushing Time		4.5 years

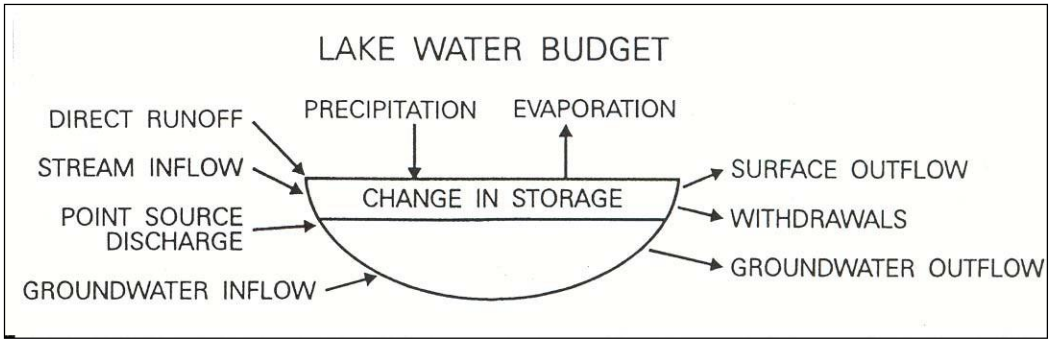
Water Yields of Adjacent Systems		
Moody Creek		333 dam^3/km^2
Kettle River at Cascade		250 dam^3/km^2
Granby River at Grand Forks		471 dam^3/km^2

5.2.0 Sources of Water Inflows and Outflows

On the Terrestrial Resource Inventory Management (TRIM) maps, [7]41 first to fifth-order streams that flow into Christina Lake and one outflow are identified. (See Appendix E Map1 - Base Map) Of these 41 inflows, only a few have perennial (year round) flows. All other streams in the drainage basin have intermittent (ephemeral) flow patterns (Aquatic Studies Branch, 1980).

Figure 8 below details possible sources of water inflows and outflows via different mechanisms of delivery and extraction.

Figure 8. Schematic Water Budget (Holdren et al., 2001)



5.2.1 Inflows to Christina Lake

A search was done on the online database system called Fisheries Information Summary System (FISS) (2005) for information pertaining to Christina Lake and for all gazetted streams that flow directly into Christina Lake. Many streams had no FISS data associated with them. TRIM maps were also reviewed. Fish Wizard (2005) was used to ascertain locations of watershed- coded streams. The following (Table 2) shows the results for watershed-coded streams and non-watershed-coded streams that flow directly into Christina Lake as well as perennial and

[7] Note on Table 2. #39 and #42 – may be report errors as noted on TRIM maps there are 41 tributaries shown flowing into Christina Lake. FISS has another stream with a watershed code attached to it (between Brooks and Spooner Creek) that is not on the TRIM map.

intermittent flow if known provided by (Walker, 2004). Our research has identified research gaps and a lack of field information for several creeks within the watershed.

Table 2. Christina Lake Inflowing Stream Systems

	Stream Name	Watershed Code	Length (km)	Perennial (P) Intermittent (I) (Walker, 2004)
1	Sutherland Creek	320-160600-13100	17.42	(P)
2	Baker Creek	320-160600-34400	3.92	(I)
3	Unnamed		?	?
4	Spaulding Creek	320-160600-41200	2.36	(I)
5	McRae Creek	320-160600-46500	27.25	(P)
6	Texas Creek	320-160600-56600	13.75	(I)
7	Unnamed	320-160600-67900	3.61	?
8	Unnamed		?	?
9	Unnamed		?	?
10	Unnamed	320-160600-76300	1.02	?
11	Unnamed	320-160600-76500	2.16	?
12	Trapper Creek	320-160600-78700	2.21	(I)
13	Unnamed		?	?
14	Unnamed		?	?
15	Unnamed		?	?
16	Sandner Creek	320-160600-97700	15.86	(P)
17	Troy Creek	320-160600-96900	7.93	(P)
18	Unnamed		?	?
19	Unnamed	320-160600-96500	3.8	?
20	Unnamed		?	?
21	Unnamed	320-160600-95900	3.77	?
22	Unnamed		?	?
23	Seggie Creek	320-160600-88700	4.02	(I)
24	Red Ochre Creek	320-160600-88100	2.57	(I)
25	Unnamed		?	?
26	Parson Creek	320-160600-82300	2.73	(P)
27	Treadmill Creek	320-160600-76800	6.08	(I)
28	Unnamed		?	?
29	Unnamed	320-160600-60700	1.67	?
30	Unnamed		?	?
31	Unnamed		?	?
32	Unnamed		?	?
33	Gill Creek	320-160600-53000	3.31	(I)
34	Stewart Creek	320-160600-42700	6.84	(P)
35	Unnamed		?	?
36	Lighthouse Creek	320-160600-36500	.61	(I)
37	Unnamed		?	(P)
38	Brooks Creek	320-160600-29500	4.56	(I)
39	Unnamed	320-160600-28000	1.17	(?)
40	Spooner Creek	320-160600-24000	2.17	(I)
41	Clark Creek	No WS code	?	(I)
42	Unnamed		?	(?)

See Appendix E Map 1 – Base Map for lake tributaries

5.2.1.0 Sutherland and Moody Creek Water Quality Monitoring Recommendations

The following draft water quality monitoring recommendations for Sutherland Creek and Moody Creek were provided by Einarson, (2005). At this time it has not been ascertained when these recommendations will be implemented (Jensen, 2005).

Sutherland Creek Water Quality Monitoring Recommendations

Water from Sutherland Creek is used for domestic use, commercial operations and irrigation. In addition to private landowner licensees, the Sutherland Creek Waterworks District draws, disinfects and distributes water to a number of users. Water quality objectives and monitoring recommendations for Sutherland Creek are currently being developed and are still in draft form. A review of existing data has been completed. Although water quality objectives were not available at the time this report was drafted. Table 3a presents draft monitoring recommendations.

Table 3. (a): Water Quality Monitoring Recommendations for Sutherland Creek

Parameter	Location	Frequency and Timing
Fecal coliform	EMS E220681 EMS E232365	Five times in a 30 day period between June 1 and August 31.
True colour, pH, specific conductance, turbidity	EMS E220681 EMS E232365	Five times in a 30 day period during clear flow and during turbid flow.
Temperature, turbidity	Any location in the watershed upstream and downstream of development	Continuous with electronic instrumentation during the ice-free period.
Non Filterable Residue	Any location in the watershed upstream and downstream of development	Five times in a 30 day period
Chlorophyll *a*	EMS E220681 EMS E232365	Once during the growing season, replicated 6 times
Hardness	EMS E220681 EMS E232365	Monthly

Moody Creek Water Quality Monitoring Recommendations

Christina Water Works District is currently using Moody Creek, as a source but will be reserved for a back up supply only beginning in 2006 (Stewart, 2005). Other water licensees draw water for domestic use, irrigation, and storage. Water quality objectives and monitoring recommendations for Moody Creek are currently being developed and are still in draft form. A review of existing data has been completed. Although water quality objectives were not available at the time this report was drafted. Table 3b presents draft monitoring recommendations.

Table 3. (b): Water Quality Monitoring Recommendations for Moody Creek

Parameter	Location	Frequency and Timing
Fecal coliform	EMS E232324	Five times in 30 day period between July 1 and August 31.
True colour, pH, specific conductance	EMS E232324	Five times in a 30 day period during clear flow and ten times in a 30 day period during turbid flow
Chlorophyll *a*	EMS E232324	Once during the growing season, replicated 6 times
Hardness	EMS E232324	Monthly
Turbidity, TOC	EMS E232324	Five times in a 30 day period between March 16 and June 30
Temperature, turbidity	Any location in the watershed upstream and downstream of development	Continuous with electronic instrumentation during the ice free period
NFR	Any location in the watershed upstream and downstream of development	Five times in a 30 day period
Temperature	EMS E232324	Continuous with electronic instrumentation during the summer months

5.2.2 Outflow from Christina Lake

Christina Lake drains via Christina Creek, which then flows into the Kettle River system. The Kettle River flows into the Columbia River near the northern end of the F.D. Roosevelt Reservoir in Washington State (Sigma Engineering, 1991). Approximately once every ten years this creek backflows into the lake when the Kettle River experiences periods of high flow (Maximenko, 1993). See Table 4 below. Information was obtained from (FISS, 2005) and (Walker, 2004).

Table 4. Christina Lake Outflow Stream Information

	Stream Name	Length (km)	FISS Data Available	Perennial (P) Intermittent (I) (Walker, 2004)
1	Christina Creek	2.49		(P)

5.3 WATERSHED USAGE INFORMATION

Many people dream of living on waterfront property. Each year the number of people, who own, lease, or rent waterfront property increases. In Canada, nearly 4 million people own property on a shoreline or containing natural water features such as creeks and ponds (Calloway and Kipp, 2002).

The Christina Lake watershed is an important multi-use area. The drainage basin supplies water for domestic, commercial, industrial, and agricultural needs within the local communities. The lake is used extensively for recreational purposes and as a site for permanent and summer residences (Cavanagh *et. al.,* 1994). Voted “BC’s” favorite lake on a CBC radio survey in 2003; Christina

Lake is famous for its exceptional water clarity, warmth, and beauty (Christina Lake Chamber of Commerce, 2005). In addition, by virtue of inaccessibility, much of the adjacent land provides ideal habitat for a diverse array of wildlife species. Therefore, maintaining the quality of the water is vital to those who use the lake and surrounding watershed as a water source and recreation area and to preserve the present level of aesthetic value it provides (Cavanagh *et. al.,* 1994).

Development near or directly adjacent to waterways often involves the removal of riparian vegetation and physical disturbance to the bank or wetlands. Riparian vegetation and wetland areas are extremely valuable in terms of their water storage capacities and wildlife habitat values. Water captured during spring run off is slowly released back into the stream system over time or dispersed through evapotranspiration. When riparian vegetation is removed or wetland areas are filled in, the risk of flooding is increased and run off water passes quickly through the system. In the absence of root mass, banks lose stability and the risk of sloughing rises. Bank failure can lead to increased sediment input affecting not only fish habitat but also drinking water quality (British Columbia, 1995).

Riparian zones act as a filter, by intercepting undesirable substances, either surface or subsurface, bound for a stream or lake system. Water temperatures are moderated by riparian vegetation that provides shade and also cover for fish and other aquatic species. Since cooler temperatures are directly related to higher dissolved oxygen levels, riparian vegetation makes a significant contribution to the value of fish habitat (British Columbia, 1995).

Lakeshore fish habitat is also at risk because of shoreline development. The shore spawning kokanee population in Christina Lake utilizes gravel shoals for spawning (Mitchell and LaCroix, 2004). Construction of retaining walls and other structures below the high water mark can have a devastating effect on kokanee spawning habitat by covering or severely altering the substrate composition. Furthermore, importing sand to construct beach areas unfavorably alters spawning habitat (Mitchell, 2005).

5.3.0 Current Land Use Activities

The community of Christina Lake is unincorporated. The watershed is entirely within Electoral Area 'C', which is governed by the Regional District of Kootenay Boundary (RDKB). Land use designations and policies were established through the Official Community Plan Bylaw No. 1250, which was adopted in 2004. The current Zoning Bylaw No. 900, 1996 is under review and will be amended to reflect the land use objectives and policies established in the Official Community Plan.

The Christina Lake watershed current land use activities include residential and commercial uses, recreation and tourism, forestry, range use, agricultural, mining, park areas, guide outfitters and trapline territories. This section outlines the land use under each of these categories.
(See Appendix E Map# 2 Land Use Map)

5.3.0.0 Zoning

The vast majority of the watershed is either within the boundaries of Gladstone Provincial Park (20,479 ha; 39% of the total area) or zoned Natural Resource (26,597 ha; 51% of the total area). The remaining land adjacent to the Christina Lake waterfront and at the south end of lake is zoned for residential; commercial; and institutional and community land uses. The zones are

summarized in Table 5 below, which also includes landbase area and the percentage of the watershed that each designation covers. The information in this table was provided by (Jennings, 2005) and (Dean, 2005).

Table 5. Land use designations

Land Use	Area (ha)	% of watershed
Gladstone (within watershed)	20,479	39
Natural Resource	26,597	51
Lake Surface	2,560	5
Residential/Commercial	1,486	3
Institutional/RDKB Protected/Rural	769	1
Watershed Total	51,891	100

5.3.0.1 Population and Settlement

In the Christina Lake area the population is 1,456 per Statistics Canada 2001 census results. This is an increase of 3.4% since the 1996 census. The number of seasonal residents at Christina Lake has been estimated to be 5,000 or more during busy summer weekends, although this number is not documented by Statistics Canada (RDKB, 2002). The summer population is much higher, and varies depending on whether the estimate is for mid-week or weekend, whether it includes campers and/or motel visitors. The majority of the population and development is concentrated at the southern and southeastern shores of the lake. There is some development at the north and northwestern portion of the lake but it is limited to boat access only (Ellis et. al., 1991). The northern half of Christina Lake is within the Gladstone Provincial Park. This protected area is approximately 393 square kilometres in total and includes all of the Sander Creek drainage and most of the Texas Creek drainage (BC Parks, 2001).

5.3.0.1.0 Residential

There are 799 permanent (year round) residential lots in the Christina Lake watershed, the majority of which are located along the southern/southeastern portion of the lake (RDKB, 2004).

There are 402 seasonal residential lots in the Christina Lake watershed (RDKB, 2004). The majority of these are located along the southern/southeastern shore, while approximately 165 are located at the northern/northwestern portion of the lake and are accessible only by boat (Hanson, 2005).

There are currently 529 vacant lots within the watershed area. The total number of residential lots per the 2004 RDKB assessment is 1730 (of these 429 are lakeshore properties).

5.3.0.1.1 Commercial/Utility/ Institutional/Recreational/Government

The total number of commercial, utility, institutional, recreational, and government lots for services to the community is 191 (RDKB, 2004). For a breakdown of each see Table 6 below.

Table 6. Land Designations per 2004 Assessment - RDKB

LAND USE DESCRIPTION	NUMBER OF LOTS
Residential	
Year Round	799
Vacant Lots	529
Seasonal	402
TOTAL	**1730 (of these 429 are lakeshore properties)**
Commercial - Services (Includes easements and foreshore holdings)	
Active	52
Vacant	16
TOTAL	**68**
Utility (includes easements)	
Railway	10
Communications	16
Water Distribution Systems	3 (10 privately owned plus 1 government)
Electrical Power Systems (incl. Non-Utility Co.)	30
TOTAL	**59**
Institutional/Recreational/Government	
Active	27
Vacant	37
TOTAL	**64**

5.3.0.2 Tourism and Recreation

Christina Lake is very popular area for tourism and recreational activities. During the summer months (mid June to mid September) the water temperature is well suited for water-based activities such as swimming, scuba diving, fishing, boating, para sailing, and water skiing. The lake also offers good water clarity and sandy beaches. Due to limited access within the watershed, most recreational activities are water-based as opposed to land-based. The access also limits the majority of the water-related activities to the southern half of the lake. Many of the seasonal cottages and campgrounds are restricted to the shoreline of the lake as topography of the region limits construction and road building (Cavanagh *et. al*., 1994). Conclusive information was not available to determine accurate levels of tourism and recreation activities during the peak tourism months (July and August). In order to ascertain the increase from the permanent resident populations the approximate level of visitors to the area (day trip or extended stay) would need to be calculated for each business such as motels, campgrounds, cottages, homes, boats in the lake etc. Population increase estimates have been done in other popular tourist destinations. Seasonal population estimates for the Christina Lake watershed could be a valuable tool for planning purposes and determining carrying capacity for the watershed.

Land-oriented activities include guided backcountry tours, several trails for hiking, mountain biking, sightseeing, golfing, and cross-country skiing. There are also community recreational facilities such as tennis courts, a baseball diamond, and children's playground and lawn bowling greens.

Christina Lake has a moderate sports fishery with the most sought after species being smallmouth bass, rainbow trout, and kokanee. See Section 7.3.4.4 Creel Surveys and Kokanee Enumerations.

5.3.0.3 Agriculture

Due mainly to the rugged topography and shallow soils over bedrock, agricultural activity has been limited in the Christina Lake watershed (Cavanagh *et al*, 1994). The majority of what little agriculture exists is located within the Agricultural Land Reserve (ARL) of the Sutherland Creek valley. (Sigma Engineering, 1991.) There are currently 41 water withdrawal licenses on Sutherland Creek with 15 designated for irrigation purposes. There are 26 water licenses within the watershed designated for irrigation purposes (this number includes the 15 licenses on Sutherland Creek) (RDKB, 2004). (See Table 9 Water Licenses within the Christina Lake Watershed)

5.3.0.4 Forestry

The Christina Lake watershed is located within the Interior Cedar Hemlock (ICH) biogeoclimatic zone (Braumandl and Curran, 1992). This zone has the widest variety of coniferous tree species of any other biogeoclimatic zone in the province. Conifers such as Western hemlock (*Tsuga heterophylla*) and Western red cedar (*Thuja plicata*) are characteristic of this zone, as well as spruce (*Picea spp.*) and subalpine fir (*Abies lasiocarpa*) as is Douglas fir (*Pseudotsuga menziesii)* and lodgepole pine (*Pinus contorta var. latifolia*) on drier sites (Ellis *et. al*., 1991). The entire watershed falls within the Arrow Boundary District Timber Supply Area (TSA) – excluding areas that have other land designations such as woodlots, parks, private land etc. Therefore, forest development plans; road permits and cutting permits are administered through the head office located in Castlegar.

Most of the logging that has taken place in the watershed is away from the lake itself as the shoreline is often to steep and rocky, and much of it is inaccessible by road (Ellis et. al., 1991). Protected areas such as Gladstone Provincial Park on the north end of the lake prohibit any logging activities. The only major licensee operating in the area is Pope and Talbot Limited (Canadian head office in Grand Forks, BC and the Forestry office for Grand Forks and Midway mills is in Midway). Pope and Talbot Ltd. operate under Forest License A18969. In addition to this, logging practices are carried out by small businesses and woodlot licensees under authorization from the Ministry of Forests. Some private landowners also log their properties and this may require proper permits for road building or usage and a timbermark to allow timber to be hauled to the processing facilities.

Logging in the Christina Lake watershed dates back to the early 1900's. In the earlier years, much of the logging activity was probably selective *(i.e. high grading)* logging (Toews and Gluns, 1983). Logging activity in the area increased in the 1970's and the annual allowable cut for the TSA was set at its current levels in 1981 (Noren, 2005). An indication of the areas in the watershed previously logged can be obtained from Table 7 below, which gives areas by age class for the watershed. **Note: As of the final editing of this edition of the CLMP, table 7 information had not been received. The information will be incorporated into the CLMP and updated at the annual review, which is scheduled for June of 2006. This item has been noted in the CLMP Implementation Strategy Manual for an immediate action item.**

Table 7. Arrow Boundary Forest District – Area by age class for the Christina Lake Watershed as of _____

AGE	AREA	
	(HA)	(%)
1 – 20 years		
21 – 40 years		
41 – 60 years		
61 – 80 years		
81 – 100 years		
101 – 120 years		
121 – 140 years		
141 – 250 years		
250 + years		
Not satisfactorily restocked (1)		
Non-forest (2)		
TOTAL (3)		

1. The “not satisfactorily stocked” category includes those areas that have been deforested either by logging or by natural events such as fire, wind or insects. Areas that have been harvested typically have a 1 to 7 year period before a regeneration survey is done that proves stocking levels (Noren, 2005).
2. The non-forest category includes lakes, swamps, rock outcrops, non-productive areas etc.
3. The total land base includes all private as well as crown land, parks, etc.

For the Christina Lake watershed the water quality parameters influenced by logging activity includes sediment concentrations, nutrient level, and temperature. Sedimentation is usually the primary concern (Ellis *et al.,* 1991). Sediment deposition in a stream can critically damage fish spawning habitat and affect water quality. Removal or destruction of forest cover from logging or fire and diversion of water from natural channels can increase risk of slides. Cleared slopes can become susceptible to slides. Increased road access to backcountry areas can disrupt wildlife migration routes and fragment or damage habitat. As Ellis *et al.,* (1991) states; sedimentation impacts would depend on stream channel stability, slopes, soil types, logging and road construction practices. An example of sediment loading occurred in the Parson Creek watershed of the Christina Lake basin in 1988. A slide occurred adjacent to a logging road in the headwaters of the creek system and triggered a 1.5 km debris torrent down Parson’s Creek. Factors thought to contribute to the slide included an unusually quick peak spring runoff, spill over runoff from drainage structures and subsurface flow in the soils. The debris torrent stopped short of Christina Lake and as a result no debris was carried in. It is probable that sediments were carried in at this time, but no water quality sampling was performed to confirm this, as the slide was not discovered for a few months.

Managing forestry activities to minimize damaging impacts is a challenging endeavor that requires consideration of all aspects of the natural environment. Despite forestry management efforts, other influences can contribute to a decline in forest health. Insect infestations, disease, and forest fires create new challenges for forest management professionals and often demand Forest Development Plan revisions (Noren, 2005).

Under the *Forest Practices Code of British Columbia Act* (1995) (now the *Forest and Range Practices Act*), forest companies are required to prepare Forest Development Plans (FDP's) to identify and guide harvesting and road building operations, and specify measures to protect forest resources during those operations (BC Ministry of Forests, 2001). On December 17, 2002, a significant number of amendments to the *Forest Practices Code of British Columbia Act* and regulations came into effect. These amendments reduce the administrative requirements of the Code during the three-year transition period until the new *Forest and Range Practices Act* is fully implemented in December 2006. The FDP requirement will soon be changing under the new *Act*. The new planning documents will be called Forest Stewardship Plans (FSP's). It is not known exactly when the new system will come into effect therefore, FDP's are still being utilized until that time. A summary of Pope and Talbot's planning and harvesting procedures and Forest Development Plan public review procedures is in Appendix D. Although FDP's are revised on a continual basis and are reviewed and updated on an annual basis, they are an overall view of harvesting and reforestation activities (to the free-to grow state) forecasted for five years. Thus giving the public time to review and critique the prescribed activities. It is up to the general public and various groups who have concerns about harvesting and reforestation methods detailed in the FDP to keep aware of the plans contents and submit viable concerns to the company through the FDP public review process. The company must review all concerns and identify how the concerns will be addressed within the plan. Many times this is the reason for plan revision throughout the year.

Bill 28 – 2003, *Forest Revitalization Act*

[8]Bill 28 was enacted by the Legislature and brought into force as of March 31, 2003. In order to allow a larger volume of fibre to be made available in a manner different from the long term tenures currently in place, the Government is re-acquiring approximately 20% of the Provincial Annual Allowable Cut (AAC) from the current holders of replaceable tenure (Bill 28, s.2). This includes approximately 8.3 million cubic metres of AAC ("volume") held by 27 tenure holders listed in the schedule to the Bill. Bill 28 provides the relevant mechanisms for doing so and for paying compensation for the related reduction in tenure and associated improvements. Although the tenure reductions are effective on proclamation of the legislation (March 31, 2003), s.3 provides a period of up to 3 years for specific amendments to the tenure areas to be made by way of Ministerial order. Pending such orders, harvesting is to continue as normal. The fibre being re-acquired will be made available through the timber sale license provisions of the *Forest Act*. Those provisions require a bid process based upon the payment of a price based upon stumpage and a bonus bid or offer. The above information was obtained from www.legis.gov.bc.ca/37th4th/1st_read.

Within the Arrow Boundary District the majority of the reallocation will go back to BC Timber Sales to allocate to Small Business Sales, First Nations, Community Forests, Woodlot expansion programs, and Forest Service Reserves as designated by the Ministry of Forests "Arrow Boundary" District Manager (Vermiere, 2005).

5.3.0.4.0 Forest Tenures

Commercial Tenure:

Pope and Talbot Ltd is the largest commercial logging company within the watershed boundary. Their timber supply area (TSA) encompasses all crown land that is not designated for other

[8] Re-acquired AAC for market based pricing to counteract current lumber tariffs

purposes. The current annual allowable cut (AAC) is 602,579 m3 (Forest License = 434,549 m3 and Tree Farm License = 168,030 m3).

Under Bill 28 *Forest Revitalization Act:* Beginning Jan 1, 2006, the AAC for the Forest License will be reduced by 78, 120 m3 to 356,429 and beginning Jan 1, 2007, the AAC for the Forest License will be reduced by a further 21,838 m3 to 334,591 m3 (Noren, 2005).

An agreement was confirmed on February 25, 2005 that will result in the west side of Christina Lake, including Moody Creek and north along the height of land to Gladstone Park being transferred to BC Timber Sales (BCTS) (Barclay, 2005). The east side of the lake will remain with Pope & Talbot. BCTS have not initiated any harvest plans for this area yet as Pope & Talbot will still be logging on the west side of Christina Lake until their current crop of permits are completed in approximately another 2-4 years (Barclay, 2005). BCTS planning will develop over the next few years as Pope & Talbot withdraws from the area (Barclay, 2005).

Woodlot Tenures:

Currently there are 45 Woodlots within the Arrow Boundary District of which 3 are within the Christina Lake watershed. Each woodlot is divided into Schedule A private land and Schedule B Crown land apportionments. Woodlot tenure holders must also develop a plan and have an annual allowable cut determined prior to undertaking any operations (Vermiere, 2005).

	Schedule A	Schedule B
1. WL1470	29 ha	600 ha
2. WL1624	28.8 ha	600 ha
3. WL1767	17.4 ha	600 ha

Under Bill 28 *Forest Revitalization Act* there are plans to expand the Woodlots within the Arrow Boundary District (Marshall, 2005).

Community Forest Tenures:

Currently, there are no Community Forest Tenures within the Christina Lake watershed. The CLSS has expressed a desire to look into the possibility of obtaining this kind of tenure on the westside of Christina Lake (Stewart Creek area) which is now currently within Pope and Talbot's TSA but will be re-allocated to BC Timber Sales in the very near future. Community Forests require full community support for this type of endeavor and entails a great deal of work prior to commencement of operations as well as ongoing operations for the duration of the tenure. A Community Forest would enable the community to make decisions on harvesting methods, sustainability, and accountability when it comes to forestry within our watershed. The CLSS will endeavor to seek community input to ascertain levels of support for this type of tenure.

5.3.0.4.1 Forest Health

The following information was paraphrased and/or directly quoted from Boundary TSA DFAM (2004) and the Provincial Bark Beetle Management Technical Implementation Guidelines Spring (BC Ministry of Forests 2003). Detailed information regarding voluntary and obligatory forest health activities occurring in the Christina Lake Watershed was not available at the time this version of the CLMP was printed. Updated information will be included in the annual update.

Responsibility for managing forest health issues falls upon the Ministry of Forests (MoF). The original intent of the 2003 Defined Forest Area Management initiative placed the responsibility of

carrying out forest health related activities on licensees. Upon further review the Province decided to take back the responsibility and allow licensees to carry out forest health initiatives on a voluntary basis. The decision for MoF to take on the responsibility of forest health related activities came after industry and MoF staff brought forward policy issues during the intended transition period (September 2003 to April 2005). Forest Investment Account[9] (FIA) funds are available for licensees who wish to carry out forest health activities voluntarily.

Bark Beetles

Forest health in the Christina Lake watershed is affected by many factors including, but not limited to, bark beetles, defoliators, diseases, animals, abiotic factors and climate. Currently, bark beetles are considered to be the most important forest health factor in the Boundary Timber Supply Area (BTSA), including the Christina Lake Beetle Management Unit (BMU). Bark beetles such as the Mountain Pine Beetle and the Douglas-fir Beetle are the only two forest health factors currently being managed for in the Christina Lake BMU as they are currently considered to pose the greatest threat to forest health in the Christina Lake BMU. Control strategies[10] currently being used to manage Douglas-fir Beetle and Mountain Pine Beetle infestations are "maintain low" and "prevention", respectively. The priority ranking[11] is 2 for Douglas-fir Beetle, and 3 for Mountain Pine Beetle.

Root Disease

Armillaria root disease was identified in Boundary TSA DFAM (2004) as one of the most difficult forest health factors to deal with. The disease is pervasive throughout the forest types of southern BC, including the BTSA. Harvesting activities can exacerbate *Armillaria* root disease intensity, resulting in unacceptable levels of mortality in regenerating or selectively harvested stands. The impact of *Armillaria* root disease varies considerably from ecosystem to ecosystem, stand to stand, and tree to tree, and is therefore difficult to predict. In the Christina Lake watershed, *Armillaria* root disease is managed using the *Armillaria* Root Disease Management Guidelines for the Nelson Forest Region (Norris *et al.*, 1998).

5.3.0.4.2 Wildfire

The threat of forest fire is possibly the biggest forestry related concern in the Christina Lake area (Noren, 2005). Forest fire suppression in BC has been intensive for several decades resulting in high-density fuel loading in many areas that would otherwise periodically burn if left to natural processes (Parish *et al.,* 1996). Some tree species have adapted to use fire to their advantage. Mature lodgepole pines, for example, have thin bark and are easily killed by fire. However, lodgepole pine cones are sealed shut by resin that must be melted before the seeds are released. A tremendous amount of seed is stockpiled between fires to re-populate burned areas ensuring continuity of the species after a fire (Parish *et al.,* 1996). Mountain pine beetle infestation can also

[9] The Forest Investment Account (FIA) is made up of funds taken from general provincial revenue and approved by an annual vote of the legislature. The FIA replaced Forest Renewal BC in October 2001. More information regarding the FIA is available at http://www.for.gov.bc.ca/hcp/fia/.

[10] Prior to 2003/04, 6 Control Strategy categories were used: prevention, suppression, maintain low, holding action, salvage, and abandon. Beginning in 2003/04, 4 Control Strategy categories replaced the original 6 categories; S=suppression (combined "prevention" and "suppression"), H=holding action (combined "maintain low" with "holding action"), V=salvage and MO=monitor (replaced "abandon").

[11] Priority Rankings (i.e. 1=high, 8=low) are formulated by determination of total number of green attacked trees, total number of infested spots (regardless of size), and the amount of susceptible area remaining.

lead to an increased fuel load. Large tracts of beetle-killed trees provide a hazardous fuel complex that contributes to highly destructive fires (Parish et. al., 1996). Because Christina Lake is an interface community and wildfire suppression has inhibited the natural fire maintenance function of the regional forest ecosystems the risk of wildfire damage to the community is high. In this region, controlled burns and stand thinning have been done within the Christina Lake watershed in the Stewart Creek area (Noren, 2005).

The new British Columbia Wildfire Act came into effect on March 31, 2005. The Act will remove fire-related provisions from the Forest Practices Code and put them into new, stand alone legislation, clearly defining specific responsibilities of all forest users with respect to fire use, prevention, control operations, and rehabilitation (Ministry of Forests, 2005).

In the summer of 2005 a "Fuel Loading Survey" will be performed by the BC Conservation Core in partnership with the Ministry of Water Land and Air Protection (Penticton) within Gladstone Provincial Park.

5.3.0.5 Mining Tenures

Title to property in British Columbia, termed surface rights, seldom includes the right to what lies beneath the surface, termed subsurface or undersurface rights. The Crown (provincial government) owns and may dispose of subsurface rights to most lands in the province, whether or not the surface is privately owned. Title to minerals can be held by one or more of the following types of tenure: located mineral title, crown granted mineral claim, or freehold (Ministry of Energy and Mines, 2005).

Historically, there has been mining exploration and some development of small mines in the Christina Lake watershed. Donna Mine, northwest of Coryell Creek (a tributary to McRae Creek), operated prior to the 1980's (Sigma Engineering, 1991). However, since no metals data exist for the creek, it is not currently possible to determine if leachates from the mine's tailings pit are reaching McRae Creek (Cavanagh et. al., 1994). Other prospects east and southeast of Christina Lake are known for copper, zinc, and chromite. Light coloured biotite granites occur throughout the watershed and may possibly contain uranium minerals (RDKB, 1975). For information on the geology of the Christina Lake watershed, see section 5.1.

A comprehensive search was done on the Province of British Columbia website (Mineral Titles Online Viewer, 2005) to ascertain how many Mineral Tenures are within the watershed. The location, size, and tenure status of each claim was available on this site. In order to ascertain mining activity levels of these tenures, David Grieve - Regional Geologist for Ministry of Energy and Mines in Cranbrook was contacted.

Within the watershed there are 18 Mineral Tenures, which are in good standing. This means that the annual license fee has been paid but does not necessarily mean that exploration or mining production is taking place at this time. The total land base area for all of these tenures combined is 4,933 hectares (Mineral Titles Online Viewer, 2005). See Table 8a "Mineral Tenures" for individual tenure information.

Mineral tenures under a "Crown Grant- 2 post claim" designation were found using Mineral Titles Reference maps M082E009, 010, 019, 020, 029, 030, and 039. Crown granted mineral claims are administered by the Mineral, Oil & Gas Revenue Branch, Ministry of Provincial Revenue and the

Land Titles Branch, Ministry of Sustainable Resource Management. The crown grant document may specify the minerals issued under the crown grant such as all base metals, all precious minerals, gold and silver, etc. In the absence of specific minerals, the crown grant would include those minerals as defined in the Mineral Act in force at the time the grant was issued. The crown grant is maintained by payment of an annual assessed mineral tax and work does not have to be performed on them to keep them in good standing. All assessment work carried out on a crown grant is subject to the provisions of the Mines Act and related statutes as applicable. (Ministry of Energy and Mines, 2005) Crown granted claims can be incorporated into other mineral titles and can include surface and subsurface rights attached to them (Grieve, 2005). Currently, there are 30 crown grants within the watershed area with the majority of these tenure types being located within the Orion Creek area as shown on Mineral Titles Reference Map M082E020 (copy located at the Community Stewardship Resource Centre – 90 Park Road, Christina Lake, BC). See Table 8b for Crown Grant Tenure listings.

Many older tenures that were well known within this area such as Fife Quarry and Donna Mine have been forfeited (abandoned). The entire watershed is not open for placer staking (Ministry of Energy and Mines, 2005).
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Photograph 2. Fife Quarry – Oscar Tedesco - Courtesy of the Boundary Museum

Approximately five percent of the provincial land base is privately owned. Within the privately owned lands, the Crown owns most of the rights to minerals. However, private ownership of minerals does exist in some lands but exactly which lands, which minerals and by whom can be unclear. The Ministry of Energy and Mines has undertaken a project to clarify who owns mineral rights in privately owned lands in the province. The Ministry is proposing to introduce a Bill entitled the *'Mineral Title Clarification Act'* in the Spring 2005 Legislative Session. The proposed Act will establish a process by which “freehold mineral rights” can be confirmed throughout the province (Ministry of Energy and Mines, 2005).

Mining activity is divided into two general categories of which levels of impact to the surrounding environment vary. Exploration mining activity for the most part is considered a low level activity.

Each level of exploration must go through a permit process, which includes a multi- agency and stakeholder referral process system and reclamation bond issuance. The higher the level of exploration activity the more stringent the referral process becomes, this would also include the level of environmental assessment, which must be performed within the mineral tenure area. Production mining activity is considered a high level activity with a higher level of accountability. This activity is generally a multi-permit process due to potential impacts. The referral process may require an environmental assessment and public input depending on the level of activity to be performed (Grieve, 2005).

According to Regional Geologist David Grieve, Ministry of Energy and Mines in Cranbrook; mining activity at this point in time within the Christina Lake watershed is considered to be low level exploration and there are no advanced exploration activities taking place.

5.3.0.6 Parks (Provincial and Regional)

Gladstone Provincial Park:

The largest park within the watershed is Gladstone Provincial Park. Gladstone was established as a Class "A" provincial park in July 1995 under the auspices of the "Protected Areas Strategy of B.C. and through the *Park Amendment Act, 1995.* The 393 square kilometres protected area includes the northern half of Christina Lake (approximately 16 kilometres of shoreline). The Park also contains the drainages of Sandner, Troy, Texas and Morrell Creeks, the headwaters of Lynch Creek, and the peaks of Mt. Gladstone (2225m) and Mt. Faith (2280m). The landscape is moderately mountainous and predominately forested. Under this provincial park designation, provincially significant low elevation forests (interior cedar hemlock), cultural heritage sites, important kokanee spawning beds, ungulate winter range, grizzly bear habitat, and four-season recreational values will be protected (BC Parks, 2001).

The creation of Gladstone Provincial Park incorporated two small existing provincial parks along Christina Lake. This included Texas Creek and Ole Johnson parks, and five former Ministry of Forests (MOF) recreation sites (BC Parks, 2001).

The Ministry of Water Land and Air Protection (Okanagan Parks Division) completed a Management Plan for the Gladstone Provincial Park in August 2001. The plan was prepared to guide the management of the park over several years. Management strategies include level of development, park access, and management of natural and cultural values (BC Parks, 2001).

The Okanagan First Nations traditional territory includes Gladstone Provincial Park and the Gladstone Provincial Park Management Plan does not limit aboriginal rights or any current and future treaty negotiations the Okanagan First Nations may participate in (BC Parks, 2001).

Within the boundaries of this protected area some pre-existing tenures were permitted to continue. This includes grazing, guide-outfitting and trapline territory permits. There is also approximately 789 hectares of privately held land and inholdings, which was excluded when the park was established (BC Parks, 2001).

The Park also contains high recreation and tourism values and provides opportunities for swimming, boating, lakeside picnics, camping areas, and sport fishing. In the backcountry, the Mount Faith area draws people internationally for guided hunting provided by the licensed guide

outfitter. The greater park area offers excellent opportunities for hunting, fishing in the various small lakes and creeks, horseback riding, mountain biking and hiking (BC Parks, 2001).

Christina Lake Provincial Day Use Park:
On the southern end of Christina Lake there is a Provincial day use park, which has a beach area, picnic tables, barbeques, toilet facilities and a large parking area. Currently, the Christina Lake Provincial Day Use Park and Texas Point Campground are managed under a contract, which is administered by Kaloya Contracting in Oyama. The two parks within the watershed are considered as part of the Boundary Bundle (provincial park groupings within this region). This company also administers the Okanagan Bundle.

Christina Lake Community Nature Park:
The Christina Lake Community Nature Park which is situated on the southeast shore of the lake is crown owned but under a special lease agreement with the province. The Regional District of Kootenay Boundary is responsible for this parkland. Under the auspices of the Christina Lake Chamber of Commerce a local Park Committee was established and oversees the maintenance of the park.

Other Considerations:
Within the watershed and along the shoreline of Christina Lake there are also several crown owned lots and 40 public access points to the lake that are currently either designated as potential future park areas of interest or under review for other usage considerations (as identified in the Official Community Plan, 2005). Additional land in District Lot 498 was purchased at the south end of the lake by the B.C. provincial government and could be designated as a park at some time in the future (RDKB, 1993). See section 5.3.5.0 " Discussion on Wildlife Inventory on Crown Land District Lot 498" for the environmental significance of this lot.

Currently, the Area "C" Parks Study Group (a local citizens group) whose primary mandate is to prepare recommendations on the implementation of the Parks and Recreation section of the new Official Community Plan (OCP) is researching the potential of each area that was outlined in the (OCP), as well as who will manage the new service and costs relative to this type of service. This report will be delivered to the Area "C" Director and Advisory Planning Committee (APC) by November, 2005.

5.3.0.7 Range and Other Tenure Holders (Licenses and Permits)

Please note: The following information does not include the names of companies or individuals that hold licenses or permits for the stated activity due to privacy considerations.

Range Licenses: There are two (2) range licenses within the Christina Lake watershed boundary (Baliko, 2005).

Guide Outfitting Territories: There is one (1) guide-outfitting license within the Christina Lake watershed boundary (Harris, 2005).

Trapline Boundary: Currently, there is one (1) trapline license (TR0801T018) within the Christina Lake watershed boundary per http://maps/gov.bc.ca

Special Use Permits (SUP's): Special use permits (outside of the realm of forestry harvesting procedures discussed in section 5.3.0.4) are issued for a variety of different reasons. A permit may be required to access private land over crown land, to build a bridge and/or road, to access a mineral tenure, gravel pit site, weather station site, or an airplane strip, just to name a few. At this time, there are no SUP's issued within the Christina Lake watershed boundary (Babiarz, 2005).

Park Use Permits: At this time, there are no Park Use Permits issued within Gladstone Provincial Park (Weston, 2005).

Private Moorage Permits: Land usage below the natural boundary of a water body such as wharfs and docks require an application submission. Permits for private moorage are for 10 years in duration (Hare, 2005). For further information see section 10.1.0 Regulatory Agencies – Lands and Water BC Inc.

5.3.1 Water Uses (Supply)

The permanent and seasonal residents of Christina Lake obtain their water supply via one or a combination of the following four methods: a community water system, licensed stream diversion, a ground water well, or directly from the lake (Shelley, 2005).

There are several community water systems within the watershed and each must meet the requirements of the *Drinking Water Protection Act*, the *Drinking Water Protection Regulation* and any other applicable legislation. The *Drinking Water Protection Act* and *Regulation* are administered by the local Health Authorities and came into effect in 2003 (Shelley, 2005).

The *Drinking Water Protection Act* and *Regulation* applies to all public water systems or commercial premises. The purpose of the *Act* and *Regulation* is to ensure that all people served by a water supply system have potable, safe drinking water for domestic or commercial use (Shelley, 2005).

All water supply systems, regardless of the number of connections or population served, must meet each requirement under the *Drinking Water Protection Act* and *Regulation*. The legislation sets out many requirements that all water supply systems must meet. Some of the requirements include meeting standards for drinking water quality, reporting of adverse water results and threats to drinking water, having qualified operators and a valid operating permit, creating emergency plans and water quality protection plans (Shelley, 2005). The *Act* and *Regulation* are available for review on the Ministry of Health Services website at http://www.healthservices.gov.bc.ca/protect/water.html

Most of the standards for drinking water quality apply to the "finished" water (meaning the water that comes out of the tap). To be considered potable, the water must meet the standards set out under the Guidelines for Canadian Drinking Water Quality, 1996 (Shelley, 2005). A copy of these guidelines can be found at http://www.hc-sc.gc.ca/hecs-sesc/water/publications.htm.

The *Drinking Water Protection Regulation* sets out the frequency for bacteriological water sampling for all water supply systems. The minimum frequency is four times per month and the frequency increases based on the population of people served by the water system. Other types of sampling, such as for chemical parameters, are done less frequently. Reporting of specified results that don't meet the Standards must be reported to the Health Authority (Shelley, 2005).

Each water supply system must have a qualified operator to monitor and perform maintenance of the system. The level of training, experience and certification required for the operator depends on the size and complexity of the water supply system (Shelley, 2005).

See Table 9 for a list of all water licenses within the Christina Lake watershed.

5.3.1.0 Community Licenses

The two largest Community Waterworks systems are

- Christina Waterworks District (CWD) – Wolverton Waterworks System was incorporated into the CWD in 1991 (Stewart, 2005).
- Sutherland Creek Waterworks District (SCWD) in the Lavalley Point area. The SCWD is investigating the option of a groundwater system (well) as the primary water supply and still using Sutherland Creek as a back up system (Black, 2005)

There are three sources of water supply that are used by these two districts: Sutherland Creek, Moody Creek, and Christina Lake.

The CWD and SCWD have a series of "Plans" in place. These plans cover the following:

- ❖ Emergency Plan (includes but is not limited to contamination of source, low flow occurrences, and chlorinator failure) – This is required by the *Drinking Water Protection Act*
- ❖ Water Conservation Plan (analyses existing conservation strategies, future requirements, and implementation schedule) – Lands and Water BC initiative
- ❖ Drought Management Plan (includes the water system profile, potential drought impacts and response procedures) – Lands and Water BC initiative
- ❖ Drought Emergency Consequence Plan (BC Emergency Response Management System – procedures if an event was to occur) – Lands and Water BC initiative

5.3.1.0.1 Christina Waterworks District (CWD):

The following information of the CWD was provided by (Stewart, 2005) and (Shelley, 2005).

The Christina Waterworks District is the largest system and was established in 1948 as per letters patent. There are currently 450 users within this district as of 2005. Users of this system include residential and commercial water consumers. The CWD is considered local government and is governed by the current "Local Improvement District" policies, which is overseen by the Ministry of Community Services (MCS). The CWD also reports to the Interior Health Authority and must adhere to the Drinking Water Protection *Act,* the Water *Act*, and other related legislation.

- Total Storage Capacity: (2) Moody Reservoir 275,000 US gallons and Wolverton 45, 000 US gallons
- Water Usage Statistics: (20,000,000 US gal/yr)
- Sampling Requirements: sample treated water daily at 4 locations for residual chlorine, weekly (4 samples) bacteriological sampling. In the near future CWD will also be installing a turbidity and chlorine analyzer plus flow meters on all sources
- Residential Users: 400
- Commercial Users: 50

- Watering Restrictions: Bylaw 38 of the CWD. The board decides on an annual basis when restrictions come into affect and when restrictions will be lifted. (June 1 to September 8, start date and end date for 2005)

The CWD is currently undergoing an upgrade to parts of the system. This upgrade entails a new larger reservoir to increase water holding capacity, new pumps and dedicated pipeline system. As part of the upgrade, on-line turbidity and chlorine analyzers will be installed and used to monitor water quality on a continuous basis. The total cost of the project is approximately $1,200,000.00.

5.3.1.0.2 Sutherland Creek Water District (SCWD):

The following information of the SCWD was provided by (Black, 2005) and (Shelley, 2005).

The Sutherland Creek Waterworks District is the second largest system within the Christina Lake watershed and was established in 1974. There are currently 211 connections within this district as of 2005. Users of this system include residential and commercial water consumers. The SCWD is considered local government is governed by the current "Local Improvement District" policies, which is overseen by the Ministry of Community, Aboriginal, and Woman's Services {MCAWS}. The SCWD also reports to the Interior Health Authority and must adhere to the Safe Drinking Water Regulations, and other related legislation.

- Total storage capacity: (2) 40,000 US gallon reservoirs

- Annual Audit of Water Supply:

  - Year 2000 58,911,955 US gallons
  - Year 2001 63,092,280 US gallons
  - Year 2002 66,618,360 US gallons (leak at Skand's started in December)
  - Year 2003 76,401,419 US gallons (leak at Skand's Jan – Mar)
  - Year 2004 77,079,370 US gallons

- Sampling Requirements: sample treated water daily for chlorine residual, weekly bacteriological samples of treated water, raw samples upon request from Interior Health
- Residential: 192
- Commercial: 18
- Agriculture: 1
- Other Pertinent Information:
  SCWD has 4 water licenses as follows
    - Sutherland Creek C045606 Domestic 27,375,000.000
    - Sutherland Creek C060473 Domestic 27,375,000.00
    - Sutherland Creek C108743 Irrigation 14.750
    - Sutherland Creek C106744 Irrigation 10.875
- Water restrictions: Voluntary water restrictions, Water Restriction Bylaw in place and will be used when voluntary water restrictions are not sufficient and enforced restrictions are necessary because of drought conditions

The SCWD is currently developing plans for a groundwater system. Currently the water comes from Sutherland Creek, a surface water source. Under the new plans, groundwater would be

used as the primary water source, with backup or emergency supply coming from Sutherland Creek. The total cost of the project is approximately $81,000 to $151,000.

5.3.1.0.3 Christina Lake Water Suppliers Society (CLWSS)(Alpine)

The following information of the CLWSS was provided by (McGowan, 2005) and (Shelley, 2005).

The CLWSS became a Society in 1997 (originally a private system from 1978). This system has a total of 104 connections with 15 connections being year-round. This system is a well, which is 95 feet deep with a 25,000 imperial gallon reservoir. There are 4 fire hydrants. Water sampling is on untreated water for fecal and total coliform and metal ions testing takes place once every 2 years. The system has installed a new flow meter so consumption levels can be monitored. There are no restrictions for watering. Utilization is at approximately 20% of capacity. Christina Lake Water Suppliers Society (CLWSS) (Alpine) reports to the Interior Health Authority and must adhere to the *Drinking Water Protection Act,* the Water *Act*, and other related legislation.

5.3.1.0.4 Fife Water Users Community (FWUC):

The following information of the FWUC was provided by (Durand, 2004) and (Shelley, 2005).

This group was formed in 1982 and currently has 19 users. Each individual has their own license for 500 gallons per day (gpd) and some users also have licenses for irrigation purposes. Water is delivered untreated; therefore there is permanent boil water advisory in effect. The raw water is sampled monthly for fecal coliform and total coliform. Fife Water Users Community reports to the Interior Health Authority and must adhere to the *Drinking Water Protection Act,* the Water *Act*, and other related legislation.

5.3.1.0.5 Other Water Groups

There are a number of recognized smaller water supply systems within the Christina Lake Watershed. These systems are generally privately owned and operated. All systems, regardless of size, must meet the same requirements as laid out under the *Drinking Water Protection Act* and *Regulation* (Shelley, 2005).

There are three (3) private residential water supply systems located in the Christina Lake Watershed that have 15 or fewer connections (Shelley, 2005).

There are six (6) commercial premises that have private water supply systems (Shelley, 2005).

Gladstone Provincial Park also has a water supply system that is operated seasonally (Shelley, 2005).

5.3.2 Waste Discharges

5.3.2.0 Point Sources

There are no known point source or direct discharges of domestic or industrial waste into Christina Lake or its tributary streams (Cavanagh *et al*. 1994, Ellis *et al*. 1991, V. Jensen, 2005).

Under the federal "*Pleasure Craft Sewage Pollution Prevention Regulations*" Christina Lake is designated as a "no dump zone" This information is available online at: wlapwww.gov.bc.ca/epd/mpp/boat_sewage.html.

5.3.2.1 Non-Point Sources

Currently, Christina Lake does not have a community sewer system and property owners are responsible for installing and maintaining individual on-site sewage treatment systems. Under the new "Sewerage System Regulation" which came into effect on May 31st, 2005, the Interior Health Authority will maintain jurisdiction for administration and enforcement of the regulation. Having regard to the Standard Practices Manual, registered practitioners or professionals (authorized persons) will be responsible for the proper design, installation and maintenance of small sewage disposal systems. Under the Regulation, homeowners are responsible for ensuring that the maintenance plan for their onsite sewage disposal systems if followed and they must keep proper records (Shelley, 2005).

A copy of the Sewerage System Regulation is available on the Ministry of Health website at http://www.healthservices.gov.bc.ca/protect/sewage.html. A list of registered practitioners is available at http://owrp.asttbc.org/.

The Ministry of Water Land and Air Protection, Environmental Protection Division – "*Environmental Management Act*" provides regulations for sewage disposal or treatment not covered under the Interior Health Authority wlapwww.gov.bc.ca/epd.

Currently, there are no public sani-dump facilities at Christina Lake. The closest public site is in Grand Forks. There are several private sani-dump sites at various resorts for customer use only (Hanlon, 2005).

5.3.3 Environmentally Sensitive Areas (ESA's)

All environmental components of the watershed have different levels of sensitivity to varying degrees of disturbance and are discussed in detail within sections of this document where appropriate.

There is no centralized sewage treatment facility in Electoral Area 'C' so property owners rely on private systems. Through the OCP and zoning bylaw two initiatives help to ensure that the water quality of Christina Lake is protected. Firstly, a **Waterfront Environmentally Sensitive Development Permit Area** was established in 1995 for properties adjacent to Christina Lake, and some of the larger creeks that drain into the lake at the south end. Owners proposing new construction or conversion of a non-residential building into a dwelling unit, or additions to the habitable floor area of buildings must demonstrate to the satisfaction of the RDKB Board of Directors that the on-site sewage disposal system is adequate to protect water quality. Exemptions apply to systems located greater than 100 metres from the natural boundary of the lake or creek and to boat access properties with approved pit toilets and no internal pressurized plumbing. Secondly, a minimum parcel size of 10 hectares was established in the Waterfront Residential Zone in 1996, which has essentially stopped any new parcels from being created adjacent to the lake (Dean, 2005).

The Regional District of Kootenay Boundary's "Floodplain Bylaw No. 677, 1995" regulates setback distances from bodies of water and watercourses, along with appropriate floodplain elevations (Dean, 2005).

See Appendix E Map 2 for watershed land use.

5.3.4 Fish

Fishing guidelines outlined in the Freshwater Fishing Regulations Synopsis are developed with maintaining a sustainable sport fishery in mind although a healthy fishery depends on several factors. Fish habitat requirements reach far beyond the lake ecosystem. Several species present in the lake utilize streams for spawning, rearing and nursery purposes and are directly affected by impacts such as altered flow patterns and sedimentation. Within the lake ecosystem, non-native species, in the form of plants or animals, can significantly alter ecosystem characteristics making it difficult for native species to find suitable habitat or compete for resources. For effective management, consideration for fisheries sustainability must be given at the watershed level.

Stream spawning fish species such as rainbow trout and kokanee are especially susceptible to poor logging and agricultural practices that can increase the levels of sediment deposition leading to the compaction of gravels required for successful spawning. In sediment choked, compacted gravels, fish eggs are unable to receive adequate dissolved oxygen delivered through water flow to sustain survival (Meehan, 1991). Over fishing is another factor that can contribute to fish population decline. Aside from sports fish, other fish inhabiting the lake and streams play an important role in the aquatic ecosystem. Non-sports fish such as Redside shiners can provide an important food source for some piscivorous species of fish (Scott and Crossman, 1973). Various fish species are also used as bioindicators; fish health provides us with tangible evidence about the health of the ecosystem in which they live (Conservation Data Centre, 2000).

The drainage area of Christina Lake is relatively small, and the climate fairly dry. These factors may create limited run-off within the watershed, thus producing very low flow conditions in some lake tributaries during the summer and early fall period. These low flow conditions likely affect the spawning and incubation success of stream spawning kokanee and the summer rearing period for rainbow trout (Smith 1974).

5.3.4.0 Fish Species in Streams that flow into Christina Lake

According to the TRIM maps (See Appendix E Map 1 for the Christina Lake Watershed Base Map), there are [12]41 first to fifth-order tributaries that flow into Christina Lake and 1 outflow. Many smaller streams may provide some fish habitat during the freshet, but dry up by late summer; only 9 tributaries and outflow provide year-round fish habitat (ARL, 2000).
These tributaries and outflow are as follows:

- Sutherland Creek: kokanee, rainbow trout, Westslope cutthroat trout, mottled Sculpin, prickly Sculpin, hybrids – Westslope cutthroat trout x rainbow trout “Cutbow”
- McRae Creek: kokanee, rainbow trout
- Stewart Creek: rainbow trout
- Gill Creek: rainbow trout
- Texas Creek: rainbow trout

[12] Note Table 10. #39 and #42 – may be report errors as noted on TRIM maps there are 41 tributaries shown flowing into Christina Lake. FISS has another stream with a watershed code attached to it (between Brooks and Spooner Creek) that is not on the TRIM map.

- Treadmill Creek: rainbow trout
- Red Ochre Creek: rainbow trout
- Troy Creek: rainbow trout
- Sandner Creek: kokanee, rainbow trout, redside shiner
- Christina Creek (outflow): Smallmouth bass, pumpkinseed sunfish, longnose sucker, redside shiner, mottled sculpin

As table 10 (Fish Presence in Tributaries and outflow of Christina Lake) indicates many streams have not been inventoried to determine fish species presence or distribution.

See Appendix E Map 5 for fish presence and absence map.

A restoration project on the lower portion of Sutherland Creek (from Christina Lake to approximately 250 metres below SCWD water intake) was completed in August of 2001. The project included the removal of an old weir (a kokanee fish barrier) and the addition of large woody debris to the stream channel to stabilize the bed and banks and to create pool and riffle sequences conducive to salmonid spawning and rearing sites. The creek has been monitored and kokanee enumerations have been conducted by Christina Lake Stewardship Society Staff and Volunteers to ascertain the success of the restoration project. During the 2004 enumeration, kokanee were reported above the weir removal site all the way up to the Sutherland Creek Water District water intake. Beyond this there is another natural barrier in the form of a logjam. Therefore, approximately 250 metres of kokanee spawning habitat was gained by the removal of the weir. See Table 11 for the stream spawning enumeration summary for Sutherland, McRae and Sandner Creek.

A large logjam was reported as being a barrier to spawning kokanee and rainbow trout on McRae Creek in 1973. In the same year a side channel was cut around the north side of the logjam to allow spawners access to spawning habitat upstream of the log jam. Over subsequent years the logjam grew larger in size blocking the side channel and again created a barrier to upstream fish movement. Recently, through the process of public consultation for the Christina Lake Management Plan, local residents expressed a desire to see the logjam removed to allow spawning fish access to upper reaches. Ministry of Water, Land and Air Protection fisheries biologists have indicated that an assessment to determine potential habitat gains and losses associated with the barrier removal must be conducted prior to the possibility of habitat enhancement projects being initiated. As of the writing of this report, the CLSS and Selkirk College (Environmental Planning) performed a Habitat Assessment on McRae Creek from the mouth of the creek to the potholes, which is approximately 2 kilometres. A final report will be available by December of 2005.

5.3.4.1 Stocking Records for Stream Systems

As indicated on the Fisheries Information Summary System (FISS) and Table 12, Kokanee stock was introduced into the McRae and Sandner Creek systems in the 1930's.

Table 12. Stocking Records for Stream Systems that Flow into Christina Lake (FISS, 2005)

Stream Name	Release Date	SPECIES PER FISS DATA	Fish Count	Stock	Life Cycle Stage
McRae Creek	1938	Kokanee	100,000	Meadow Creek	Eyed Egg
McRae Creek	1939	Kokanee	75,000	Unknown	Fry
Sandner Creek	1935	Kokanee	150,000	Kootenay	Eyed Egg
Sandner Creek	1936	Kokanee	150,000	Kokanee Creek	Eyed Egg
Sandner Creek	1938	Kokanee	100,000	Meadow Creek	Eyed Egg
Sandner Creek	1939	Kokanee	75,000	Lardeau River	Eyed Egg

5.3.4.2 Introduced Species Account for Streams

Kokanee have been introduced into McRae and Sandner Creek systems as per government stocking records (FISS) and there has been a difference in opinion on whether stream spawning kokanee existed prior to the introduction. Lincoln Sandner wrote that when his father Charles Sandner came to Christina Lake in 1896, there were literally millions of kokanee in the lake, and they spawned not only on the beaches but also in the creeks (Sandner *et al.*, 1994). According to Molnar (2004), stream spawning kokanee were introduced into Christina Lake streams in the 1930's and shore spawning kokanee have always been present.

5.3.5 Wildlife

The Christina Lake watershed provides a diverse and complex array of wildlife habitat types. From lowland floodplains to alpine slopes myriad habitat types are represented in the area. While some may value wildlife for their known and potential economic values, for others the aesthetic, spiritual or intrinsic values are reason enough to take conservation measures. Because ecosystems of any type are complex networks of interconnected organisms, the loss or severe decline of one component can affect all remaining species, often in ways that humans cannot predict or fully understand. Because of intensive human development and activities in the dry valley bottoms of BC's southern interior, some areas of the Christina Lake watershed are considered to be the last remaining intact natural habitats of their kind (Ramsay, 2001).

The warm, flowing waters of Christina Creek and somewhat intact riparian zone may be the only suitable habitat left for 2 provincially blue-listed fish species, the speckled dace and within the Kettle River system in southern BC (Ramsay, 2001). This area also supports a multitude of dragonfly species. In 2001 on crown-owned District Lot 498, which straddles Christina Creek, a wildlife survey undertaken by BC's Conservation Data Centre identified wildlife that inhabit or use the aforementioned parcel of land. Forty mammal species, 140 bird species, 16 dragonfly species (4 of which are red or blue listed in BC), 6 reptiles and 5 rare plant species were observed within District Lot 498 (R. Walker, 2001). Other areas of the watershed also support an abundance of wildlife. Gladstone Provincial Park, which encompasses the northern half of the lake, protects important kokanee spawning habitat, ungulate winter range, and regionally important habitat for grizzly bears (BC Parks, 2001).

With elevation change, habitats, and consequently wildlife species occurrence and distribution, tend to change. Many species use a variety of habitat types to meet their needs from season to season. Ungulates such as mule deer, mountain goats and moose utilize valuable winter range habitat in the area although their summer range is much more extensive (G. Furness, 2004). Grizzly bears, black bears, and birds of prey are frequently observed near the main kokanee

spawning channels in the late summer and fall yet the full extent of their range is far greater in size. Grizzly bears, for example, change habitat with the season; feeding on new growth on south facing slopes in the spring, shifting to berry patches and marmot colonies in the summer, and descending to concentrate on kokanee spawning streams in the fall (McTaggart-Cowan, 1978). A single male adult Grizzly bear can have a range in excess of 440 square kilometres. For comparison, Gladstone Provincial Park has an area of about 393 square kilometres (BC Parks, 2001) and the entire Christina Lake watershed is 519 square kilometres. See Appendix E Map 10 – Grizzly bear management priorities.

Within the Christina Lake watershed Ungulates include mule and white tail deer, mountain goats, moose, and elk (RDKB, 1993). The semi-alpine and alpine elevations of Mt. St. Thomas, Mt. Gladstone, and the headwaters of Sandner Creek support a small population of grizzly bear and the Texas Creek basin supports a small population of cougar. Black bear and coyote are more plentiful and more widely distributed throughout the watershed (RDKB, 1993). Wolves are believed to be extirpated from the Watershed (BC Parks, 2001). Small mammals are widely distributed from low elevation to alpine slopes. These include squirrel, rabbit, marmot, and raccoon. Badgers, although rare, are present (R. Walker, 2004). Other fur bearing mammals are present in varying populations such as mink, muskrat, beaver, wolverine, martin and weasel (RDKB, 1993).

The term bioindicators refers to organisms such as lichens, amphibians, and fish that serve as an indication of ecosystem health. These types of organisms are very sensitive to habitat disturbances and often provide the first signs that a problem exists through a change in population abundance, health and /or distribution.

Effective wildlife management for some species requires consideration of large tracts of land while others require very limited areas with specific or unique attributes for survival. Wildlife biologists face the challenging task of balancing the needs of wildlife with the needs of human development. For an example: there are no nesting Loons on Christina Lake due to lack of appropriate habitat (Walker, 2005). See Appendix E Map 11 – Connectivity corridors.

Table 13 is a summary of the harvest rates from 2000 to 2003 for Management Unit 8-15, which includes Christina Lake.

Table 13. Harvest Information for MU 8-15 (Includes Christina Lake) – (Harris, 2005)

SPECIES		**2003**	**2002**	**2001**	**2000**
Whitetail deer		403	356	399	327
Mule deer		86	100	92	72
Mountain Goat		0	1	2	1
Moose		12	9	1	4
Elk		9	4	9	13
Black bear		19	18	9	18
Mountain Sheep		0	4	3	4
Cougar		2	2	11	5

According to Harris, (2005) Christina Lake is the centre of abundance for wild turkeys for Region 8. The estimated population is approximately 400 birds. The harvest has been small – likely 3-5 birds per year.

5.3.5.0 Discussion on Wildlife Inventory of Crown land D.L. 498 – Christina Creek.

The following information is modified from a prepared report submitted by (Walker, 2001) and (Ramsey, 2001) pertaining to the importance of conserving/protecting District Lot 498. Also refer to Section 5.3.0.6 "Parks Provincial/Regional – Other Considerations".

This is one of the last undeveloped lowland riparian habitats in the Christina Lake area and the only one left straddling Christina Creek. It is an invaluable habitat for the species of birds listed below. Many of the species would cease to exist in this area if this lot were to be developed. Warblers are particularly vulnerable. As well as an important breeding area, it serves as a resting and feeding habitat for migrating birds in the spring and fall.

Tables 14 (common breeding birds), 15 (resting and feeding habitats for migrating birds – spring and fall), 16 (birds that are non-breeding visitors), 17 (mammals that have been reported within DL498), and 18 (reptiles); have been reported as occurring in DL498 but can also occur within the Christina Lake watershed were suitable habitat is available.

For a listing of plants and insects for DL498 see (Ramsey, 2001) report housed at the CLSS office the "Community Stewardship Resource Centre".

5.3.5.1 Species at Risk

Provincial:

In British Columbia, the Conservation Data Centre (CDC), within the Ministry of Sustainable Resource Management, assigns the provincial species at risk rank, which is based solely on its status in British Columbia (Ministry of Sustainable Resource Management, 2002). Rankings (i.e. red, blue, or yellow status) are based purely on biological assessments and do not examine the potential social and economic implications associated with species at risk designation (Harcombe, 2005). British Columbia has no specific species at risk legislation. The provincial *Wildlife Act* protects all wildlife[13] from direct harm except as allowed by regulation however the legislation offers no measures to protect habitat for species that are not legally designated by the Deputy Minister of Water, Land, and Air Protection. Legal designation may confer special protection for selected red- and blue-listed species, their residences, or their critical habitat. Legal designation as 'endangered' or 'threatened' under the *Wildlife Act* increases the penalties for harming a species, and also enables the protection of habitat in a Critical Wildlife Management Area (Ministry of Sustainable Resource Management, 2002). At present, four species are legally designated in BC, none of which occur in the Christina Lake watershed. Species and plant communities referred to as Identified Wildlife under the *Forest and Range Practices Act* require special management attention (Ministry of Sustainable Resource Management, 2005).

[13] Under the *Wildlife Amendment Act* several new definitions were added and the terms threatened species, endangered species and wildlife were redefined in 2004. The *Wildlife Act* originally used the term wildlife to describe all of the aforementioned terms. The current definitions are as follows: endangered species means a species designated by regulation under section 6 (2) or (4) as an endangered species, threatened species means a species designated by regulation under section 6 (3) or (4) as a threatened species, wildlife (a) means raptors and game and other species of vertebrates prescribed by regulation, and (b) for the purposes of sections 3 to 5, 7, 8, 84 (6.1) to (6.4), 97.1 to 98.1 and 108 (2) (v), includes fish, but does not include species at risk.. Several other definitions were added including the term species which is defined as a species, sub-species, variety or genetically or geographically distinct population of animals, fish, plants, or other organisms, except bacteria and viruses.

According to information available on the Ministry of Sustainable Resource Management website, "the goals of the Identified Wildlife Management Strategy (IWMS) are to minimize the effects of forest and range practices on Identified Wildlife situated on Crown land and to maintain their limiting habitats throughout their current ranges and, where appropriate, their historic ranges. In some cases, with direction from Recovery Teams, this will entail restoration of previously occupied habitats, particularly for those species most at risk. Identified Wildlife are managed through the establishment of wildlife habitat areas (WHAs), general wildlife measures (GWMs) and wildlife habitat area objectives, or through other management practices specified in strategic or landscape level plans."

Federal:

The *Species at Risk Act* (SARA) came into affect on June 1, 2004. The act means that you, the government of Canada, and any agency that issues permits to owners of land that encompass areas within the designated species at risk listing are obligated to protect the species and its habitat. The act applies to all federal lands and waterways, all species of plant, lichen, moss, bird, butterfly, moth, mammal, fish, mollusc, reptile, and amphibian on the list, and all of their environments. The *Species at Risk Act* serves as a safety net for the listed species and if provincial or territorial environmental legislation falls short of protecting them, the act is there to cover all possible shortcomings within the provincial legislative framework. In other words, if you own property or are within an area indicative of these species, SARA applies to your land. The *Act* first received parliamentary assent in 2002, after a quarter century of groundwork by a committee of scientists and wildlife experts to build a list of imperiled species. It was not until June 1 of 2004 that the all-important enforcement provisions were out into affect, and they are stringent. A landowner can face up to a fine of up to $250,000, or even one to five years in jail, for failing to comply with SARA's regulations (Farr, 2004). This means destroying or damaging the critical habitat of a protected species. Without this protection certain species may face eminent extirpation (extinction). The cumulative impact of human activities could wipe out whole species. Many species within our country are extirpated, or completely vanished from certain areas. If you are buying or currently own a property, you are advised to consult the authorities about what restrictions to expect for any new development. Any person who treasures the natural world around them will get onside on SARA and willingly revise their projects to protect a plant or animal at risk. For detailed information about SARA and how it may affect you, or how you can actively participate in species recovery efforts, go to www.speciesatrisk.gc.ca (Farr, 2004). See Appendix E Map 9 – Species at risk.

See Table 19. Confirmed Species at Risk in the Christina Lake Watershed

Photograph 3. River Jewelwing (*Calopteryx aequabilis)* Species at Risk – Photograph Courtesy of Ministry of Water Land and Air Protection – Orville Dyer – Wildlife Biologist – 2004

5.3.5.2 Introduction of Non- Native Wildlife Species

Non-native wildlife species[14] (also called alien, exotic, introduced, or non-indigenous species) come from one part of the world and are transported beyond their natural range and become established in a new area. Species that are considered non-native in this province may come from outside British Columbia or be native to some parts of British Columbia, but are counted as non-native in regions of the province where they have been introduced (MWLAP, 2005). There are also species that are considered accidentals or casuals as they are considered to be out of their natural range, which could be due to change in historic range, loss of habitat, suppression of natural events, or climate change. According to local resident Susan Walker (2005), on one occasion this spring she witnessed a Broad-Tailed Hummingbird on her property. This species natural range is generally within the Western United States to Guatemala. Another example; is a Great Egret has been spotted at the mouth of Sutherland Creek 2 years in a row (2003 and 2004) while CLSS Staff where monitoring the creek and performing Kokanee enumerations. The Great Egret's natural range occurs from Maine and southern Canada west to the Great Lakes, south to Texas, the Gulf Coast states, Florida, and along the Atlantic Coast.

Not all species that arrive in new places are able to make themselves at home and start reproducing and spreading. However, alien species can get established if given advantages such as:

- An agreeable climate
- No or few natural predators, parasites, or diseases
- An abundance of food that lack protection against the newcomer

[14] Other Non-Native Species are discussed in Sections 5.3.4.2 (Fish in Streams) and 5.3.6 (Plants) and 7.3.4.2 (Fish in Christina Lake)

- An ability to out-compete native species and monopolize the best resources

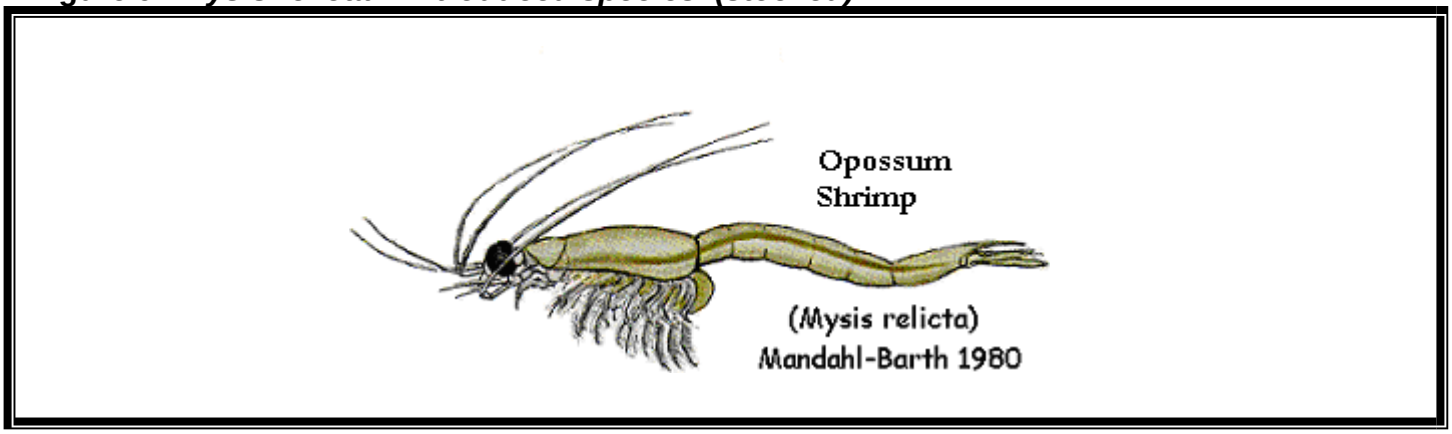
The natural range of a species is defined by physical barriers that prevent dispersal; usually inhospitable habitats where the species is unable to survive. Humans have created many opportunities for plants, animals, and microorganisms to spread beyond their natural ranges – carrying them across oceans, mountains and deserts, and transferring them from one water body to another. In some cases this has been deliberate, though often with unexpected consequences, while other cases it is unplanned. There is a cause for concern because the rate of non-native species introduction is accelerating rapidly as global commerce and travel increase (MWLAP, 2005).

Everybody recognizes starlings and English sparrows, of which the former is a serious predator of native birds eggs and nestlings. Other non-native birds include the "game birds" such as the California quail, ring-necked pheasant, and the wild turkey (now becoming abundant in parts of the Boundary region), as well as non-game birds such as the rock dove (common domestic pigeon) (Walker, 2005).

The potential impact of non-native mammals in the Christina Lake watershed has yet to be discovered. Dogs do harass deer and cats do prey upon native songbirds. The impact and loss of native species to domestic pets within our watershed is unknown. The common house mouse does exist but at this time is not considered to be ecologically or economically problematic (RBCM, 2005). Other species that may be present are the opossum and European rabbit (RBCM, 2005).

Non-native species M*ysis relicta* (also called opossum shrimp or mysis shrimp) were introduced (stocked) into Christina Lake in 1966 (Stringer, 1977). According to Stringer (1977), 80,000 of these organisms were introduced in hopes of boosting the productivity of Christina Lake by providing extra forage for game fish thus enhancing the fisheries industry. The decision for the introduction to several lakes in British Columbia was based on several other North American and northern European lakes that observed increased productivity within a few years after the introduction of *Mysis relicta* (MWLAP, 2005).

Figure 9. ***Mysis relicta – Introduced species (stocked)***



In the beginning, fish populations rose variably for the lakes, but then began to collapse. Scientists discovered that *Mysis relicta* is a good prey item for large Kokanee, but not for Kokanee aged less than a year as the shrimp are too large for small kokanee to consume (MWLAP, 2005).

One of the major food sources for young Kokanee is a small zooplankton species call *Daphnia*, otherwise termed the "water flea". Unfortunately, *Daphnia* is also the preferred food item for *Mysis relicta*. According to MWLAP (2005), this lead to competition for the same food source, but the shrimps are more efficient predators than the Kokanee. They feed during the night, whereas the Kokanee do not. *Mysis relicta* also have a rapid generation time, have few predators, and normally inhabit different zones of the lake than the Kokanee. Currently, almost nothing is known about the status of *Mysis relicta* in Christina Lake, except that it appears to be common and widespread (ARL, 2000). According to Aquatic Resources Limited, (2000) a survey to determine this species abundance and distribution was recommended but has not occurred to date.

5.3.6 Introduction of Non-Native Invasive Plant Species

Introduced invasive plant species are considered the second most serious factor responsible for the extinction of native species and loss of biodiversity worldwide next to habitat loss. Non-native plants are one of the main contributors to the loss of natural diversity in our environment (Canadian Wildlife Service, 2004). In BC alone, agricultural losses due to non-native plant infestations are estimated at $50 million a year (Canadian Wildlife Service, 2004). To help address some of these issues the Invasive Plant Strategy of British Columbia manual was developed (Fraser Basin Council, 2004).

Many non-native plant species were introduced accidentally while other were intentionally brought in as garden ornaments that subsequently escaped. In the absence of natural predators these aggressive plants are able to invade natural plant communities and dominate the site displacing native species and altering the ecosystem. "They transform the landscape and in so doing undermine the economic and environmental health of the areas they infest. This problem crosses all political, ecological, and land ownership boundaries, impacting on all industries and activities that rely on a healthy ecosystem" (Cranston, 2003).

According to Boundary Weed Coordinator Barb Stewart, (2005) the scope of the invasive species problem:

- Out compete native grasses and wildflowers including rare and endangered species.
- Destroy natural habitat for birds, butterflies and other wildlife, domestic animals, and fish and aquatic organisms.
- Reduce yield and forage quality of agricultural crops and natural forage
- Increase wildfire hazard and interfere with regeneration of forests
- Accelerate soil erosion and stream sedimentation, consume critical water resources and negatively impact water quality
- Decrease land values
- Endanger public health and safety, increase allergies and hayfever and are potentially toxic to humans, pets, livestock and wildlife
- Clog waterways use for swimming and boating and reduce visibility on transportation corridors
- Destroy recreation opportunities and the beauty of landscape
- Increase costs for maintaining resources and public utilities.

Invasive plants will continue to spread and negatively impact resources unless management is undertaken (Stewart, 2005).

Invasive plants have been grouped into aquatic, semi-aquatic/riparian and terrestrial invasive plants. A list of introduced invasive plants present in the watershed is contained in Table 20 Noxious and Introduced invasive plants present or of concern within the Christina Lake Watershed (Stewart, 2005).

Invasive Aquatic Plants:

Eurasian watermilfoil (*Myriophyllum spicatum)* was raised as an issue of concern both in survey responses and through identified research gaps. Milfoil continues to increase in Christina Lake despite management efforts (Haberstock, 2004) and many survey respondents indicated a concern over the impacts it has on recreational quality and habitat for native species. In the absence of management, the Eurasian watermilfoil will spread to shallow areas with suitable substrate throughout the lake impacting recreation and aquatic habitat values.

Photograph 4. Eurasian watermilfoil (*Myriophyllum spicatum)*

The Regional District of Kootenay Boundary has had a milfoil control program in place since 1988. The program employs two to three SCUBA divers who hand pull milfoil and remove it from the lake. This program is able to contain large infestations, but does not have the resources to remove all milfoil. A review of the effectiveness of the program by a third party is in progress, however the report for the first stage has not yet been received (MacKay, 2005). Despite management efforts by the Regional District of Kootenay-Boundary and the BC Ministry of Water, Land and Air Protection (formerly BC Environment), the abundance of milfoil has steadily increased in Christina Lake since the first plants were discovered in 1986 (Haberstock, *et al*. 1995). Milfoil can be very difficult to distinguish from native northern milfoil species often requiring pigment or DNA analysis (University of Winnipeg, 2004). Due to its vegetative reproduction ability, milfoil spreads extremely quickly. Fragments often develop roots before they detach from the parent plant (Canadian Wildlife Service, 2004). The spread of milfoil has many negative ramifications. Swimming and recreation areas can become congested, native species lose

valuable habitat, native plants are displaced, and stagnant water created by milfoil mats provides breeding ground for mosquitoes (University of Winnipeg, 2004). Local residents and tourists alike have commented on increased amounts of milfoil in the shallow (littoral) regions of Christina Lake.

Invasive Semi-Aquatic/Riparian Plants

Some invasive plants have the competitive ability to dominate riparian areas replacing beneficial native species that a variety of wildlife utilize for nesting habitat, foraging, or security cover. In some locations these invaders have lead to huge changes in species present and diversity. Wetlands lose 50-100% of their native biomass due to purple loosestrife invasion resulting in displacement of food, animals and many birds which will not nest in Purple Loosestrife (Thompson *et al*. 1987) Fortunately Purple Loosestrife is not yet present at the Lake. Several invasive species with potential to dominate riparian areas are being monitored including Common Mugwort (*Artemesia vulgaris*), Orange Hawkweed *(Hieracium aurantiacum*) and efforts are underway by the landowner/land managers to control these infestations (Stewart, 2005).

Terrestrial Noxious Weeds and Invasive Plants

Significant infestations of terrestrial noxious and invasive plants exist in the watershed, with the highest densities on the lower valley slopes and along roadways. Terrestrial introduced invasive plant distribution in the Christina Lake watershed is displayed in Map 14 in Appendix E. Mechanical, chemical, and biological methods are used to control priority infestations and education is used to curb new introduction and reduce spread through awareness (Stewart, 2005).

According to Boundary Weed Coordinator Barb Stewart, (2005), “species of highest concern include Blueweed, Spotted knapweed, Dalmatian toadflax and Hoary alyssum. Biological control insects have been released on the knapweed species and reductions in density are visible in some locations. The bioagent for Dalmatian toadflax has been very successful in the area resulting in dramatic declines in the density and distribution. Inventory and management continue on Blueweed and Hoary Alyssum to find and remove it from roadways to reduce spread. Other invasive plants of concern present in the area include Japanese knotweed, Scotch Broom, Orange Hawkweed, Yellow Hawkweed, Scentless Chamomile, Oxeye daisy, and Hound’s tongue. Species which are not yet present, but are known in nearby jurisdictions include: Yellow starthistle, Plumeless thistle and Leafy spurge”.

The British Columbia Weed Control Act stipulates that all land occupiers are required to control designated noxious weeds on their property. A copy of the Weed Control Act and Regulations can be found at http://www.agf.gov.bc.ca/cropprot/acts.htm. This law applies to both crown and private land. There is no enforcement of the Act presently in the Boundary, although the need for enforcement is reviewed on an annual basis through the Boundary Weed Management Committee (BWMC).

5.3.7 Other Assessments and Analysis

A number of assessments, plans, and surveys have been completed for the Italy-Sutherland and Moody Creek drainages. The existing documents include, but are not limited to, Italy Sutherland Planning Team (1993), Timberland Consultants Ltd. (1996), Timberland Consultants Ltd. (1997), Corbett *et. al*. (1997), Corbett *et. al.* (1998), and Henderson Environmental Consulting Ltd. (2000). Full reference listings for these documents are provided in the reference section.

SECTION 6.0

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6.0 LAKE CHARACTERISTICS – GENERAL TERMINOLOGY

This section explains the meaning of some of the technical terms that will be used in section 7.0 "Diagnosis of Christina Lake". Also see the glossary at the end of this document.

6.1 LAKE ZONATION

The following depth zones (lake Zonation) are recognized in lakes:

Littoral zone extends from the shore just above the influence of waves and spray to a depth where light is barely sufficient for rooted plants to grow.

Photic (*or *"euphotic") zone is the lighted and usually well-mixed portion that extends from the lake surface down to where the light level is 1% of that at the surface.

Aphotic zone is positioned below the littoral and photic zones to the bottom of the lake where light levels are too low for photosynthesis. Respiration occurs at all depths so the aphotic zone is a region of oxygen consumption. This deep, unlit region is also known as the *profundal zone*.

Compensation depth is the depth at which rates of photosynthesis and respiration are equal.

Sublittoral zone, which is the deepest area of plant growth, is a transition between littoral and profundal zones.

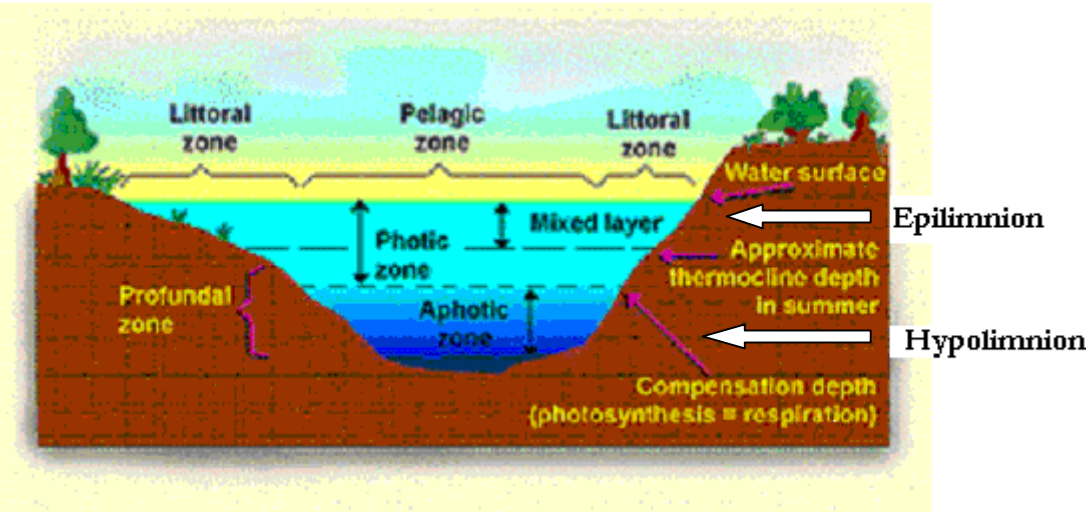
Pelagic (or *limnetic) zone* is the surface water layer in offshore areas beyond the influence of the shoreline.

Epilimnion is the surface layer of a thermally stratified lake.

Hypolimnion is the cooler layer of water at the bottom of a thermally stratified lake.

Thermocline is characterized by a considerable change in temperature with little change in depth. It is the transition area between the epilimnion and hypolimnion.

Figure 10. Lake Zonation



(Information Courtesy of the University of Guelph - Modified)

6.2 EUTROPHICATION

Over thousands of years, through the natural aging of shallow lakes, a lake may eventually become a marsh and then, finally, a terrestrial system (Rast and Holland, 1988). Following excessive additions of silt, nutrients and organic matter, gradual deterioration of a lake will occur.

Rooted plant biomass will increase, water clarity will become reduced, the lake volume will decrease and algal blooms will be more frequent (Cooke *et al*., 1993). This is the process of eutrophication.

The observed water quality in the lake reflects in part the cumulative effects of the materials carried in all waters flowing into the waterbody (Rast and Holland, 1988). The process of eutrophication can be accelerated through increased input of nutrients and sediments carried into the lake due to human settlement, septic leachate, sewage discharge, clearing of forests and development of farms within the lake's watershed (Rast and Holland, 1988). This is generally termed cultural eutrophication (Cooke *et al.,* 1993). An increased growth rate of the flora and fauna in a lake is associated with a loss in recreational value, and a potentially unsafe water supply (Cooke *et al.,* 1993).

A lake undergoing cultural eutrophication can be restored so that it will again have water quality more characteristic of the natural situation (Rast and Holland, 1988). However, prevention of cultural eutrophication is easier than reversing the process. If cultural eutrophication is left unmanaged, the result will be significant ecological changes (such as increased algal blooms, reduced water clarity and changes to fish populations) and significant reduction in appeal of the lake for residents and recreational user groups who use it (Jensen, 2005).

6.3 TROPHIC STATUS

According to Daniel *et al.,* (1994) trophic status refers to the amount of biological productivity in a lake system and is directly related to nutrient inputs. The amount of algae and aquatic plant growth, water transparency, plankton chlorophyll a levels, phosphorus concentration, dissolved oxygen in the hypolimnion (bottom layer of a thermally stratified lake), and populations of other organisms such as fish, are all indicators of trophic status. Highly productive lakes with abundant aquatic life (mainly algae and macrophytes) are called eutrophic and are usually relatively shallow and warm in the summer. Lakes, which produce little aquatic life, are called oligotrophic. These lakes are characteristically deep and cold, usually with clear water and steep rocky shores. Mesotrophic lakes are waterbodies in transition between oligotrophic and eutrophic. There is a continuum of trophic states that range from ultra-oligotrophic through to mesotrophic to hyper-eutrophic. The productivity of a lake is dependent on many factors. One of the most important is the amount of nutrients, particularly phosphorus, in the water. Individual lakes or reservoirs will respond differently to phosphorus loadings because of differences in basin depth, water residence time, degree of stratification, and watershed characteristics such as geology, soil type, vegetation, topography, and climate (Daniel *et. al.*, 1994).

6.3.0 Nutrients: Limiting vs. Non-Limiting

There are a number of things that are required for aquatic life. For algae and aquatic plants, sunlight, oxygen, hydrogen, carbon, nitrogen, phosphorus and a number of micronutrients are essential. Oxygen and hydrogen exist in chemical abundance far in excess of plant requirements (Wetzel, 1983). The ratio of carbon ©: nitrogen (N): phosphorus (P) by weight in plants is 40C:7N:1P and this is the ratio which is needed in their environment for growth (Wetzel, 1983). Assuming that sunlight and other micronutrients are available, phosphorus will become the first of these three nutrients to become limited. However, if phosphorus is in excess within the aquatic environment, then increased levels of photosynthesis can occur until the nitrogen becomes scarce and therefore becomes the next limiting nutrient (Wetzel, 1983). Therefore, lakes are most commonly phosphorus limited but can also be nitrogen limited or co-limited by phosphorus and

nitrogen (Rast and Holland, 1988). From this information, it is apparent that phosphorus and nitrogen are the main nutrients of concern. Increased nutrient concentrations entering the aquatic environment are almost always an impact of pollution (Wetzel, 1983). When assessing the available nutrient levels in the aquatic system, it should be noted that only the dissolved reactive fraction and some portion of the particulate fraction of phosphorus are available to organisms for growth (Cooke *et al., 1993).* In lakes (with clear water – no suspended sediments) generally total P is considered to equal available phosphorus (it is all cycling through the system) (Cavanagh *et al*, 1994).

6.3.1 Phosphorus Limited Lakes

Excessive growth of algae and aquatic plants can cause decreased dissolved oxygen levels, decreased recreational value due to odors and aesthetics, and poor habitat conditions for other aquatic organisms such as fish (Wetzel, 1983). A reduction in phosphorus inputs is generally the most effective method to reduce excessive growth of algae in a lake that is receiving a continuous loading of nutrients (Wetzel, 1983). Atmospheric levels of phosphorus are very low, as it does not have a gaseous phase and the nutrient is chemically reactive (Wetzel, 1983). These two characteristics make phosphorus technologically easier to control and remove than nitrogen (Wetzel, 1983). Once external loading to a lake is decreased the lake will require from 2 to 10 years, depending on the water exchange rate of the lake, for recovery from eutrophication symptoms such as increased algal growth (Wetzel, 1983).

SECTION 7.0

CHRISTINA LAKE CHARACTERISTICS

7.0 CHRISTINA LAKE CHARACTERISTICS

Christina Lake is situated approximately 26 kilometers east of the city of Grand Forks in south-central British Columbia. Christina Lake is 18.7 km long with a median width of 600 metres (RDKB, 1993) and is oriented in a north-south direction and is characterized as long and narrow with a steep, U-shaped, glacially carved bottom (Cavanagh *et al*, 1994).

Christina Lake and its tributaries are utilized as a water source for irrigation, domestic, commercial and industrial purposes (Land and Water BC Inc., 2005). Many residents draw drinking water directly from the lake while others rely on waterworks to disinfect drinking water drawn from the lake or local streams. The lake also provides recreational opportunities and supports a variety of aquatic life forms. The main economic driving force in the area is tourism, however without good water quality many tourists may choose to vacation elsewhere.

Non-point sources (NPS) of pollution are the largest contributors to water quality degradation in Christina Lake (Cavanagh *et al*., 1994). Land use activities such as shoreline and stream bank alterations, residential, agriculture, and forestry practices may also impact water quality by adding nutrients, pesticides, herbicides, and possible bacterial contamination. The overland flow of sediments eventually deposits those pollutants into streams and the lake. Groundwater and atmospheric deposition also provide avenues for pollution to reach the lake. The most significant contributors of NPS pollution to Christina Lake are poorly maintained and/or located septic tank or tile field systems (Cavanagh *et al*., 1994). Close proximity to the lake, inappropriate soil types, and shallow bedrock make septic contamination a major concern (more information about community sewer system feasibility can be found in (Kerr Wood Leidal, 1991 and Sussex Consultants Ltd., 1994).

Although water quality data collected annually by the Ministry of Water, Land, and Air Protection (now Ministry of Environment) suggests that the overall water quality in Christina Lake is good (as described below), local residents and lake users have noticed changes in the lake over time. Shallow regions of the lake, particularly the south end, are thought to have lower water clarity, increased aquatic plants and algae, and odor problems during the summer months. Local physicians have also reported an increased incidence of ear, throat, and eye infections in people using the south end of the lake for recreational purposes (Cavanagh *et al*., 1994).

7.1 MORPHOMETRIC DATA

The mean (overall average) depth of Christina Lake is approximately 37 meters. The maximum depth of Christina Lake is 54.0 meters (RDKB, 1975). See Appendix E Map 4 - bathymetric features of the lake. Please note that this maps features are in feet. To convert feet to metres (1 ft = 0.3048 m)

Table 22. LIST OF MORPHOMETRIC DATA FOR CHRISTINA LAKE (Cavanagh *et al*, 1994)

Surface Area		25.1 km^2
Volume		$9.295x10^5dam^3$
Volume of Epilimnion (V_e) (0-8 m)		$1.962x10^5dam^3$
Volume of Hypolimnion (V_h) (9-54 m)		$7.323x10^5dam^3$
Mean Depth		37.0 m
Maximum Depth		54.0 m
Fetch – Unobstructed Length		18.7 km
Littoral Area (% of total surface area)		5%

7.1.0 Flushing Rate and Water Retention Time)

The flushing rate (lake volume ÷ outflow) of Christina Lake is estimated at 4.5 years. A large percentage of the precipitation falls during the winter months as snow, consequently maximum lake water levels occur in May and June during the snowmelt freshet. Minimum water levels occur during October and November. (Cavanagh *et al*, 1994)

7.2 WATER QUALITY DATA COLLECTION

The BC Ministry of Environment and Interior Health Authority conduct water quality monitoring programs on Christina Lake. BC Environment monitors water chemistry, dissolved oxygen and water clarity in spring and fall. The Interior Health Authority conducts recreational water quality testing once per month during June, July, and August at local beaches. These programs and findings will be discussed separately.

7.2.0 Bacteriological Sampling

Cavanagh *et a*l (1994) reported the deep-water lake sites had very low concentrations of coliform bacteria to that point in time. Cavanah also summarized the Central Kootenay Valley Health Unit (formerly West Kootenay Health Unit) of the Ministry of Health seasonal coliform analyses at four recreational beach sites on the southern portion of the lake indicating that the summer fecal coliform levels were consistently low between 1967 and 1992.

More recently the Interior Health Authority conducts recreational water quality testing once per month during June, July, and August at local beaches (Shelley, 2005). These sample sites include Christina Lake day use area, Schulli's campground, Skand's campground, CLARA beach, and Gladstone Provincial Park beach. Three samples from each beach are collected and are tested for fecal coliform bacteria only. The water samples have tested well below the Guidelines for Canadian Recreational Water Quality (1992) of 200 fecal coliform per 100mL (Shelley, 2005). A copy of the Guideline is available at http://www.hc-sc.gc.ca/hecs-sesc/water/recreational_water.htm .

The tributaries to the lake have had elevated coliform counts since testing in these systems commenced in 1991. Because some of the creeks serve as major sources of drinking water, the raw water 90th percentile values exceeding 10/100 mL for Christina, McRae and Sutherland creeks are cause for concern. The likely reason for the elevated fecal coliform levels is livestock and wildlife activity in close proximity to the creeks. Because these are not human sources, the likelihood of disease transmittance is reduced yet regardless of this fact, the coliform values exceed the criterion established for drinking water that is treated only through disinfection (Cavanagh *et al*, 1994).

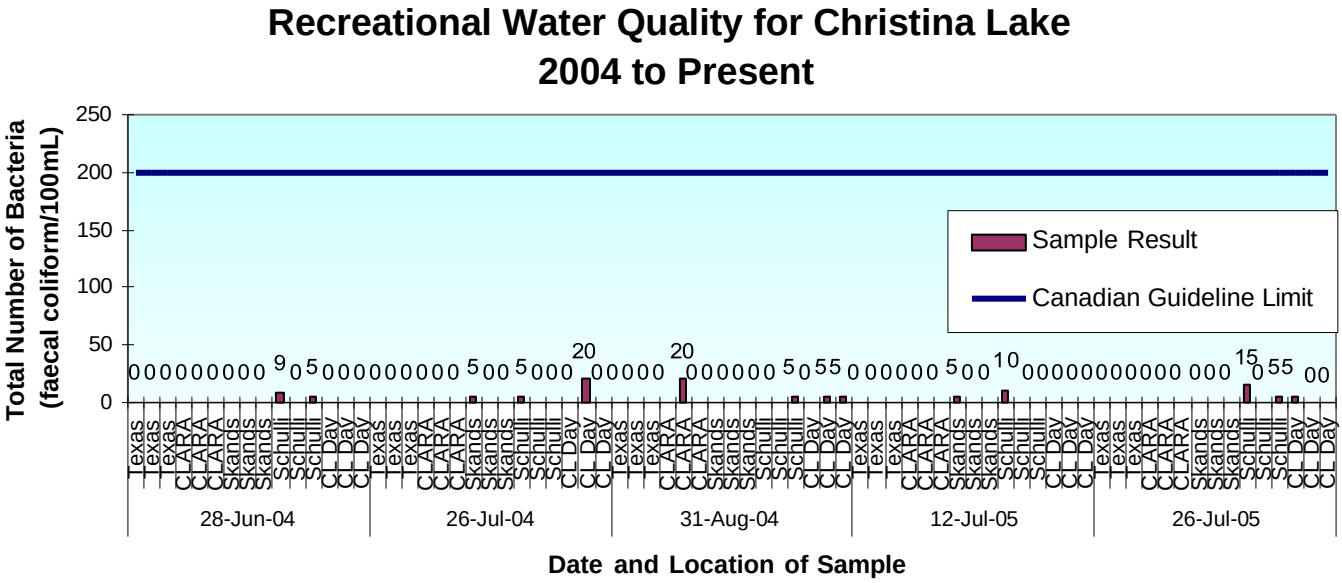


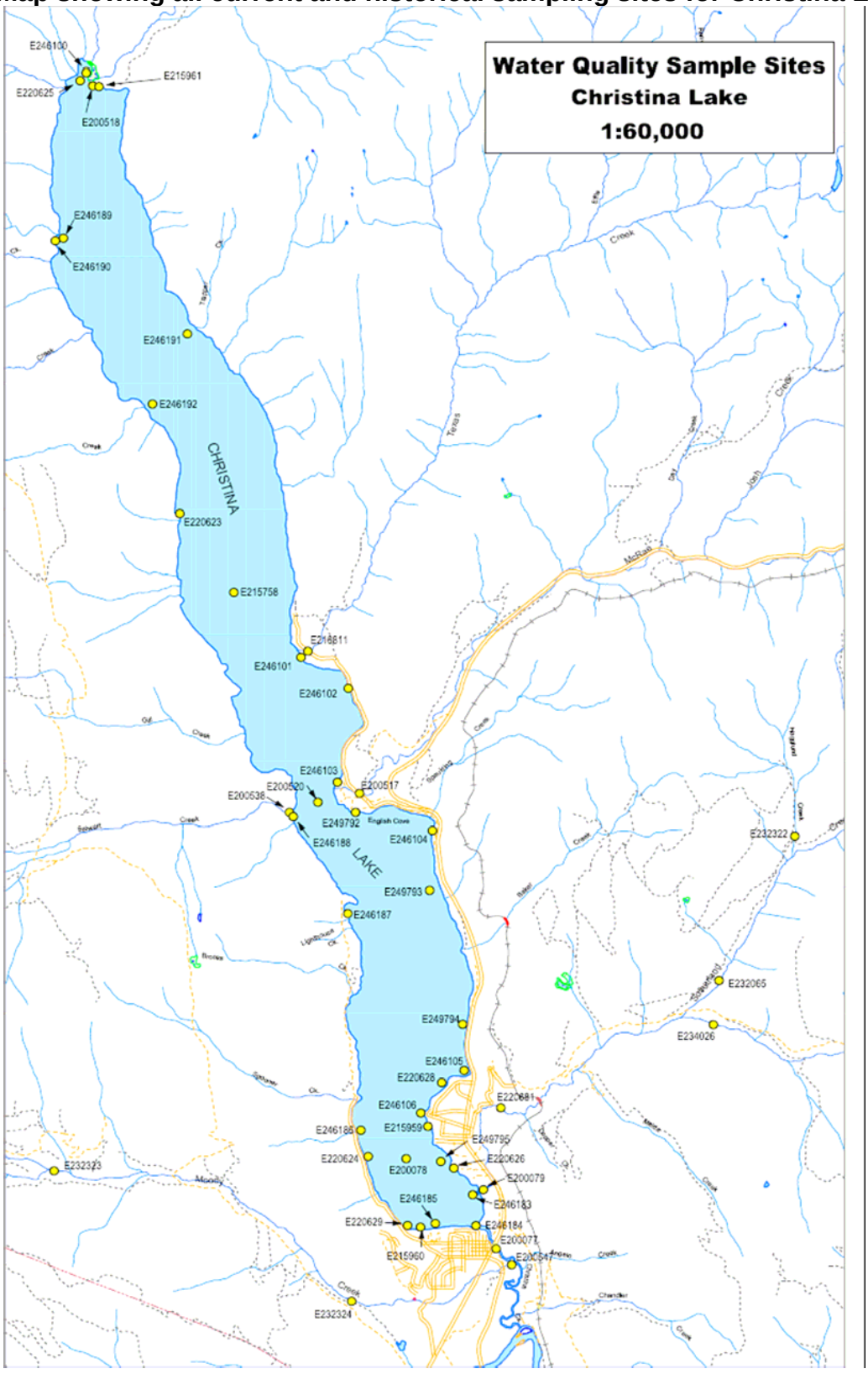
Figure 11. Summary of recreational water sampling results (red columns) for Christina Lake in 2004 to present, compared to the allowable limits of the Guidelines for Canadian Recreational Water Quality (blue line) (Shelley, 2005).

See Table 21 - Listing of recreational water sampling results for each of the samples taken at five locations around Christina Lake in 2004.

7.2.1 Water Chemistry Sampling

The provincial Ministry of Water Land and Air Protection (MWLAP) has conducted various water quality data collection programs at Christina Lake since the spring of 1972 (Ellis et al. 1991, Cavanagh *et al*. 1994). The purpose of long-term monitoring of Christina Lake water quality is to describe temporal trends in relation to changes in the watershed and climate. Historically much of the MWLAP data collection has been done in the spring and fall of the year at two deep sites; station 0200078 in the south basin, and station 0200520 near English Point. In 1991, additional sites were established, three of them in shallow waters, and a third deep water site (E215758) was also added to the program in the north basin (north of Texas Point) over the deepest point in the lake. The shallow sites were sampled by MWLAP in 1994 and between 1998 and 2001. Figure 12 shows all current and historical sampling sites for Christina Lake.

Figure 12. Map showing all current and historical sampling sites for Christina Lake



Spring sampling is important because the lake is relatively isothermal and homogeneous at that time. Spring samples estimate nutrient concentrations and the potential summer algal biomass and trophic status of the lake (McKean, 1992). Fall sampling occurs in late September or early October, during which time the lake is stratified and a thermocline is still present. Temperature stratification patterns are important to the water quality of a lake as it affects oxygen solubility, and the distribution of dissolved and suspended compounds (Ministry of Environment, Lands and Parks, 1998). Monthly or seasonal sampling through the spring summer and fall months was conducted by WLAP in 1991, 1992 and 1994. Monthly sampling provides a better estimate of water clarity and algal production (Jensen, 2005).

Christina Lake Water Quality (CLWQ) objectives (Table 23a) were set in 1994 based on a comprehensive review of lake and watershed information (Cavanagh *et al*. 1994). Water quality objectives are site specific management targets which protect the most sensitive water uses.

Table 23a. Water Quality Objectives for Christina Lake (Cavanaugh *et al*. 1994).

Parameter	Objective
Total phosphorus	-less than 7 *u*g/L @spring overturn
Total nitrogen	-less than or equal to 200 *u*g/L @spring overturn
Secchi Depth	-3 meter minimum at any time -annual mean greater than 10 meters
Chlorophyll-a (Apr – Oct mean)	-less than or equal to 2.5 ug/L for phytoplankton -less than or equal to 10 mg/m^2 for periphyton
Dissolved oxygen	-less than or equal to 8 mg/L at any site and depth
Turbidity	-mean value less than or equal to 1 NTU -maximum value less than or equal to 5 NTU
Periphyton	-stable community structure dominated (greater than 50% of cells) primarily by pinnate diatoms. -less than or equal to 10 mg/m^2 for periphyton
Pelagic phytoplankton	-stable community structure not dominated by blue-greens (less than 10% of cells in any sample). -dominant genera (greater than 10% of cells) should include *Melosira*, *Asterionella*, *Fragilaria*, *Synedra*, *Peridinium*, *Dinobryon*, and *Mallomonas*.
Zooplankton	-stable community structure dominated (greater than 10% of cells) primarily by *Bosmina longirostris*, *Epischura nevadensis* and *Kellicotia longispina*.
Fecal coliforms	-less than or equal to 10/100 mL (90th percentile)

Cavanagh recommended that a monitoring program be implemented, to check whether the objectives were being achieved (Table 23b). The results of this program as well as trend information from the last decade are discussed in the sections below. While, no comprehensive program to monitor objectives has been conducted since 1994, the annual spring sampling (MWLAP) is suitable for checking attainment of the Christina Lake nutrient objectives.

Table 23b. Recommended Water Quality Monitoring for Christina Lake 1994-1995 (Cavanaugh *et al*. 1994).

Location	Frequency	Parameters Measured
Deep stations	Monthly, April to October	Phytoplankton, zooplankton, dissolved oxygen and temperature profiles, Secchi depth, MF fecal coliforms, chlorophyll-a, turbidity
Deep stations, 3 depths/station		Total phosphorus, total dissolved phosphorus, nitrate, nitrite, ammonia, organic nitrogen.
6 shallow stations		Periphyton
6 tributaries and 6 shallow stations		Dissolved oxygen, temperature, total phosphorus, total dissolved phosphorus, nitrate, nitrite, ammonia, organic nitrogen, turbidity
6 tributaries		MF fecal coliforms
6 shallow stations	Weekly, July and August	

7.2.2 Extinction Depth

Cavanagh *et al*. (1994) reported that water clarity or extinction depth in Christina Lake, as measured using a Secchi disk, was exceptional with an apparent trend toward increased water clarity (1972-1992). The mean values at all three deep sites exceeded 10 meters. Prior to 1981, sampling occurred at various times between June and October (Cavanagh *et al*. 1994, Ellis *et al*. 1991) and may affect trend assessments.

Since 1981 Secchi disk visibility was usually recorded during the spring and fall of each year. Spring and fall clarity remains very good at Christina Lake compared to other lakes in southern BC (Table 23c), with little apparent trend other than decreases during years of higher run-off. The minimum Secchi disk visibility recorded since 1993 was 8.5 m in spring 1997 (Station 0200078), while the maximum depth was 13.5 m in fall of 2001 and 2002 (Station E215758). Although seasonal data would be needed to properly determine attainment, these results suggest water clarity of Christina Lake is better than the water quality objectives for Christina Lake (Table 23a) established by Cavanagh *et al*. (1994). The Secchi depth objectives specify a minimum of 3 metres, and a seasonal mean of greater than 10 metres. The long term means for Secchi depths, using all data for 0200078 (1972-2004) and E215758 (1991-2004) are 11.2 metres and 12.9 metres respectively. Further monitoring is required to characterize seasonal water clarity and determine whether the 3 metre minimum objective is adequately conservative.

Table 23c Christina Lake extinction depths (m) during spring and fall sampling at three deep stations 1972-2004.

	Station 0200078				Station E215758				Station 0200520			
Year	n	Spring	n	Fall	n	Spring	n	Fall	n	Spring	n	Fall
1993	1	10.0	1	13.2	1	12.3			1	10.5	1	14.8
1994	1	10.5	2	11.5	1	12.5	1	13.8	1	11.5	1	13.6
1995	1	12.8	1	13.5	1	12.8	1	14.5	1	13.0		
1996	1	9.5	1	13.0	1	9.8						
1997	1	8.5	1	11.5	1	9.2	1	12.0				
1998	1	9.0	1	11.8	1	12.0	1	14.1				
1999	1	10.8	1	10.3	1	11.5	1	11.0	1	11.0		
2000	1	11.6	1	10.8	1	12.8	1	11.8				
2001	1	12.0	1	12.5	1	12.7	1	13.5				
2002	1	10.9	1	11.8	1	9.7	1	13.5				
2003	1	9.9	1	13.0	1	9.2	1	13.2				
2004	1	10.9	1	10.3	1	9.2	1	11.8				

7.2.3 Temperature

Historically, Christina Lake has been characterized as a dimictic lake, mixing annually in the spring and late fall, from top to bottom. In some recent years however, winter temperatures have not been sufficiently cold for the lake to freeze over. Under these conditions, the lake has one long period of mixing, from November to April (Cavanagh et al. 1994) and would be considered monomictic (Jensen, 2005). Local records of ice cover on Christina Lake received from Ron Walker show only ten years since1959, when Christina Lake did not freeze over. Six of those 10 winters were recorded during the last decade (1994-2004). See Table 24 Christina Lake Ice Cover (Walker, 2005)

Fall temperature and oxygen profiles for deep stations 0200078 and E215758, between 1995-2004, are illustrated in Figures 13 (a to q). Surface temperatures at the time of fall sampling have been as low as 14 degrees Celsius and as high as 25.5 degrees Celsius. As temperatures cool in the fall, heat loss exceeds input and the warm surface layer or epilimnion deepens. In some years, the lake is close to turnover (2000) at the time of sampling, whereas in other years a distinct thermocline remains in the fall. Care needs to be taken to use this information when determining sampling depths.

7.2.4 Dissolved Oxygen (D.O.) Profile

An aerobic environment just above the sediments is important in preventing phosphorus from moving from sediments into the water column. A reduction in the oxygen concentration of the water near the sediment weakens this oxidized microzone barrier (Wetzel, 1983).

During the 1980s and 1990s dissolved oxygen profiles in Christina Lake were reported to be characteristic of an oligotrophic lake (Cavanagh et al. 1994, Ellis *et al*. 1991). Dissolved oxygen concentrations all exceeded the provincial working criterion of 5 mg/L to protect salmonids. A more stringent dissolved oxygen concentration objective of 8 mg/L was set by Cavanagh using data for the south and shallower site (24m) to reflect conditions at that time.

Monitoring in 1994 (Ministry of Environment, Lands and Parks 1996), found that 97% of all concentrations met or exceeded the objective of 8 mg/L. Five samples collected below 40 meters at the Texas point station (E215758) ranged from 4.5 – 7.8 mg/L and did not meet the objective.

Dissolved oxygen profiles have been collected in the fall at stations 0200078 and E215758 since 1995. These profiles continue to show adequate levels of oxygen at depths above 40 metres (Figures 13 a - q). This is important for salmonids as they seek cooler temperatures in the hypolimnion (below ~ 20 m) during hot summer months. Dissolved oxygen concentrations were collected at depths below 40 meters at the deep site north of Texas Point (E215758) in 1996, 1997, 1998, and 2003. In these years, dissolved oxygen concentrations below 40 meters did not meet the water quality objective. These samples ranged from 2.1 to 6.1 mg/L. This range is slightly lower than the seasonal data collected in October of 1994, however statistical differences, trend assessment, and oxygen depletion rates cannot be determined because of limited data.

In all years, highest concentrations appeared in the metalimnion. This has been noted in earlier reports and is a result of increased phytoplankton production, which occurs due to increased nutrient concentrations in the thermocline (Wetzel 1983, Cavanagh *et. al*. 1994).

7.2.5 Nutrients

Nitrogen and phosphorus are both major nutrients which affect the primary productivity of fresh water, accordingly they are used as indicators of water quality. High levels of nutrients (particularly of phosphorus) result in algal blooms, excessive growth of aquatic plants and overall undesirable water quality (Cavanagh *et a*l, 1994). These nutrients can be of natural origin or derived from human activities (agriculture, logging, sewage waste disposal, etc.). Cavanagh cautioned that the potential for seasonal, elevated inputs from agricultural activity along Sutherland Creek and highly concentrated individual sewage disposal units along the lake shoreline, could result in poorer water quality in the future.

Phosphorus

Sources of phosphorus include soils and minerals, animal waste, septic tank leachate, decaying plant and animal remains and fertilizers. Phosphorus enters fresh waters from atmospheric precipitation, groundwater, and surface runoff (Wetzel 1983). Productivity of freshwaters is usually limited by available phosphorus.

Total phosphorus concentrations have been measured since 1972 at station 0200078 in the south basin, from 1976 to 1995 at station 0200520 at English Point, and since 1991 at station E215758 (Table 25) in the north basin. Between 1973 and 1993, spring overturn phosphorus concentrations for Christina Lake ranged from 3 to 16 ug/L with no consistent trend or evidence of overall lake deterioration (Cavanagh et al. 1994). During the next ten years, phosphorus concentrations have ranged from 3.0 to 17.0 ug/L (Figure 14) with slightly greater TP concentrations in the south basin (8 ug/L) compared to the north basin (7 ug/L). Overall no trend was apparent over the 30 year period. Between 1996 and 2001 however, all spring overturn total phosphorus and dissolved phosphorus concentrations at all sampling stations exceeded the Christina Lake objective of 7 ug/L (Table 25), with the exception of total dissolved phosphorus in 2001. The increased concentrations of phosphorus in Christina Lake during the late 1990s correspond to increased precipitation (1995-1997) and presumably increased inflow into the lake (Vic Jensen, Ministry of Environment, personal communication) and appears to be a regional phenomenon. Since 2002, phosphorus levels have decreased substantially below the spring objective at all sampling stations.

Cavanagh *et al.* (1994) suggested that the majority of nutrients entering the lake from stream sources might concentrate in the lake near the thermocline because of temperature and density equilibrium between the stream and lake at that depth. The present strategy of sampling the hypolimnion and epilimnion may not detect this. Seasonal monitoring in 1994 sampled these three zones however found no elevation of phosphorus in the thermocline region (Table 26). Seasonal trends in phosphorus concentrations during 1994 are illustrated in Figure 15 showing declining values through late spring and early summer with some slight increase occurring in the fall. Throughout this sampling period, levels remained at or just below the 7.0 ug/L objective.

Nitrogen

Nitrogen is present in natural waters in several different forms depending on the source and environmental conditions (Wetzel 1983). Blue-green algae have the ability to transform atmospheric nitrogen (N_2) to ammonium (NH_4^+) through a process called nitrification. Under low oxygen conditions, some bacteria can reduce nitrate to nitrogen gas or back to nitrite and then ammonium in a process called nitrogen reduction. Nitrite and nitrate can also be incorporated by organisms. This material eventually decays and the nitrogen is released as ammonia. Ammonia is an energy efficient source of nitrogen for most plants (Wetzel, 2001). Algal blooms may result from increased nitrate and/or ammonia concentrations, whereas cyanobacteria can use all forms of nitrogen as they are able to fix nitrogen. Primary sources of nitrogen to freshwaters are precipitation, sewage or septic tank leachate, fertilizers, and erosion and groundwater inputs.

The forms of nitrogen monitored since 1973 are total nitrogen, Kjeldahl nitrogen, ammonia, and nitrate nitrogen (Table 25). Consistent with Ellis' results (1991) organic nitrogen was the form of nitrogen measured in the highest concentrations in Christina Lake. Kjeldahl nitrogen, dissolved nitrogen and total nitrogen values are very similar, while nitrate and ammonia concentrations are lower.

Mean spring overturn total nitrogen concentrations for the three deep sites have remained below the Christina Lake Water Quality Objectives (<200 ug/L) in all years since data have been collected. Nitrate-nitrogen is almost always near or below the detection limit with the exceptions of 1978, 1981, and 1993. Almost all readings for dissolved ammonia were near or below the 0.005 mg/L detection limit.

Nitrogen concentrations did not show increased levels during years of increased precipitation as did phosphorus concentrations and shows a slightly declining long-term trend. During the period 1996-2000 the N:P ratio is near or below the levels at which nitrogen becomes the limiting nutrient (see section below N:P ratios).

During the spring and summer of 1994 the calculated total organic nitrogen in the epilimnion of all stations ranged from 90 to 110 ug/L, 103 – 130 ug/L for the metalimnion, and 98 – 120 ug/L for the hypolimnion. Seasonal patterns in total nitrogen in 1994 showed early summer depletion followed by recovery in the epilimnion and metalimnion in the fall, and steadily increasing concentrations over the season in the hypolimnion. Increased concentrations of dissolved ammonia are noted at station 0200078 in the epilimnion in July and August, and in the hypolimnion (E215758) in September (Table 27). These concentrations patterns are similar to those reported by Ellis et al. (1991). At no time did the concentrations exceed objectives.

N:P ratios

N:P ratios of 15:1 or higher are indicative of phosphorus limitation, 5-15:1 indicate co-limitation, and ≤ 5:1 is nitrogen limited (Nordin 1985). When nitrogen is limiting, there is a greater chance that nuisance algae such as Cyanobacteria (blue-green algae) will become more numerous. The optimum time to sample a lake to determine the ratio of total nitrogen to total phosphorus is just after ice off. Realistically this is not always easy to do and may partially explain the variance in N:P ratios between 1973-2004 (Table 25). Additionally, increased phosphorus concentrations between 1996-2000 did not coincide with increases in nitrogen levels. The N:P ratios during this time ranged from 4:1 to 10:1.

Since 1973, N:P ratios have remained fairly consistent with phosphorus being the most frequent limiting nutrient. Cavanagh et al. (1994) reported N:P ratios in the range of 7:1 to 39:1. N:P ratios between 1993-2004 range from 4:1 to 40:1. As such, it appears that the limiting nutrient in Christina Lake may vary between years and within individual growing seasons. Other methods of determining nutrient depletion and limitation are available and should be used if further research is conducted in this area.

7.2.6 Nutrient Sources: Internal and External

Internal

In 1994 Cavanagh et al. reported that internal nutrient loading from sediments in Christina Lake was unlikely, due to the high dissolved oxygen concentrations throughout the year. While, dissolved oxygen concentrations at depths below 40 have not met the CLWQ objective of 8 mg/L, there is no indication of anoxia or complete oxygen loss in the waters near the bottom of Christina Lake. The low oxygen concentrations below 40 meters are a concern and should be investigated further. A reduction in the oxygen concentration of the water near the sediment weakens the oxidized microzone barrier at the sediment water interface. This aerobic zone is important in preventing phosphorus from moving from sediments into the water column (Wetzel, 1983).

External

Point Sources

Point sources refer to activities which release concentrated contaminants at a single place. An example might be a wastewater treatment plant discharging effluent from an outfall. There are no point source or direct discharges of domestic or industrial waste into Christina Lake or its tributary streams (Cavanagh et al. 1994, Ellis et al. 1991, V. Jensen, pers. comm. 2005).

Non-point Sources

Non-point sources of nutrients refers to activities which can contribute contaminants to a water body in a diffuse manner. Examples are atmospheric deposition, boating, agricultural and road runoff, forestry activities, septic tanks and tile fields. No new estimate of non point source nutrient input to Christina Lake has been developed since Cavanagh's estimate in 1994. The 1994 estimates may be reasonable, if it's assumed that no change in commercial or residential septic discharge has occurred, nor any increase in watershed disturbance due to forest harvest or stormwater inputs.

Septic tank facilities such as those that service the campgrounds account for large seasonal surges of phosphorus into the lake (Cavanagh *et al*. 1994). The tile fields of these facilities may be

close to or seasonally below the water table and the phosphorus retention capacity of the soils are potentially very poor. Individual houses and cottages are also thought to input significant amounts of domestic waste. The majority of waste treatment systems are septic tanks with subsurface effluent disposal. Less than 25% of these were maintained in accordance with recommended practices as determined by a questionnaire conducted by the engineering firm of Kerr Wood Leidal (Ellis et al. 1991). The results of this survey determined that the phosphorus contribution of these systems is higher than if systems were properly maintained. Sewage from residential and commercial sources was estimated to be approximately one third of the phosphorus load to Christina Lake (Cavanagh et al. 1994) or approximately 1275 kg's per year (Jensen, 2005).

Marinas and boating activities can also be a source of nutrient loading. However, in 2000, the provincial government designated Christina Lake as a no-discharge zone under the *Pleasure Craft Sewage Pollution Prevention Regulations* and the *Non-Pleasure Craft Sewage Pollution Prevention Regulations.* This is not considered a significant source of nutrients to Christina Lake. Only McRae and Sutherland creeks have significant year-round flows into Christina Lake. McRae Creek is the largest tributary within the lake drainage and is less developed than Sutherland Creek. As such its nutrient contributions are considered less important than Sutherland's, which has been identified as the major source of nutrients for the lake (Cavanagh *et al.* 1994). Phosphorus concentrations from Sutherland Creek are typically higher than concentrations found within the lake, with more than 50% of summer load occurring in the month of May, which will directly influence algal production. Watershed sources of phosphorus which would include all natural processes, forestry, agriculture and sources other than sewage was estimated to be about 46% of the total annual load or approximately 1860 kg's per year (Cavanagh *et al*. 1994).

Atmospheric input of phosphorus was estimated from studies elsewhere at 20% of the total load or approximately 800 kg's per year (Cavanagh *et al*. 1994). Wetzel (1983) noted that contribution of phosphorus is generally lower than that of nitrogen except in agricultural areas. The major source of phosphorus in precipitation is from dust generated over the land.

7.2.7 Nutrient Budgets

A simple nutrient budget for Christina Lake was developed by Cavanagh *et al.* 1994. These authors identified the sources listed above and provided estimates of each. At the time their report was prepared, phosphorus concentrations of tributaries were not known other than estimates for Sutherland Creek. Recent sampling programs on these tributaries may provide more precise estimates of nutrient loading from these sources. Although the scope of this report did not enable this, it would be valuable to revisit the calculations and update the total nutrient loading estimate for Christina Lake with this information.

7.2.8 Nutrient Models

An extension of the nutrient budget developed by Cavanagh et al. (1994) would be to evaluate a nutrient model for Christina Lake. A water quality or nutrient model is a set of mathematical equations that represent the physical, chemical, and biological characteristics and processes of a water body in a way that approximates reality (Tetra Tech Inc, 2002). Nutrient models can predict concentrations of phytoplankton, Secchi disk depth or dissolved oxygen levels. The total concentration of phosphorus in a lake can be predicted as a function of the annual phosphorus loading. They can also be used to simulate water quality changes that could be expected as a result of changes in nutrient loads, varying management decisions, and possibly, climate change.

These simulations, called "scenarios," allow us to predict positive or negative changes on lake water quality. The following benefits of developing a lake nutrient model have been identified.

However, it is important to note that predictions can have uncertainties ranging from 30 to 300% (United Nations Environment Programme, 2005).

In order to 'predict' reality, a first step in developing a model is to gather specific information for the lake in question. Information required includes:

1. A determination of the trophic status of the lake.
2. Physical characteristics of the lake including size and depth, flushing rate, patterns of stratification and mixing.
3. External and internal sources of phosphorus loading.
4. Annual soil loss and the movement of sediment and sediment-bound nutrients.

The first three items listed above are described in earlier reports (Ellis *et al*. 1991, and Cavanagh *et al.* 1994). In order to estimate phosphorus loadings, Cavanagh estimated sedimentation rate coefficients based on Dillon and Rigler (1975) with modifications incorporating flushing rate (Nordin 1993). Detailed hydrologic records or discharge estimates for tributaries to Christina Lake would be required to estimate nutrient loading. For the purposes of developing a nutrient model for Christina Lake, information for annual soil loss and the movement of sediment and sediment-bound nutrients is currently lacking, but might be estimated from water quality data for the tributaries.

There are simple models available for a nominal fee. For example, the EUTROMOD model available from the North American Lake Management Society (NALMS) is used for managing eutrophication in lakes. The model is a simple, spreadsheet-based collection of models (Reckhow *et al.,* 1992). The results of EUTROMOD are ultimately designed to predict the trophic state of the lake under various future scenarios.

7.3 BIOLOGICAL CHARACTERISTICS

7.3.0 Aquatic Plants

The characteristics and history of a lake are highly dependent upon it's level of primary productivity. A common threat to lake ecosystems is increased nutrient inputs which can lead to algal blooms and reduced water clarity, nuisance growth of aquatic plants, and anoxia (United Nations Environment Programme, 2005). Various monitoring studies of Christina Lake have documented rooted and floating plants in the littoral zone, suspended algae (plankton), and attached algae (periphyton).

For a list of aquatic plant species identified in Christina Lake refer to the Christina Lake Water Quality Assessment and Objectives, Technical Appendix, September 1994. A copy of this report is available at the Community Stewardship Resource Centre, 90 Park Road, Christina Lake, BC. For information on Eurasian watermilfoil *(Myriophyllum spicatum)* refer to section 5.3.6.

7.3.1 Phytoplankton

The concentration of phytoplankton chlorophyll-*a* provides a measure of the phytoplankton biomass in lake water. This variable directly relates to the productivity and trophic status of the water body (Ministry of Water, Land and Air Protection, 1998).

The majority (90%) of epilimnetic chlorophyll-*a* concentrations recorded between 1980-1992 (sampled in spring and fall) fell within the range for oligotrophic lakes, 0.3-3.0 *u*g/L (Cavanagh et al. 1994). Since 1993, only 18.4 % of the spring and fall chlorophyll numbers were above the water quality objective of 2.5 *u*g/L (Table 28). Most of the higher chlorophyll-*a* values occurred during the late 1990's concurrent with the higher concentrations of phosphorus measured between 1996-2001 (Section 5.2.4). As the chlorophyll-*a* objective is expressed as a seasonal average (2.5 *u*g/L), the spring and fall sampling is insufficient to properly check the objective.

During 1994, chlorophyll-*a* concentrations were sampled March through October. All chlorophyll-*a* concentrations were found to meet the CLWQ objective (Table 29) and showed the typical pattern of increased chlorophyll-*a* during the spring and fall plankton growth periods.

Phytoplankton taxonomy was reported in the 1994 attainment monitoring program (Ministry of Environment 1996). In 1994 all deep sites were sampled in June, August, September, and October for a total of 12 samples for the entire season. The objective of blue-green algae comprising less than 10% of the algal species composition was not met in 4 of these samples. Three of these occurred in June (one at each deep site) and one in September at station 0200078. The objective of having >10% of the species composition dominated by desirable algal species and considered characteristic of oligotrophic lakes was met in only 3 of the 12 samples.

7.3.2 Periphyton

In 1991 attached periphytic algal species (algae growing on lake bottom substrates) were sampled for community composition and biomass using plexiglass plates moored in shallow, near shore waters (Cavanagh et al. 1994). Diatoms were found to be the most representative group of this community. Compared to algal species sampled at deep sites (phytoplankton), the blue-green algae were present in higher number. This reflects the elevated nutrient levels present in shallow sites, probably as a result of near-shore septic tanks, or fertilizer leaching to the lake, or stream inputs. Cavanagh *et al.* used these data to set the periphyton objectives.

The 1994 attainment monitoring of periphyton growing on stones in shallow waters of the lake found that seasonal levels (June – October) of chlorophyll-*a* concentrations in periphyton were above the Christina Lake objective and sometimes above the provincial criteria of 50 mg/m^2 (Ministry of Environment, Land and Parks, 1996). In addition, the species composition objective (> 50% cells of pinnate diatoms) was not met at any site or time (Ministry of Environment, Land and Parks, 1996).

Periphyton sampling using rock substrates was conducted at fourteen to sixteen sites in August of 1998, 1999, 2000, and 2001 by the Christina Lake Stewardship Society (Table 30). With the exception of Treadmill Creek in 2000 (E246192), for all years, and at all sampling sites, periphyton chlorophyll-*a* concentrations did not exceed the objective of 10 mg/m^2. Samples at site E246192 ranged from 2.8 to 16.3 mg/m^2. If the Treadmill site is omitted, the highest chlorophyll-*a* concentration in all sites and years is 4.59 mg/m^2. The cause of these higher concentrations at Treadmill Creek compared to other sites is unclear, nor is it clear why chlorophyll-*a* concentrations

decreased between 1994 and recent sampling. While the periphyton data may be valuable in observing trends, it must be used with caution because periphyton growth is often highly variable at a site. Christina Lake periphyton chlorophyll-*a* between 1998 and 2001 exhibited percent relative standard deviations ranging from 27 to 105%. According to MWLAP (1998) the percent relative standard deviation for six or more replicates should ideally be no more than about 10%. Increased replicate collection at each site may improve this situation.

The differences in sampling methods (1991-92 plexi glass plates; 1994 and 1998-2001 stones) and changing locations for periphyton sampling over the years, preclude trend assessment at this point.

7.3.3 Zooplankton

The taxonomic diversity of Christina Lake zooplankton was sampled between 1991and 1992, and is reported in Cavanagh *et al*. (1994). Based on these surveys Christina Lake's Water Quality objectives for zooplankton were set at >10% for any rotifers (*Kellicottia*, *Conochilus*) and >10% for any of the crustaceans (*Bosmina*, *Epishura*, *Diacyclops*). Attainment monitoring in 1994 (Ministry of Environment, Lands and Parks 1996), reported that community composition of rotifers and crustaceans met the CLWQ objective (Table 23a). Taxonomic samples have not been collected since 1994.

Zooplankton settled volume data have been collected in the spring since the early 1980s and in the fall since 1976. Macroinvertebrate biomass (volume of organisms per volume of water filtered) is an estimate of the zooplankton standing crop in a lake. Increased levels of nutrients may promote primary and secondary production (Ministry of Environment 1997). Spring concentrations ranged from a low of 0.03 ml/m^3 to a high of 1.94 ml/m^3, while fall concentrations ranged from 0.07 to 1.94 ml/m^3 (Figures 16a and 16b). There appears to be no trend in zooplankton at deep stations in Christina Lake, but considerable year-to-year variation.

The MWLAP sampling procedures of vertical net hauls during daylight hours generally precludes catching and estimating Mysis populations.

7.3.4 Fish

Christina Lake is a popular recreational destination and increasingly residential and commercial developments are expanding along the south shores. New development is confined to the south end of the lake because the north half is protected within the Gladstone Provincial Park. The rate of development along the south shore is leading to concerns over water quality and fish habitat, particularly near-shore habitats (G.L. Ventures, 2001).

The Christina Lake recreational fishery attracts many anglers each year. Rainbow trout *(Oncorhynchus mykiss)*, kokanee *(Oncorhynchus nerka)*, and bass *(Micropterus spp.)* are the most popularly sought after species (Webster and Wilson, 2005). More recently there have been concerns raised over the size and abundance of sports fish and angling restrictions have been imposed in an attempt to help conserve fish stocks. While rainbow trout have become smaller over time, kokanee have not changed in the period 1991-2004 (Wilson, 2005). (See table 35 below)

Historically, Christina Lake has provided a moderate to poor fishery. Early complaints indicate that fish size was not satisfactory to fishers (Smith, 1974); and more recently size and success

has become a problem. Christina Lake is a warm water lake that hosts a wide range of fish species. Currently, 18 species are confirmed to be present and up to 15 other species may also occur in the lake (Table 31). Christina Lake supports both warm-water fish species such as centrarchids (bass and sunfish), ictaluruds (catfish); as well as cold-water species such as salmonids (trout, kokanee, and whitefish), and lotidae (burbot) (Mitchell and LaCroix, 2004). Many species have been introduced over the last century and have naturalized. In the early 1900's there were few stigmas associated with the stocking of ponds, lakes and rivers with non-native fish species for food, sport, commercial or aesthetic reasons. Many of the western Canadian fish introductions were welcomed as a reminder of back home, and records indicate that exotic species such as the Smallmouth Bass (*Micropterus dolomieu)* were introduced (stocked) into the Christina Lake (Kettle system) as early as 1901 (RBCM, 2005). (See Table 32 and 33) Other non-native fish species present in Christina Lake are believed to be immigrants from species introduced to the F.D. Roosevelt Reservoir, in Washington State (e.g. carp, pumpkinseed sunfish, bullheads, tiger musky) (ARL, 2000).

Historically, a commercial fishery concentrated on [15]shore spawning kokanee from the turn of the century until the 1960's. For Christina Lake the commercial fishery was primarily drag seine licenses. It was believed that the shore spawning kokanee were a superior tasting fish at spawning time and could be caught in abundance and eventually a market developed at Christina Lake. It must be noted here that shore spawning kokanee do not go red like the stream spawning kokanee do which made them more appealing for the consumer. Fresh kokanee were boxed and shipped as far away as Calgary and Spokane with Trail being the biggest part of the market (Thomas, 2004). See Table 34 Christina Lake Commercial Kokanee Fishery Catch Estimates (Includes a summary of the diary notes of R.A. Wolverton and documented catches of Ole Johnson)

Permit control was gradually obtained by the Fish and Wildlife Branch and both commercial and sustenance permits were reduced and eventually eliminated. Three factors tended to destroy the commercial enterprise. They were (1) a declining size, (2) a conflict with sport-fishing interests and, (3) a change in spawning times influenced no doubt by selective fishing of the early spawning component. (Bull, 1980)

Records of kokanee size at maturity indicate a fluctuating pattern. George Stringer (formerly Regional Manager of the Fish and Wildlife Branch, Ministry of Recreation and Conservation) suggests this growth variation is related directly to population size. If the small size of individual fish were due to over abundance; an apparent size increase would be expected after the commercial fishery activity. While there has been fluctuation following the closure of the commercial fishery, there is little difference in kokanee length in the 1950's compared with spawner data collected from 2001 to 2004. See Table 35 on the following page.

[15] Spawning time for shore spawning kokanee differs from stream spawners – For shore spawners usually mid November to mid January – varies with temperature – (Thomas, 2004) and stream spawning kokanee usually spawn between mid August to mid September.

Table 35. Kokanee mean length in Christina Lake (from commercial catches – shore spawners 1952 to 1964 and Kokanee surveys 2001 to 2004)

Dec. 1952	16 individuals	Mean length 18.3 cm.
Dec. 1953	100 individuals	Mean length 20.0 cm. (18.8 cm. – 21.4 cm.)
Dec. 1964	75 individuals	Mean length 29.4 cm. (27.3 cm. – 31.8 cm.)
Dec. 2001	73 individuals	Mean length 19.2 cm (17.6 cm – 22.8 cm)
Dec. 2002	94 individuals	Mean length 26.3 cm (12.7 cm – 36.7 cm)
Dec. 2003	99 individuals	Mean length 23.9 cm (20.0 – 30.8 cm)
Dec. 2004	87 individuals	Mean length 22.4 cm (19.0 – 35.3 cm)

The size of kokanee from shore spawner surveys from 2001 to 2004 are included in the above table. This shows that there has not been a lot of change over time in spawner size. From this data it is difficult to determine if the commercial kokanee harvest had an impact on kokanee size. However, it does indicate that anglers may be incorrect about the kokanee getting smaller in recent years.

Another type of fishing in Christina Lake from the early days was burbot *(Lota lota)* fishing (also commonly but incorrectly called freshwater lingcod*),* which was done to some degree on a commercial basis*.* There was a market for burbot as they were caught later in the year than kokanee. The main method for catching them was to use setlines ranging from 200 feet to a mile long. "Nowadays, however, the ling fishing in the lake has also dwindled away to the point were it is considered pretty good if you catch a couple in a day's fishing". (Sandner et al, 1994) Local anglers indicate that the population of this species has declined drastically in recent years (ARL, 2000).

As the abovementioned and following information in this section indicates there is a lack of conclusive information to make a diagnosis on the state of the fisheries in the Christina Lake watershed. Stream and lake foreshore habitat loss, potential over harvesting of certain species, and competition from introduced species may be adversely affecting fish populations in Christina Lake (Wilson, 2005).

7.3.4.0 Fish Species

Information obtained from Fisheries Information Summary System (FISS, 2005), (Fish Wizard, 2005), and Aquatic Resources Limited report number 335-1 (Christina Lake Fish and Fish Habitat Inventory) (ARL, 2000); revealed that there are currently 18 confirmed fish species that reside in Christina Lake. Of the 18 confirmed fish species, 9 have been introduced and 3 have been stocked. Historically, Christina Lake had indigenous rainbow trout and kokanee populations. However, subsequent stocking of these species from other gene pools (such as the Lardeau River rainbow trout) means that what is left of the indigenous populations today in Christina Lake is unknown.

There are also 15 unconfirmed species that could potentially occur in the lake's watershed. See Table 31 for confirmed and unconfirmed fish species listing.

7.3.4.1 Stocking Records for Christina Lake

As indicated on the Fisheries Information Summary System (FISS) stocking records, rainbow trout and kokanee were stocked into the Christina Lake system between 1914 to 1963. Also, bass was stocked into the lake in 1901 but FISS does not identify which species. Records from the Royal

British Columbia Museum indicate that it was smallmouth bass that was stocked into Christina Lake in 1901. See Table 32 Stocking Records for Christina Lake.

7.3.4.2 Introduced Species Account for Christina Lake

This section outlines fish species that have been introduced into Christina Lake, but it also must be noted here that other introduction and/or stocked species are discussed within this document such as Eurasian water-milfoil *(Myriophyllum spicatum)* section 5.3.6 and Opossum shrimp (*Mysis relicta) section 5.3.5.2*

It is suspected that fish species such as the pumpkinseed sunfish, brown and black bullhead, tiger musky, walleye, carp, tench, as well as largemouth and smallmouth bass, immigrated from Washington state via the Columbia River system and/or the Kettle River system into Christina Lake via Christina Creek. It is unknown at this time the status of these exotic species and the possible impacts that these species may have on native fish populations. See Table 33 Introduced Species Account for Christina Lake.

The following excerpt has been directly quoted from the Royal British Columbia Museum website "Living Landscapes" – Columbia Basin – Exotic Species Topics – Fish: livinglandscapes.bc.ca/cbasin/history/exoticspecies.htm:

"At the international workshop in April, 1998, "Toward Ecosystem-Based Management in the Upper Columbia River Basin," (Sustainable Fisheries Foundation, 1998) a common refrain echoed throughout was the need to avoid introduction of exotic fish species, and their parasites and diseases. Comments such as these were common in the summary report: "water quality sufficient to maintain *native* fisheries..."; "...biodiversity of *indigenous* species maintained..."(emphasis added). Participants recognized that perhaps the only ecological good that came of the power dams was the restriction on upstream migration of non-native fish. Nevertheless, a number of exotics occur in the Columbia Basin. Both brook trout (actually, a char) and brown trout have been widely stocked in the region. Carp, brown and black bullhead, pumpkinseed, smallmouth and largemouth bass, and black crappie are all in the Columbia River system, waiting for a chance to invade further upstream. These all have the potential to displace native sport fish; although, as warm-water fish, they may have trouble establishing large populations in the cold waters of the Columbia Basin. Walleye have already been reported from Arrow Lake; if confirmed, and if they establish a breeding population, woe betide the kokanee and trout populations which are already reeling from dam-related nutrient deficits".

7.3.4.3 Fish Species at Risk

There is one confirmed fish species within the Christina Lake watershed that is blue listed under the Provincial species at risk. The species is the Westslope cutthroat trout. The blue ranking means that this species is threatened. See section 5.3.5.1 for further information on species at risk and the federal and provincial ranking systems. See table 19 for a complete listing of species at risk within the watershed.

7.3.4.4 Creel Surveys and Shore Spawner Kokanee Enumerations

Creel Surveys

A report called the Okanagan Region Large Lake Creel Census 2004: Kalamalka, Wood and Christina Lakes was produced by (Webster and Wilson, 2005). This report summarizes data collected for this shore-based creel survey which was done April through July of 2004. Within the

contents of this report, angler effort, catch per unit of effort (CPUE), angler catch and composition are all documented. Information was collected via the following methods:

- Angler interviews
- Biological sampling (species, length, weight, sex, maturity, and diet) – age structures were obtained by collecting samples of scales, otoliths, or a portion of pectoral fin
- Boat counts for overall estimates of angler effort

Table 36. CPUE values for Christina Lake in 2004. (Webster and Wilson, 2005)

SPECIES	NO. KEPT	NO. RELEASED	C.P.U.E. KEPT	C.P.U.E. RELEASED	C.P.U.E. TOTAL
KO	60	65	0.116	0.125	0.241
RB	22	17	0.042	0.033	0.075
SMB	15	56	0.029	0.108	0.137
ALL SPECIES	**97**	**138**	**0.187**	**0.266**	**0.453**
ROD HRS = 518					

Harvest rates for Christina Lake showed that anglers retained 56% of all rainbow trout caught and 21% of all smallmouth bass. Both Smallmouth and largemouth bass play a significant role in the Christina Lake fishery. Anglers indicated that 0% of non-sport species were retained. Christina Lake angler hours for 2004 were calculated to be 518 angler hours. The report also revealed that Christina Lake had the highest estimated CPUE of the three lakes that were surveyed (the other two being Kalamalka and Wood Lake) (Webster and Wilson, 2005)

Table 37. Species Preference by interviewed anglers for Kalamalka, Christina and Wood Lakes in 2004. (Webster and Wilson, 2005)

	Percent of Interviewed Anglers Interested in Catching:					
	ANY SPECIES	RB	KO	LT	OTHER	BASS
Kalamalka	54	29	11	22	0	0
Wood	15	4	83	0	1	0
Christina	40	30	20	0	0	18

More anglers targeted rainbow trout in 2004, although rainbow trout only made up 17% of the 2004 catch composition.

Table 38. Catch Composition for Christina, Wood and Kalamalka Lakes in 2004. (Webster and Wilson, 2005)

SPECIES	CHRISTINA LAKE		WOOD LAKE		KALAMALKA LAKE	
	No. of fish	Percent of catch	No. of fish	Percent of catch	No. of fish	Percent of catch
KO	125	**53**	598	**93**	34	**37**
RB	39	**17**	8	**1**	29	**32**
SMB	71	**30**	0	**0**	0	**0**
Other	0	**0**	22	**3**	19	**21**
YP	0	**0**	14	**2**	0	**0**
WF	0	**0**	4	**1**	0	**0**
LT	0	**0**	0	**0**	9	**10**

The report notes that the average kokanee size increased 13mm since the 1991 report and that zooplankton is the preferred diet of Christina Lake Kokanee - (the stability of the zooplankton population within the lake is undetermined) (Webster and Wilson, 2005).

A series of recommendations is also incorporated into the report such as:

- Develop a schedule for future creel surveys to monitor effort, catch success and condition of fish
- Develop a rainbow trout stock assessment program to determine if declines in fish size since 1991 are real.

A copy of this report is available at the Christina Lake Stewardship Society office.

Shore Spawner Kokanee Enumerations

Shore spawner Kokanee enumerations have been conducted on Christina Lake since 2001 with limited success. Although habitat types and location of redds were observed and recorded during the 2001 enumeration, only 372 spawning kokanee were directly observed. The G.L. Ventures (2001) report has conflicting information stating in table 3.3 that 73 samples were collected but reports 42 samples were collected in section 4.41. The field observations were made during daylight hours (G.L. Ventures, 2001).

In 2002, dead kokanee samples were collected from the surface of the lake since the timing of the enumeration failed to coincide with the spawning event. (Mitchell and LaCroix, 2003). The exact number of samples collected is unknown

Results from the 2003 enumeration suggested that there was a significant discrepancy between the very low number of spawners (4 in total) and the large number of redds observed. Speculation that the shore spawners emerged at night was confirmed when sampling done after dark revealed large numbers of kokanee milling around the gill nets. A recommendation was made to change the timing of the fieldwork in future surveys. A total of 99 samples were collected (Mitchell and LaCroix, 2003).

The 2004 enumeration was conducted at night. As was previously suspected, the kokanee spawners were observed converging on the gravel shoals of the lakeshore after dark. The spawners were counted with the aid of a boat and large spotlights. A GPS unit was used to

capture data to eventually map areas where spawners and redds were observed. Between 570 and 820 kokanee spawners were observed over the course of 4 nighttime enumeration sessions. Redds were also counted during a daytime field survey. Initial observations suggested that there were more redds than the number of observed spawners could have excavated. A recommendation to begin the field surveys earlier in December to pinpoint the onset of the spawning event was made to ensure that a true peak number of spawners are observed. The shore spawner kokanee enumerations are expected to continue on an annual basis (McLean and Webster, 2005).

See Appendix E Map 5 for Kokanee shore spawning sites on Christina Lake.

SECTION 8.0

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8.0 LAKE MANAGEMENT OBJECTIVES AND ACTIONS

8.1 ANAYSIS OF POTENTIAL MANAGEMENT OBJECTIVES

Management objectives were established using the 5 goal statements in section 1.3, survey results, and identified research gaps.

Goal 1: Identify current and potential sources of water quality degradation.
Objective 1.1: Continue with and expand upon current water quality monitoring program(s).
Objective 1.2: Investigate the potential sediment inputs to the lake.
Objective 1.3: Investigate the potential fecal contaminant inputs to the lake.
Objective 1.4: Estimate the potential nutrient inputs to the lake.

Goal 2: Monitor, protect, and restore fisheries and wildlife values within the Christina Lake watershed.

Objective 2.1: Identify the need for restoring native fish habitat.
Objective 2.2: Promote fisheries research and data collection to address population knowledge gaps.
Objective 2.3: Improve wildlife habitat
Objective 2.4: Promote wildlife research and data collection.

Goal 3: Increase public awareness of lake management issues and provide workable options for watershed users.

Objective 3.1: Develop and deliver workshops for residents and lake users.
Objective 3.2: Produce informative material and signage
Objective 3.3: Coordinate community involvement activities.
Objective 3.4: Develop and deliver school programs

Goal 4: Create and maintain a locally based resource library that will be accessible to the public.

Objective 4.1: Establish a data retrieval system

Goal 5: Sustain the Christina Lake community and local economy within the context of a healthy watershed.

Objective 5.1: Sustain the CLMP through volunteerism and an annual review process

8.2 ANALYSIS OF POTENTIAL ACTIONS UNDER VARIOUS MANAGEMENT OBJECTIVES

For each management objective, a comprehensive list of potential actions was compiled. The advantages and disadvantages of each action were summarized and the CLMP Science Technical Committee and Community Advisory Committee reviewed and discussed the overall

merits of each action. Each action was analyzed for cost versus benefit, and the capacity of all stakeholders to implement each action. The Committee's determined which actions were realistic and likely to be effective in the watershed. The Committee recommended which actions where to go forward in the plan and prioritized each action into short and long term implementation strategies. The recommended short-term actions were then incorporated into the companion document the "Implementation Strategy Manual".

The long term recommended actions will be reviewed for implementation potential on an annual basis by the CLMP Committee.

See table 39 Management Goals and Objectives – Complete listing of all short term and long term action items.

SECTION 9.0

RECOMMENDATIONS

9.0 RECOMMENDATIONS

9.01 RECOMMENDED SHORT TERM ACTION ITEMS

The recommended short term actions which are detailed within the Implementation Strategy Manual were placed under broad categories to reflect the type of work that the action would entail. For example: some actions have a public education component while another action is field research oriented. The actions set out in this manual will be undertaken in 2005 and 2006.

The following actions for immediate implementation are as follows:

Category – Core operation initiatives:

- Secure core funding to keep the Community Stewardship Resource Centre (CSRC) open (project nucleus)
- Build and maintain a constituency of involved citizens
- Form an agreement with project participants to ensure future participation in CLMP revision and implementation
- Produce an annual CLMP progress report

Category – Public education and community involvement initiatives:

- Update/install informative signage
- Develop and distribute a water conservation brochure
- Coordinate local “Lake Clean-Up Day” event
- Coordinate a “Fire Preparedness” informational display
- Develop a “Wildfire and Property Protection” video
- Continue media releases
- Improve distribution of water quality and other data to the public
- Determine community’s interest in applying for a Community Forest license
- Promote acquisition and conservation of District Lot 498
- Develop and deliver school programs
- Develop and deliver an Internet-based habitat atlas for the Christina Lake watershed
- Develop and deliver a map-based pamphlet about natural resources in the Christina Lake watershed

Category – Continue and expand upon current monitoring programs:

- Support recommendations in Cavanagh *et al.* (1994) to expand the current MWLAP water quality monitoring program
- Establish a volunteer biological water quality monitoring program for major lake tributaries and Christina Creek
- Establish a volunteer hydrometric data collection program
- Conduct shoreline and tributary survey to identify potential restoration sites
  - ► Habitat degradation: if the stock assessment shows there are problems with recruitment (more for kokanee and rainbow trout), what is the current state of the habitat (in particular where do rainbow trout spawn) and what benefits could possibly accrue to the lake if restoration is undertaken?
- Conduct sediment core sample collection and analysis

- Promote a survey of Eurasian watermilfoil infestation sites and conduct inventories of terrestrial noxious and invasive weeds

Category – Fisheries and wildlife initiatives:

- Assess potential fish habitat gains/losses associated with barrier removal on McRae Creek
- Provide support for a hydroacoustic kokanee population assessment
- Conduct kokanee shore spawner enumeration
- Conduct kokanee stream spawner enumeration
- Conduct research about exotic species interactions with native species in aquatic ecosystems
- Conduct creel surveys

Rationale:

- A need for basic stock assessment information on kokanee, rainbow trout, and burbot; methods could include spawner surveys for each species, more creel data, in-lake population assessments, and fry assessments.
- Exotic species interactions – What is the status of these species? What are the possible impacts of all of the warm water species in the lake? Are *mysis relicta* a problem? What can be done about any of the exotics if they are a problem?
- Over fishing: New regulations are in place for Christina Lake; they need to followed up with creel surveys and aerial boat counts to determine if they are being effective or if they need to be changed (made more or less stringent).

9.02 RECOMMENDED LONG TERM ACTION ITEMS FOR ANNUAL REVIEW

The Christina Lake Management Plan action items recommended for annual review and are considered long term priorities are as follows (the numbers beside each long term action relate to Table 39):

- Conduct an assessment of groundwater quality (1.1B)
- Organize volunteer water sampling program for major lake tributaries (1.1E)
- Encourage “Best Management Practices for sediment and erosion control for public roads (1.2A)
- Encourage responsible forestry practices in the watershed ((1.2B)
- Seek out government subsidy programs for property owners wishing to upgrade septic systems (1.3B)
- Investigate the potential for community sewage systems (1.3C)
- Consider conducting a sanitary survey of onsite sewage disposal systems and the possibility of septic inspections on private property as part of the condition of sale (1.3D)
  a.) Septic systems have been identified as a potential pollution risk at Christina Lake (Cavanagh et al, 1994). A functional, sanitary survey of the existing septic systems could provide valuable data about the locations and proper operation of systems and help identify the actual risk, if any, of lake pollution from onsite sewage disposal. The data from this study could used to plan future infrastructure and gain support for potential changes in waste disposal methods at Christina Lake.
- Develop a nutrient budget for Christina Lake (1.4C)
- Conduct a population assessment of Burbot *(Lota lota)* (2.2C)

- Determine status of the non-native mysis shrimp *(Mysis relicta)* population in Christina Lake (2.2D)
- Preserve and/or protect habitat for species at risk (2.3B)
- Promote a wildlife inventory study for the Christina Lake area (2.4A)
- Conduct plant surveys (2.4B)
- Pilot noxious weed assessment program (3.1B)
- Encourage residents to make their home/property fire safe (3.1C)
- Support initiatives to phase our 2 stroke engines from the lake (3.2I)

The action items listed above where selected for long term implementation for a variety of reasons. Mainly due to cost and current funding availability and identified research gaps indicated that other field work would have to be performed prior to endeavoring certain aspects of each long term action.

SECTION 10.0

MANAGEMENT PLAN IMPLEMENTATION

10.0 MANAGEMENT PLAN IMPLEMENTATION

The Christina Lake Management Plan has a companion document called the Implementation Strategy Manual. This manual outlines each short term recommended action as discussed in Section 9.01 and describes in detail the implementation strategy for each. Information includes potential funding sources, which stakeholders will be involved, if "Best Management Practices" are required, and other appropriate information to provide guidance and improve the potential for successfully completing each action. The following sections list the available resources and stakeholders involved with the CLMP.

10.1 RESOURCES

It was announced in June of 2005 that the Provincial government in British Columbia would be restructuring various agencies and areas of responsibility. The government agencies mandates and contact listing will be amended following finalization of these changes.

10.1.0 Regulatory Agencies

The Christina Lake area is unincorporated and nearly all community and government services are provided from outside the area. The jurisdictional roles that are outlined within this section are mainly focused on the representative government agencies whose mandate correlates with the overall proper functioning of the watershed and has encompassing environmental *Acts, Legislation, and Regulations.* There are many other government administrative bodies that represent other interests within the area.

The majority of the affected regulatory agencies have been consulted and involved in the development of the lake management plan. It is essential to identify all affected regulatory agencies and obtain all necessary approvals and permits.

Local Government:

Regional District of Kootenay Boundary (RDKB)

Electoral area "C" (Christina Lake) is represented locally by an elected Area Director who sits on the Board of Directors for the Kootenay Boundary Regional District. The Area Director appoints a number of local citizens to sit on the Advisory Planning Commission (APC). The APC's sole purpose to provide local input on the land use issues and development applications in the community.

The Regional District of Kootenay Boundary (RDKB) is responsible for providing the following:

- Preparation and administration of Official Community Plans (OCP) and Zoning Bylaws
- Processing applications to amend the OCP or Zoning Bylaws
- Issuing Development Permits and Commenting on Subdivision Proposals
- Issuing Building Permits
- Eurasian Watermilfoil Program (Annual reports available on line)

Contact: Information:
Main Office: 843 Rossland Avenue, Trail, BC
Phone: 1-800-355-7352 (within BC) or 250-368-9148
Website: www.rdkb.com

Interior Health Authority – Health Protection/Health Inspection Programs
The following information was submitted by Lesley Shelley, Public Health Inspector, Interior Health Authority, Grand Forks.

Drinking Water Program:

- Legislation: Drinking Water Protection Act and Drinking Water Protection Regulation
- Guidelines: Guidelines for Canadian Drinking Water Quality, 1996
  Various industry or government Best Management Practices
- Activities: Inspection of water supply systems, consultation, complaint investigation, education and enforcement

Recreational Water Program:

- Legislation: Health Act
- Guidelines: Guidelines for Canadian Recreational Water Quality, 1992
- Activities: Inspection and sampling of recreational water (beaches), complaint investigation and education

Land Use Program:

- Legislation: Health Act, Sewerage System Regulation, Subdivision Regulation
- Guidelines: Interior Health Subdivision Guideline
- Activities: Comment on proposed subdivision applications and zoning or Official Community Plan amendments. Administration and enforcement of the Sewerage System Regulation

Other programs: Food Safety Program, Tobacco Enforcement Program, Communicable Diseases Program, Emergency Preparedness, Personal Services and Industrial Camps inspection

Contact: Public Health Inspection
Box 2647 – 7649 22nd St.
Grand Forks, BC
V0H 1H0
Phone: (250) 443-2190
Fax: (250) 442-3922
Web: http://www.interiorhealth.ca/

Provincial Government:

Ministry of Water, Land and Air Protection

The Ministry of Water, Land, and Air Protection's (MWLAP) general responsibilities are listed below as per their website (2005):

- Environmental protection of water, land, and air quality including climate change and environmental emergencies,
- Environmental stewardship of biodiversity, including wildlife, fish, and protected areas,
- Park and wildlife recreation management, including hunting, angling, park recreation, and wildlife viewing, and
- Environmental monitoring and enforcement including the Conservation Officer Service and State of Environment reporting.

The Christina Lake watershed is within MWLAP Region 8 and the regional office is located in Penticton. Further information regarding MWLAP can be found on their website at http://wlapwww.gov.bc.ca.

BC Parks

According to the BC Parks website (2005), BC Parks is responsible for the designation, management, and conservation of a system of ecological reserves, provincial parks, and recreation areas located throughout the province. As a public trust, BC Parks' mission is to protect representative and special natural places within the province's Protected Areas System for conservation, outdoor recreation, education, and scientific study. BC Parks' authority is drawn from three pieces of legislation; the *Park Act*, *Ecological Reserve Act*, and the *Environment and Land Use Act*, and their associated regulations, policies, and agreements.

The largest provincial park in the Christina Lake watershed is Gladstone Provincial Park, designated in July 1995. The BC Parks Area Supervisor who manages activities in the Christina Lake area is based in the MWLAP office in Penticton. More information about BC Parks is available online at http://wlapwww.gov.bc.ca/bcparks.

Conservation Officer Service

The following information was taken directly from the Conservation Officer Service website (2005) and is available at http://wlapwww.gov.bc.ca/cos/index.htm.

The Conservation Officer Service (COS) is the delivery arm of the Enforcement program in the Ministry of Water, Land, and Air Protection. It works with other professional staff in the Ministry to achieve compliance with provincial and federal environmental legislation.

The COS is administered from its headquarters in Victoria and 3 regional centres in Nanaimo, Prince George, and Kamloops. The Conservation Officer responsible for the Christina Lake area is based in Grand Forks. More detailed information regarding the Conservation Officer Service is available online as noted above.

Permit and Authorization Service Bureau

The Permit and Authorization Bureau (PASB) is responsible for processing fish and wildlife permits, commercial licenses, and BC Parks' park use permits. More specifically, the PASB administers:

- Permits issued under the *Wildlife Act,*
- CITES export permits (for some species indigenous to BC),
- Accompany-to-hunt permits,
- Guide Outfitter and Assistant Guide Outfitter licenses,
- Angling Guide and Assistant Angling Guide licenses,
- Trapping Licenses and Fur Trader licenses, and
- Park Use Permit applications, fees, royalties, renewal and amendments.

More information about the PASB can be viewed online at http://wlapwww.gov.bc.ca/pasb. The PASB office is located in Victoria.

Ministry of Forests

The general responsibilities of the Ministry of Forests (MoF) are to:

- Protect, manage, and improve the province's forest and range resources,
- Establish performance standards ensuring long-term resource sustainability and health,
- Enforce compliance with the regulations of the Forest and Range Practices Act,
- Monitor pricing and revenue requirements for a more competitive forest sector,
- Enhance opportunities to generate wealth from forest and range resources,
- Maintain and expand international markets for BC forest products, and
- Ensure the public receives fair value for the use of its forest and range resources (BC Ministry of Forests, 2005).

The Christina Lake watershed is located within the Arrow-Boundary Forest District and regional offices are located in Grand Forks and Castlegar. More information about the roles and responsibilities of the MoF can be found on their website at http://www.for.gov.bc.ca.

BC Timber Sales

Implemented in April 2003, BC Timber Sales (BCTS) replaced the Ministry of Forests' Small Business Forest Enterprises Program. Although the BCTS share resources and office space with the Field Services division of the MoF, BCTS is managed independently.

BCTS develops and sells publicly owned timber to establish market price and optimize net revenue to the Crown. On the basis of highest bid, BCTS sells blocks of timber across the province to a variety of customers including market loggers, sawmill operators, timber processors and remanufacturers. BCTS also completes forest planning, timber cruising, layout/engineering, road construction/maintenance, and silviculture activities such as tree planting, surveys, and stand treatments through private sector contractors and BCTS staff. BCTS' three main goals are:

- To provide a credible reference point for costs and pricing of timber harvested from public land in BC,
- To optimize net revenue to the province within the parameters dictated by their benchmarking mandate and sound forest management practices, and
- To provide opportunities for customers to purchase timber in an open and competitive market.

The administration and management centre for the Kootenay business area (i.e. Arrow Boundary Forest District, Kootenay Lake Forest District, and the Rocky Mountain Forest district) is located in

Nelson. Field teams are located in Grand Forks, Castlegar, and Cranbrook. More information regarding BCTS is available online at http://www.for.gov.bc.ca/bcts/.

Ministry of Agriculture, Food, and Fisheries
The Christina Lake watershed lies within the Ministry of Agriculture, Food, and Fisheries' (MAFF) Regional Operations-South area. According to the MAFF website (2005), the agency is responsible for the following:

- Monitoring and regulating agriculture, food and fisheries competitiveness,
- Maintaining the health of animal, plant, and fish production systems,
- Delivery of risk management programs providing basic protection for farmers,
- Food safety and quality of BC food, agriculture, and seafood products,
- Agriculture licensing, regulation, and development, and
- Environmental sustainability and resource development.

As is the case with other provincial government agencies, MAFF consults with the Regional District of Kootenay Boundary, the Agricultural Land Commission, and other provincial and federal government agencies on a project-by-project basis as required. The MAFF regional office responsible for providing services to the Christina Lake area is located in Kelowna. More information regarding MAFF can be found on their website at http://www.

Provincial Agricultural Land Commission
The following information was taken directly from the Provincial Agricultural Land Commission (ALC) website (2005).

"The Provincial Agricultural Land Commission is an independent Provincial agency responsible for administering the Province's land use zone in favour of agriculture. The purpose of the commission is:

- To preserve agricultural land,
- To encourage farming in collaboration with other communities of interest, and
- To encourage local governments, First Nations, the government and its agents to enable and accommodate farm use of agricultural land and uses compatible with agriculture in their plans, bylaws, and policies."

The ALC head office is located in Burnaby. Further information regarding the ALC is available at http://www.alc.gov.bc.ca/commission.

Ministry of Transportation
The Ministry of Transportation (MoT) website (2005) defines the agency's responsibilities as:

- Creating an integrated provincial transportation plan,
- Maintaining and improving the highway system,
- Attracting private sector investment and involvement to deliver new infrastructure, and
- Applications of the Motor Vehicle Act and the Motor Carrier Commission Act.

The Christina Lake watershed is situated within the Southern Interior Region – West Kootenay District operating area of the MoT. The highway maintenance contractor for the Christina Lake area is Emcon Services Inc. based in Grand Forks. Regional MoT offices are located in Grand

Forks and Nelson. More information regarding the MoT is available on their website at http://www.gov.bc.ca/bvprd/bc/channel.do?action=ministry&channelID=-8394&navId=NAV_ID_province

Land and Water BC Inc.
Land and Water BC Inc. (LWBC) is a crown agency whose mission statement is to "facilitate economic development in the Province of British Columbia by:

- Encouraging investment in, and sustainable use of, the Province's land and water resources,
- Providing timely and continued access to land and water resources through tenures, licenses and land sales, and
- Promoting responsible economic development and revenue generation (Land and Water BC Inc., 2005)."

More specific responsibilities include establishing high water marks, issuing water licenses, and forming lease agreements with citizens who wish to use crown land or water resources for various purposes. LWBC regional offices are located in Penticton and Kamloops. More detailed information is available online at http://www.lwbc.bc.ca.

Ministry of Sustainable Resource Management
According to the Ministry of Sustainable Resource Management (MSRM) website (2005), MSRM is responsible for the following:

- Sustainable development of land and water resources,
- Effective delivery of integrated, science-based land, resource and geographic information,
- Timely decisions for sustainable land and water allocation and management, and
- Corporate leadership to land and water resource policy, planning and integration.

The Christina Lake watershed is part of the Kootenay Region and the Southern Interior Region on a broader scale. Regional offices are located in Nelson and Kamloops. Data exchange agreements necessary for use of MSRM's digital data are arranged through the head office in Victoria. Further details regarding MSRM's roles and responsibilities can be accessed on their website at http://www.gov.bc.ca/bvprd/bc/channel.do?action=ministry&channelID=-8377&navId=NAV_ID_province

Ministry of Energy and Mines
According to the Ministry of Energy and Mines (MEM) website (2005), MEM is responsible for the following:

- Administers programs in oil and gas, mining and minerals, electricity and alternate energy,
- Research, develop, and manage new ventures that result in increased investment in oil and gas resource development, mining development, and electricity and alternate energies.

Christina Lake is considered part of the Kootenay region although defined boundaries separating regions within the province are not delineated. The Kootenay regional office is located in Cranbrook. More information regarding MEM can be found on their website at http://www.gov.bc.ca/bvprd/bc/channel.do?action=ministry&channelID=-8383&navId=NAV_ID_province/.

Federal Government:

Department of Fisheries and Oceans Canada

According to The Department of Fisheries and Oceans Canada (DFO) website (2005), the DFO plays a leading role in managing and safeguarding oceans and inland waters and their resources for Canadians. The DFO's core activities include:

- Marine safety,
- Scientific research,
- Conservation and sustainable resource use,
- Protection of oceans environment and fish habitat, and
- Maritime trade, commerce and ocean development.

Environment Canada

- According to the Environment Canada (EC) website (2005), EC's mandate is:
- To preserve and enhance the quality of the natural environment, including water, air, and soil quality,
- To conserve Canada's renewable resources including migratory birds and other non-domestic flora and fauna,
- To conserve and protect Canada's water resources,
- To carry out meteorological data collection and weather predictions/reporting,
- To enforce the rules made by the Canada-United States International Joint Commission relating to boundary waters, and
- To coordinate environmental policies and programs for the federal government.

Through funding programs such as the EcoAction Community Funding Program, Environment Canada also provides funding to organizations undertaking environmental and community based projects. More information about Environment Canada is available online at http://www.ec.gc.ca/.

10.1.1 Best Management Practices

According to the BC Ministry of Water, Land, and Air Protection, Guidelines and Best Management Practices (BMPs) are approaches based on known science that, if followed, should allow developers to meet the required standard or achieve the desired objective. The information contained within the BMP and Guideline documents is intended to help developers ensure that proposed development activities are planned and carried out in compliance with the various legislation, regulations, and policies that apply to the activity in question (Ministry of Water, Land and Air Protection, 2005) http://wlapwww.gov.bc.ca/wld/BMP/bmpintro.html).

BMP and Guideline documents can have a provincial and/or regional context. Provincial documents apply to the entire province but may contain region specific sections. Regional documents have been developed for a specific purpose and may not be applicable to other regions (Ministry of Water, Land, and Air Protection, 2005). For more information on Guidelines and BMPs that may apply to local development activities visit the Ministry of Water, Land, and Air Protection website at http://wlapwww.gov.bc.ca.

10.1.2 List of Stakeholders and Other Important Contacts

Organization/Association	Contact Name	Phone	Fax	Location
Christina Lake Stewardship Society	Marion Beattie (President)	250-447-2504	250-447-2509	Christina Lake
	Grace McGregor (Vice President)			
	Brenda LaCroix (Stewardship Coordinator, CLMP Project Manager)			
RDKB	Joey Tatangelo (Area C Director)	250-447-9345		Christina Lake
	Main Office	1-800-355-7352	250-368-3990	Trail
Interior Health Authority	Lesley Shelley (Public Health Inspector)	250-443-2193	250-442-3922	Grand Forks
	Serge Zibin (Senior Drinking Water Officer)	250-505-7234	250-505-7211	Nelson
MWLAP Water Quality	Vic Jensen	250-490-8200	250-490-2231	Penticton
MWLAP Fisheries	Andrew Wilson Steve Matthews Jerry Mitchell			
MWLAP Wildlife	Brian Harris or Orville Dyer			
MWLAP BC Parks	Mike Ladd Mark Weston			
MWLAP Conservation Officer	Dave Webster	250-442-4355	250-442-4312	Grand Forks
Ministry of Agriculture	Carl Withler	250-861-7229		Kelowna
Ministry of Sustainable Resource Management	Susan Lindler (DEA – Mapping)	250-356-5079		Victoria
	Frank Wilmer	250-354-6333	250-354-6367	Nelson
Ministry of Transportation	Earl Lindsay	250-442-4398		Grand Forks
Land and Water BC	Al Hare	250-490-8200	250-490-2231	Penticton
Department of Fisheries and Oceans	Brad Mason (Community Mapping Network)	604-666-7015	604-666-7907	Vancouver
	Cindy Harlow (Fisheries Officer)	250-804-7000	250-804-7010	Salmon Arm

Ministry of Forests	Ted Evans	250-365-8600	250-365-8588	Castlegar
	Connie Herman	250-442-4374		Grand Forks
Selkirk College	Donna Delparte (Head, GIS Program)	250-365-7292		Castlegar
	Ian Parfitt (CLMP GIS data storage)			
	Frank Fowler (Geology)			
	Louise Porto (Fisheries)			
	Rob Macrae (Environment)			
Pope and Talbot Ltd.	Doug Noren	250-449-2562	250-449-2388	Midway
	Randy Waterous (annual DEA)	250-449-2552		
	Aaron Gunther	250-449-2500		
Christina Waterworks District	Bill Stewart	250-447-6148	250-447-6148	Christina Lake
Sutherland Creek Waterworks District	Bob Black	250-447-6188	250-447-6188	Christina Lake
	Peter Darbyshire	250-447-9385		
Fife Water Users Community	Ernie Wayne or David Durand	250-447-6697		Christina Lake
Alpine Water Suppliers Society	Bill McGowan	250-447-9430		Christina Lake
Boundary Weed Management Committee	Barb Stewart	250-446-2232	250-446-2232	Rock Creek
Italy Sutherland Watershed	Dave Durand	250-447-6697		Christina Lake
Okanagan Nations Alliance	Deana Machin (Program Manager)	250-707-0095	250-707-0166	Westbank
BC Lake Stewardship Society		250-717-1212		Kelowna
Living by Water	Sarah Kipp Clive Calloway	250-832-7405		Salmon Arm
Permit Authorization and Services Bureau		1-866-433-7272	250-387-0922	Victoria
MLA	Katrine Conroy	1-866-755-0556 250-387-3655		Castlegar Victoria

SECTION 11.0

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11.0 PLAN REVIEW AND REVISIONS

This Plan and Implementation Strategy Manual does not indicate the completion of the lake management planning process. The CLMP and Manual will be subject to ongoing evaluation and revision. A portion of the resources allocated to its implementation must focus on refining and updating it as changes occur and as resources will allow. On an annual basis, review of the plan and implementation strategy should also include a representative from all stakeholders groups and agencies. The Science/Technical Committee and Community Advisory Committee must remain intact in order for the plan to continue. The review should also include regulators who may be called upon to write permits and assist or cooperate in some way to implement the various management options. Ensuring that this occurs must be the first and ongoing priority.

A memorandum of understanding (MOU) in support of the plan and recommended actions will be kept on file in the Christina Lake Stewardship Society office with an example document in Appendix F. All data exchange agreements (DEA's) will be kept on file as well. Appendix F will have a listing of appropriate contacts for updating and securing DEA's on an annual basis or when required.

GLOSSARY OF TERMS RELATING TO WATER QUALITY

(Cavanagh *et al*. 1994, Rysavy, S. and I. Sharpe 1999)

Algae		Simple photosynthetic non-vascular plants, mostly aquatic. Most are microscopic; some reach large sizes. (see Phytoplankton)
Algae Bloom		Abundant growth of algae that results in mats or scums forming in or on the water. Not all types of algae form blooms.
Ambient Water Quality Monitoring		Monitoring to collect baseline information on a water resource, which can therefore be used to determine if a water quality problem exists and how water quality is changing.
Anaerobic		Describes processes that occur in the absence of molecular oxygen.
Anoxia		A condition of no oxygen in the water. Often occurs near the bottom of stratified lakes in the summer and under ice in the winter.
Aquatic Life, Aquatic Organism		Organism, which spends a critical part or all of its life cycle in water, and relies on a particular aquatic habitat for its survival.
Bathymetry		The measurement of depths in water body.
Bathymetric Map		A contour map of a lake's depth.
Benthos		Macroscopic (seen without the aid of a microscope) organisms living in and on the bottom of sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate.
Biomass		The weight of biological matter. Standing crop is the amount of biomass (e.g. fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.
Biota		All plant and animal species occurring in a specified area.
Chlorophyll		A green pigment in algae and other green plants that is essential for the conversion of sunlight, carbon dioxide, and water to sugar. Sugar is then converted to starch, proteins, fats, and other organic molecules (photosynthesis).
Chlorophyll -*a*		A pigment found in the cells of photosynthesizing plants. The quantity of chlorophyll –*a* in a water sample indicates the amount of photosynthesizing algae per volume of water.
Chlorination		The use of chlorine as a disinfectant of water that is to be used for drinking purposes.
Cladocera		A group of microscopic aquatic animals, often part of

		the zooplankton community. Commonly called “water fleas”. *Daphnia* is a typical example.
Coliform Bacteria		A group of microorganisms normally found in the intestines of humans and other warm-blooded animals. Their presence in water may indicate contamination from human or animal wastes; hence various types are used as indicators of sanitary quality for certain water uses. (see *Escherichia coli,* Fecal Coliform, Microbiological Indicator)
Copepods		A group of microscopic aquatic animals, often part of the zooplankton community. No common name *Cyclops* is a typical example.
Cultural Eutrophication		Eutrophication that is caused or accelerated by human activities.
dam^3		Cubic decametre. (1000m^3)
Density Flows		A flow of water of one density (determined by temperature or salinity) over or under water of another density (e.g. flow of cold river water under warm reservoir surface water).
Designated Water Use		A water use that is to be protected at a specific location. Designated water used for the purposes of setting water quality criteria and water quality objectives in British Columbia include: drinking, public water supply and food processing; aquatic and wildlife; agriculture (irrigation, livestock watering); recreation and aesthetics; and industrial water supply.
Detritus		Nonliving dissolved and particulate organic material from the metabolic activities and deaths of terrestrial and aquatic organisms.
Disinfection		The destruction of microorganisms by the use of a chemical agent (disinfectant) such as chlorine (see Chlorination) or through physical means such as ultra-violet irradiation.
Dissolved Oxygen		Oxygen content in water that comes from being in contact with the surface, from agitation (as in streams), or from being released by photosynthesizing aquatic plants. Oxygen is depleted by bacteria that decomposes vegetation or other organic material and from respiration by plants and animals.
Drainage Lakes		Lakes having a defined surface inlet and outlet.
Drainage Basin		Land area from which water flows into a stream or lake.
Ecology		Scientific study of relationships between organisms, and their environment. Also, defined as the study of the structure and function of nature.
Ecosystem		A natural community of organisms occupying a given area. An ecosystem is the sum of many physical, chemical, and biological characteristics, including all of the interactions between the organisms and their

		environment.
Effluent		Liquid waste that is discharged into the environment as a by-product of human activity. Often a complex mixture of contaminants which are potential pollutants. Under the B.C. *Waste Management Act,* effluent is defined as “a deleterious material flowing in or out of works".
Emergent Macrophyte		Aquatic plants (larger than algae) that root in lake sediments and have some pert of the plant above (but not floating in) water. Examples: Cattails, reeds, and rushes.
Environment		Collectively, the surrounding conditions, influences, and living and inert matter, which affect a particular organism or biological community.
Epilimnion		The surface layer of a thermally stratified lake. (see metalimnion, hypolimnion)
Erosion		Breakdown and movement of land surfaces, which is often intensified by human disturbances.
Escherichia coli (E. coli)		A type of coliform bacteria. A microbiological indicator of sanitary quality and a potential pathogen.
Eutrophic		Describes a lake that has high nutrient concentrations, abundant plant and algae growth, and low water clarity.
Eutrophication		The process of physical, chemical, and biological changes associated with nutrient, organic matter, silt enrichment and sedimentation of a lake ore reservoir. Eutrophication can occur naturally over time or can be accelerated by human activities. (see cultural eutrophication)
Fall Overturn		The Autumn mixing, top to bottom, of lake water caused by cooling and wind-derived energy.
Fecal Coliform		Bacteria that are associated with mammal feces. Fecal coliform bacteria tests determine if feces have entered and contaminated a water body. They are not necessarily harmful, but indicate the potential presence of other disease-causing organisms.
Floating-leaved Macrophyte		Aquatic plants that grow partially in the water with the primary leaves floating on the water surface. Examples: lily pads and pondweed.
Flood Plain		Land adjacent to lakes or rivers which is covered as water levels rise and overflow the normal water channels.
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.
Flux		The rate at which a measurable amount of material flows past a designated point in a given amount of time.
Forage Fish		Fish that are prey for game fish, including a variety of panfish and minnows.

Freshet		A suddenly increased period of flow in a river or stream as a result of spring snowmelt or heavy rainfall.
Giardiasis		An intestinal disease, also call beaver fever, caused by the parasite *Giardia lamblia,* which may be present in untreated water used for drinking or preparing food. This parasite can survive normal chlorination and can be removed from the water by filtration.
Ground Water		Water found beneath the soil surface and saturating the stratum at which it is located; often connected to lakes.
Hydrographic Map		A map showing the location of areas or objects within a lake.
Hypolimnion		When a lake is thermally stratified, the hypolimnion is the cooler layer of water at the bottom of the lake. (see Epilimnion)
Influent		A tributary stream.
Isotherm		The same temperature throughout; fall overturn.
Limnology		The study of fresh water bodies including biological, geological, physical, and chemical aspects.
Littoral Zone		That portion of a water body extending from the shoreline lakeward to the greatest depth occupied by rooted plants.
Macroinvertebrates		Aquatic insects, worms, clams, snails, and other animals visible without the aid of a microscope which may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.
Macrophyte		The larger aquatic plants, including aquatic mosses, liverworts, larger algae, and vascular plants.
Marginal Zone		The area where land and water meet at the perimeter of a lake. Includes plant species, insects, and animals that thrive in this narrow specialized ecological system.
Mesotrophic		Describes a lake that has moderate concentrations of nutrients, a moderate amount of plant and algae growth, and moderate water clarity (generally 7 – 13 feet as measured with a Secchi disk).
Metalimnion		The middle layer of water between the epilimnion and hypolimnion of a stratified lake. The metalimnion is located at the thermocline.
Morphometry		Relating to a lake's physical structure (example: depth, shoreline length)
Microbiological Indicator		Microscopic organisms that when present in water, are indicative of pollutant inputs (generally sanitary pollution).
Monitoring		Continued observation, measurement, and evaluation, with appropriate controls, to examine changes over a period of time. For example, water quality in a water body is monitored to ensure that water quality objectives are not exceeded.

Mysis		A group of small (1 cm.) crustacean animals living in deep waters of some lakes. Commonly but incorrectly called “shrimp”.
Nitrogen		A plant nutrient that can be present in water in various forms such as nitrate, nitrite, ammonia, or dissolved nitrogen gas.
Nitrogen Total		A nutrient that plays a significant role in biological metabolism. Total nitrogen refers to all forms of nitrogen in the water column (both organic and inorganic).
Non-point Source Pollution		Pollution that comes from diffuse sources, carried into water bodies by various forms of runoff. It includes microorganisms, pesticides, fertilizers, and other deleterious materials from fields, urban and suburban land and forests.
Nutrient		Organic and inorganic substances necessary for the growth and development of plants and animals. More narrowly, a substance containing phosphorus, nitrogen or potassium, which are essential to plants.
Nutrient Budget		Quantitative assessment of nutrients (example: nitrogen or phosphorus) moving into, being retained in and moving out of an ecosystem; commonly constructed for phosphorus due to its tendency to control lake trophic state.
Nutrient Cycling		The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).
Objective		A guideline against which environmental quality at a particular location can be measured. Often used to guide environmental management decisions and practices to protect users and the environment. They do not have legal standing.
Ogliotrophic		Describes a lake that has low nutrient concentrations, little plant or algae growth and very clear water.
Ordinary High Water Mark		Physical demarcation line indicating the highest point that water level reaches and maintains for some time. Line is visible on rocks or shoreline and by the location of certain types of vegetation.
Pathogen		A microorganism capable of producing disease. They are of great concern to human health relative to drinking water and swimming beaches.
Pelagic Zone		This is the open area of a lake from the edge of the littoral zone to the center of the lake.
Periphyton		Algae attached to submerged surfaces (plants, rocks etc.)
PH		Represents on a scale of 0 – 14 the acidity of a solution. A pH of 7 is neutral; acid solutions such as

		vinegar have a pH less than 7, and basic solutions have a pH that is greater than 7.
Phosphorus		A plant nutrient that be present in water in various forms. Phosphorus can be dissolved in water (orthophosphorus), absorbed into particles or taken up by plants.
Phosphorus (total)		A nutrient that plays a major role in biological metabolism. It is often the most significant nutrient with respect to primary productivity in fresh water systems. Total phosphorus refers to all forms (inorganic and organic).
Phytoplankton		Microscopic algae and microbes that float freely in open water of lakes and oceans.
Pisciverous		Animals that eat fish and fish that eat other fish.
Respiration		Process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.
Secchi Disk		A black and white 20 cm diameter disk this is attached to a rope. The disk is used to measure water transparency in open water.
Stratification (Thermal Stratification)		The state in which a lake forms distinct layers (the epilimnion and hypolimnion), usually because of temperature differences between the surface and the bottom of the lake. These layers do not mix while the lake is completely stratified.
Thermocline		When measuring temperature from the top to the bottom of a lake, the thermocline is characterized by a considerable change in temperature with little change in depth. It is the transition area between the epilimnion and hypolimnion.
Topographic Map		A map showing the elevation of the landscape at contours of 2, 5, 10, or 20 feet or meters. Can be used to delineate the watershed.
Transparency		Generally, water clarity of open water measured by a Secchi Disk is called Secchi Disk Transparency. Secchi Disk Transparency is a measurement of the depth that sunlight can penetrate through water and then reflect back up to the surface.
Trophic State		Characterizes a lake according to the amount of plants that grow in a lake. Trophic state also characterizes the water clarity and the amount of nutrients in the water. (see Ogliotrophic, Mesotrophic, and Eutrophic)
Turbidity		A measurement of the effects of light absorbing and light scattering substances that are suspended in water. Turbidity is determined by passing light through a sample and measuring the amount of light that is scattered by suspended particles. Turbidity is not the

		same as transparency.
Turnover (Lake Turnover)		The seasonal mixing of water layers that occurs when temperature differences lessen between the top and bottom layers of water. Turnover occurs during the fall in most lakes. Lakes that freeze over during the winter will also turnover after the spring thaw.
Watershed		The area that drains to a lake via streams, surface runoff and ground water.
Winterkill		Fish kill in lakes generally caused by the depletion of oxygen in water while the lake is frozen over.
Zooplankton		Microscopic animals in water that eat algae and are eaten by fish.

REFERENCES (Reviewed and Cited Literature)

Acton, S.L., Simony, P.S., and Heaman, L.M. 2002. Nature of the basement to Quesnel Terrane near Christina Lake, southeastern British Columbia. Can. J. Earth Sci. 39: 65-78 (2002)

Adams, W. 2005. Personal communications pertaining to First Nations and European Settlement of the Christina Lake area. Boundary Museum Curator. Feb 21, 2005

Agricultural Land Commission. 2005. Accessed general information regarding ALC's responsibilities. Available at: http://www.alc.gov.bc.ca

Akrigg, G.P.V. 1995. Christina of Christina Lake and Shuswap. Published in Boundary History. The thirteenth report of the Boundary Historical Society. p. 9-15

Aquatic Resources Limited (ARL). 2000. Christina Lake fish and fish habitat inventory: Results of the October 1999 lake survey and August 1999 tributary surveys. Report and appendices. ARL Report No. 335-1 (March 2000)

Aquatic Resources Limited (ARL). 2001. Christina Lake tributary surveys. ARL Report No. 379-1 (March 2001)

Aquatic Studies Branch. 1980. Information review on selected lakes in British Columbia for aquatic plant management. Unpublished report. British Columbia Ministry of Environment. On record at 3rd floor, 765 Broughton Street, Victoria, BC., V8V 1X4.

BC Parks. 2001. Management Plan for Gladstone Provincial Park. Okanagan District. 58 p. ISBN 0-7726-4671-6

BC Parks. 2005. Accessed general information regarding BC Parks' responsibilities. Available at: http://wlapwww.gov.bc.ca/bcparks

BC Statistics. 2004. British Columbia's Fisheries and Aquaculture Section 2002. Ministry of Management Services. 107 p. (available in PDF format at http://www.agf.gov.bc.ca/fish_stats/pdf/Bc_Fisheries_&_Aquaculture_Sector_2002.pdf)

BC Timber Sales. 2005. Accessed general information regarding BCTS responsibilities. Available at: http://www.for.gov.bc.ca/bcts

BC Treaty Commission. 2005. Overview of the BC treaty process, lands and resources, Aboriginal title and crown title, private property, land protection, parks and protected areas, land use planning, wildlife management. www.bctreaty.net

Babiarz, R. 2005 Personal communications with Rob Babiarz of the Ministry of Forests in Castlegar pertaining to Special Use Permits within the Christina Lake Watershed.

Baliko, W. 2005. Personal communications with Werner Baliko of the Ministry of Forests in Grand Forks pertaining to Range Licenses within the Christina Lake Watershed.

Barclay, A. 2005. Personal communications with Al Barclay of the Ministry of Forests in Grand Forks pertaining to Bill 28 and BC Timber Sales allocations within the Christina Lake watershed.

Black, B. 2005. Personal communications with Bob Black (Chairman for the SCWD Board of Trustees) pertaining to the Sutherland Creek Water District.

Boundary Museum. 2005. Sinixt: the lakes people. Brochure. The History of Christina Lake. Text files. Located 7370 – 5th Street, Grand Forks, British Columbia.

Boundary Museum Society. 1996. Interior Salish traverse the Boundary. Located 7370 – 5th Street, Grand Forks, British Columbia. 55 p.

Boundary TSA DFAM. 2004. Boundary TSA DFAM Forest Health Strategy. Prepared for District Manager, Arrow-Boundary Forest District, Castlegar, BC.

British Columbia. 1973. Surveys and inventory Christina Lake tributaries. (specific author unknown) Okanagan Sub-Region Southern Interior Region. Technical Report. Ministry of Environment, Province of British Columbia. 5 p.

Braumandl, T.F. and Curran, M.P. 1992. A field guide for site identification and interpretation for the Nelson Forest Region. Land Management Handbook Number 20. BC Ministry of Forests. ISSN 0229-1622.

British Columbia. 1995. Riparian management area guidebook. Forest practices code of British Columbia. Ministry of Forests and BC Environment. 64 p.

British Columbia. 2001. BC Ministry of Fisheries, BC Ministry of Environment, Lands and Parks , and Fisheries and Oceans Canada. 2001. Watershed-based fish sustainability planning – Conserving B.C. fish populations and their habitat. A guidebook for participants. 85 p. (available in PDF format at www.dfo-mpo.gc.ca/library/255159.pdf)

Bryan, A. 1995. Proposal to Establish the Sandner Creek Wildlife Management Area. Draft report prepared for BC Environment, Okanagan Sub-Region, Penticton, BC and The BC Habitat Conservation Trust Fund.

Bull, C. 1980. Reflections on the Christina Lake kokanee. Memorandum. File 0241. Ministry of Recreation and Conservation, Fish and Wildlife Branch, Province of British Columbia. 16 p.

Canadian Wildlife Service. 2004. Eurasian water-milfoil (*Myriophyllum spicatum* L.). Canadian Wildlife Service. 8 p. http://cws-scf.ec.gc.ca/publications/inv/p1_e.cfm

Carl, Clifford G., W.A. Clemens, and C.C. Lindsey. 1967. *The Fresh-water Fishes of British Columbia*. B.C. Prov. Mus. Handb. 192 pp.

Cavanagh, N., Nordin, R. and Bryan, J. 1994. Christina Lake water quality assessment and objectives. Water Quality Branch, Environmental Protection Department, Ministry Environment, Lands and Parks, Province of British Columbia. Overview 18 p, Technical Appendix 106 p.

Christina Lake Chamber of Commerce. 2005. Lake Living – History. Website: www.christinalake.com/lakeliving/history.htm

Christina Lake Chamber of Commerce. 2005. Lake Living – Community. Available online: http://www.christinalake.com/lakeliving/community.htm

Clemens, J. 2000. Personal communications with local resident and fisherman Jordan Clemens pertaining to Tiger musky.

Conservation Data Centre. 2000. Brochure. Extinct and Extirpated Species. BC Ministry of Environment, Lands, and Parks.

Conservation Officer Service. 2005. Accessed general information regarding responsibilities of the Conservation Officer Service. Available at: http://wlapwww.gov.bc.ca/cos/index.htm

Cooke, G.D., Welch, E.B., Peterson, S.A., and Newroth, P.R. 1993. Restoration and management of lakes and reservoirs. Second Edition. Lewis Publishers. Florida.

Corbett, P. 1997. Italy-Sutherland Watershed Plan: Ecosystem, Terrestrial Habitats, and Forest Health Assessments. Prepared for Ministry of Forests, Boundary District.

Corbett, P. 1998. Italy-Sutherland Community Watershed Forest Development Planning. Prepared for Ministry of Forests, Boundary Forest Region.

Cranston, R. 2003. Noxious Weeds and Invasive Plant – Impacts. Draft briefing note. Unpublished.

Daniel, T.C., Sharpley, A.N., Edwards, D.R., Wedepohl, R., and Lemunyon, J.L. 1994. Minimizing surface water eutrophication from agriculture by phosphorus management. Journal of Soul and Water Conservation 49:30-38.

David Suzuki Foundation. 2005. Forests and Lands: Overcutting Supernatural BC. Website: http://www.davidsuzuki.org/Forests/Canada/BC/Overcut/

Dean, D. 2005. Personal communications pertaining to RDKB bylaws, zoning, and OCP/APC initiatives. Regional District of Kootenay Boundary – Planning. Trail.

Dillon, P.J. and Figler, F.H. 1975. A simple method for predicting the capacity of a lake for development based on lake trophic status. J. Fish. Res. B. Can. 32: 1519-1531.

Duff, W. 1964. The Indian history of British Columbia. Vol. 1 The impact of the white man. Anthropology in British Columbia memoir No. 5. Victoria. Department of Recreation and

Conservation. Provincial Museum of Natural History and Anthropology. Province of British Columbia. 117 p.

Durand, D. 2004. Personal communications pertaining to the Fife water users community.

Dyer, O. 2004. Personal communications about species at risk in the Christina Lake watershed. Wildlife Biologist (Penticton), Ministry of Water Land and Air Protection, Province of British Columbia.

Einarson, D. 2005. Draft Sutherland and Moody Creek water quality monitoring recommendations (tables 3a and 3b). Environmental Impact Biologist (Kamloops), Environment Section, Ministry of Water Land and Air Protection, Province of British Columbia.

Ellis, J.R., Wilkins, S.P., and Bryan, J.E. 1991. Assessment of Christina Lake water quality data 1972 – 1990. Environmental Protection Department, Ministry Environment, Lands and Parks, Province of British Columbia. 52 p.

Ernst, A. and Daggett, C. 2000. Expanded archival fisheries research within the Okanagan Nation. Final Draft. May, 2000. Running Horse Consulting, Vernon, B.C. 112 –123 pp. plus Appendix I.

Environment Canada. 2005. Accessed general information regarding Environment Canada's general responsibilities. Available at: http://www.ec.gc.ca

Farr, M. 2004. SARA's ark. The species at risk act protects 233 flora and fauna. Does it put cottage permits in peril? Published in Cottage Life September/October 2004. pp. 31-32.

Fish Wizard. 2005. Stream reports. Database maintained by the Ministry of Water, Land and Air Protection, Province of British Columbia; and the Department of Fisheries and Oceans, Canada. www.pisces.env.gov.bc.ca

Fisheries Information Summary System (FISS). 2005. Fish inventory - stocking records, fish distribution reports, stream reports, individual fish data reports (angling surveys), and lake surveys physical information. Database maintained by the Ministry of Sustainable Resource Management, Province of British Columbia. www.bcfisheries.gov.bc.ca srmapps.gov.bc.ca/apps/fidq/stockingQuery.do

Fraser Basin Council. 2004. Invasive plant strategy for British Columbia. 30 p. Available online at: www.fraserbasin.bc/publications/documents/invasive_plant_strategy04.pdf

Freeman, B. 2004 and 2005. Personal communication regarding brook trout in Christina Lake and long term changes in water quality.

Freisinger, M.A. 1979. Natives of the Kettle River: A preliminary report on the archaeological resources of the Boundary area. Published in Boundary Historical Society. The 8th report of the Boundary Historical Society. 72-74 p.

Fort Steel. 2005. Dewdney trail information site. www.fortsteele.bc.ca/exhibits/kootenay/vrtour/tour-09.asp

Furness, G. 2004. Personal communication with Grant Furness, Senior Ecosystem Biologist, BC Environment, Okanagan Sub-Region, Penticton, BC regarding ungulate winter range in the Christina Lake watershed.

Gibbons, M.V., Gibbons, H.L., and Sytsma, M.D. 1994. A citizen's manual for developing integrated aquatic vegetation management plans. Washington State department of Ecology. www.ecy.wa.gov/programs/wq/plants/management/manual/index.html

G.L. Ventures. 2001. Christina Lake shore spawning kokanee habitat assessment 2001. Ministry of Water, Land and Air Protection, Penticton, Province of British Columbia. 41 p.

Green, B. 2005. Personal communication pertaining to the traditional territories of the Secwepemc (Shuswap) and the Ktunaxa (Kutenai) (Feb. 21, 2005).

Grieve, D. 2005. Personal communication pertaining to mining activity levels within the Christina Lake watershed (March 24, 2005). Regional Geologist, Ministry of Energy and Mines.

Haberstock, D. *et al.* 1994 – 2004. Control of Eurasian watermilfoil, Christina Lake milfoil control program (Annual Report). Regional District of Kootenay Boundary, Trail, British Columbia.

Hanlon, E. 2005. Personal communications pertaining to other permitted waste disposal sites within the Christina Lake watershed. Boundary Septic Service, Grand Forks, British Columbia.

Hanson, R. 2005. Personal communications pertaining to boat access district lots and the Park Study Group.

Harcombe, A. 2005. Personal communications with Andrew Harcombe, Manager, Conservation Data Centre. Regarding species at risk designation criteria. Victoria, BC.

Hare, A. 2005. Personal communications pertaining to high water mark elevation of Christina Lake and private moorage permits. Lands and Water BC. Penticton

Harris, B. 2004 and 2005. Personal communications with Brian Harris pertaining to the wildlife harvest in MU 8-15 from 2000 to 2003 and guide/outfitting licenses. Wildlife Biologist (Penticton), Ministry of Water Land and Air Protection, Province of British Columbia.

Heinrichs, R. 2000 and 2001. Boundary species at risk document compiled by Rick Heinrichs. Ministry of Water Land and Air Protection. Ecosystem Specialist. Unpublished. Grand Forks, British Columbia. 1 p. On file at the Community Stewardship Resource Centre (CLSS) Christina Lake, BC

Henderson Environmental Consultants Ltd. 2000. Watershed Assessment (IWAP) of Italy-Sutherland Creek. Prepared for Pope and Talbot Ltd., Midway Division.

Holdren, C., Jones, W., and Taggart, J. 2001. Managing lakes and reservoirs. North American Lake Management Society and Terrene Institute in cooperation with the Office of Water Assessment. Watershed Protection division. The U.S. Environmental Protection Agency, Madison, WI.

Hoy, T. and Jackaman W. 2004. Geology and mineral potential of the Grand Forks mapsheet (082E/01), southeastern British Columbia. Project funding agency: BC and Yukon Chamber of Mines, Rock to Riches Program. Geological Fieldwork 2004, Paper 2005-1.

Hudson Bay Company Archives (HBCA). 2005. Cartographic records, Fort Colville records, First Nations records. gov.mb.ca/chc/archives/hbca/about/hbca.html

Italy-Sutherland Planning Team. 1993. Italy-Sutherland Watershed Plan. Prepared for approval by Ministry of Forests, Boundary Forest District.

Jennings, M. 2004 and 2005. Production of CLMP maps as identified with Selkirk college logo and GIS identified research gaps. Selkirk College practicum student – Advanced diploma in GIS program. Castlegar, British Columbia.

Jensen, V. 2005. Personal communications with Vic Jensen pertaining to water quality for Christina Lake. Environmental Impact Assessment Biologist, (Penticton), Ministry of Water Land and Air Protection, Province of British Columbia.

Kay, A. 2002. *Mysis relicta* and Kokanee salmon (*Oncorhynchus nerka*) in Okanagan Lake: From 1970 and into the future. Published in the Okanagan Lake action plan, year 6 (2001) report. Fisheries project report no. RD 96, 2002.

Kennedy, D. and Bouchard, R. 1975. British Columbia Indian Language Project: Utilization of fish by the Colville-Okanagan Indian people. Victoria. Province of British Columbia. 75 p.

Kerr Wood Leidal Associates Ltd. 1991. Report on Water Supply and Wastewater Disposal at Christina Lake. Prepared for Regional District of Kootenay-Boundary and Christina Lake Study Committee. 74p.

Kipp, S. and C. Callaway. 2002. On the Living Edge: Your Handbook for Shoreline Living (British Columbia edition). The Federation of British Columbia Naturalists.142 p.

Kokelj, J. 2003. Lakelse Lake draft management plan. Prepared for the Lakelse Watershed Society. Ministry of Water Land and Air Protection, Skeena Region. 75 p.

Kokelj, J. 2004. Round Lake draft management plan. Prepared for the Round Lake Watershed Enhancement Society. Ministry of Water Land and Air Protection, Skeena Region. 55 p.

Land and Water British Columbia Inc. 2005. Accessed general information regarding the mandate of LWBC. Available at: http://lwbc.bc.ca

Land and Water British Columbia Inc. 2005. Water License Data Query. Accessed water license holder data by stream/water body name. Query page available: http://www.elp.gov.bc.ca:8000/pls/wtrwhse/water_licences.input

Lightowlers, C. 1995. Lake management planning: A generic plan outline. Water Management Co-op, BC Environment, Province of British Columbia. 34 p.

Machin, D. 2005. Personal communications with Deana Machin, Program Manager from the Okanagan Nations Alliance, 3255 C Shannon lake Road, Westbank, BC V4T 1V4. Information pertaining to traditional territories of the various bands within the Colville-Okanagan area and First Nations treaty negotiations.

MacKay, B. 2005. Personal communication with Bruce MacKay, Director of Finance, Regional District of Kootenay-Boundary, regarding the current milfoil program and assessment.

Marshall, F. 2005. Personal communications with Fred Marshall (President of the Woodlot Association) pertaining to the possible Woodlot expansion program within the Arrow Boundary Forest District.

Maximenko, M. 1993. Personal communications pertaining to Christina Creek. (Former) Director for Area C, RDKB.

McGowan, B. 2005. Personal communications with Bill McGowan pertaining to information on Christina Lake Water Suppliers Society (Alpine).

McKean, J.C.P. 1992. Saanich peninsula area, Elk and Beaver Lakes water quality assessment and objectives. Water Quality Branch, Ministry of Environment, Lands and Parks, Victoria, British Columbia.

McLean, R. and J. Webster. 2005. Christina Lake Kokanee Shore-Spawner Enumeration 2004/2005. Prepared for BC Ministry of Water, Land and Air Protection, Environmental Stewardship Division, Fish and Wildlife, Science & Allocation Section, Penticton, BC, and the British Columbia Conservation Foundation, Surrey, BC.

McPhail, J.D. and P.A. Larkin. 1994. Field key to the freshwater fishes of British Columbia. BC Resources Inventory Committee Publication. 239p.

McTaggart Cowan, I. & C. J. Guiguet (1978) The mammals of British Columbia. Victoria: Province of British Columbia 7th printing. B.C. Provincial Museum Handbook No. 11. 416p.

Meehan, W.R. ed. 1991. Influence of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. American Fisheries Society, Bethesda, MD 751 pp.

Mineral Titles Online Viewer, 2005. A map viewer and search database for mineral tenures. www.mtonline.gov.bc.ca

Ministry of Agriculture, Food, and Fisheries. 2005. Accessed general information regarding MAFF's responsibilities. Available at: http://www.gov.bc.ca/agf

Ministry of Energy and Mines. 2005. Accessed general information regarding Ministry's area of responsibility. Available at: http://www.em.gov.bc.ca

Ministry of Environment. 1997. Freshwater Biological Sampling Manual. Resource Inventory Committee, Victoria, British Columbia.

Ministry of Environment, Lands and Parks. 1994. Water Quality in British Columbia: Objectives Attainment in 1994. Water Quality Branch. Victoria, British Columbia.

Ministry of Environment, Lands and Parks. 1996. Water Quality in British Columbia: Objectives attainment in 1994. June 1996. Water Quality Branch. Environment Protection Branch. Available online at:: http://wlapww.gov.bc.ca/wat/wq/attain/ambient94.pdf

Ministry of Environment, Lands and Parks. 1998. Guidelines for Interpreting Water Quality Data. Resource Inventory Committee, Victoria, British Columbia.

Ministry of Forests. 1995. Riparian Management Area Guidebook. Forest Practices Branch, BC. Ministry of Forests and BC Environment, Victoria, BC.

Ministry of Forests. 2001. Forest Development Plan Guidebook. 2nd. Ed. Forest Practices Branch, BC. Ministry of Forests, Victoria, BC. Forest Practices of British Columbia Guidebook.

Ministry of Forests. 2001. Watershed assessment procedure guidebook. 2nd ed., Version 2.1 For. Prac. Br., Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook.

Ministry of Forests. 2003. Provincial Bark Beetle Management Technical Implementation Guidelines. Available online at: http://www.for.gov.bc.ca/hfp/forsite/fhdata/bbstrategy.htm).

Ministry of Forests. 2005. Accessed general information regarding MoF responsibilities. Available at: http://www.for.gov.bc.ca

Ministry of Forests. 2005. Legislation and Regulations. Wildfire Act. Available online: http://www.for.gov.bc.ca/tasb/legsregs/wildfire/wildfireact/wildfire.htm

Ministry of Sustainable Resource Management. 2002. Species Ranking in British Columbia. Brochure. ISBN 0-7726-7706-9.

Ministry of Sustainable Resource Management. 2005. Accessed information pertaining to the Kootenay Boundary Land Use Plan – 1995, the Kootenay Boundary Land Use Plan Implementation Strategy – 1997, and the Kootenay Boundary Higher Level Plan Order – 2001 (and subsequent variances from 2002 onward). Available online at: http://srmwww.gov.bc.ca/kor/hlp/main.htm

Ministry of Sustainable Resource Management. 2005. Accessed general information regarding MSRM's responsibilities. Available online at: http://www.gov.bc.ca/srm

Ministry of Transportation. 2005. Accessed general information regarding MoT responsibilities. Available at: http://www.gov.bc.ca/tran

Ministry of Water, Land and Air Protection. 2003. Water Quality in British Columbia: Objectives Attainment in 1994. Water Management Branch. Victoria, British Columbia.

Ministry of Water Land and Air Protection. 2005. Alien species in British Columbia. Website: wlapwww.gov.bc.ca/wld/aliensp/index.html.

Ministry of Water, Land, and Air Protection. 2005. Accessed general information regarding WLAP's responsibilities. Available at:: http://wlapwww.gov.bc.ca

Mitchell, J. 2005. Personal communications with Jerry Mitchell pertaining to shoreline and streambank modification – impacts on fisheries and water quality. Fisheries Biologist (Penticton), Ministry of Water Land and Air Protection, Province of British Columbia.

Mitchell, J., and LaCroix, B. 2004. Christina Lake shore-spawning kokanee enumeration study – 2003. Ministry of Water, Land and Air Protection, Fish and Wildlife Science and Allocation Section, Penticton, Pr ovince of British Columbia. 33 p. plus Appendices.

Molnar, L. 2004. Personal communication with Les Molnar pertaining to kokanee stocks in Christina Lake.

Noren, D. 2004 and 2005. Personal communications with Doug Noren, Registered Professional Forester, Pope and Talbot Ltd., concerning forestry practices within the Christina Lake watershed.

Noren, D. 2005. Personal communication with Doug Noren, Registered Professional Forester, regarding watershed assessments in the Christina Lake area.

Norris, D., J. McLaughlin, and M.P. Curran. 1998. Armillaria Root Disease Management Guidelines for the Nelson Forest Region. Technical Report TR – 014. Resource Management Section, Ministry of Forests, Nelson Forest Region.

Northcote, T.G., and Larkin, P.A. 1956. Indices of productivity in British Columbia lakes. *J. Fish. Res. Bd. Canada,* 13(4): 515-540.

Okanagan Nation Alliance. 1999. Cascade heritage power park project Aboriginal interests and use study. September, 1999. 38 p.

Parish, R., R. Coupe, and D. Lloyd. 1996. Plants of Southern Interior British Columbia. Lone Pine Publishing, Vancouver, BC. 462 p.

Permit and Authorization Service Bureau. 2005. Accessed general information regarding the role of the PASB. Available at: http://wlapwww.gov.bc.ca/pasb

Ramsay, L. 2001. Christina Creek Conservation Evaluation. BC Conservation Data Centre. Victoria, BC.

Rast, W. and Holland, M. 1988. Eutrophication of lakes and reservoirs: A framework for making management decisions. Ambio 17 (1): 2-12.

Reckhow, K.H., S. Coffey, M.H. Henning, K. Smith, and R. Banting. 1992. EUTROMOD: technical guidance and spreadsheet models for nutrient loading and lake eutrophication. Draft report. Durham, NC: School of the Environment, Duke University.

Regional District of Kootenay Boundary (RDKB). 1975. The Christina Lake study. Planning Department, Trail, British Columbia. 91 p. plus Addendum.

Regional District of Kootenay Boundary (RDKB). 1993. Christina Lake official community plan background report. Planning Department, Trail, British Columbia. 35 p.

Regional District of Kootenay Boundary (RDKB). 2002. Electoral Area "C"/ Christina Lake, 2002 background report. Planning Department, Trail, British Columbia. 32 p.

Reserve Management Inc. 2002. Okanagan Nation Alliance organizational review. Produced for Okanagan Nation Alliance, Westbank, B.C. Produced by: Reserve Management Inc. Vernon, B.C. Draft #1 – 12 April, 2002. 25 p.

Resource Information Standards Committee (RISC). 2005. Standards: Aquatic ecosystem – manual listings. Database maintained by the Ministry of Sustainable Resource Management, Province of British Columbia. srmwww.gov.bc.ca/risc/pubs/aquatic/index.htm

Retzer, B. and Haberstock, D. 1989. The 1988 Christina Lake eurasian watermilfoil control program. Water Quality Branch, Ministry of Environment, Lands and Parks, Province of British Columbia.

Retzer, B. and Haberstock, D. 1990. The 1989 Christina Lake eurasian watermilfoil control program. Water Quality Branch, Ministry of Environment, Lands and Parks, Province of British Columbia.

Retzer, B. and Haberstock, D. 1991. The 1990 Christina Lake eurasian watermilfoil control program. Water Quality Branch, Ministry of Environment, Lands and Parks, Province of British Columbia.

Retzer, B. and Haberstock, D. 1992. The 1991 Christina Lake eurasian watermilfoil control program. Water Quality Branch, Ministry of Environment, Lands and Parks, Province of British Columbia.

Retzer, B. and Haberstock, D. 1993. The 1992 Christina Lake Eurasian watermilfoil control program. Water Quality Branch, Ministry of Environment, Lands and Parks, Province of British Columbia.

Robert Williams and Associates. 1967. Initial planning report for the Regional District of Kootenay Boundary. (Filed at the Regional District of Kootenay Boundary office, Trail, British Columbia) 72 p.

Robert Williams and Associates. 1968 to 1971. Regional District of Kootenay Boundary: Planning study. One completed for each year. (Filed at the Regional District of Kootenay Boundary office, Trail, British Columbia)

Royal British Columbia Museum (RBCM). 2005. Freshwater fishes of the Columbia Basin – Introduced fishes. Living Landscapes. 142.36.5.21/cbasin/peter_myles/intr_fishes.html

Royal British Columbia Museum (RBCM). 2005. Natural history. A compendium of environmental and resource information. Introducing aliens. Living Landscapes. Livinglandscapes.bc.ca/cbasin/history/exoticspecies.htm

Royal British Columbia Museum (RBCM). 2005. Biodiversity issues in the Thompson-Okanagan. Living Landscapes. Livinglandscapes.bc.ca/thomp-ok/env-changes/biodiv/ch5.html/history/exoticspecies.htm

Russo, G. 2005. Water quality data analysis for Christina Lake and in collaboration with Vic Jensen (2005) drafted water quality sections 7.2, 7.3.1, 7.3.2, 7.3.3 and associated recommendations. G. Russo is an Environmental Consultant from Victoria, British Columbia.

Ryder, J.M. and P. Stokes. 1996. Christina Lake community watershed: Detailed terrain mapping and assessment of slope stability, erosion, potential and sediment transfer. Unpublished report prepared for Pope & Talbot Ltd.

Rysavy, S. and I. Sharpe. 1995. Lake Kathlyn management plan. Rough draft #1. BC Environment, Province of British Columbia. 36 p.

Rysavy, S. and I. Sharpe. 1999. Tyhee Lake management plan. Prepared for the Tyhee Lake Protection Society. (Additions and revisions by L. Westenhofer and E. Gaudreau). BC Environment, Province of British Columbia. 119 p.

Sandner, L. and Others. 1994. Christina Lake an illustrated history. Merritt, BC: Sonotek Publishing Ltd. 128 p.

Sandner, R.F. 1967. Memories of Christina Lake. Published in Boundary Historical Society. The fifth report of the Boundary Historical Society. p. 33-36

Scott, W.B. and Crossman, E.J. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184. 966 p.

Shelley, L. 2004. Interior Health Authority – Summary of Roles and Responsibilities (Public Health Inspection). Informal document. On file CRSC.

Shelley, L. 2005. Personal communication with Lesley Shelley, Interior Health Authority (IHA) Environmental Health Officer, regarding the IHA recreational water quality testing program at Christina Lake and water uses (supply).

Sigma Engineering Ltd. 1991. Assessment of Christina Lake water quality data 1972-1990. For Water Quality Branch, Ministry of Environment, Lands and Parks, Province of British Columbia. This report was also reproduced as a BC Environment report. Ellis, J.R>, Wilkins, S.P., and Bryan, J.E. 1991. (ISBN 0-7726-1380).

Simbrec, R.M. 2001. Archaeology Report. Published in Boundary History. The fourteenth report of the Boundary Historical Society. p. 171-175

Smith, D. 1974. Surveys and inventory Christina Lake creel survey. Okanagan Sub-Region Southern Interior Region. Technical Report. Ministry of Environment, Province of British Columbia. 12 p.

Smith, D. 1991. Memorandum to S.V.H. Willett, Regional Manager, Fish and Wildlife, Southern Interior Region, re: Water Reserve Request for Sandner Creek. BCE file 40.3501.

Spitzer, D. 1991. Introduction to instructional and performance technology. Second edition. Boise State University.

Statistics Canada. 2001. 2001 Community Profile – Kootenay Boundary (Christina Lake). www.12.statcan.ca/english/profil01/Details/details1.cfm

Stewart, B. 2005. Personal communications with Barb Stewart, Boundary Weed Coordinator, pertaining to terrestrial and aquatic invasive plant species within the Christina Lake watershed. Boundary Weed Management Committee.

Stewart, W. 2005 Personal communication with Christina Waterworks District (CWD) System Technician Bill Stewart pertaining to the CWD system and upgrading procedures.

Stringer, G.E. 1961. Preliminary report on Kokanee fishing in Christina Lake. Okanagan Sub-Region Southern Interior Region. Technical Report. Ministry of Environment, Province of British Columbia. 12 p.

Stringer, G.E. 1963. A report on the Christina Lake kokanee harvest, 1962. Fish and Game Branch, Province of British Columbia. (Filed at the Ministry of Water, Land and Air Protection, Penticton) 2 p.

Stringer, G.E. 1977. Christina Lake data. Memorandum, March 8, 1977. Fish and Game Branch, Province of British Columbia. (Filed at the Ministry of Water, Land and Air Protection, Penticton) 6 p.

Sussex Consultants Ltd. 1994. 1994 Christina Lake Incorporation Study. Technical Report. Prepared for the BC Ministry of Municipal Affairs. 66p.

Sutherland Creek Waterworks District (SCWD). 2005. SCWD, Christina Lake: Emergency Plan, Water Conservation Plan, Drought Management Plan, Drought Emergency Consequence Plan, Outdoor Water Use Restriction Bylaw, Water Level Alarm System, Alternate Water Source Investigation. 198p.

Tetra Tech Inc. 2002. Jordon Lake Nutrient Response Model. The Jordon Lake Project Partners. North Carolina, USA

Thomas, R. 2004. Personal communication regarding the historical kokanee and burbot fisheries at Christina Lake.

Thompson, D.Q., Stuckey, R.L., and E.B. Thompson. 1987 Spread, impact , and control of Purple loosestrife (*Lythrum salicaria*) in North American Wetlands. US Fish and Wildlfie Service. 55 pp. Jamestown, ND: Northern Prairie Wildlife Research Home Page. Available at www.npwrc.usgs.gov/resource/1999/loosstrf/lossstrf.htm (Version 04June99)

Timberland Consultants Ltd. 1996. Italy-Sutherland Road/Hillslope/Gully Rehabilitation Level I Assessment WRP97DBO-05. Prepared for Pope and Talbot Ltd., Midway Division.

Timberland Consultants Ltd. 1997. Italy-Sutherland Level II Road/Hillslope/Gully Rehabilitation Assessment WRPDBO-05. Prepared for Pope and Talbot Ltd., Midway Division.

Toews, D. and D.R. Gluns. 1983. Sutherland/Italy Creek preliminary hydrological overview. Hydrology Section, Ministry of Forests. Boundary Forest District. Nelson, British Columbia.

United Nations Environment Programme. 2005. Planning and Management of Lakes and Reservoirs. http://www.unep.or.jp/ietc/publications/techpublications/techpub-11/index.asp#1.

University of Guelph. 2004. The University o f Guelph website resource library. Lake zonation diagram and glossary of terms. www.lib.uoguelph.ca/resources

University of Winnipeg. 2004. Eurasian watermilfoil. http://io.uwinnipeg.ca/~simmons/ysesp/exotic4.htm

Vermiere, L. 2005 Personal communications with Lester Vermiere pertaining to the reallocation of timber resources and the woodlot program.

Walker, R. 2001. Communications on file at the Christina Lake Stewardship Society office from Ron Walker pertaining to the environmental significance of conserving DL 498. Includes species listing and communications with Leah Ramsey (2001).

Walker, R. 2004 and 2005. Personal communications pertaining to wildlife species, stream systems that flow into Christina Lake, ice on/off of Christina Lake.

Walker, S. 2005. Personal communications pertaining to wildlife species within the Christina Lake watershed.

Weston, M. 2005. Personal communications with Mark Weston, BC Parks, Penticton pertaining to Park Use Permits within the Gladstone Provincial Park Area.

Webster, J. and Wilson, A. 2005. Okanagan region large lake creel census 2004: Kalamalka, Wood and Christina Lakes. Prepared for the Ministry of Water Land and Air Protection, Penticton. 37 p.

Wetzel, R.G. 1983 Limnology. Saunders College Publishing. Toronto, Canada.

Wilson, A. 2004 and 2005. Personal communications with Andrew Wilson pertaining to fish species and habitat requirements within the Christina Lake watershed. Fisheries Biologist (Penticton), Ministry of Water Land and Air Protection, Province of British Columbia.

Wolverton, R.E. 1954. From the diary of R.E. Wolverton. Timespan 1944 to 1954. (Filed at the Ministry of Water, Land and Air Protection, Penticton) 15 p.

MAP REFERENCES (FEATURE LAYERS)

Note: All maps are available for viewing online at: shim.bc.ca/Christina_lake/main.cfm

CBE format
Area Represented. Title [type of Map]. Place of Publication: publisher; date of publication. Physical description example

In Text Citation
format - (Area Represented, Year) example - (Boundary Forest District, 2001)

Base Map

Christina Lake Watershed. Terrain Resource Inventory Mapping [Base Mapping Layer]. Victoria: Ministry of Sustainable Resource Management, Base Mapping and Geomatic Services department, 2004. ESRI Coverage.

Land Use Map

Electoral Area C, Regional District of the Kootenay-Boundary, British Columbia. Official Community Plan Land Use Designation Area [Thematic Map Layer]. Trail: Regional District of the Kootenay-Boundary, 2004. AutoCad Drawing File

Electoral Area C, Regional District of the Kootenay-Boundary, British Columbia. Public Access Points [Thematic Map Layer]. 2004. Trail: Regional District of the Kootenay-Boundary. AutoCad Drawing File

Kootenay Region, British Columbia. Community Watersheds [Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 2004. ESRI Coverage.

Kootenay Region, British Columbia. Points of Water Diversion [Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 2004. ESRI Coverage.

Kootenay Region, British Columbia. Wells [Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 2004. ESRI Coverage.

Boundary Forest District, British Columbia. Woodlots [Thematic Map Layer]. Grand Forks: Ministry of Forests. Microstation Drawing File.

Kootenay Region, British Columbia. Resource Management Zones[Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 1995. ESRI Coverage.

Kootenay Region, British Columbia. Enhanced Resource Development Zones[Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 1995. ESRI Coverage.

Boundary Forest District, British Columbia. Forest Recreation Map [Recreation Map]. Grand Forks: Ministry of Forests, 2002. One page.

Boundary Forest District, British Columbia. Range Permit Usage Areas [Thematic Map Layer]. Grand Forks: Ministry of Forests, 2003. ESRI Shapefile.

Christina Lake Bathymetric Map

Christina Lake, British Columbia. Christina Lake Bathymetric Map [Bathymetric Map]. Department of Recreation and Conversation Fish and Game Branch, 1952. One page.

Fish Habitat Map

Boundary Forest District, British Columbia. Fish Presence/Absence [Thematic Map Layer]. Grand Forks: Ministry of Forests; 2001. ESRI Shapefile.

Boundary Forest District, British Columbia. In Stream Work Window [Thematic Map Layer]. Grand Forks: Ministry of Forests; 2001. ESRI Shapefile.

Tabloid maps base data

Kettle River Watershed, British Columbia. Watershed Atlas [Base Mapping Layer] Victoria: Ministry of Sustainable Resource Management, 2000. ESRI Coverage.

Province of British Columbia. Transportation Centre Line Network [Base Mapping Layer] Victoria: Ministry of Transportation, 2000. ESRI Coverage.

Land Cover Map

Kootenay Region, British Columbia. Provincial Biogeoclimatic Subzone/Variant [Thematic Map Layer]. Nelson: Ministry of Forests Research Branch. 2004. ESRI Coverage.

Kootenay Region, British Columbia. Baseline Thematic Mapping [Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 2003. ESRI Coverage.

Connectivity Corridors

Arrow-Boundary Forest District, British Columbia. Connectivity Corridors [Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 2002. ESRI Coverage.

Grizzly Bear Map

Kootenay Region, British Columbia. Grizzly Bear Management Priorities [Thematic Map Layer]. Nelson: Ministry of Sustainable Resource Management, 2000. ESRI Coverage.

Species at Risk Map

Province of British Columbia. Species at Risk [Thematic Map Layer]. Victoria: Conservation Data Centre. 2004. ESRI Coverage.

Terrain & Soils Map

Boundary Forest Region, British Columbia. Forest Renewal BC Terrain Mapping [Thematic Map Layer]. Victoria: Ministry of Energy and Mines, 2000. ESRI Coverage.

Ungulate Winter Range

Boundary Forest District, British Columbia. Ungulate Winter Range (Draft) [Thematic Map Layer]. Kamloops: Ministry of Sustainable Resource Management, 2003. ESRI Coverage.

Christina Lake Management Plan Priority Issues Survey – 2004

GROUP SURVEY

Which best describe you? :

Lakeshore resident	
Watershed resident	
Lake user	

Number of years you have lived in the Christina Lake watershed: _____

LAKE WATER QUALITY	Not concerned				Very Concerned	
1. Algae Blooms	1	2	3	4	5	N/A
2. Build up of nutrients	1	2	3	4	5	N/A
3. Water Clarity	1	2	3	4	5	N/A
4. Sedimentation/ Muck accumulation	1	2	3	4	5	N/A
5. Bacterial/ Fecal Contamination	1	2	3	4	5	N/A
6. Drinking water quality	1	2	3	4	5	N/A

Comments:

WATERSHED AND SHORELINE ACTIVITIES	Not concerned				Very Concerned	
7. Impact of development on shorelines	1	2	3	4	5	N/A
8. Impact of development on streams	1	2	3	4	5	N/A
9. Lack of lakeshore development guidelines (ex. Setbacks and buffer zones)	1	2	3	4	5	N/A
10. Lack of land development requirements (ex. Zoning, building permits)	1	2	3	4	5	N/A
11. Septic system maintenance (leakage)	1	2	3	4	5	N/A
12. Residential pesticide runoff	1	2	3	4	5	N/A
13. Residential fertilizer runoff	1	2	3	4	5	N/A
14. Animal waste runoff	1	2	3	4	5	N/A
15. Runoff from roads and ditches	1	2	3	4	5	N/A
16. Clearing of shoreline vegetation	1	2	3	4	5	N/A
17. Clearing of vegetation along streams	1	2	3	4	5	N/A
18. Introduction of non-native plants (noxious weeds)	1	2	3	4	5	N/A
19. Fire hazards within the watershed	1	2	3	4	5	N/A
20. Forestry practices within the watershed	1	2	3	4	5	N/A

Comments:

RECREATION	Not concerned				Very Concerned	
21. Poor water quality for swimming	1	2	3	4	5	N/A
22. Water pollution from motorized boats	1	2	3	4	5	N/A
23. Noise from motorized boats	1	2	3	4	5	N/A
24. Motorcraft impacts on shorelines (ex. Erosion)	1	2	3	4	5	N/A
25. Motorcraft impacts on wetlands and waterfowl	1	2	3	4	5	N/A
26. Public lake access	1	2	3	4	5	N/A
27. Boat launch/marina adequate	1	2	3	4	5	N/A
28. Maintenance of recreation sites adequate	1	2	3	4	5	N/A

Comments:

LAKE LEVEL EFFECTS	Not concerned				Very Concerned	
29. Effect of extreme low water on lake ecosystem	1	2	3	4	5	N/A
30. Effects of high lake levels on lake ecosystem	1	2	3	4	5	N/A
STREAM LEVEL EFFECTS						
31. Effect of extreme low water on streams	1	2	3	4	5	N/A
32. Effect of high water levels on streams	1	2	3	4	5	N/A

Comments:

AQUATIC PLANTS	Not concerned				Very Concerned	
33. Increased plants in the lake	1	2	3	4	5	N/A
34. Introduction of non-native plants to the lake (Eurasian watermilfoil)	1	2	3	4	5	N/A

Comments:

FISHERIES, WATERFOWL AND WILDLIFE	Not concerned				Very Concerned	
35. Fisheries sustainability	1	2	3	4	5	N/A
36. Loss of fish habitat	1	2	3	4	5	N/A
37. Wildlife (Species at Risk)	1	2	3	4	5	N/A
38. Beaver problems	1	2	3	4	5	N/A
39. Conservation of waterfowl and wildlife habitat	1	2	3	4	5	N/A

Comments:

PUBLIC PARTICIPATION	Not concerned				Very Concerned	
40. Lack of funding for lake projects	1	2	3	4	5	N/A
41. Lack of support from government agencies	1	2	3	4	5	N/A
42. Lack of community participation	1	2	3	4	5	N/A
43. Lack of public education about lake issues	1	2	3	4	5	N/A

Comments:

ACCESS AND GROWTH MANAGEMENT WITHIN THE BASIN	Not concerned				Very Concerned	
44. Vandalism at public sites	1	2	3	4	5	N/A
45. Policing at public sites	1	2	3	4	5	N/A
46. Adequate parking for vehicles	1	2	3	4	5	N/A

Comments:

List your 5 most important concerns (listed above) in ranked order (1 being most important)

1

2

3

4

5 _____

Please list any important issues not addressed in this survey.

1 _____

2 _____

3 _____

	YES	NO
I would like to receive a summary of the survey results:	☐	☐

If you answered YES above, please provide the following informati n:

Name _____

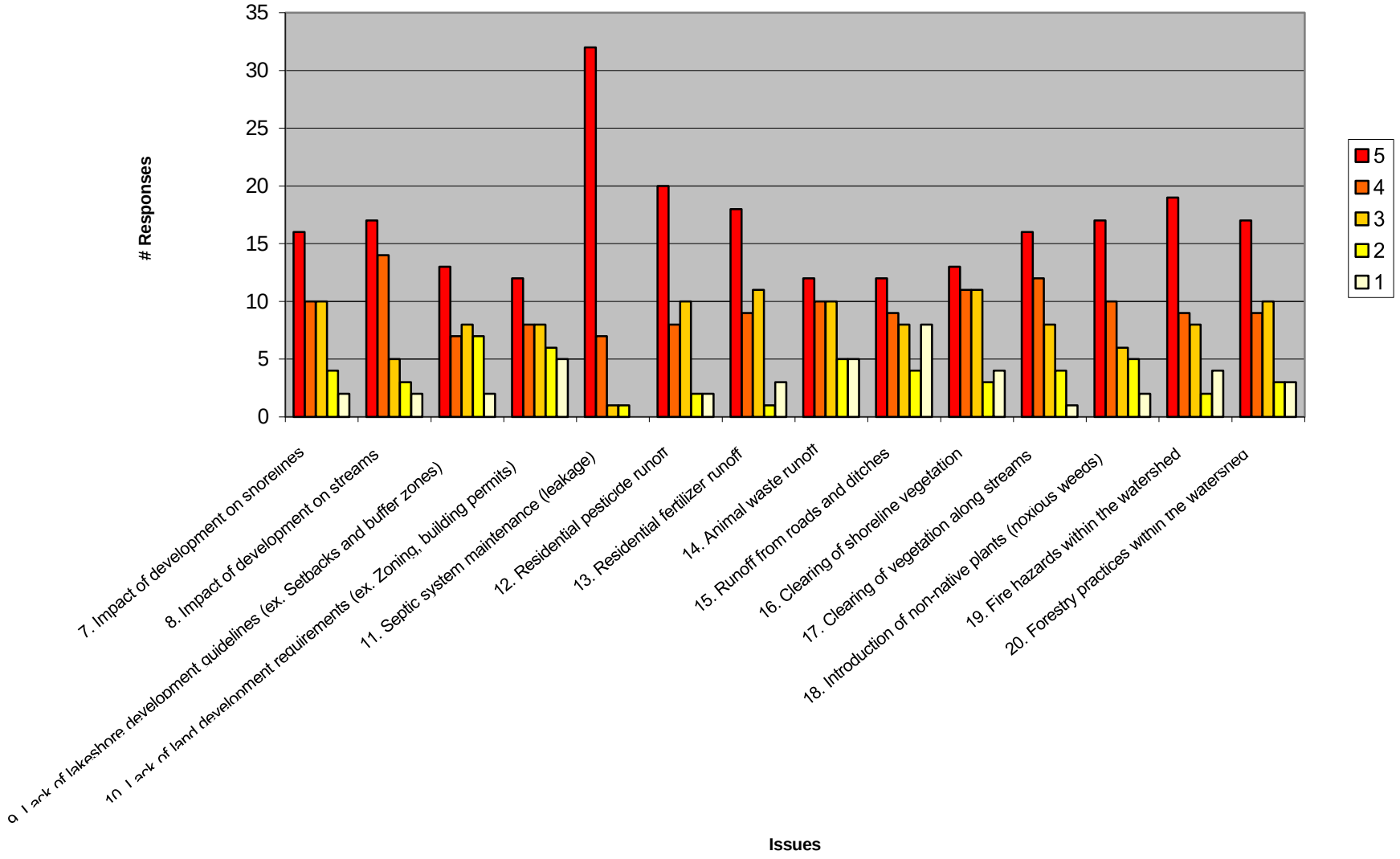
Mailing Address _____

Email _____

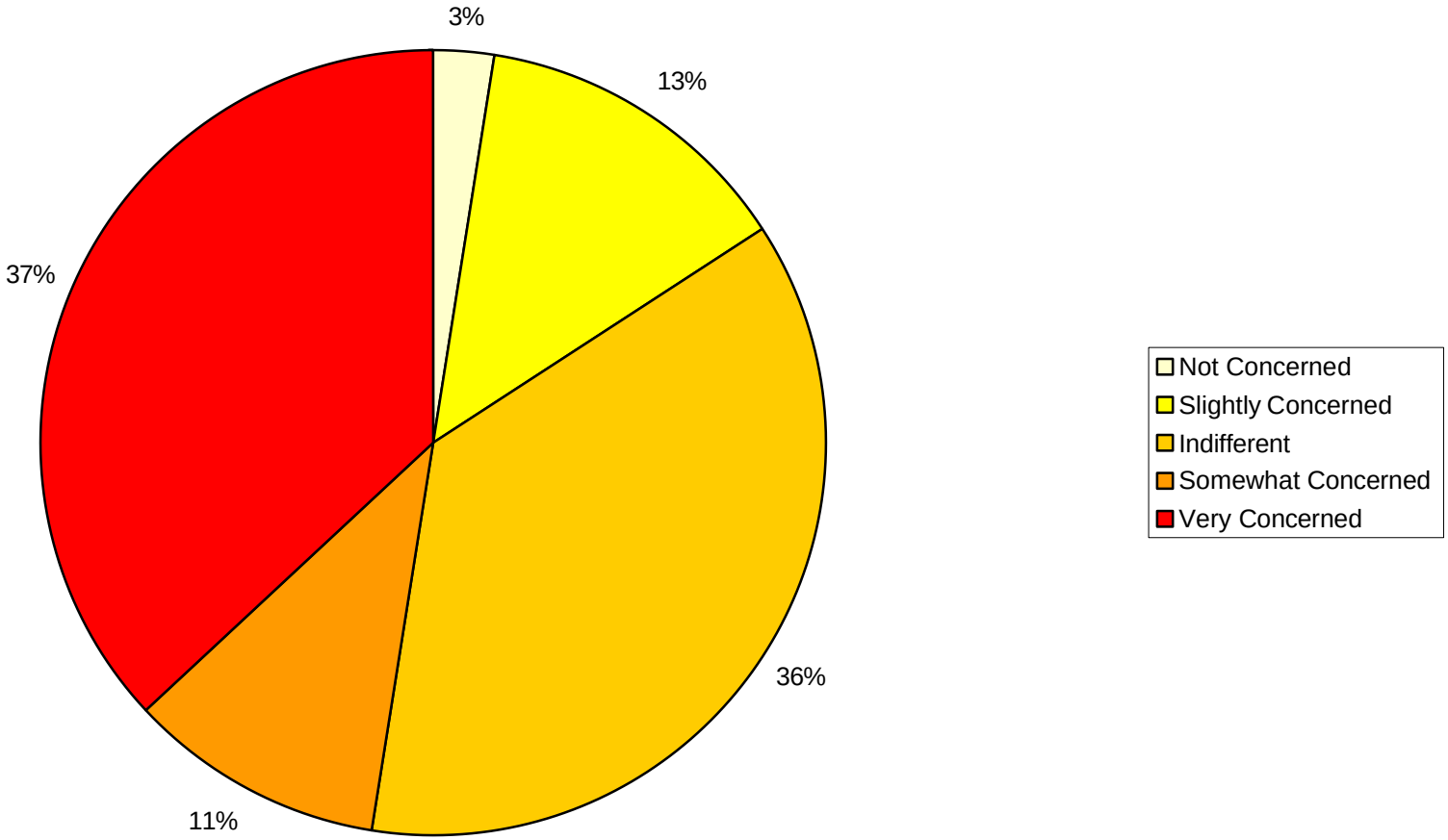
Thank-you for taking the time to fill out this survey.

Please mail the survey to the Christina Lake Stewardship Society at PO Box 373, Christina Lake, BC V0H 1E0
OR
Phone Brenda LaCroix at 447-2504 to arrange for a pick up or drop off of your survey – Fax 250-447-2509
OR
Drop off your completed survey at the Community Stewardship Resource Centre located at the Christina Lake Community Hall – 90 Park Road, Christina Lake, BC

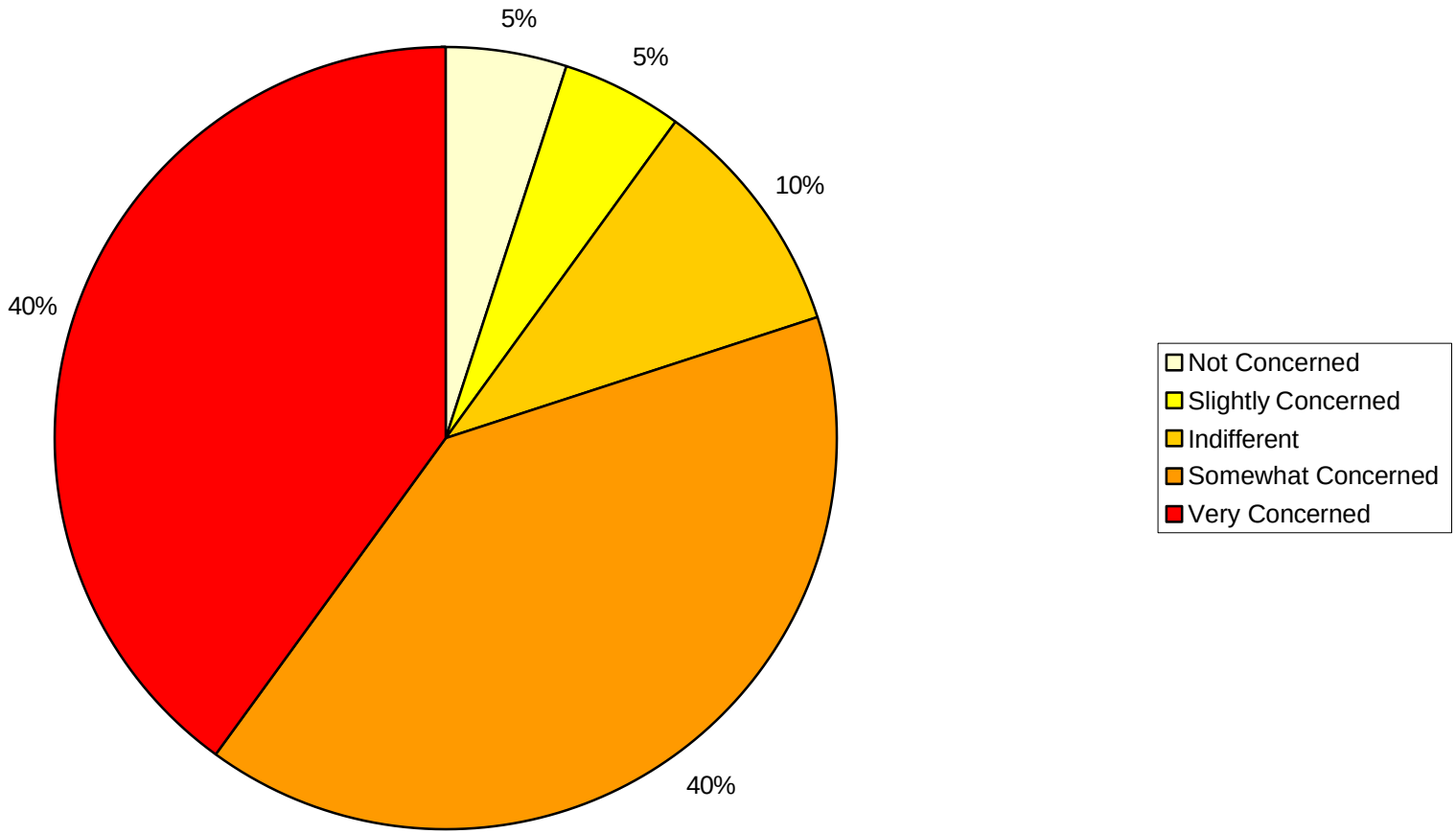
Watershed And Shoreline Activities



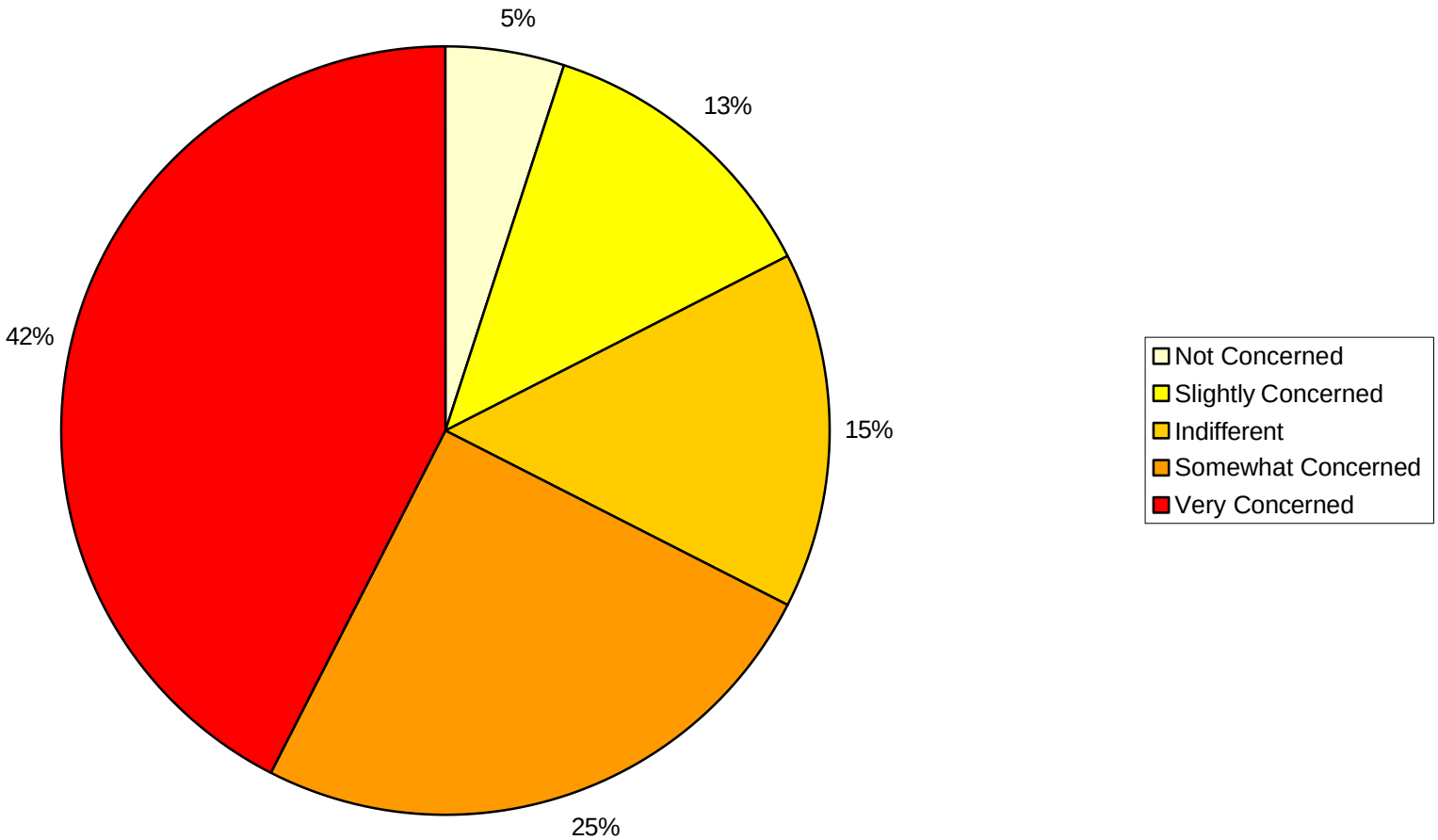
Group Survey Results - Wildlife Values



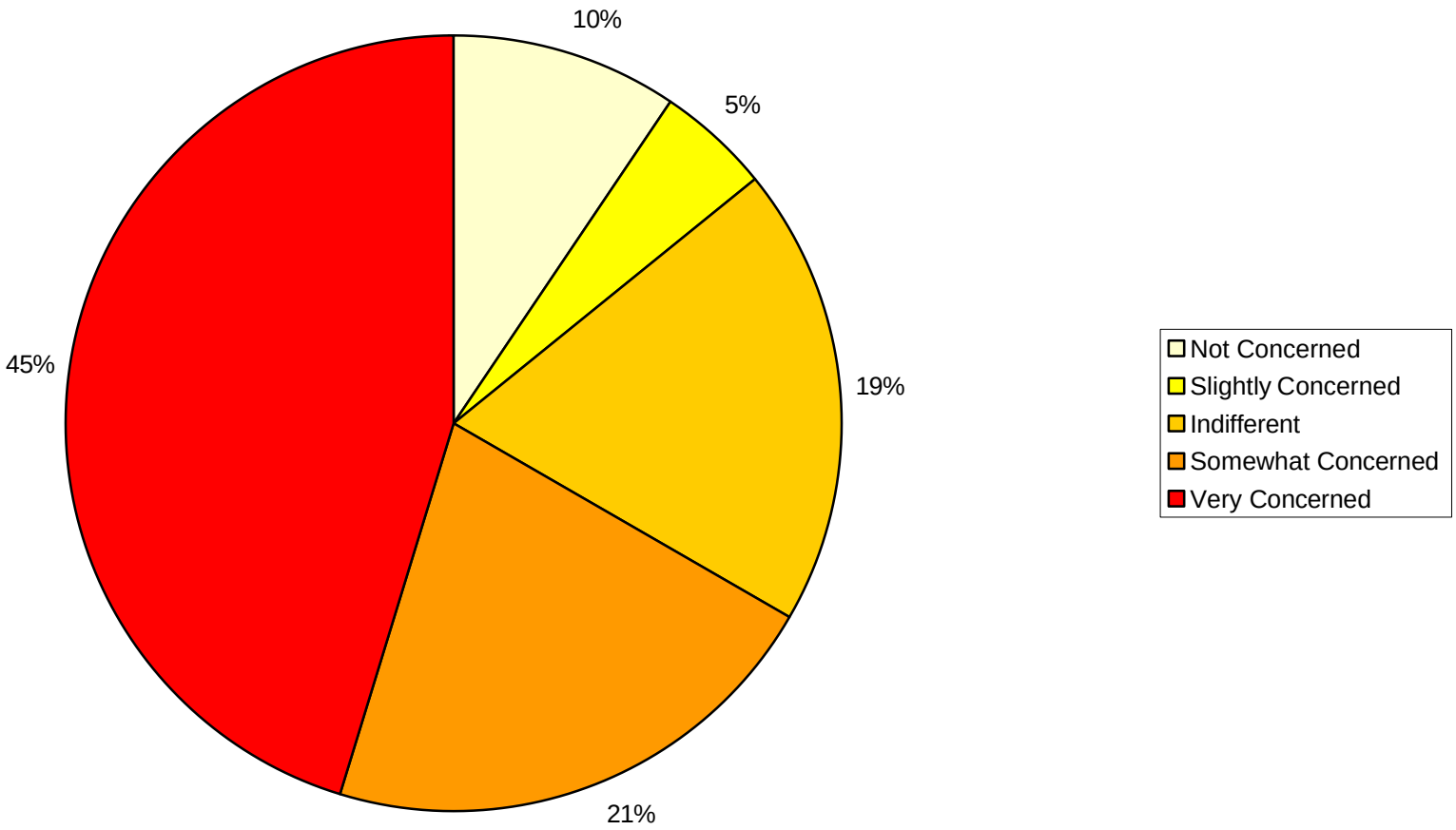
Group Survey Results - Fisheries Sustainability



Group Survey Results - Non-Native Plants



Group Survey Results - Forestry Practices



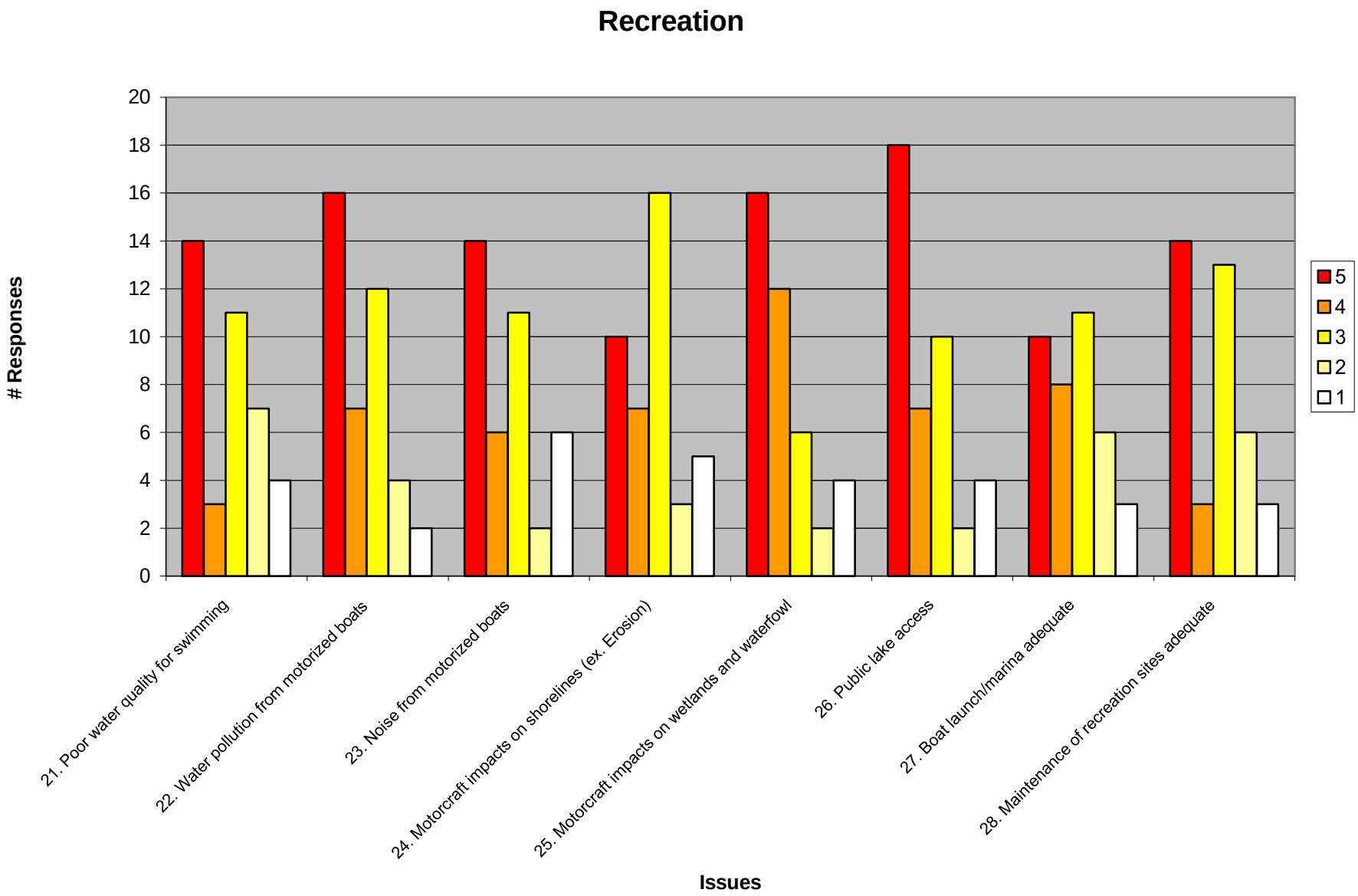
CLMP Collated Group Survey Results

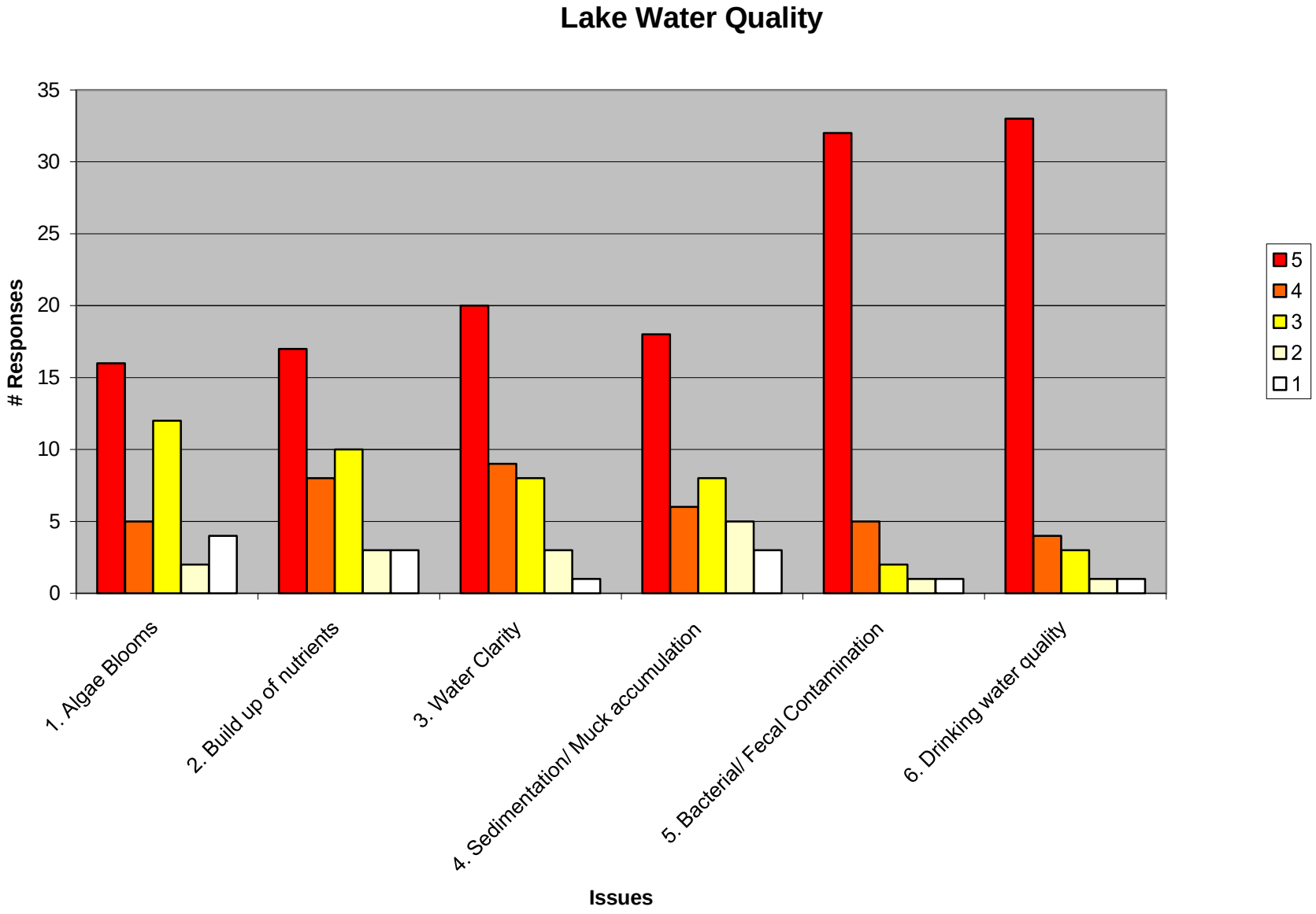
Rating	Issue	Total Score
1	Drinking water quality	193
2	Septic system maintenance (leakage)	193
3	Bacterial/ Fecal Contamination	189
4	Introduction of non-native plants to the lake (Eurasian watermilfoil)	184
5	Loss of fish habitat	175
6	Residential pesticide runoff	168
7	Water Clarity	167
8	Impact of development on streams	164
9	Residential fertilizer runoff	164
10	Clearing of vegetation along streams	161
11	Fire hazards within the watershed	163
12	Forestry practices within the watershed	160
13	Increased plants in the lake	160
14	Conservation of waterfowl and wildlife habitat	162
15	Impact of development on shorelines	160

CLMP Collated Group Survey Results

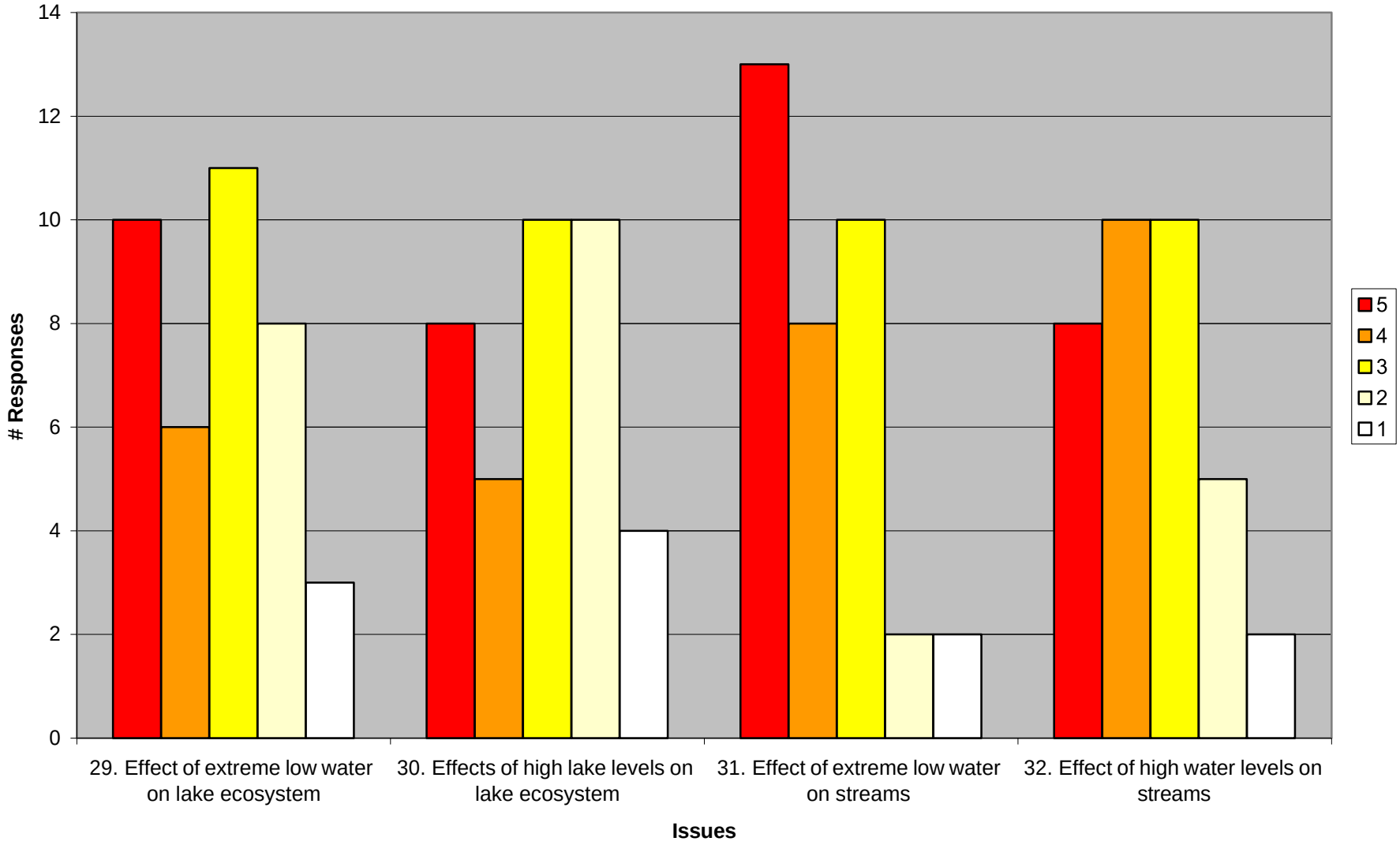
16	Fisheries sustainability	**162**
17	Public lake access	**156**
18	Motorcraft impacts on wetlands and waterfowl	**154**
19	Build up of nutrients	**156**
20	Water pollution from motorized boats	**154**
21	Sedimentation/ Muck accumulation	**151**
22	Introduction of non-native plants (noxious weeds)	**155**
23	Clearing of shoreline vegetation	**152**
24	Animal waste runoff	**145**
25	Algae Blooms	**144**
26	Lack of support from government agencies	**148**
27	Lack of funding for lake projects	**145**
28	Vandalism at public sites	**142**
29	Runoff from roads and ditches	**136**
30	Motorcraft impacts on shorelines (ex. Erosion)	**137**

31	Lack of community participation	**140**
32	Lack of public education about lake issues	**138**
33	Maintenance of recreation sites adequate	**136**
34	Wildlife (Species at Risk)	**139**
35	Noise from motorized boats	**137**
36	Effect of extreme low water on streams	**133**
37	Policing at public sites	**135**
38	Poor water quality for swimming	**133**
39	Boat launch/marina adequate	**130**
40	Lack of lakeshore development guidelines (ex. Setbacks and buffer zones)	**133**
41	Lack of land development requirements (ex. Zoning, building permits)	**133**
42	Effect of extreme low water on lake ecosystem	**126**
43	Adequate parking for vehicles	**127**
44	Effect of high water levels on streams	**122**
45	Beaver problems	**122**
46	Effects of high lake levels on lake ecosystem	**114**

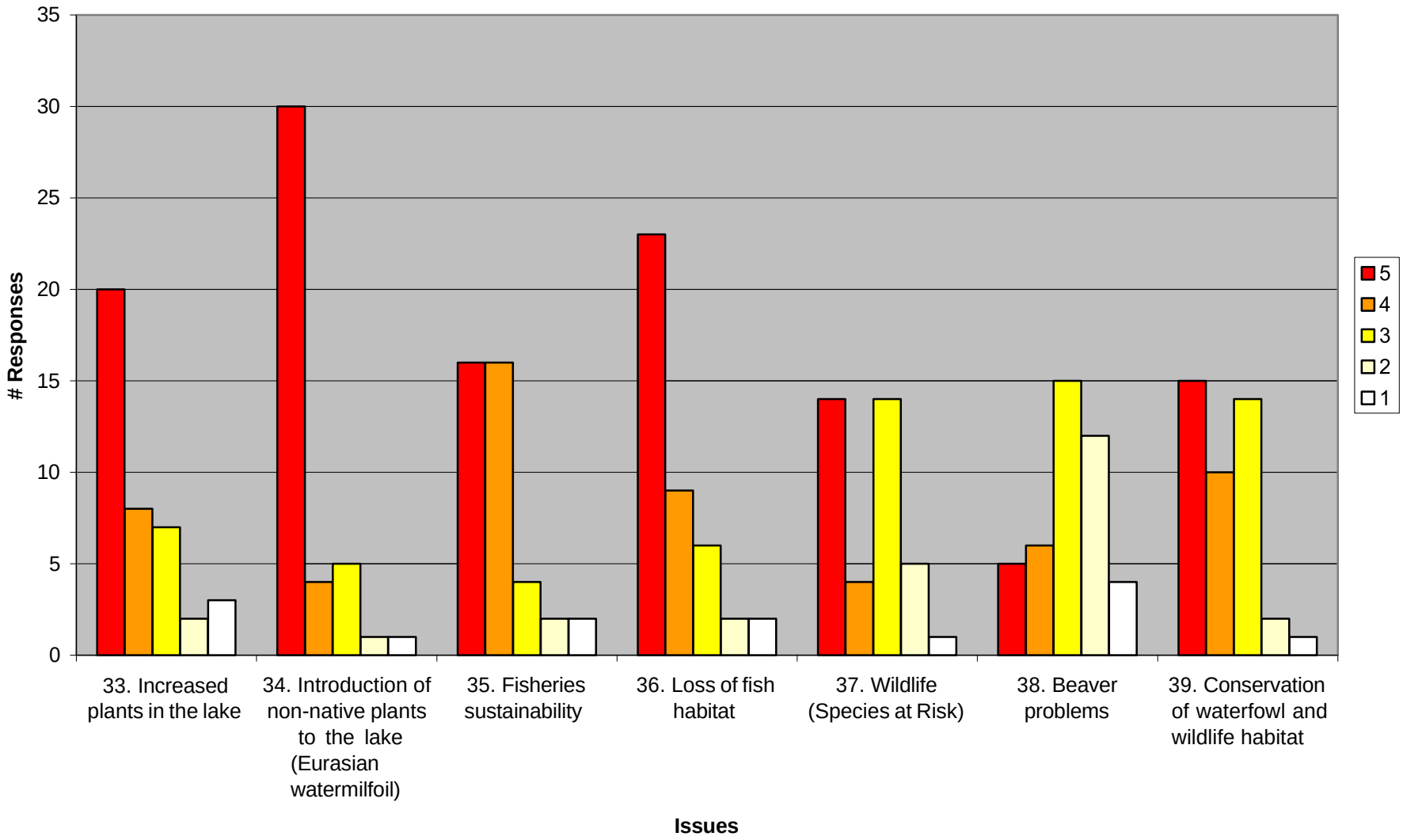

Recreation
Responses
20
18
16
14
12
10
8
6
4
2
0
5
4
3
2
1
21. Poor water quality for swimming
22. Water pollution from motorized boats
23. Noise from motorized boats
24. Motorcraft impacts on shorelines (ex. Erosion)
25. Motorcraft impacts on wetlands and waterfowl
26. Public lake access
27. Boat launch/marina adequate
28. Maintenance of recreation sites adequate
Issues


Lake Water Quality
35
30
25
20
15
10
5
0
Responses
1. Algae Blooms
2. Build up of nutrients
3. Water Clarity
4. Sedimentation/ Muck accumulation
5. Bacterial/ Fecal Contamination
6. Drinking water quality
Issues
5
4
3
2
1

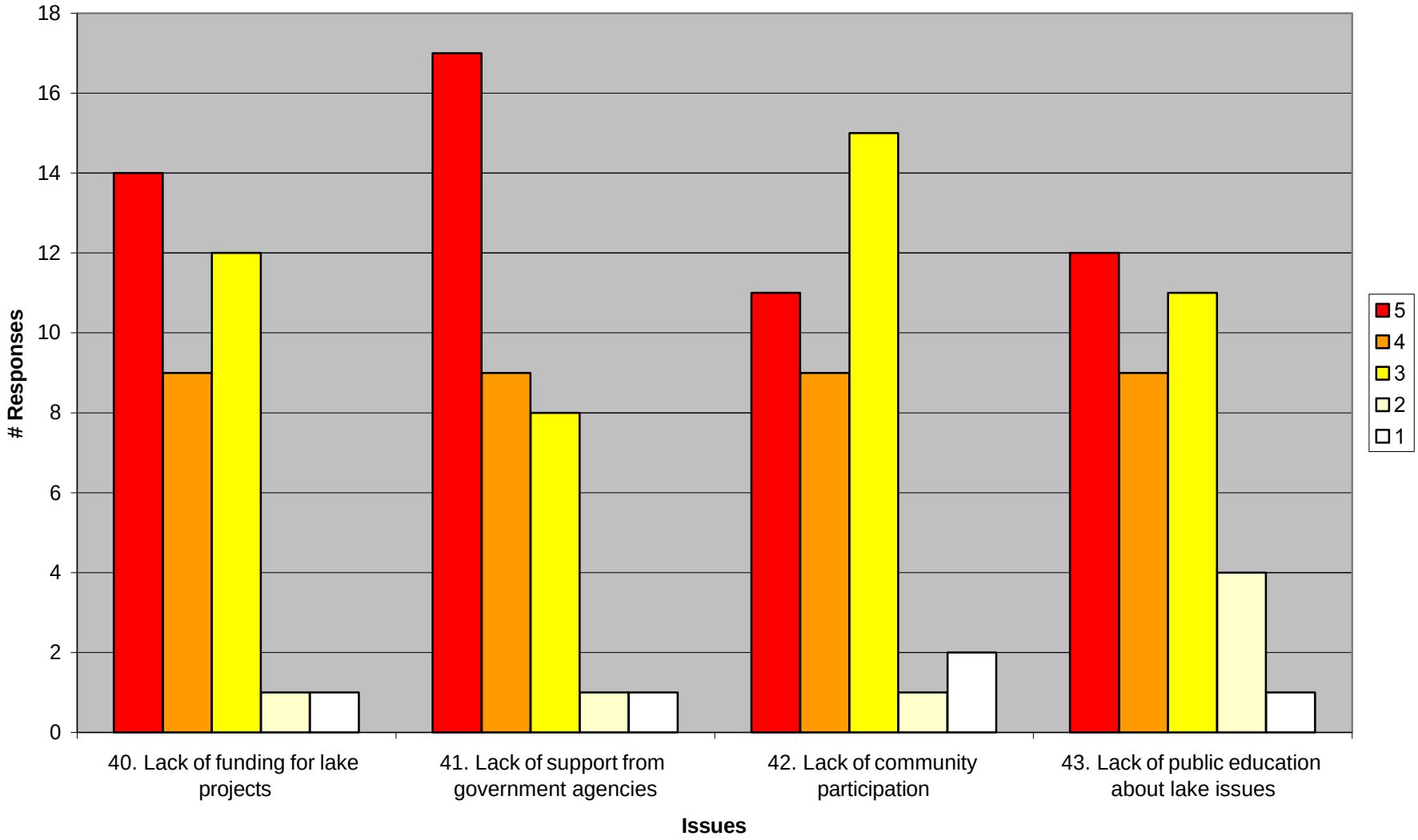
Lake/Stream Level Effects



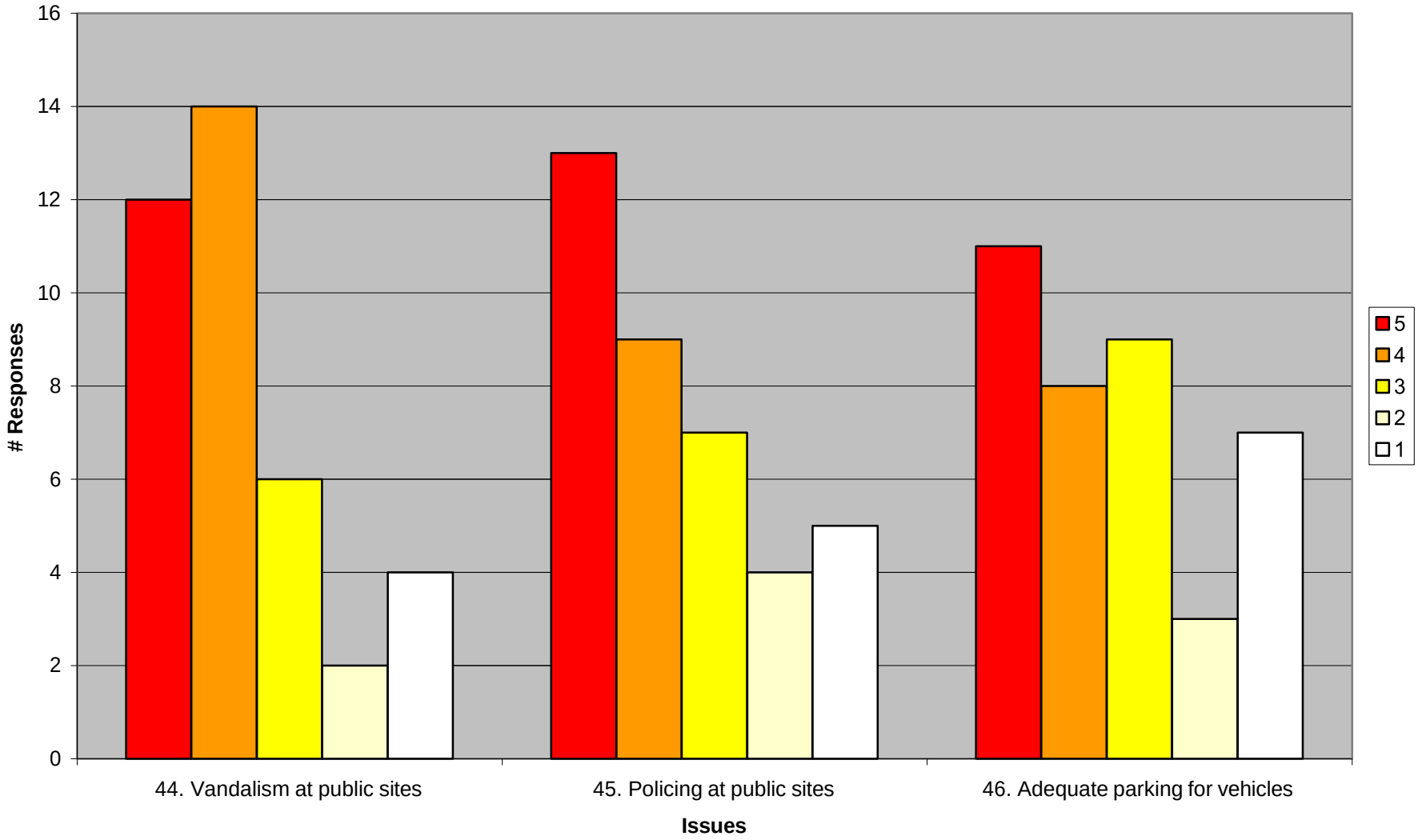
Aquatic Plants / Fisheries, Waterfowl, and Wildlife



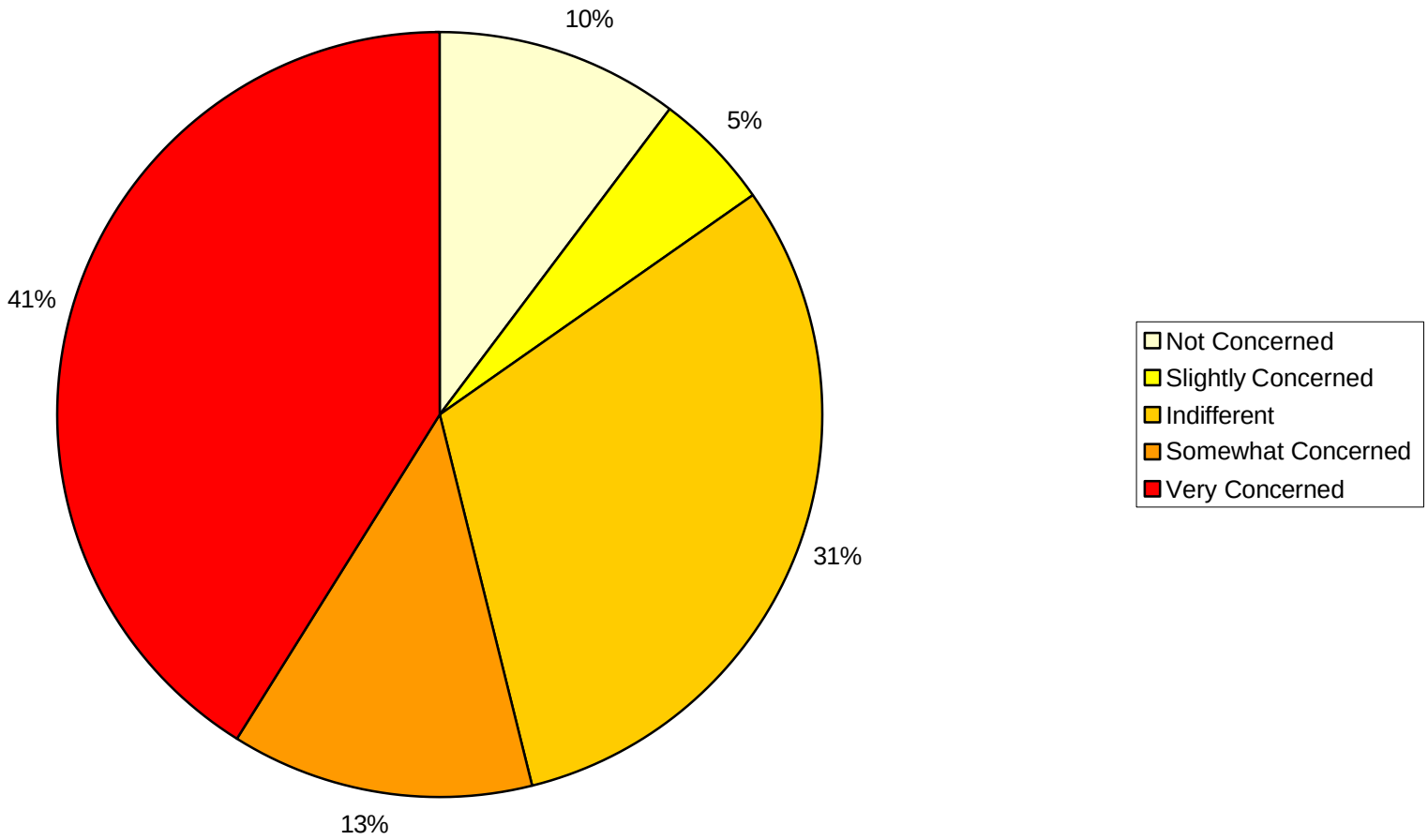
Public Participation



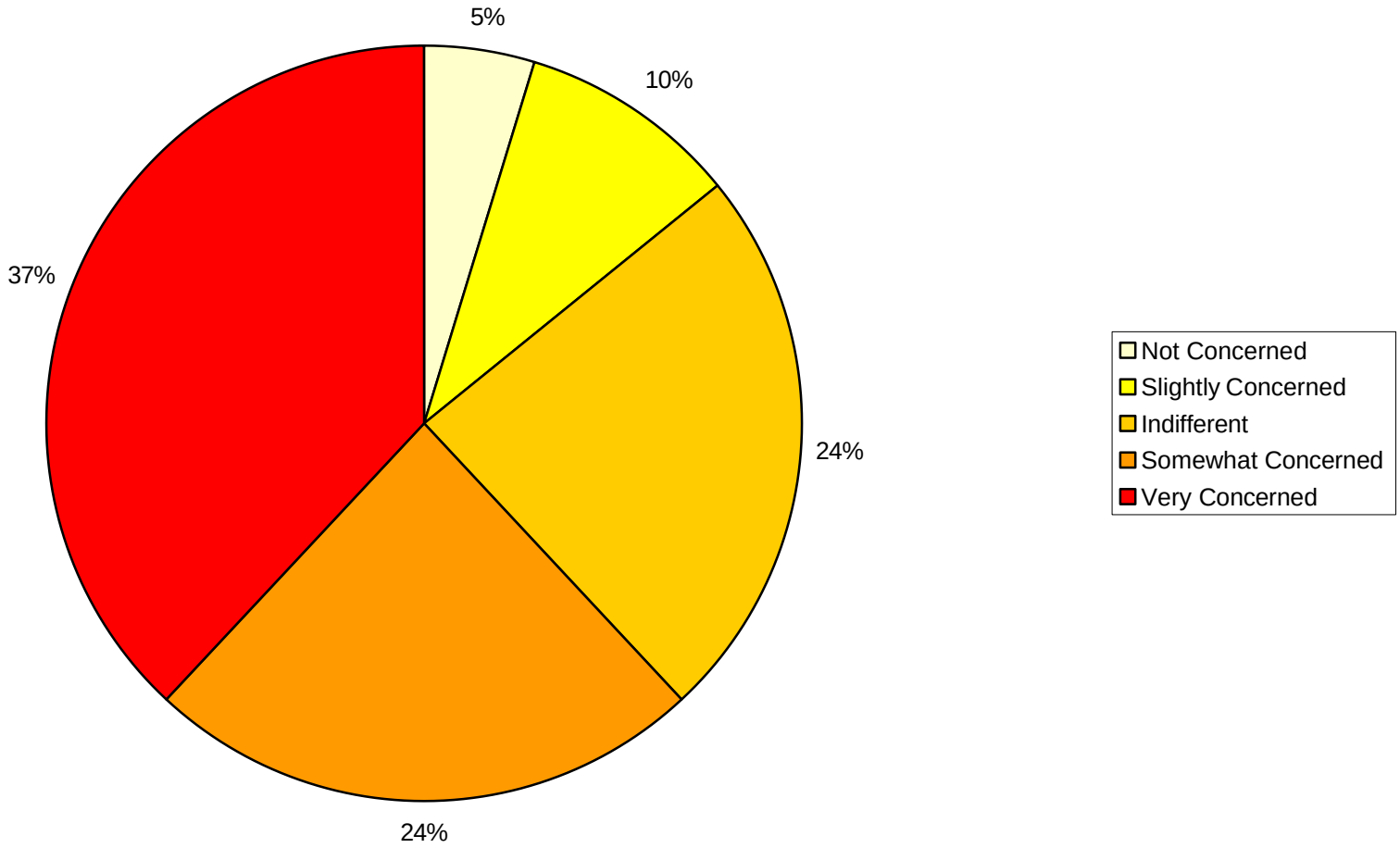
Access, Growth Management



Group Survey Results - Water Quality



Group Survey Results - Shoreline Development



Christina Lake Management Plan Priority Issues Survey – 2004

INDIVIDUAL SURVEY

Submission deadline October 29, 2004

Which best describes you? :

Lakeshore resident ☐

Watershed resident ☐

Lake user ☐

Number of years you have lived in the Christina Lake watershed: _____

LAKE WATER QUALITY	Not concerned				Very Concerned	
1. Algae Blooms	1	2	3	4	5	N/A
2. Build up of nutrients	1	2	3	4	5	N/A
3. Water Clarity	1	2	3	4	5	N/A
4. Sedimentation/ Muck accumulation	1	2	3	4	5	N/A
5. Bacterial/ Fecal Contamination	1	2	3	4	5	N/A
6. Drinking water quality	1	2	3	4	5	N/A

Comments:

WATERSHED AND SHORELINE ACTIVITIES	Not concerned				Very Concerned	
7. Impact of development on shorelines	1	2	3	4	5	N/A
8. Impact of development on streams	1	2	3	4	5	N/A
9. Lack of lakeshore development guidelines (ex. Setbacks and buffer zones)	1	2	3	4	5	N/A
10. Lack of land development requirements (ex. Zoning, building permits)	1	2	3	4	5	N/A
11. Septic system maintenance (leakage)	1	2	3	4	5	N/A
12. Residential pesticide runoff	1	2	3	4	5	N/A
13. Residential fertilizer runoff	1	2	3	4	5	N/A
14. Animal waste runoff	1	2	3	4	5	N/A
15. Runoff from roads and ditches	1	2	3	4	5	N/A
16. Clearing of shoreline vegetation	1	2	3	4	5	N/A
17. Clearing of vegetation along streams	1	2	3	4	5	N/A
18. Introduction of non-native plants (noxious weeds)	1	2	3	4	5	N/A
19. Fire hazards within the watershed	1	2	3	4	5	N/A
20. Forestry practices within the watershed	1	2	3	4	5	N/A

Comments:

RECREATION	Not concerned				Very Concerned	
21. Poor water quality for swimming	1	2	3	4	5	N/A
22. Water pollution from motorized boats	1	2	3	4	5	N/A
23. Motorcraft impacts on shorelines (ex. Erosion)	1	2	3	4	5	N/A
24. Motorcraft impacts on wetlands and waterfowl	1	2	3	4	5	N/A

Comments:

LAKE LEVEL EFFECTS	Not concerned	Very Concerned

25. Effect of extreme low water on lake ecosystem	1	2	3	4	5	N/A
STREAM LEVEL EFFECTS						
26. Effect of extreme low water on streams	1	2	3	4	5	N/A
27. Effect of high water levels on streams	1	2	3	4	5	N/A

Comments:

AQUATIC PLANTS	Not concerned				Very Concerned	
28. Increased plants in the lake	1	2	3	4	5	N/A
29. Introduction of non-native plants to the lake (Eurasian watermilfoil)	1	2	3	4	5	N/A

Comments:

FISHERIES, WATERFOWL AND WILDLIFE	Not concerned				Very Concerned	
30. Fisheries sustainability	1	2	3	4	5	N/A
31. Recreational Fishery – Kokanee	1	2	3	4	5	N/A
32. Recreational Fishery – Rainbow Trout	1	2	3	4	5	N/A
33. Recreational Fishery – Bass	1	2	3	4	5	N/A
34. Effects of introduced fish species on native species	1	2	3	4	5	N/A
35. Loss of fish habitat	1	2	3	4	5	N/A
36. Wildlife (Species at Risk)	1	2	3	4	5	N/A
37. Availability of Ungulate winter range (Elk, Deer)	1	2	3	4	5	N/A
38. Grizzly Bear refuge (human impacts)	1	2	3	4	5	N/A
39. Level of road access to back country (recreational/hunting)	1	2	3	4	5	N/A
40. Level of road access to back country (habitat fragmentation)	1	2	3	4	5	N/A
41. Conservation of waterfowl and wildlife habitat	1	2	3	4	5	N/A
42. Other species of concern (please list below and why)	1	2	3	4	5	N/A

Comments:

PUBLIC PARTICIPATION	Not concerned				Very Concerned	
43. Lack of funding for lake projects	1	2	3	4	5	N/A
44. Lack of support from government agencies	1	2	3	4	5	N/A
45. Lack of community participation	1	2	3	4	5	N/A
46. Lack of public education about lake issues	1	2	3	4	5	N/A

Comments:

List your 5 most important concerns (listed above) in ranked order (1 being most important)

1 _____

2 _____

3 _____

4 _____

5 _____

Please list any important issues not addressed in this survey.

_____

_____

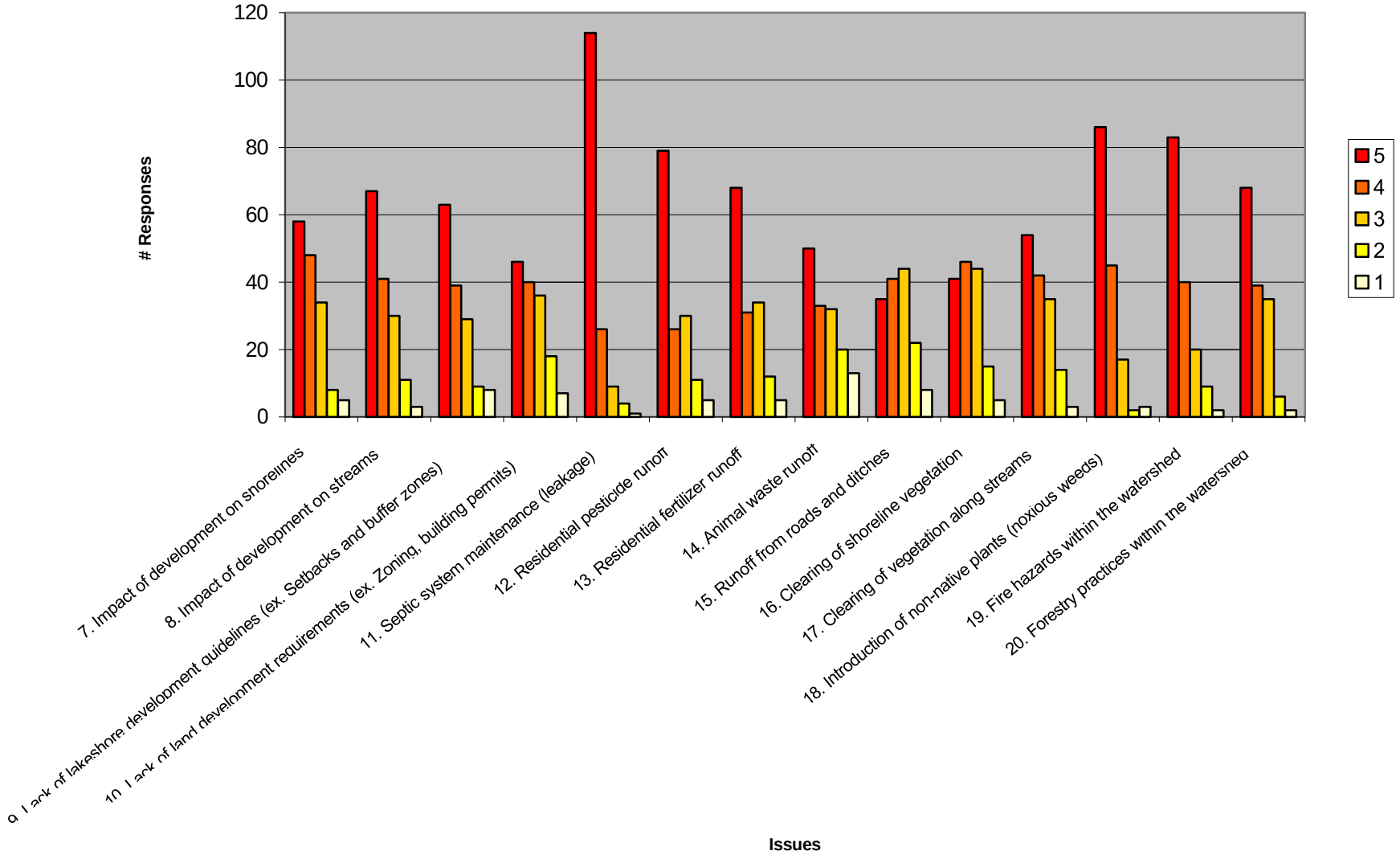
Thank-you for taking the time to fill out this survey.

THIS SURVEY IS ALSO AVAILABLE ON OUR WEBSITE AT LAKESTEWARD.CA OR AT JIMMY BEANS COFFEE SHOP AND THE HUCKLEBERRY MOUNTAIN MARKET

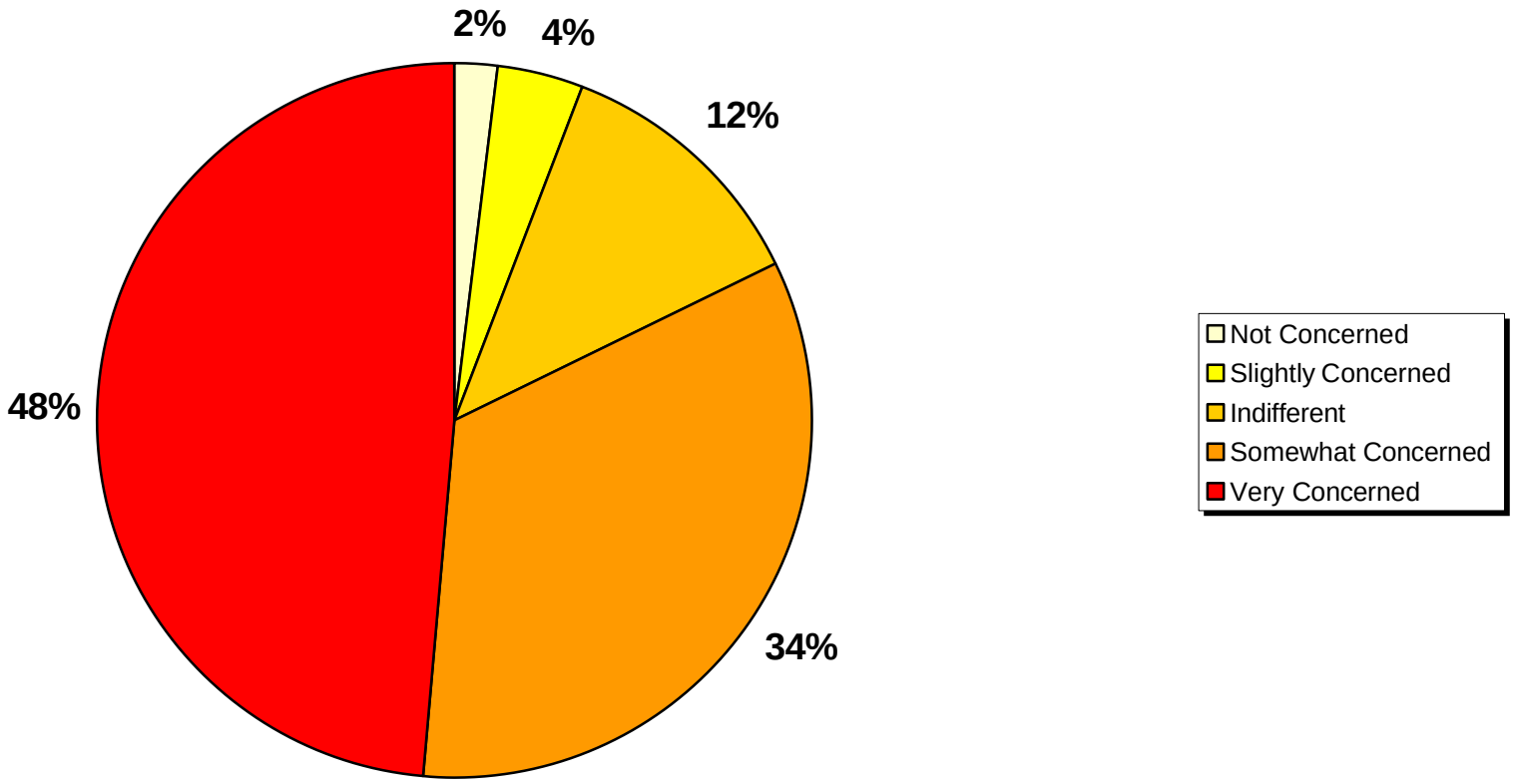
Please mail the survey to the Christina Lake Stewardship Society at PO Box 373, Christina Lake, BC V0H 1E0
OR
Drop off at Jimmy Beans Coffee Shop or Huckleberry Mountain Market
OR
Drop off your completed survey at the Community Stewardship Resource Centre located at the Christina Lake Community Hall – 90 Park Road, Christina Lake, BC

A summary of the survey results will be available on our website at lakesteward.ca and in the local newspapers by November 5, 2004.

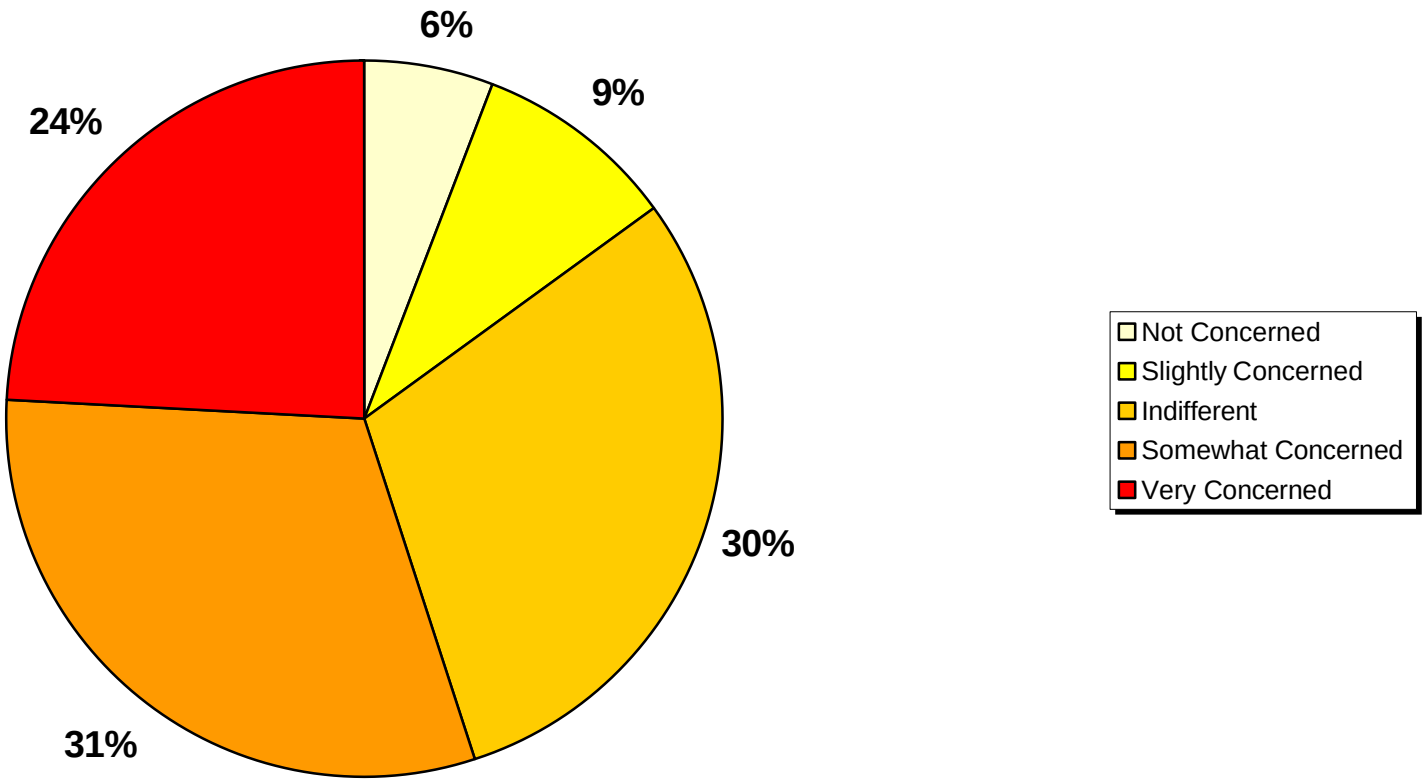
Watershed And Shoreline Activities



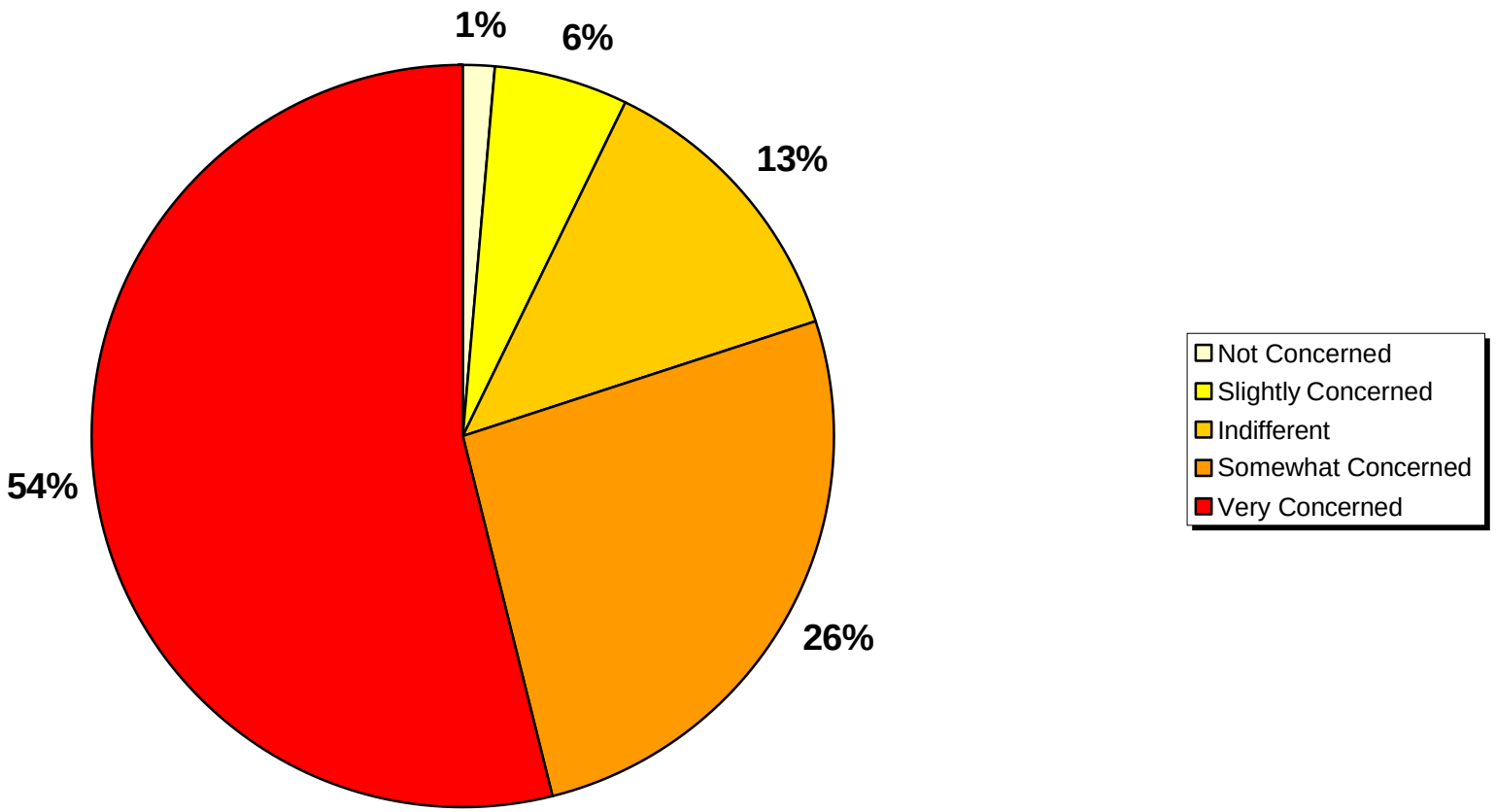
Survey Responses Regarding Non-Native Plants in the Christina Lake Watershed



Survey Responses Regarding Wildlife Values in the Christina Lake Watershed



Survey Results Regarding Forestry Practices



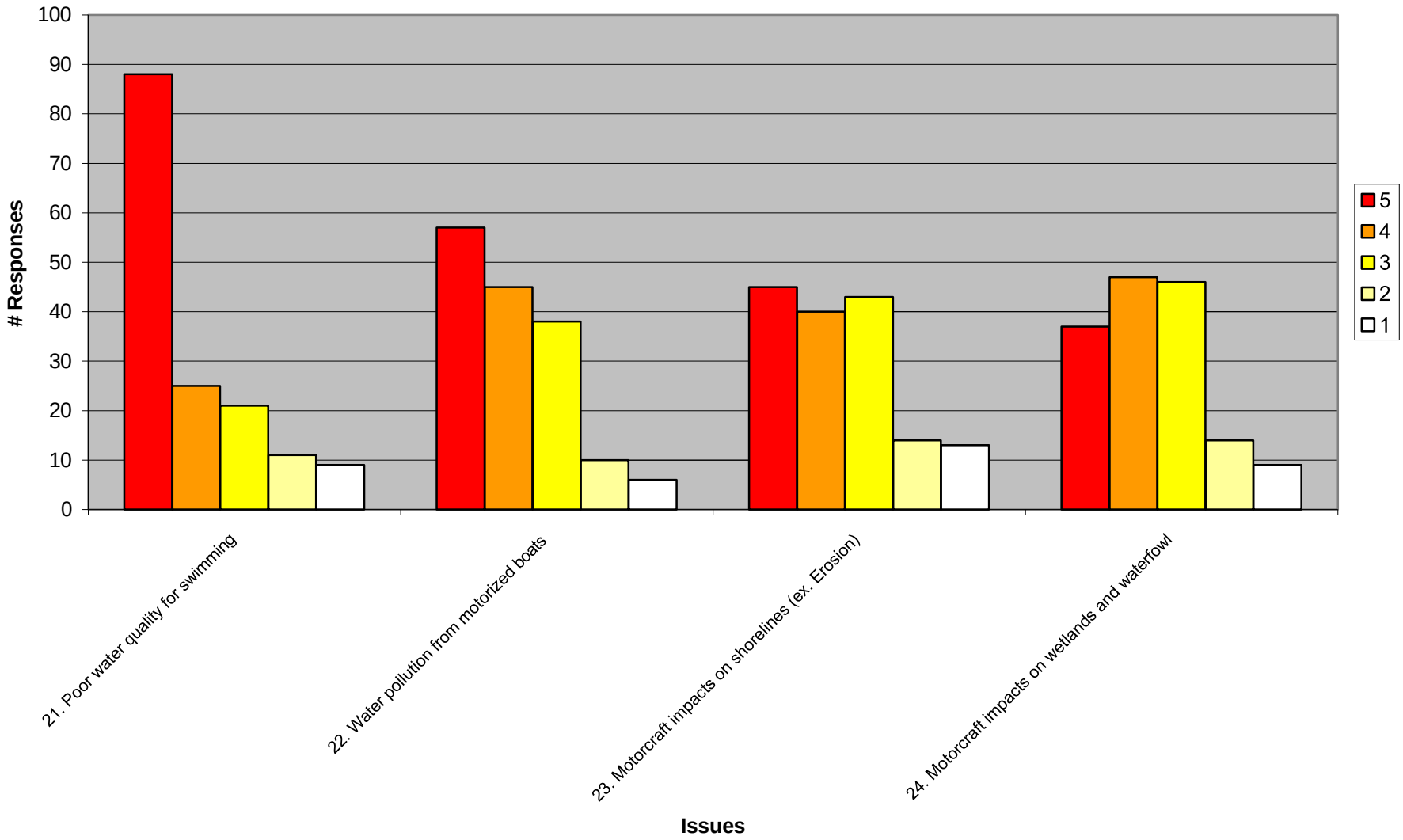
CLMP Collated Individual Survey Results

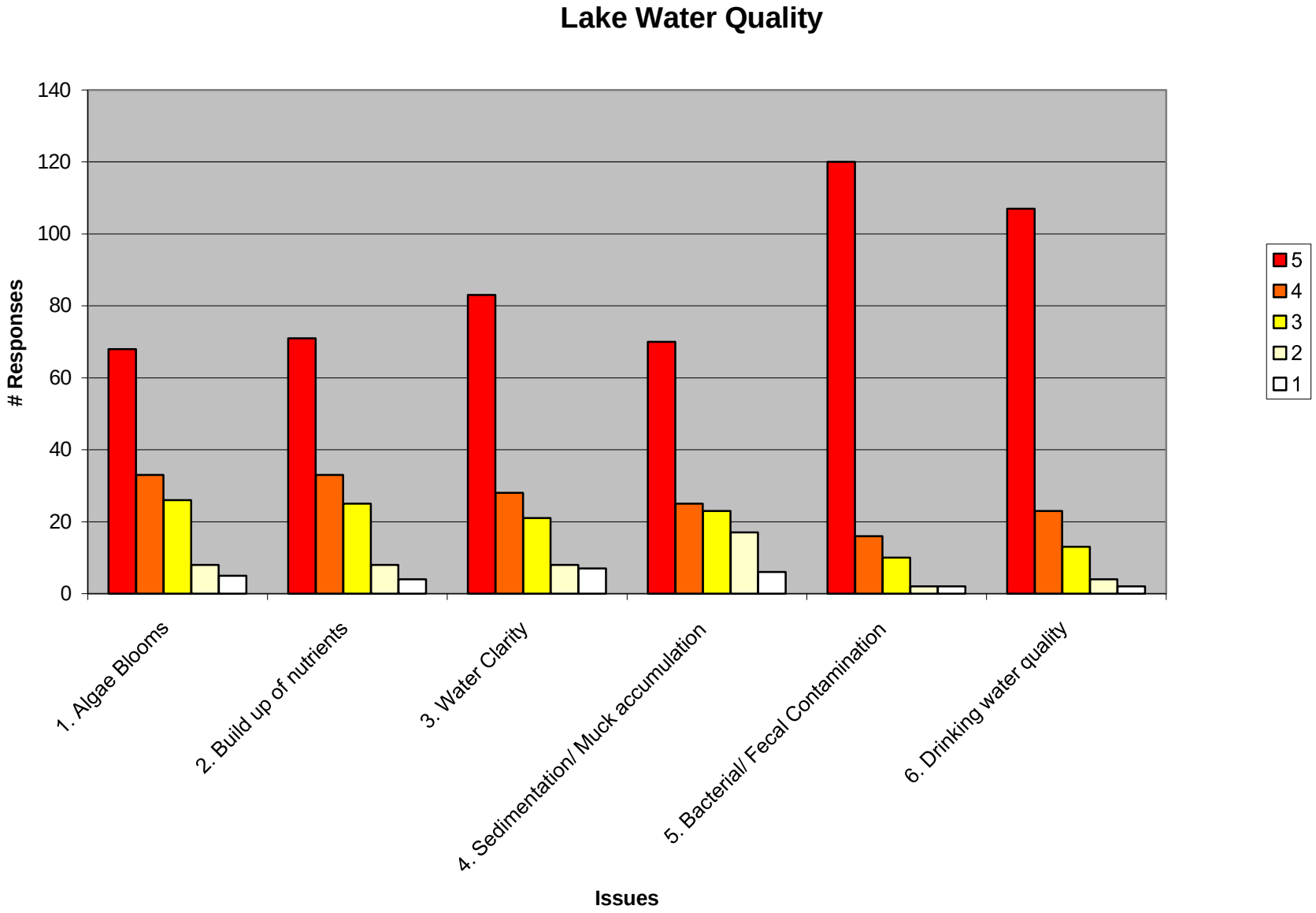
Rank	Issue	Score	% Respondents who indicated "very concerned"	% Respondents who indicated "not concerned"
1	Introduction of non-native plants to the lake (Eurasian watermilfoil)	732	81	1
2	Septic system maintenance (leakage)	710	73	1
3	Bacterial/ Fecal Contamination	700	77	1
4	Drinking water quality	676	69	1
5	Introduction of non-native plants (noxious weeds)	668	55	2
6	Fire hazards within the watershed	655	53	1
7	Increased plants in the lake	643	47	2
8	Poor water quality for swimming	634	56	6
9	Effects of introduced species on native species	626	44	3
10	Lack of support from government agencies	618	44	2
11	Residential pesticide runoff	616	51	3
12	Forestry practices within the watershed	615	44	1
13	Impact of development on streams	614	43	2
14	Water Clarity	613	53	4
15	Loss of fish habitat	612	42	1
16	Impact of development on shorelines	605	37	3

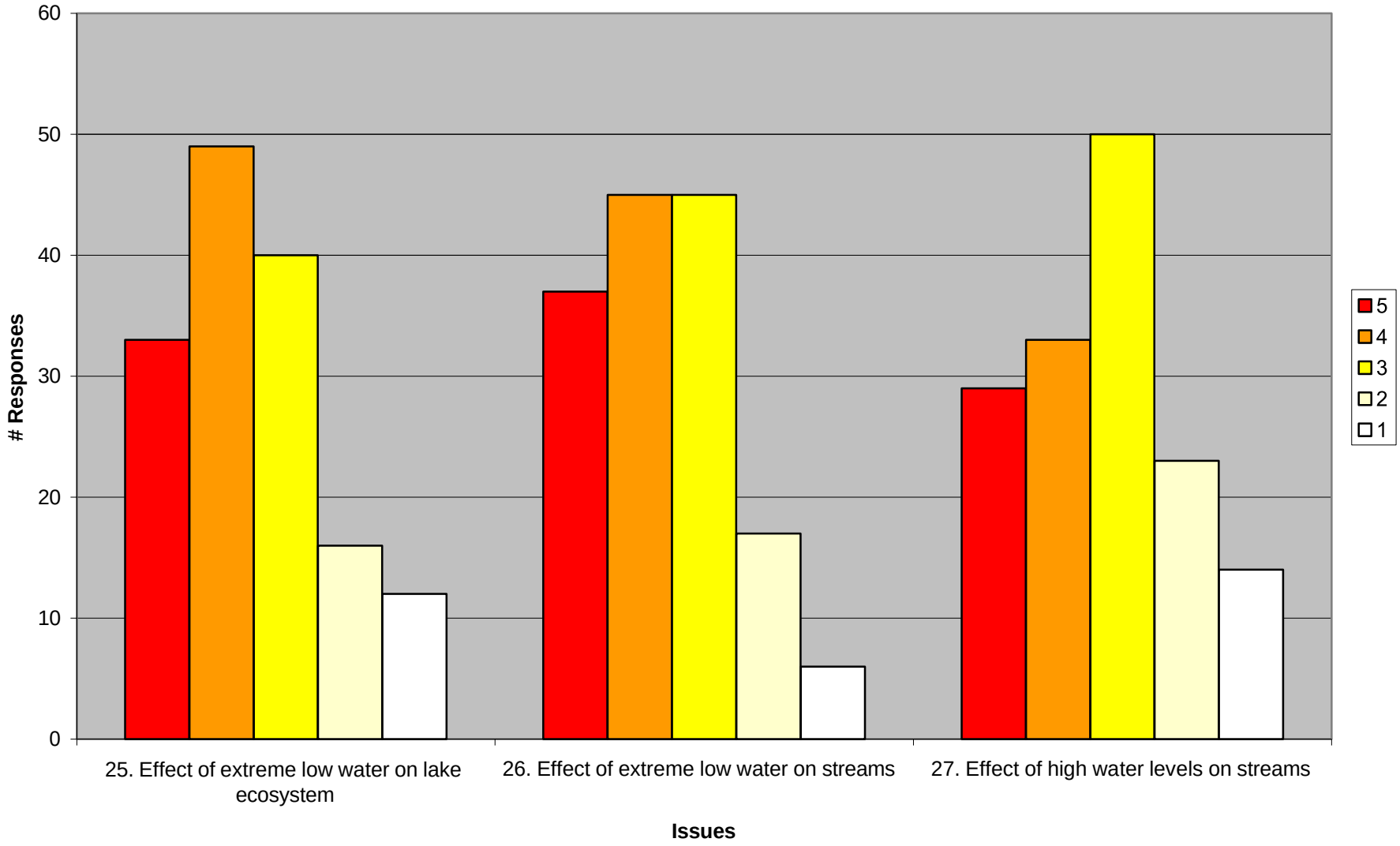
17	Water pollution from motorized boats	**605**	**37**	**4**
18	Residential fertilizer runoff	**595**	**44**	**3**
19	Fisheries sustainability	**586**	**33**	**3**
20	Lack of funding for lake projects	**586**	**40**	**3**
21	Lack of lakeshore development guidelines (ex. Setbacks and buffer zones)	**584**	**40**	**5**
22	Conservation of waterfowl and wildlife habitat	**584**	**29**	**2**
23	Build up of nutrients	**582**	**46**	**3**
24	Clearing of vegetation along streams	**574**	**35**	**2**
25	Lack of public education about lake issues	**574**	**28**	**3**
26	Algae Blooms	**571**	**44**	**3**
27	Recreational Fishery - Kokanee	**565**	**30**	**5**
28	Recreational Fishery - Rainbow Trout	**564**	**31**	**6**
29	Sedimentation/ Muck accumulation	**559**	**45**	**4**
30	Clearing of shoreline vegetation	**556**	**26**	**3**
31	Motorcraft impacts on shorelines (ex. Erosion)	**555**	**29**	**8**

32	Motorcraft impacts on wetlands and waterfowl	**548**	**24**	**6**
33	Lack of land development requirements (ex. Zoning, building permits)	**541**	**29**	**4**
34	Effect of extreme low water on streams	**540**	**24**	**4**
35	Animal waste runoff	**531**	**32**	**8**
36	Lack of community participation	**530**	**22**	**3**
37	Recreational Fishery - Bass	**530**	**26**	**6**
38	Wildlife (Species at Risk)	**526**	**25**	**2**
39	Effect of extreme low water on lake ecosystem	**525**	**21**	**8**
40	Runoff from roads and ditches	**523**	**22**	**5**
41	Effect of high water levels on streams	**487**	**19**	**9**
42	Level of road access to backcountry (habitat fragmentation)	**459**	**15**	**5**
43	Availability of ungulate winter range (deer, elk)	**457**	**17**	**6**
44	Grizzly bear refuge (human impacts)	**456**	**16**	**10**
45	Level of road access to backcountry (recreational/hunting)	**421**	**10**	**10**
46	Other species of concern	**128**	**8**	**5**

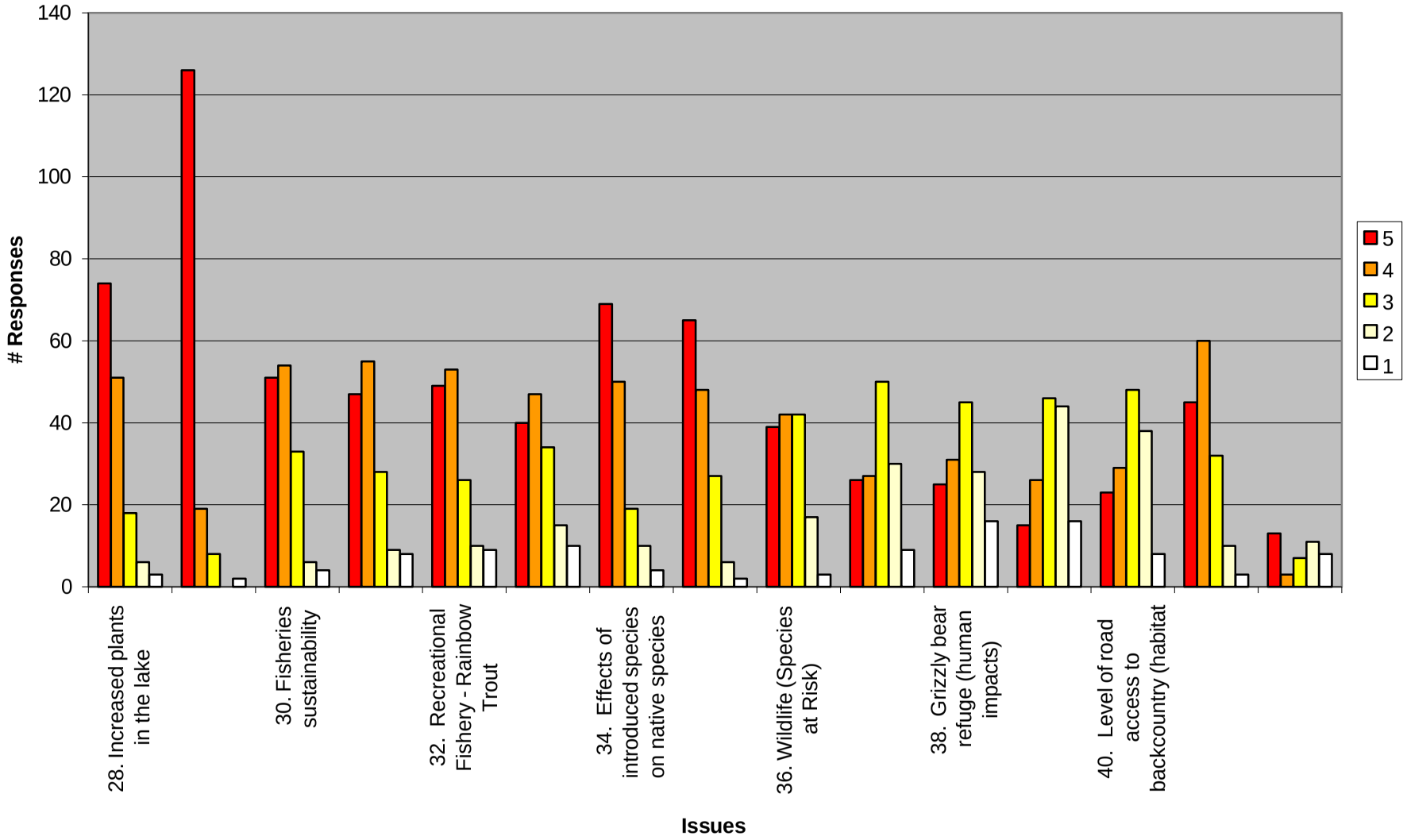
Recreation


100
90
80
70
60
50
40
30
20
10
0
Responses
5
4
3
2
1
21. Poor water quality for swimming
22. Water pollution from motorized boats
23. Motorcraft impacts on shorelines (ex. Erosion)
24. Motorcraft impacts on wetlands and waterfowl
Issues

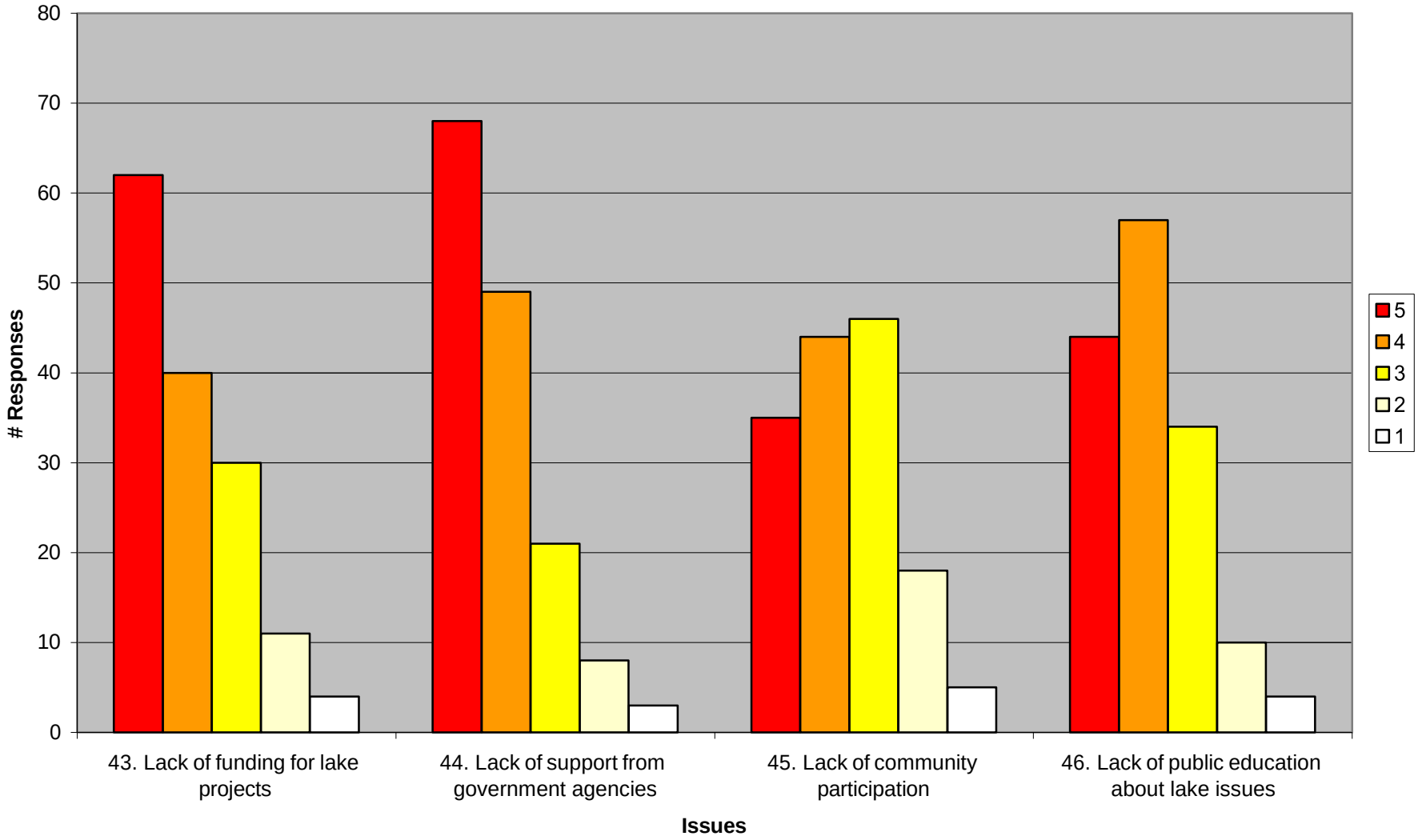

Lake Water Quality
140
120
100
80
60
40
20
0
Responses
1. Algae Blooms
2. Build up of nutrients
3. Water Clarity
4. Sedimentation/ Muck accumulation
5. Bacterial/ Fecal Contamination
6. Drinking water quality
Issues
5
4
3
2
1


Lake/Stream Level Effects
60
50
40
30
20
10
0
Responses
5
4
3
2
1
25. Effect of extreme low water on lake ecosystem
26. Effect of extreme low water on streams
27. Effect of high water levels on streams
Issues

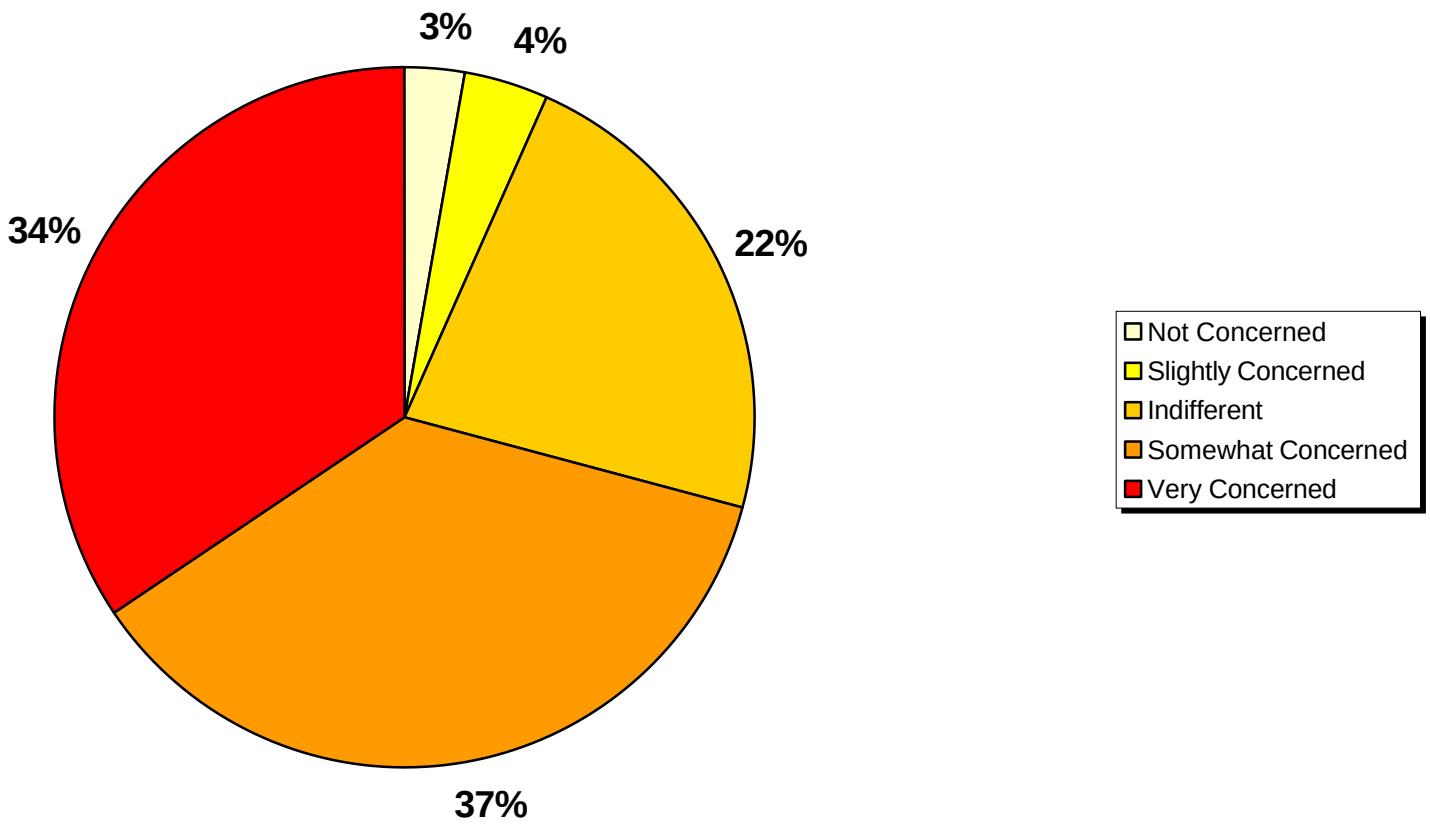
Aquatic Plants / Fisheries, Waterfowl, and Wildlife



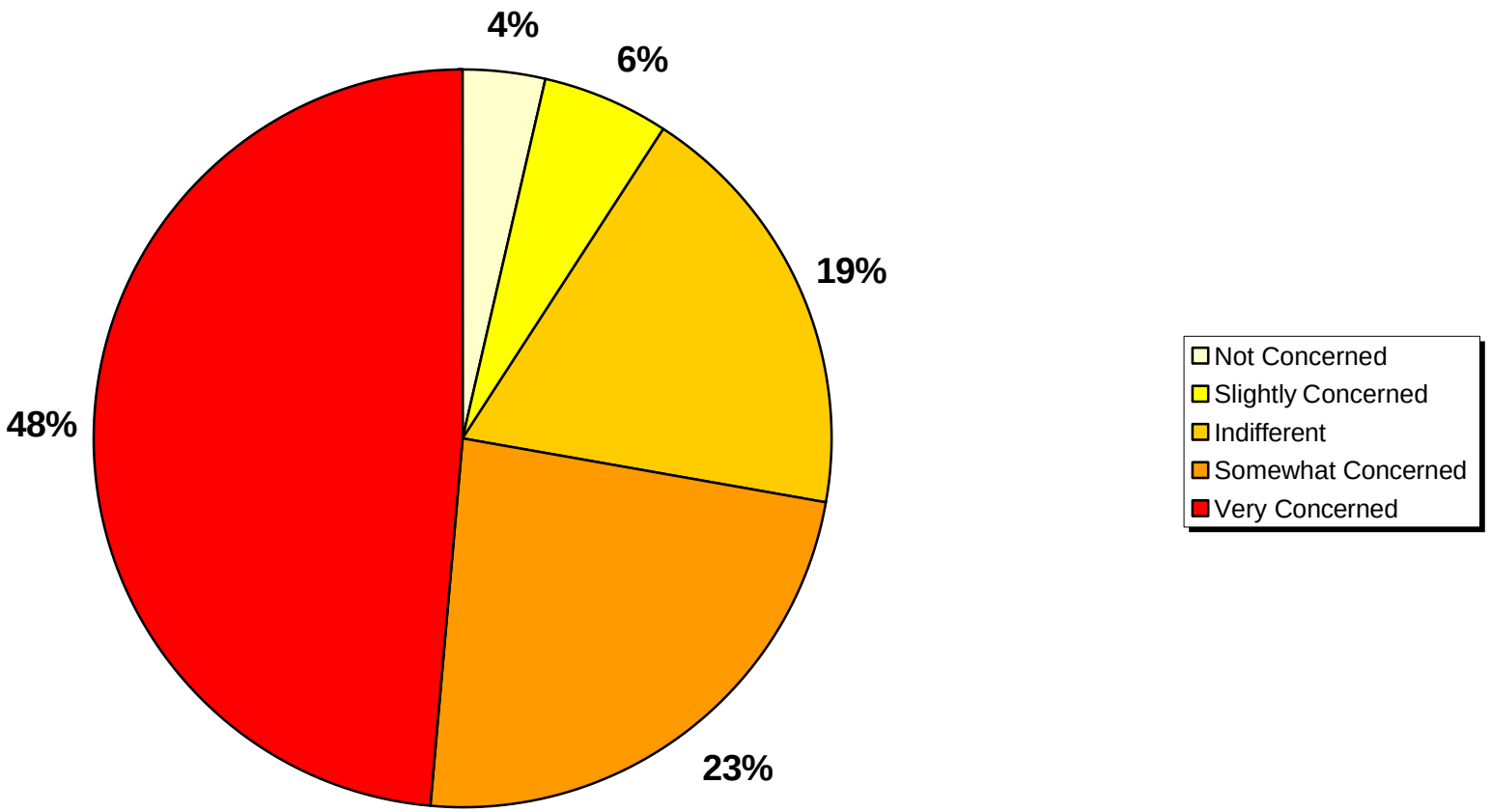
Public Participation



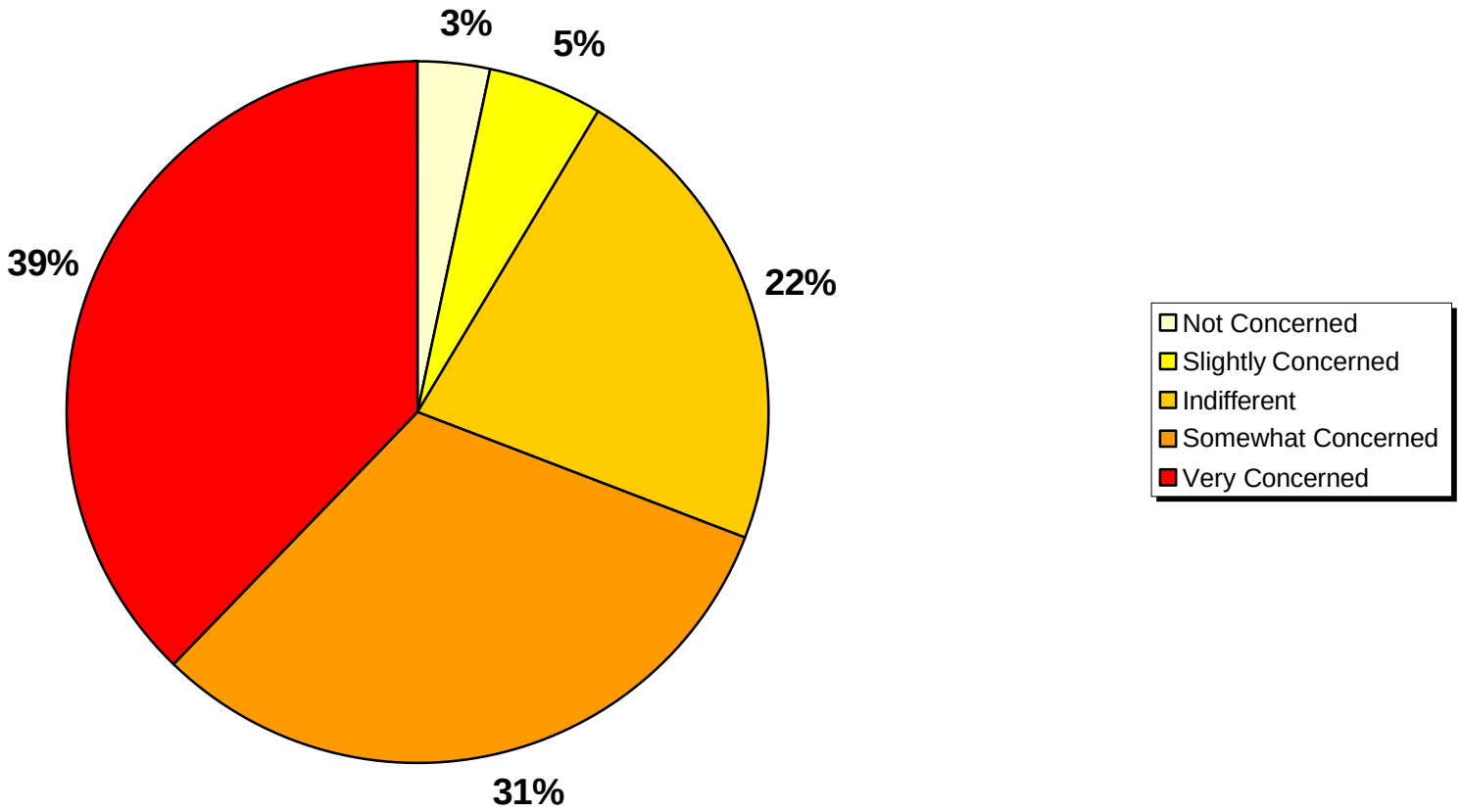
Survey Responses Regarding the State of Christina Lake Fish Stocks



Survey Responses Regarding Christina Lake Water Quality



Survey Responses Regarding Shoreline Development Impacts at Christina Lake



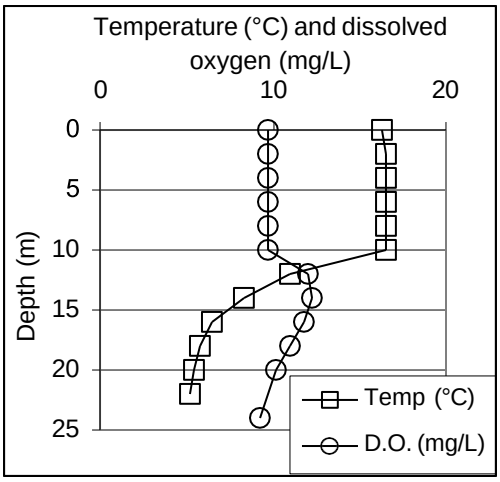


Figure 13.a Depth profiles of temperature and dissolved oxygen at Station 0200078 – Oct 1995.

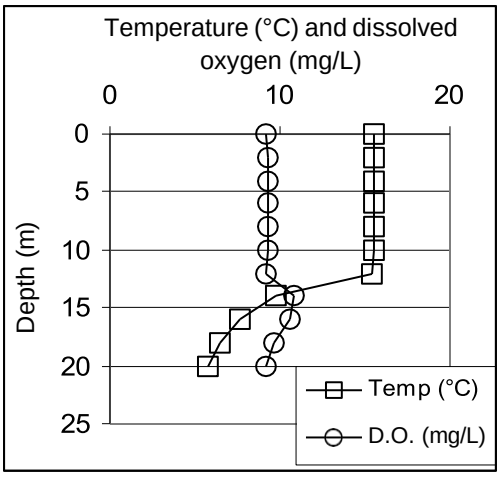


Figure 13.b Depth profiles of temperature and dissolved oxygen at station 0200078 – 03/10/96

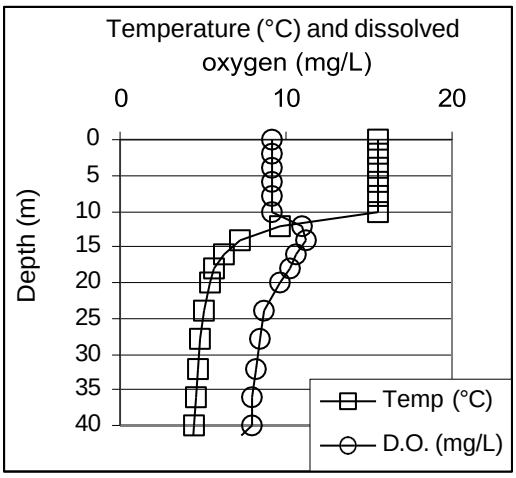


Figure 13.c Depth profiles of temperature and dissolved oxygen at Station 215758 - Oct 1996

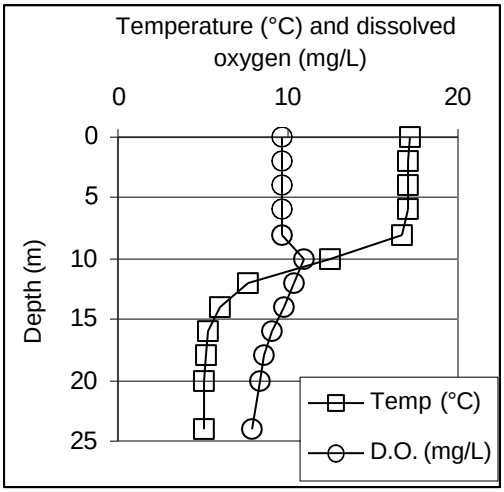


Figure 13. d Depth profiles of temperature and dissolved oxygen at Station 0200078 – 30/09/97

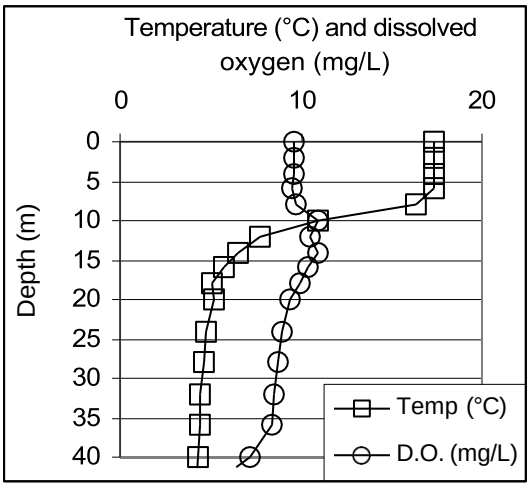


Figure 13. e Depth profiles of temperature and dissolved oxygen at Station 215758 - Sept 1997

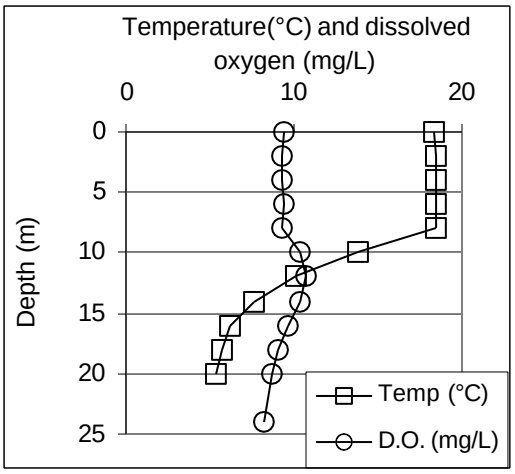


Figure 13. f Depth profiles of temperature and dissolved oxygen at Station 0200078 - Oct 1998

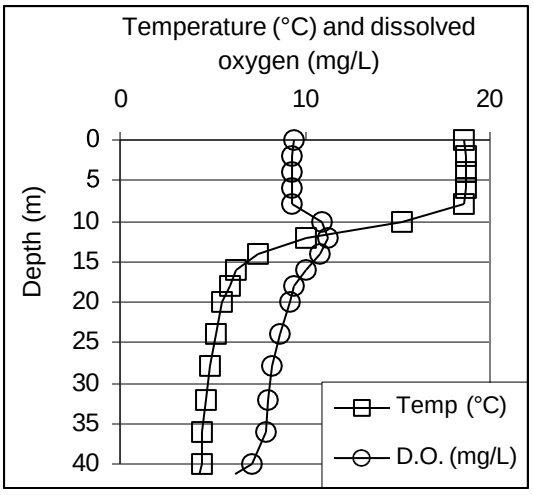


Figure 13. g Depth profile of temperature and dissolved oxygen at Station 215758 - Oct 1998

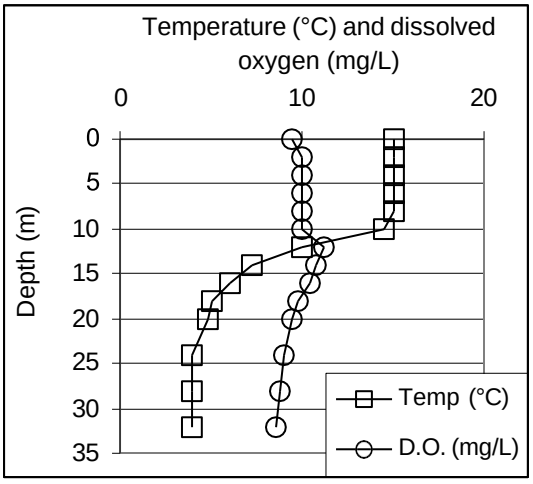


Figure 13. h Depth profiles of temperature and dissolved oxygen at Station 215758 - Sept 1999

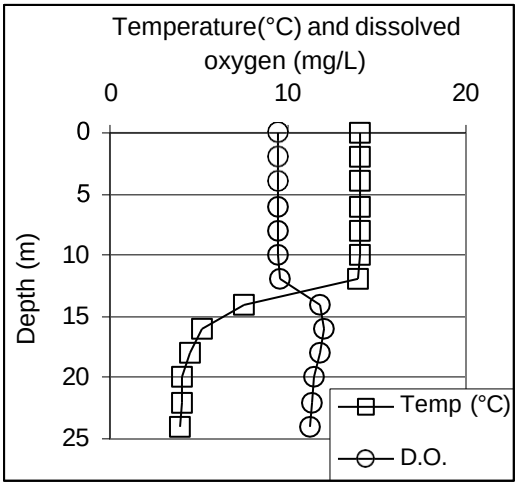


Figure 13. i Depth profiles of temperature and dissolved oxygen at Station 0200078 - Oct 2000

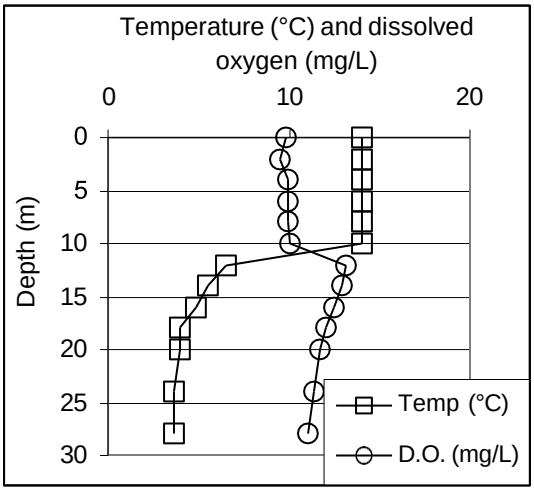


Figure 13. j Depth profiles of temperature and dissolved oxygen at Station 215758 - Oct 2000

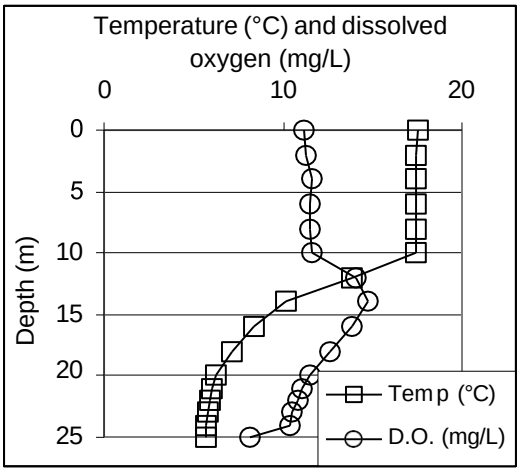


Figure 13. k Depth profiles of temperature and dissolved oxygen at Station 0200078 - Oct 2001

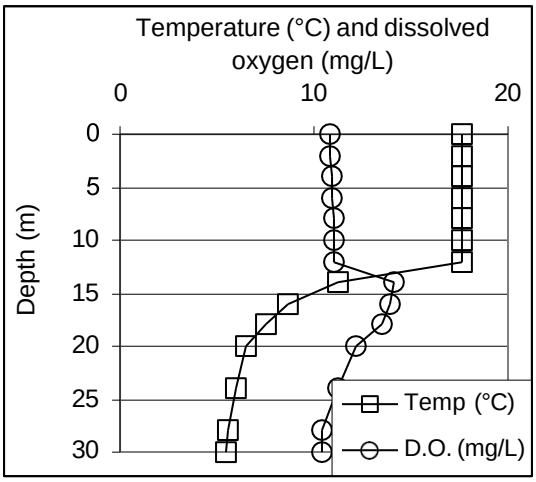


Figure 13. l Depth profiles of temperature and dissolved oxygen at Station 215758 - Oct 2001

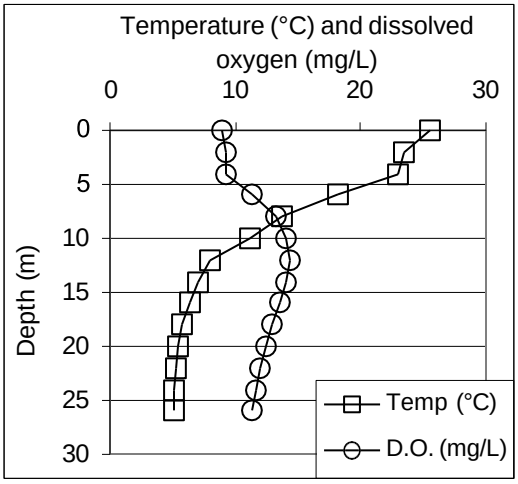


Figure 13. m Depth profiles of temperature and dissolved oxygen at Station 0200078 - July 2002

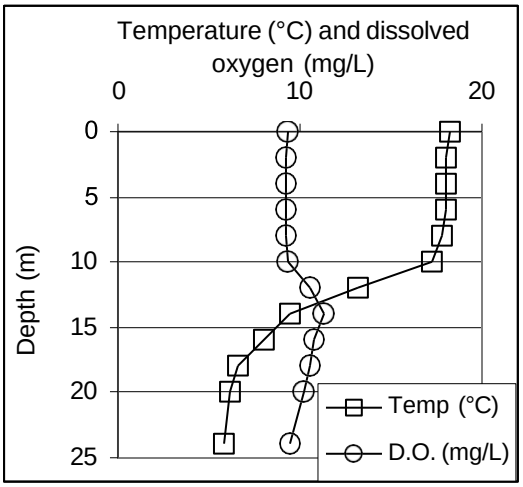


Figure 13. n Depth profiles of temperature and dissolved oxygen at Station 0200078 - Sept 2003

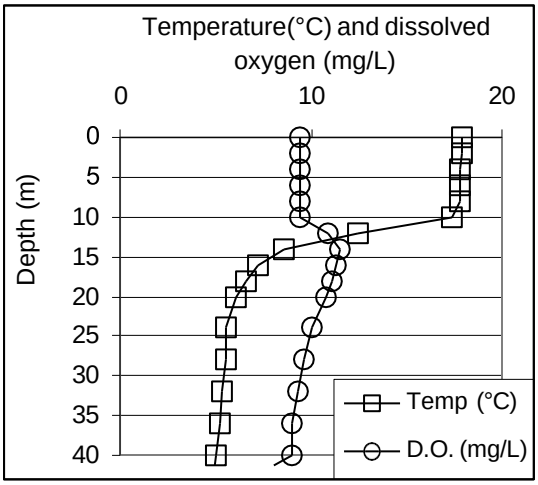


Figure 13. o Depth profiles of temperature and dissolved oxygen at Station215758 - Sept 2003

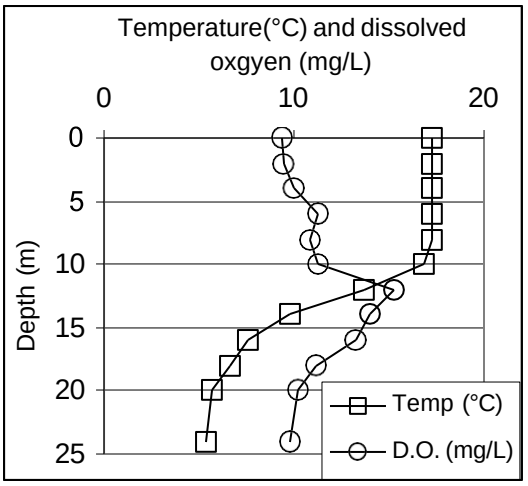


Figure 13. p Depth profiles of temperature and dissolved oxygen at Station 0200078 - Sept 2004

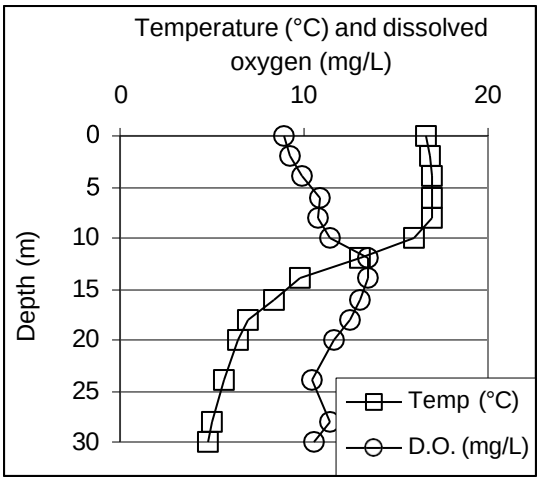


Figure 13. q Depth profiles of temperature and dissolved oxygen at Station 215758 - Sept 2004

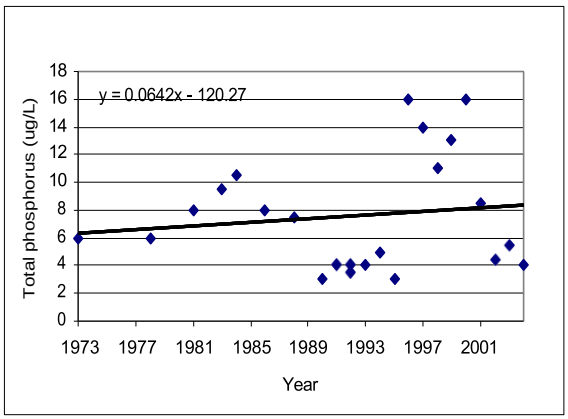


Figure 14. Mean spring overturn phosphorus concentrations at station 0200078, 1973-2004.

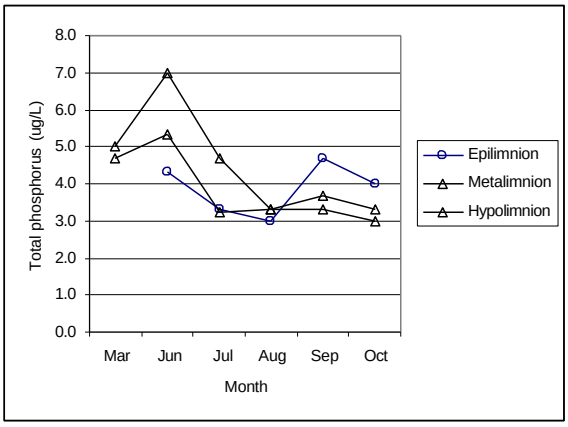


Figure 15. Summer trends in total phosphorus concentrations in Christina Lake 1994.

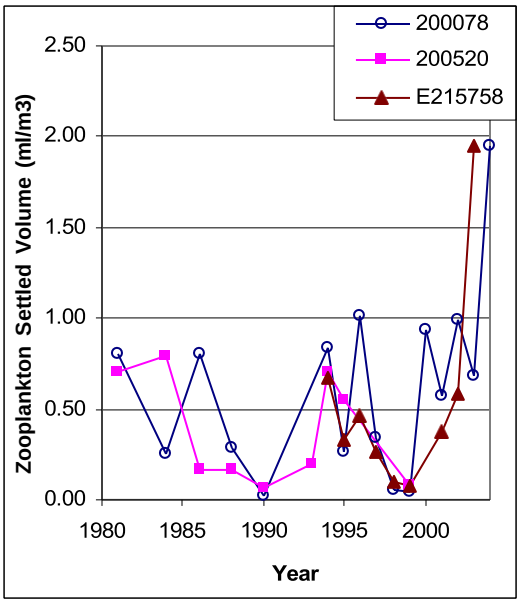


Figure 16a. Spring zooplankton settled volume for deep sampling sites in Christina Lake.

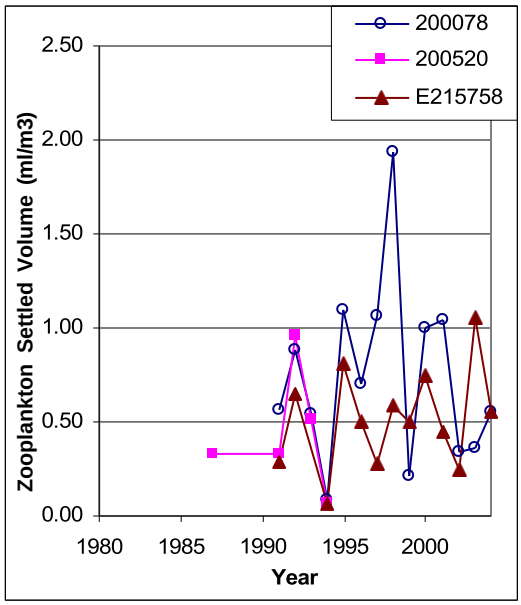


Figure 16b. Fall zooplankton settled volume for deep sampling sites in Christina Lake.

Table 8. a Mineral Tenures

Tenure Number	Claim Name	Map Number	Tenure Expiry/Renewal Date	Status	Area (ha)
393541	Molly Gibson	82E.020	2005/June/30	Good	500.0
393542	Motherlode	82E.020	2005/June/30	Good	500.0
395681	Lode #1	82E.020	2005/June/30	Good	25.0
395682	Lode #2	82E.020	2005/June/30	Good	25.0
395683	Lode #3	82E.020	2005/June/30	Good	25.0
395684	Lode #4	82E.020	2005/June/30	Good	25.0
395685	Lode #5	82E.020	2005/June/30	Good	25.0
395386	Lode #6	82E.020	2005/June/30	Good	25.0
395687	Lode #7	82E.020	2005/June/30	Good	25.0
502048	Tag 1	82E.020	2006/Jan/12	Good	527.857
502135	Tag 2	82E.020	2006/Jan/12	Good	528.079
502201	Tag 3	82E.020	2006/Jan/12	Good	464.371
502262	Tag 5	82E.030	2006/Jan/12	Good	506.462
502293	Tag 6	82E.030	2006/Jan/12	Good	379.736
502361	Tag 10	82E.020	2006/Jan/12	Good	527.846
502403	Tag 12	82E.010	2006/Jan/12	Good	528.844
507156	Ace	82E.030	2006/Feb/15	Good	211.005
509181	Caledonia	82E.010	2006/Mar/17	Good	84.702
				Total Area	**4,933 (ha)**

TABLE 8. b Crown Grant Tenures (2 post claims)

L1145	L13489	L1186S	L5001	L177S	L11137
L962	L5003	L1185S	L5000	L13490	L1753S
L1182S	L5004	L1184S	L5717	L1157	L11137
L1183S	L12489	L14469	L5718	L5002	L5436
L178S	L4331	L14566	L12490	L3879	L12491

Table 10. Fish Presence in Tributaries and Outflow of Christina Lake

	Stream Name	Watershed Code	Perennial (P) Intermittent (I) (Walker, 2004)	Fish Bearing	SPECIES PER FISS DATA	ARL. 2000/2001
1	Sutherland Creek	320-160600-13100	(P)	Yes	Kokanee, Rainbow Trout, Westslope Cutthroat Trout	Kokanee, Rainbow Trout, Westslope Cutthroat Trout, Mottled Sculpin, Prickly Sculpin, Hybrids – Westslope Cutthroat Trout x Rainbow Trout "Cutbow"
2	Baker Creek	320-160600-34400	(I)	No record		
3	Unnamed		?	No record		
4	Spaulding Creek	320-160600-41200	(I)	No record		
5	McRae Creek	320-160600-46500	(P)	Yes	Kokanee, Rainbow Trout	Kokanee, Rainbow Trout
6	Texas Creek	320-160600-56600	(I)	Yes	Rainbow Trout	Rainbow Trout
7	Unnamed	320-160600-67900	?	No record		
8	Unnamed		?	No record		
9	Unnamed		?	No record		
10	Unnamed	320-160600-76300	?	No record		
11	Unnamed	320-160600-76500	?	No record		
12	Trapper Creek	320-160600-78700	(I)	No record		
13	Unnamed		?	No record		
14	Unnamed		?	No record		
15	Unnamed		?	No record		
16	Sander Creek	320-160600-97700	(P)	Yes	Kokanee, Rainbow Trout	Kokanee, Rainbow Trout, Redside Shiner
17	Troy Creek	320-160600-	(P)	Yes,		Rainbow Trout

		96900		ARL 335-1/379-1		
18	Unnamed		?	No record		
19	Unnamed	320-160600-96500	?	No record		
20	Unnamed		?	No record		
21	Unnamed	320-160600-95900	?	No record		
22	Unnamed		?	No record		
23	Seggie Creek	320-160600-88700	(I)	No record		
24	Red Ochre Creek	320-160600-88100	(I)	Yes, ARL 335-1/379-1		Rainbow Trout
25	Unnamed		?	No record		
26	Parson Creek	320-160600-82300	(P)	No record		
27	Treadmill Creek	320-160600-76800	(I)	Yes, ARL 335-1/379-1		Rainbow Trout
28	Unnamed		?	No record		
29	Unnamed	320-160600-60700	?	No record		
30	Unnamed		?	No record		
31	Unnamed		?	No record		
32	Unnamed		?	No record		
33	Gill Creek	320-160600-53000	(I)	Yes, ARL 335-1/379-1		Rainbow Trout
34	Stewart Creek	320-160600-42700	(P)	Yes, ARL 335-1/379-1		Rainbow Trout
35	Unnamed		?	No record		
36	Lighthouse Creek	320-160600-36500	(I)	No record		
37	Unnamed		(P)	No record		

38	Brooks Creek	320-160600-29500	(I)	No record		
39	Unnamed	320-160600-28000	?	No record		Not on TRIM but on FISS
40	Spooner Creek	320-160600-24000	(I)	No record		
41	Clark Creek	No WS code	(I)	No record		
42	Unnamed		(?)	No fish record		On TRIM but not on FISS
43	Christina Creek (outflow)	320-160600-00000	(P)	Yes	Carp, Rainbow Trout	Smallmouth Bass, Pumpkinseed Sunfish, Longnose Sucker, Redside Shiner, Mottled Sculpin

Information for Table 10 was collected from the following sources:
Fisheries Information Summary System (FISS): This online provincial government database contains a catalogue of fisheries information suitable for planning purposes.

Aquatic Resources Limited: Two project reports prepared for the Christina Lake Stewardship Society

1.) Christina Lake Fish and Fish Habitat Inventory ARL, Report No. 335-1 (March , 2000)
A baseline assessment of the current state of Christina Lake's fish fauna and habitats
2.) Christina Lake Creel Surveys and Tributary Surveys, ARL Report No. 379-1 (March, 2001)
Describes the nature, extent and distribution of fish habitats in large Christina Lake Tributaries as well as angling effort and catch via a creel survey

Ron Walker – Local Naturalist: Perennial and intermittent stream information.

Table 11. Stream Spawning Kokanee Enumeration Summary

YEAR	CREEK NAME	Peak Count
2000	Sutherland	MWLAP DATA?
	McRae	MWLAP DATA?
	Sandner	MWLAP DATA?
2001	Sutherland (CLSS)	549
	McRae	MWLAP DATA?
	Sandner	MWLAP DATA?
2002	Sutherland (CLSS)	No fish access due to low or no water at mouth of creek
	McRae	MWLAP DATA?
	Sandner	MWLAP DATA?
2003	Sutherland (CLSS)	738
	McRae	MWLAP DATA?
	Sandner	MWLAP DATA?
2004	Sutherland (CLSS)	696
	McRae (CLSS)	371
	Sandner (CLSS)	5703

Table 19. Confirmed Species at Risk in the Christina Lake Watershed

	Common Name	Scientific Name	Provincial Listing	COSEWIC (SARA)	Information Source
Fish	Westslope Cutthroat Trout	*Oncorhynchus clarki lewisi*	Blue		Aquatic Resources Ltd. (2000)
Amphibians	Tiger Salamander	*Ambystoma tigrinum*	Red	Schedule 1 (endangered)	R. Walker (2005)
Reptiles	Rubber Boa	*Charine bottae*	Yellow	Schedule 1 (special concern)	R. Walker (2000)
	Blue Racer	*Coluber constrictor foxii*	Blue	Schedule 1 (endangered)	R. Walker (2000)
	Gopher Snake	*Pituophis catenifer deserticola*	Blue		R. Walker (2000)
	Western Rattlesnake	*Crotalus oreganus*	Blue		R. Walker (2005)
	Western Skink	*Eumeces skiltonianus*	Blue	Schedule 1 (special concern)	R. Walker (2005)
	Painted Turtle	*Chrysemys picta*	Blue		R.Walker (2000)
Birds	American Bittern	*Botaurus lentiginosus*	Blue		R. Walker (2005)
	Bald Eagle	*Haliaeetus leucocephalus*	Blue		R. Walker (2005)
	Canyon Wren	*Catherpes mexicanus*	Blue		R. Walker (2005)
	Great Blue Heron	*Ardea herodias*	Blue		R. Walker (2005)
	Short-eared Owl	*Asio flammeus*	Blue		R. Walker (2000)
	Western Screech Owl	*Otus kennicottii macfarlanei*	Red		R. Walker (2005)
	Peregrine Falcon	*Falco peregrinus anatum*	Red	Schedule 1 (threatened)	R. Walker (2000)
Mammals	Grizzly Bear	*Ursus arctos*	Blue		R. Walker (2005)
	Wolverine	*Gulo gulo iuscus*	Blue		R. Walker (2005)
	Fisher	*Martes pennanti*	Red		R. Walker (2005)
Dragonflies	River Jewelwing	*Calopteryx aequabilis*	Red		L. Ramsay (2000)
	Western River Cruiser	*Macromia magnifica*	Blue		L. Ramsay (2000)
	Emma's Dancer	*Argia emma*	Blue		L. Ramsay (2000)

	Olive Clubtail	*Stylurus olivaceus*	Red		L. Ramsay (2000)

Plants	Cup Clover	*Trifolium cyanthiferum*	Red		L. Ramsay (2000)
	Nettle-leaved Giant Hyssop	*Agastache urticifolia*	Blue		L. Ramsay (2000)
	False Mermaid	*Floerkea proserpinacoides*	Blue		L. Ramsay (2000)
	Water Marigold	*Megalodonta beckii var. beckii*	Blue		L. Ramsay (2000)
	Silvery Sagebrush	*Artemisia cana*	Red		R. Walker (2005)
	Tall Beggarticks	*Bidens vulgata*	Red		R. Walker (2005)
	Least Moonwort	*Botrychium simplex*	Blue		R. Walker (2005)
	Slender Hawk's Beard	*Crepis atribarba var. atribarba*	Red		R. Walker (2005)
	Purple-leaved Willowherb	*Epilobium ciliatum*	Blue		R. Walker (2005)
	Small Bedstraw	*Galium trifidum var. trifidum*	Blue		R. Walker (2005)
	Small White Waterlily	*Nymphaea leibergii*	Blue		R. Walker (2005)
	Fragrant White Rein Orchid	*Platanthera dilatata var. albiflora*	Blue		R. Walker (2005)
	White Wintergreen	*Pyrola ecliptica*	Blue		R. Walker (2005)
	Pinkfairies	*Clarkia pulchella*	Blue		R. Walker (2005)
	Slender collomia	*Collomia tenella*	Red		R. Walker (2005)
	Tall Bluebells	*Mertensia paniculata*	Blue		R. Walker (2005)

Table 20. Noxious and Introduced Invasive Plants Present or of Concern within the Christina Lake Watershed

Common name *(latin name)*	Weed Act Designation	Present or not in Christina Watershed	BWMC Invasiveness rating	Habitat of concern	Current Management Strategy
Category 1					
Dalmatian Toadflax (*Linaria dalmatica*)	Provincial Noxious	Present	1- Extremely invasive	terrestrial	Biological Control successful
Leafy Spurge (*Euphorbia esula)*	Provincial Noxious	Present	1- Extremely invasive	terrestrial	manual/chemical
Rush Skeletonweed (*Chondrilla juncaea*)	Provincial Noxious	Present	1- Extremely invasive	terrestrial	Education to prevent introduction
Spotted Knapweed *(Centaurea Beiberstein* ii)	Provincial Noxious	Present	1- Extremely invasive	terrestrial	Biological Control starting to have impact
Yellow Starthistle (*Centaurea solstitialis*)	Provincial Noxious	not yet, but close	1- Extremely invasive	terrestrial	Education to prevent introduction
Common Bugloss (*Anchusa officinalis)*	Regional Noxious (RDKB)	no	1- Extremely invasive	terrestrial	Education to prevent introduction
Field Scabious *(Knautia arvense)*	Regional Noxious (RDKB)	no	1- Extremely invasive	terrestrial	Education to prevent introduction
Perennial Pepperweed (*Lepidum latifolium*)	Regional Noxious (other areas)	no	1- Extremely invasive	terrestrial	Education to prevent introduction
Purple Loosestrife *(Lythrum salicaria)*	not listed	no	1- Extremely invasive	riparian/semiaquatic	Education to prevent introduction
Category 2					
Diffuse knapweed (*Centaurea diffusa*)	Provincial Noxious	Present	2- Very invasive	terrestrial	Biological Control successful
Hound's tongue (*cynoglossum offinciale*)	Provincial Noxious	Present	2- Very invasive	terrestrial/riparian	Biological Control/manual
Hoary Alyssum (*Berteroa incana*)	Regional Noxious (RDKB)	Present	2- Very invasive	terrestrial	manual/chemical
Blueweed (*Echium vulgare*)	Regional Noxious(other areas)	Present	2- Very invasive	terrestrial	manual/chemical
Orange Hawkweed (*Hieracium aurantiacu* m)	Regional Noxious (other areas)	Present	2- Very invasive	terrestrial/riparian	manual/chemical
Sulphur Cinquefoil (*Potentilla recta)*	Regional Noxious (other areas)	Present	2- Very invasive	terrestrial	biocontrol under research
Plumeless thistle (*Carduus acanthoide* s)	Regional Noxious (other areas)	not yet, but close	2- Very invasive	terrestrial	Education to prevent introduction
Puncturevine (*Tribulus terrestris)*	Regional Noxious (other areas)	no	2- Very invasive	terrestrial/riparian	Education to prevent introduction
Scotch thistle *(Onopordum acanthium)*	Regional Noxious (other areas)	no	2- Very invasive	terrestrial	Education to prevent introduction
Tansy Ragwort *(Senecio jacobaea)*	Provincial Noxious	no	2- Very invasive	terrestrial	Education to prevent introduction
Category 3					
Bull thistle *(Cirsium vulgare)*	not listed	Present	3- Invasive	terrestrial	monitor
Burdock *(Arctium spp* .)	Regional Noxious(other areas)	Present	3- Invasive	terrestrial	monitor
Canada thistle (*Cirsium arvense*)	Provincial Noxious	Present	3- Invasive	riparian	Biological Control/manual
Common Tansy *(Tanacetum vulgare)*	Regional Noxious (other areas)	Present	3- Invasive	terrestrial/riparian	monitor
Oxeye Daisy (*Chrysanthemum leucanthemum*)	Regional Noxious (other areas)	Present	3- Invasive	terrestrial	monitor
Russian Knapweed *(Acroptilon repens*)	Regional Noxious (other areas)	Present	3- Invasive	terrestrial	manual/chemical
Scentless Chamomile (*Matricaria maritima*)	Provincial Noxious	Present	3- Invasive	terrestrial	manual/chemical
Yellow Toadflax *(Linaria vulgaris*)	Provincial Noxious	Present	3- Invasive	terrestrial	monitor, bioagents present
Other Invasive Plant Species					
Common Mugwort *(Artemesia vulgaris)*	not listed	Present	not listed	riparian	manual
Chicory *(Chicorum intybus)*	not listed	Present	not listed	terrestrial	monitor
Eurasian Watermilfoil *(Myriophyllum spicatum)*	not listed	Present	not listed	Aquatic	ongoing manual program RDKB
Japanese knotweed *(Polygonum cuspidatum)*	not listed	Present	not listed	terrestrial/riparian	monitor
Russian thistle *(Salsola kali)*	Regional Noxious (other areas)	Present	not listed	agricultural	none
Scotch Broom *(Cytisus scoparius)*	not listed	Present	not listed	terrestrial	monitor
Yellow flowered hawkweeds *(Hieracium pratense and others)*	not listed	Present	not listed	terrestrial/riparian	monitor

Table 21. Listing of recreational water sampling results for each of the samples taken at five locations around Christina Lake in 2004.

Date of Sample	Location of Sample	Result of Testing * (faecal coliform per 100mL)
June 28, 2004	Texas Point Beach (Gladstone Provincial Park)	Less than 5
		Less than 5
		Less than 5
	CLARA Beach (Alpine Area)	Less than 5
		Less than 1
		Less than 5
	Skand's Campground	Less than 5
		Less than 5
		Less than 5
	Schullis Campground	9
		Less than 1
		5
	Christina Lake Day Use Area (CL Prov. Park)	Less than 5
		Less than 5
		Less than 5
July 26, 2004	Texas Point Beach (Gladstone Provincial Park)	Less than 5
		Less than 5
		Less than 5
	CLARA Beach (Alpine Area)	Less than 5
		Less than 5
		Less than 5
	Skand's Campground	5
		Less than 5
		Less than 5
	Schullis Campground	5
		Less than 5
		Less than 5
	Christina Lake Day Use Area (CL Prov. Park)	Less than 5
		20
		Less than 5
August 31, 2004	Texas Point Beach (Gladstone Provincial Park)	Less than 5
		Less than 5
		Less than 5
	CLARA Beach (Alpine Area)	Less than 5
		20
		Less than 5
	Skand's Campground	Less than 5
		Less than 5

		Less than 5
	Schullis Campground	Less than 5
		Less than 5
		5
	Christina Lake Day Use Area (CL Prov. Park)	Less than 5
		5
		5

* Note: Samples results that are “less than 5” or “less than 1” faecal coliform per 100mL can be considered zero for all practical purposes (as per BCCDC laboratory).

Table 24. Christina Lake Ice cover

YEAR	ICE ON	ICE OFF	COMMENTS
1959-60		Apr 4/60	
1960-61			No ice
1961-62		Apr 4/62	
1962-63	Feb 3/63	Mar 14/63	
1963-64	Jan 18/64	Apr 8/64	
1964-65	Jan 26/65	Apr 11/65	
1965-66	Feb 25/66	Mar 21/66	Ice on south end only
1966-67			No ice
1967-68	Feb 5/68	Mar 2/68	Ice on south end Jan 10/68
1968-69	Jan 11/69	Apr 10/69	
1969-70	Feb 3/70	Mar 24/70	
1970-71	Feb 1/71	Apr 10/71	
1971-72	Jan 8/72	Apr 6/72	
1972-73	Jan 9/73	Apr 5/73	
1973-74	Feb 9/74	?	
1974-75	Jan 15/75	Apr 15/75	
1975-76	Jan 21/76	Apr 6/76	Open water Lavalley Point to English Point
1976-77	Feb 4/77	Mar 15/77	Ice off lower (southern) half Mar 9/77
1977-78	Jan 20/78	Mar 27/78	
1979-80	Jan 18/80	?	
1980-81			No ice
1981-82	Jan 15/82	Apr 2/82	
1982-83	Jan 10/83	Feb 28/83	
1983-84	Jan 18/84	Apr 2/84	
1984-85	Jan 8/85	Apr 14/85	
1985-86	Dec 4/85	Apr 8/86	
1986-87			No ice
1987-88	Jan 18/88	Mar 25/88	
1988-89	Feb 5/89	Apr 2/89	
1989-90	Jan 22/90	Apr 22/90	
1990-91	Jan 2/91	Apr 6/91	
1991-92			No ice
1992-93	Jan 17/93	?	
1993-94	Jan 2/94	Feb 2/94	Froze again Feb 9/94 to Mar 1/94
1994-95	Dec 30/94	Apr 6/95	
1995-96	Feb 11/96	Apr 5/96	
1996-97	Jan 8/97	Apr 13/97	
1997-98			No ice
1998-99			No ice
1999-00			No ice
2000-01	Jan 13/01	Mar 25/01	
2001-02			No ice
2002-03			No ice
2003-04	Jan 23/04	Mar 18/04	Off with high wind
2004-05	Feb 10/05	Mar 12, 2005	Off with high wind

Table 31. Confirmed and Unconfirmed Fish Species Listing for Christina Lake.

Note: Fish Species collected during the Christina Lake Fish and Fish Habitat Inventory survey - Aquatic Resources Limited report number 335-1 are indicated in bold.

Confirmed

SPECIES	FISH WIZARD	FISS DATA	COMMENTS – (ARL, 2000) unless otherwise referenced
Carp *(Cyprinus carpio)*			**Introduced species**. Present in Christina Lake. Reported in FISS. Collected during survey.
Northern Pikeminnow *(Ptychocheilus oregonensis*)			Present in Christina Lake. Reported in FISS. Collected during survey.
Tench *(Tincta tincta)*			**Introduced species**. Present in Christina Lake. Reported by McPhail and Carveth (1993) and Scott and Crossman (1973).
Bridgelip Sucker *(C. columbianus)*			Present in Kettle River system and in Christina Lake. Collected during survey. Reported in FISS.
Black Catfish "Bullhead" *(Ameiurus melas)*			**Introduced species**. Not previously reported from the Kettle River system. Easily confused with Brown Bullhead (*A. nebulosus*). Collected during survey.
Brown Catfish "Bullhead" *(A. nebulosus)*			**Introduced species**. Present in Christina Lake. Reported in FISS.
Rainbow Trout *(Oncorhynchus mykiss)*			Native and **Introduced Species**. Present in Christina Lake. Reported in FISS. Extensively stocked from 1914 to 1963. See Table 32 for stocking records. Collected in lake and tributaries during survey.
Kokanee *(Oncorhynchus nerka)*			Native and **Introduced** shore spawners. Present in Christina Lake. Reported in FISS. Shore spawning and Stream spawning populations present. See Table 32 for stocking

			records. Collected during survey.
Mountain Whitefish *(Prosopium williamsoni)*			Present in Christina Lake. Reported in FISS. Collected during survey.
Burbot *(Lota lota)*			Present in Christina Lake. Reported in FISS. Not collected during survey, but confirmed from angler reports.
Prickly Sculpin *(Cottus asper)*			Present in Christina Lake. Reported in FISS. Collected during survey.
Slimy Sculpin *(C. cognatus)*			Present in Kettle River. Collected in Sutherland Creek. Recorded in June 1952 Christina Lake Angling Survey per FISS
Largemouth Bass *(Micropterus salmoides)*			**Introduced species**. Present in Christina Lake. Reported in FISS. Collected during the survey.
Smallmouth Bass *(M. dolomieui)*			**Introduced species**. Present in Christina Lake. Reported in FISS. Collected during the survey. RMBC records indicate this species was stocked in CL in 1901 (RBCM, 2005)
Pumpkinseed Sunfish *(Lepomis gibbosus)*			**Introduced species**. Present in Christina Lake. Reported in FISS. Collected during the survey.
Walleye *(Schizostedion vitreum)*			**Introduced species**. Reported in FISS as occurring in Christina Lake.
Tiger Musky (Tiger Muskellunge) (*Esox masquinongy x E. lucius*)			**Introduced species**. Caught by Christina Lake Resident. Photographed (Clemens, 2000). Specimen in freezer at MWLAP Penticton.
Inconnu *(Stenodus leucichthys)*			**Introduced Species.** Recorded in December 1952 Christina Lake Angling Survey (FISS, 2005). This may have been entered in error onto the FISS database as this species range is northern drainages

			(species is similar to whitefish)

Unconfirmed species

SPECIES	FISH WIZARD	FISS DATA	COMMENTS – (ARL, 2000) unless otherwise referenced
White Sturgeon *(Acipenser transmontanus)*			Anecdotal reports from Christina Lake but unconfirmed
Chiselmouth *(Acrocheilus aleuticus)*			Rare species. Present in Kettle River system, but probably not in the Christina Lake Watershed but unconfirmed.
Lake Chub *(Couesius plumbeus)*			Present in Kettle River system. Possibly occurs in Christina Lake, but unconfirmed.
Peamouth Chub *(Mylocheilus caurinus)*			Present in Kettle River system. Possibly occurs in Christina Lake, but unconfirmed.
Longnose Dace *(Rhinichthys cataractae)*			Present in Kettle River system. Mainly river-dwelling, but could potentially occur in Christina Lake but unconfirmed.
Leopard Dace *(R. falcatus)*			Present in Kettle River system. Possibly occurs in Christina Lake, but unconfirmed.
Speckled Dace *(R. osculus)*			Present in Kettle River system. Possibly occurs in Christina Lake, but unconfirmed.
Umatilla Dace *(R. umatilla)*			Present in Kettle River system. Possibly occurs in Christina Lake, but unconfirmed.
Redside shiner *(Richardsonius balteatus)*			Present in Christina Creek downstream from lake. Most likely to occur in Christina Lake but unconfirmed.
Longnose Sucker *(Catastomus catastomus)*			Present in Christina Creek downstream from lake. Most likely to occur in Christina Lake but unconfirmed.
Brown Trout *(Salmo trutta)*			**Introduced** into Kettle River system. Not known for Christina Lake Watershed.
Brook Trout *(Salvelinus fontinalis)*			**Introduced** into Kettle River system. Bob Freeman local resident and avid angler states that he has caught Brook Trout at north end of lake in the

			marsh area near Sandner Creek. (Freeman, 2004)
Mottled Sculpin *(C. bairdi)*			Collected in Christina Creek and Sutherland Creek. Most likely to occur in Christina Lake but unconfirmed.
Shorthead Sculpin *(C. confusus)*			Present in Kettle River. Not recorded from Christina Lake, but may occur. Not confirmed
Torrent Sculpin *(C. rhotheus)*			Present in Kettle River. Not recorded from Christina Lake, but may occur. Not confirmed

Table 32. Stocking Records for Christina Lake (FISS, 2005)

Release Date	Species	Fish Count	Stock	Life Cycle Stage
1901	Bass (smallmouth) (SMB per RBCM, 2004	500	Bay of Quinte	Fry
1914	Rainbow Trout	13,300	Lardeau River	Fry
1915	Rainbow Trout	30,000	Lardeau River	Fry
1916	Rainbow Trout	25,000	Lardeau River	Fry
1919	Rainbow Trout	12,000	Lardeau River	Fry
1920	Rainbow Trout	18,000	Lardeau River	Fry
1923	Rainbow Trout	30,000	Lardeau Fry	Fry
1925	Rainbow Trout	5,000	Lardeau River	Fry
1927	Rainbow Trout	20,000	Pinantan	Fry
1928	Rainbow Trout	15,000	Lardeau River	Eyed Egg
1929	Rainbow Trout	40,000	Lardeau River	Eyed Egg
1930	Rainbow Trout	30,000	Lardeau River	Fry
1931	Rainbow Trout	25,000	Lardeau River	Eyed Egg
1931	Kokanee	20,000	Kootenay	Eyed Egg
1932	Rainbow Trout	25,000	Pinantan	Eyed Egg
1932	Kokanee	50,000	Kootenay	Eyed Egg
1933	Kokanee	150,000	Kootenay	Eyed Egg
1934	Rainbow Trout	35,000	Cottonwood	Eyed Egg
1935	Rainbow Trout	30,000	Cottonwood	Eyed Egg
1936	Rainbow Trout	40,000	Cottonwood	Eyed Egg
1937	Rainbow Trout	40,000	Pennask	Eyed Egg
1938	Rainbow Trout	40,000	Pennask	Eyed Egg
1939	Rainbow Trout	60,000	Lardeau River	Eyed Egg
1940	Rainbow Trout	200,000	Pinantan	Eyed Egg
1940	Kokanee	150,000	Unknown	Eyed Egg
1941	Rainbow Trout	200,000	Pennask	Eyed Egg
1942	Rainbow Trout	200,000	Pennask	Eyed Egg
1943	Rainbow Trout	195,200	Lardeau River	Eyed Egg
1944	Rainbow Trout	180,000	Pennask	Eyed Egg
1945	Rainbow Trout	95,000	Pennask	Eyed Egg
1946	Rainbow Trout	145,680	Pennask	Eyed Egg
1947	Rainbow Trout	130,000	Pennask	Eyed Egg
1948	Rainbow Trout	50,000	Pennask	Fry
1949	Rainbow Trout	100,000	Lardeau River	Fry and Eyed Egg
1950	Rainbow Trout	48,768	Swalwell	Fingerling
1951	Rainbow Trout	31,000	Swalwell	Fingerling and Fry
1952	Rainbow Trout	45,225	Swalwell	Fingerling
1953	Rainbow Trout	71,533	Swalwell	Fingerling

1954	Rainbow Trout	24,990	Loon Creek	Unknown
1956	Rainbow Trout	26,000	Loon Creek	Fingerling
1957	Rainbow Trout	21,500	Swalwell	Fingerling
1958	Rainbow Trout	26,000	California	Fingerling
1959	Rainbow Trout	26,000	Swalwell	Fingerling
1960	Rainbow Trout	26,000	Drew-Wash	Fingerling
1961	Rainbow Trout	26,000	Swalwell	Fingerling
1962	Rainbow Trout	9,000	Drew-Wash	Yearling
1963	Rainbow Trout	26,000	McLeary	Fingerling

Table 33. Introduced Species Account for Christina Lake

INTRODUCED SPECIES	COMMENTS AND POTENTIAL IMPACT ON NATIVE SPECIES
Carp *(Cyprinus carpio)*	The carp was introduced into the Columbia River system in Washington State during the 1880's (Scott and Crossman, 1973), and the fish in Christina Lake are believed to be descendents of these fish which immigrated via the Kettle River. (ARL, 2000)
Tench *(Tincta tincta)*	Populations currently established in BC may have originated from a series of small lakes near Spokane, Washington, where Tench were introduced around 1895 (Carl et al ., 1967)
Black Bullhead *(Ameiurus melas)*	It is believed that Black Bullhead immigrated into Christina Lake from Washington State via the Kettle river. (ARL, 2000)
Brown Bullhead *(A. nebulosus)*	It is believed that Brown Bullhead immigrated into Christina Lake from Washington State via the Kettle river. (ARL , 2000)
Rainbow Trout *(Oncorhynchus mykiss)*	Native and Introduced Stock. Extensively stocked from 1914 to 1963. See Table 7.3.4.1 for stocking records
Kokanee *(Oncorhynchus nerka)*	Native and Introduced shore and stream spawning stock. It is believed shore spawning kokanee have always been present prior to stocking and that stream spawning kokanee were introduced into Christina Lake and not present prior to stocking in the 1930's. (Molnar, 2004) Lincoln Sandner wrote that when his father Charles Sandner came to Christina Lake in 1896, there were literally millions of kokanee in the lake, and they spawned not only on the beaches but also in the creeks (Sandner et al, 1994). See Table 7.3.4.1 for stocking records.
Brown Trout *(Salmo trutta)*	Introduced into Kettle River system. Not known for Christina Lake Watershed. (ARL, 2000)
Brook Trout *(Salvelinus fontinalis)*	Introduced into Kettle River system. Not known for Christina Lake Watershed. (ARL, 2000)
Largemouth Bass *(Micropterus salmoides)*	May have dispersed into the lake from an introduced population in Washington State via the Kettle River. (ARL, 2000) Note per RBMC (2005) it was smallmouth bass that was stocked in 1901 and largemouth bass came here escaped from a private pond near the Kootenai River in Idaho (Carl et al. 1967)
Smallmouth Bass *(M. dolomieui)*	It is believed that Smallmouth Bass immigrated into Christina Lake from an introduced population in Washington State via the Kettle river. (ARL, 2000)

	Note per RBMC (2005) it was smallmouth bass that was stocked in 1901 and largemouth bass came here escaped from a private pond near the Kootenai River in Idaho (Carl et al. 1967)
Pumpkinseed Sunfish (*Lepomis gibbosus*)	It is believed that Pumpkinseed Sunfish immigrated into Christina Lake from an introduced population in Washington State via the Kettle river. (ARL, 2000)
Walleye *(Schizostedion vitreum)*	It is believed that Walleye immigrated into Christina Lake from an introduced population in Washington State via the Kettle River. (G.L. Ventures, 2001)
Tiger Musky (Tiger Muskellunge) (*Esox masquinongy x E. lucius*)	Suspected arrived from Curlew Lake. Sterile Stock. (G.L. Ventures, 2001)
Inconnu *(Stenodus leucichthys)*	Recorded in December 1952 Christina Lake Angling Survey (FISS, 2005). This may have been entered in error onto the FISS database as this species range is northern drainages (species is similar to whitefish)

Table 34. Christina Lake Commercial Kokanee Fishery Catch Estimates (Includes a summary based on the the diary notes of R.A. Wolverton and documented catches of Ole Johnson)

YEAR	POUNDS	LITERARY SOURCE
1898 – 1899 (fall/early winter)	28,000	Scott and Crossman (1973)
*1927	31,400	Stringer (1963)
1935	20,000	Mitchell and LaCroix (2003)
1944	1,275 5,100 (4 fish to the pound/ 100 fish per box = 25 lbs/box = 51 boxes) Previous year 70 fish to a box which indicates the fish were larger the previous year	(Wolverton, 1954)
1945	150 (5 fish to a pound)	(Wolverton, 1954)
1946	550	(Wolverton, 1954)
1947	Did not fish	(Wolverton, 1954)
1948	2,520 (100 fish to a box at 40 lbs/box)	(Wolverton, 1954)
1949	3,136 (100 fish to a box at 40 lbs/box)	(Wolverton, 1954)
1950	140	(Wolverton, 1954)
1951	None for this season	(Wolverton, 1954)
1952	200 (6 fish to a pound)	(Wolverton, 1954)
1953	1,725	(Wolverton, 1954)
1954	2,000	Smith (1974) p 2
1955	90	Smith (1974) p 2
1956	15	Smith (1974) p 2
1962	360	Stringer (1963)

TOTAL IN METRIC TONS = 91,561 lbs ÷ 2,204.6 lbs/metric ton = 41.54 metric tons

Note: Only commercial harvest figures shown. Catch records may not reflect actual total as numerous kokanee commercial licenses were held at this time and documentation for all annual catch totals was not available.

** No daily closures in 1927*

Table 39. CLMP Management Goals and Objectives (Short and Long Term Actions)

*Note : Items in **Bold** font indicate actions recommended for short term implementation (I.e. start up in 2005/2006); other items are subject to annual review to determine if/when implementation can/will occur*

Goal 1: Identify current and potential sources of water quality degradation.

Objective 1.1: Continue with and expand upon current water quality monitoring program(s).

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Organize a volunteer biological water quality monitoring program for major lake tributaries and Christina Creek	**¤Establish/coordinate volunteer biological water quality monitoring program using benthic macroinvertebrate community as water quality indicators ¤Volunteer training would include gathering benthic macroinvertebrate reference collection and simplified method of identifying of benthic macroinvertebrates ¤Organisms could be identified to 'Class' or 'Order' level eliminating the need for costly lab analysis**	**¤Some cost for sample collection equipment**	**¤Inexpensive ¤Generates local interest, local participation ¤Collection of biological data gives more complete picture of water quality than physical/chemical data alone ¤Useful method for assessing long term impacts ¤May be part of a combined monitoring program including Actions D,E, and F. ¤ MWLAP has recent data from Sutherland and Sandner Creeks ¤ MWLAP can provide technical assistance**	**¤Success depends on dedicated volunteers**	**¤ Can WLAP provide insect identification services? ¤ Training? ¤ Volunteer group leader to organize program and reporting mechanisms ¤ Who will take the lead?**
B. Conduct an assessment of groundwater quality	¤In cooperation with WLAP commission a groundwater assessment to determine overall groundwater quality ¤Estimate potential impacts to lake water quality via groundwater	¤Very costly to drill observation wells	¤Provides invaluable data in determining NPS impacts to groundwater quality	¤Requires large time and money commitment to establish program ¤ MWLAP assistance unlikely	¤ Interior Health Authority will be conducting groundwater assessments in the near future as the Sutherland Creek water system moves to a groundwater (well) source rather than the current surface water source. ¤ need to discuss with Des Anderson
C. Support initiatives to implement recommendations made in WLAP's 1994 "Christina Lake Water Quality Assessment and Objectives"	**¤Revisit recommendations made in previous water quality reports and implement as necessary**	**¤Some costs to expand current sampling program ($ amount unknown) ¤Ongoing time commitment from volunteers**	**¤Provides more data to identify sources of water quality degradation ¤ MWLAP has some $$ available for analysis**	**¤Funding sources? ¤Requires committed volunteers**	**¤ MWLAP may have some money available for lab analysis ¤ Expand program to include monthly nutrient and chlorophyll A sampling between April and November and weekly/biweekly secchi measurements (must include near shore sampling) ¤ Committee members would like to see shallow water sampling during the summer and fall as well, could we incorporate this with IHA sampling?**

D. Organize volunteer hydrometric data collection program for Christina Lake, Christina Creek and major tributaries	**¤Coordinate volunteer program to collect water level/flow measurements from permanent measurement structures**	**¤Some cost to install measurement structures, readings taken by volunteers**	**¤Current data is very limited, would provide data set to determine long term trends in water levels ¤ Data may be useful in examining long term trends associated with climate change**	**¤Requires committed volunteers ¤ Assistance from Provincial and Federal governments not available**	**¤ Old gauge site on Christina Creek could be re-established/calibrated ¤ Establish minimum of 2 stations, outflow and 1 inflow ¤ Provincial and Federal governments downsizing hydrometric data programs so no $$ available from them**
E. Organize volunteer water sampling program for major lake tributaries	¤Develop and implement a volunteer water sampling program for Sutherland, McRae, etc. creeks to determine level of impact to lake water quality from non-point sources in the watershed ¤May include metals analysis to determine impact of former mining activities, nutrient analysis, turbidity measurements, sediment trap use and bacteriological analysis	¤Some cost for sampling equipment ¤Analysis could be paid for by MWLAP?	¤Very limited stream data exists, this data would be very valuable in determining long term trends and identifying impacts to water quality	¤ Requires committed volunteers	¤ Need to organize existing data first ¤ Community watershed data and objectives being prepared for Moody and Italy/Sutherland Creeks (Dennis Einarson)

Objective 1.2: Investigate the potential sediment inputs to the lake.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Encourage Best Management Practices for sediment and erosion control for public roads	¤Work in cooperation with Ministry of Transportation, Ministry of Forests, and others responsible for road maintenance to ensure that acceptable, effective erosion control measures are being taken to minimize sediment input	¤ Some time involved with communications	¤ Could potentially reduce sedimentation	¤ May be difficult to monitor success rate	¤ RDKB could/should impose development requirements for those who subdivide/develop to plan for roads, storm water run off, servicing, etc. ¤ Currently there is no Liquid Waste Management plan in place
B. Encourage responsible forestry practices in the watershed	¤Promote Best Management Practices for forest harvesting and road building procedures to minimize sediment inputs to lake tributaries ¤ Identify and work with groups already actively involved in working with resource developers such as the Italy/Sutherland Planning Team to coordinate efforts ¤ Ensure that contingency plans are in place to deal with landslides, floods, and forest fires	¤ Some time involved with communications	¤ Could potentially reduce sedimentation ¤ Could potentially preserve drinking water quality	¤ May be difficult to monitor success rate	¤ In the near(?) future the Drinking Water Protection Act will manage activities that have the potential to harm drinking water quality ¤ Doug Noren will provide more info on P&T's BMP's

C. Conduct lakeshore and tributary survey	**¤Survey the lakeshore and tributaries to identify current and potential sources of sediment input and erosion problems (consider use of sediment traps to confirm suspicions)**	**¤ Could be done by volunteers ¤ Significant time commitment**	**¤Controlling sediment input indirectly helps control nutrient inputs and fecal contamination carried to the lake through surface water runoff**	**¤ Requires use of a boat to survey lakeshore**	**¤ Shoreline video should not be used by CLSS due to privacy issues**
D. Pilot shoreline enhancement project	**¤Seek out property owners wishing to participate in shoreline enhancement project to return part of shoreline to natural habitat using natural vegetation, etc.**	**¤Cost of materials (may get donations) ¤Labour may be provided by volunteers, students, etc.**	**¤ Improved shoreline habitat ¤ Improved ability of shoreline vegetation to intercept nutrients bound for the lake through groundwater ¤ Increased water quality ¤ Increased public awareness of lakeshore development issues directly affecting water quality**	**¤ May be difficult to find property owners willing to participate**	**¤ Real Estate Agents ("On the Living Edge" books) ¤ Set up meeting with shoreline owners and government representatives on shoreline requirements ¤ Directors to organize and coordinate with shoreline property owners to find possible candidates ¤ Donation of native plants/volunteers**
E. Conduct a sediment core analysis	**¤ Collect and analyse a sediment core sample to determine long term trends in ecosystem conditions and changes**	**¤ Very expensive but may be able to get Selkirk College involved**	**¤ Provides data from which inferences can be made about past and present nutrient concentrations of and sediment inputs to the lake**	**¤ High cost may inhibit this type of sampling**	**¤ Contact Selkirk College to determine their capabilities in conducting sediment core sample collection and analysis ¤ Selkirk College has done core sampling on a number of local lakes (analytical capabilities unknown) ¤ Diatom assemblage analysis would have to be done by another organization (UBC, IOS)**

Objective 1.3: Investigate the potential fecal contaminant inputs to the lake.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Implement Actions described under Objective 1.2	¤Fecal contaminants and sediment are often carried to surface water through similar delivery mechanisms (I.e. surface runoff), see above	¤ see above	¤ see above	¤ see above	¤ see above
B. Seek out government subsidy programs for property owners wishing to upgrade septic systems	¤Identify subsidy programs available for residents wishing to upgrade septic systems (OR if programs do not exist urge government to establish such program)	¤ Significant time involved in researching sources and applying for funds	¤Provides incentive for property owners to upgrade systems ¤ Upgrading failing/inadequate septic systems may significantly reduce fecal contamination reaching the lake	¤If funding is available it may be limited ¤Funding likely not available for unincorporated communities	¤ RDKB will have to seek out and apply for this type of funding ¤ Tax incentives??? (RDKB) ¤ Contacted the Canadian Housing and Mortgage Corp. and was told to
C. Install a sewage system	¤ Install a community sewage collection and treatment system	¤ Very expensive	¤ Significant reduction in nutrient and fecal contaminant inputs to the lake ¤ Decreased risk to human health ¤ Increased water quality for drinking and recreation	¤ Very costly ¤ Community has already voted against this due to high cost/increase in taxes ¤ Could not provide service to all areas due to layout of the community	¤ May want to review this at a later date when scientific data is obtained to ascertain conditions (see nutrient model 1.4 D)
D. Conduct a septic inventory	¤ In cooperation with Interior Health, conduct a septic system inventory to identify systems that require upgrading and/or those that are potentially contaminating the lake	¤ Large time commitment	¤ Would identify systems that are likely failing and contributing to water quality degradation	¤ Property owners may be unwilling to participate ¤ IHA septic system data would take significant time to review (see notes)	¤ Interior Health has documentation regarding septic systems but not in digital database

Objective 1.4: Estimate the potential nutrient inputs to the lake.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Implement Actions under Objectives 1.2 and 1.3	¤ Nutrient can be carried to surface water by the same delivery mechanisms (I.e. surface runoff) that carry sediment and fecal contaminants	¤ see above	¤ see above	¤ see above	¤ see above
B. Conduct sediment core analysis	**¤ Obtain and analyze sediment core sample to determine background conditions ¤ See also Action E under Objective 1.2**	**¤ Sample collection may be done by Selkirk College ¤ Sample analysis could be very costly ($5000+)**	**¤ Can have Selkirk College involved in sample collection and analysis (awaiting further info)**	**¤ Sample analysis cost may inhibit this project**	**¤ see 1.2(e)**
C. Conduct nutrient loading modeling	¤ Create a nutrient model (I.e. phosphorus) to determine nutrient loading to the lake	¤ Requires large time and $$ commitment	¤ Identifies sources of nutrient inputs to the lake	¤ All background data required may not be available (I.e. detailed soils data)	¤ Vic Jensen?

Goal 2: Monitor, protect, and restore fisheries and wildlife values.

Objective 2.1: Identify the need for restoring native fish habitat.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Remove fish barriers on Sutherland and McRae Creeks	**¤ Work in cooperation with WLAP to remove fish passage barriers on Sutherland and McRae Creeks or install fish passage structure so fish can access upper reaches**	**¤ costly to remove barriers**	**¤ Increase access to habitat for stream spawning fish such as kokanee and rainbow trout**	**¤ If improperly done, removal of barriers could cause problems downstream (e.g. property damage) ¤ Installation of fish ladders may not be feasible**	**¤ MWLAP cannot recommend any enhancement techniques until habitat assessments are done ¤ Cost? MWLAP/CLSS Partner for funding? (Habitat Conservation Foundation, EcoAction etc.) ¤ Local community member has compiled some statistics on habitat gained and increased fish stock percentage and is willing to volunteer to see the blockage on McRae removed**
B. Implement Action D under Objective 1.2	¤ Restoring shoreline habitat will improve fish habitat	¤ see above	¤ see above	¤ see above	See 1.2 (D) above - short-term action will be implemented

Objective 2.2: Promote fisheries research and data collection to address population knowledge gaps.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes

A. Promote a fisheries inventory study for Christina Lake	**¤ Encourage government agencies (WLAP) to undertake a fisheries inventory to identify species present, confirm suspected species, and assess available habitat** **¤ Acoustic Control Surveys (Basic Stock Assessment Techniques) - Kokanee Escapement, Periodic Creel Surveys**	**¤ Very expensive**	**¤ A comprehensive inventory has not been done, would identify species present, abundance, stock origin, and habitat availability**	**¤ Relies upon commitment by MWLAP to provide professional services, $$, and technical assistance**	**¤ Must fill in gaps and then go forward** **¤ We need to know how many of each stock , age classes, limiting factors etc.** **¤ MWLAP/CLSS Partner for funding**

B. Conduct DNA testing on kokanee, rainbow trout, westslope cutthroat trout (stream resident)	**¤ Initiate a fish sample collection and DNA testing program to determine native, introduced strains, and hybrids**	**¤ Cost could be covered through government funds?**	**¤ Some kokanee DNA testing already being done as part of the 2004/05 Shore Spawning Kokanee Enumeration**	**¤ May be difficult to secure funding/MWLAP cooperation/assistance**	**¤ Must fill in gaps and then go forward ¤ We need to know how many of each stock , age classes, limiting factors etc. ¤ MWLAP/CLSS partner for funding**
C. Conduct a population assessment of Burbot (*Lota lota)*	¤ Work in cooperation with WLAP to commission a study of the population status and effects of non-native species on Burbot in Christina Lake	¤ Cost could be covered through government funds?	¤ Gain understanding of the population status and effects of non-native species on Burbot	¤ Requires commitment from MWLAP which may be unlikely	¤ Must fill in gaps and then go forward ¤ We need to know how many of each stock , age classes, limiting factors etc. ¤MWLAP/CLSS partner for funding
D. Conduct a population and impact assessment on the non-native mysis shrimp (*Mysis relicta)*	¤ Work in cooperation with WLAP to commission a study of the population status of and effects to native species imposed by *Mysis relicta*	¤ Cost could be covered through government funds?	¤ Gain better understanding of the size and distribution of the *Mysis relicta* population in Christina Lake and the effects of this introduced species on native species	¤ Requires commitment from MWLAP which may be unlikely	¤ Andrew - How was this done on Okanagan Lake? ¤ Cost?

Objective 2.3: Improve wildlife habitat

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Promote the establishment of wildlife corridors, natural environment parks, and green spaces	**¤ Work in cooperation with local and provincial governments to maintain habitat connectivity corridors for wildlife movement through the Christina Lake watershed ¤ Encourage the RDKB to build a fund for community projects or land acquisition**	**¤ May involve some land acquisition costs ¤ May qualify for funding from other sources (land conservancy organisations); ¤ Donations of private land**	**¤ Lessens the potential for habitat fragmentation for species which require a large home range (e.g. Grizzly bears (*Ursus arctos horribilis*))**	**¤ May be difficult to gain consensus among property owners/lease holders of lands within wildlife corridors**	**¤ RDKB Park Designation - steering committee just being formed ¤ The Land Conservancy of BC is currently working on some parcels of land within the watershed - "conservation covenants"**
B. Preserve and/or restore habitat for species at risk	¤ After species at risk have been identified through wildlife inventory, undertake small scale habitat restoration projects	¤ Costs would vary depending on size of project	¤ Increase chance of survival for species at risk by providing suitable habitat	¤ May require work over several months/years to determine seasonal use of various habitat types	¤ Need proper inventory of species to determine requirements see 2.4(a)

Objective 2.4: Promote wildlife research and data collection.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Promote a wildlife inventory study for the Christina Lake area	¤ Work in cooperation with government (WLAP) to commission a wildlife inventory study to confirm existing species, confirm suspected species, and identify species at risk within the Christina Lake watershed	¤ Requires large time and money commitment	¤ No wildlife inventory for the area exists, this data would be invaluable	¤ May be difficult to identify species that use habitat seasonally	¤ Who can do? ¤Is MWLAP planning on doing this at some point? ¤ What about BC Parks for the Gladstone area? ¤Selkirk College?
B. Conduct plant surveys	¤ Conduct plant surveys to identify areas of non-native plant infestations	¤ Variable depending on size of project	¤ Increase knowledge of local plants and noxious weed issues	¤ May be difficult to access sites on private property	¤TEM, VRI? - Barb Stewart?
C. Promote a survey of Eurasian watermilfoil infestation sites and conduct inventories of terrestrial noxious and invasive weeds	¤ Encourage MWLAP/RDKB to carry out survey of milfoil sites to determine trends in distribution. Barb Stewart, Boundary Weed Coordinator will be providing schedule information for terrestrial noxious and invasive weeds	¤ Likely requires a large time and money commitment	¤ Data would provide a view of how much and in which locations milfoil infestations are increasing in size, becoming newly established or being kept under control from year to year ¤ Would give an estimate on the success rate of the current milfoil control program	¤ May be difficult to differentiate between native and non-native milfoil	¤ Selkirk College may be interested in participating ¤ Transboundary funding? ¤ Inclusion on noxious weed list? ¤ Federal govt. monitoring spread of milfoil Canada-wide - may have new funding available in the near future ¤ RDKB has a 2 year contract with D.G. Readan and Assoc. to do an assessment on EWM in Christina Lake. Results will be in fall/2005

Goal 3: Increase public awareness of lake management issues and provide workable options for watershed users.

Objective 3.1: Develop and deliver workshops for residents and lake users.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Public education about shoreline impacts	**¤ In cooperation with government reps, host workshops/information sessions on the "do's and don'ts" of shoreline development**	**¤ Relatively low cost**	**¤ Improved water quality, preservation of shoreline habitat**	**¤ Unwillingness of residents to comply with rules and lack of enforcement by government may do little to encourage responsible shoreline development**	**¤ CLSS, Chamber of Commerce - promote to Businesses and Tourists (Brochures)**
B. Pilot noxious weed assessment program	¤ Partner with government agency to conduct property assessments with regard to noxious weed infestations as per the BC Weed Control Act (site visit, recommended procedures to remove weeds, etc.) ¤ Provide incentive? ¤ Could have Selkirk students involved	¤ Relatively low cost ¤ Some cost to property owner for removal methods	¤ Help property owners learn to identify noxious weeds ¤ Recommended removal methods ¤ Increase public awareness of problem weeds	¤ Property owners may be reluctant to participate	¤ Barb Stewart?

C. Encourage residents to make their home/property fire safe	¤ In cooperation with MOF provide public education through workshops and printed information regarding fire safety for interface communities	¤ Some printing costs, any timber removal or other costs would be borne by the property owner	¤ Residents would be better protected from forest fire damage	¤ Cost of thinning may be too much for private property owners to bear	¤ CLSS - invite guest speakers and have community workshops

Objective 3.2: Produce informative material and signage

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Update informative signage	**¤ Update information signage at marina and other public access points regarding milfoil, non-native species, fishing regulations, etc. including contact numbers for further information or reporting purposes**	**¤ Some cost and time for sign production and placement**	**¤ Increase public awareness**	**¤ Signs may be subject to vandalism**	**¤ Multi Partner seek funding - Phoenix Foundation, Vancouver Foundation etc.**
B. Public education on fisheries issues	**¤ Make local fisheries information available through workshops, pamphlets, media releases, etc.**	**¤ Some minor copying costs**	**¤ Increase public awareness of fisheries issues**	**¤ Requires committed volunteers**	**¤MWLAP/CLSS**
C. Public education about non-native plant issues in the Christina Lake watershed	**¤ Make local non-native plant information available through workshops, pamphlets, media releases, etc.**	**¤ Some minor copying costs**	**¤ Increase public awareness about non-native plants**	**¤ Limited as to how much information can be provided (I.e. no database)**	**¤ Barb Stewart?**
D. Encourage residents to become involved in the forest development plan public review process	**¤ Make easy to understand information available for those who wish to participate in the public review process but find the process intimidating**	**¤ Some printing costs for pamphlets/hand outs**	**¤ Increase public awareness about forestry issues**	**¤ Residents may require technical assistance to understand FDP language and mapped information**	**¤ May also include forest health issues within this section ¤ Doug Noren and Randy Waterous - P & T put on their website; OK to put on ours?**
E. Continue media releases	**¤ Continue to supply media releases about lake management issues, volunteer opportunities, and projects to local newspapers**	**¤ May require some time for research**	**¤ Increase public awareness of lake issues ¤ Inform public of volunteer opportunities**	**¤ Information may not reach tourists or seasonal residents who do not read local papers**	**¤ CLSS**

F. Provide brochures to vacation rental agency	**¤ Distribute 'green guest guide' and 'shoreline living' brochures to local vacation property rental agencies**	**¤ Some printing costs**	**¤ Encourages guests to minimize impact on local environment ¤ Informs visitors of local issues**	**¤ Guests may not read material or be overwhelmed if too much is presented at once**	**¤ CLSS, Chamber of Commerce, real estate agents, vacation property rental agencies**
G. Develop and deliver an internet-based habitat atlas for the Christina Lake watershed	**¤ Delivered through the Community Mapping Network ¤ Online tutorial how to view, query, and use the atlas**	**¤ $5,000-$10,000**	**¤ All resource information would be available on the Internet for free viewing ¤ Parts of the plan including zoning could be made available**	**¤ Difficult to determine success**	**¤ Brad Mason, RDKB, CLSS - Need some funding to continue to set up CMN - very important to keep all data current and continue progression of information/ includes analytical work as well**
H. Develop and deliver a map-based pamphlet about natural resources in the Christina Lake watershed	**¤ Delivered through the GIS resources at Selkirk College**	**¤ Printing costs**	**¤ Something that could reach all households and businesses for outreach and education**	**¤ Not everyone has access to the Internet ¤ Small learning curve to use and access the information ¤ Must be kept up to date**	**¤ Need some funding**
I. Support initiatives to phase out 2 stroke engines from the lake	¤ Investigate other lakes who have implemented 'phase-out' strategies and determine feasibility to see how this might work at Christina Lake	¤ Some cost for signage	¤ Could potentially reduce the risk of hydrocarbon contaminants reaching surface water, soil, sediment, food chain, etc.	¤ Possible high impact to boat owners as costs to replace motor may be beyond financial means	¤ Some information has been gathered detailing the negative ecological impacts of 2 stroke engines ¤ Need scientific proof that there is an impact on the lake from boats with two stroke engines - fuel spillage etc.
J. Provide information on impact of fertilizer/pesticide use	**¤ Distribute brochures and produce media releases ¤ Encourage businesses to promote environmentally friendly products**	**¤ Some printing costs for brochures, pamphlets**	**¤ Would inform residents on how to minimize nutrient/chemical inputs to surface/groundwater, soil, sediment, food chain, etc. ¤ Could potentially reduce amount of nutrient/chemical input to surface/groundwater, soil, sediment, food chain**	**¤ May be difficult to convince people to change products ¤ Some people may not see the harm in using products that are not considered enviro friendly ¤ Some businesses may not want to discontinue products that are high sellers and not enviro friendly**	**¤ Some research involved ¤ One on one contact with businesses ¤ Brochure development and print out and delivery**

Objective 3.3: Coordinate community involvement activities.

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Apply for a Community Forest License through the MOF	¤ The MOF is currently taking back annual allowable cut from their major licensees and through their Forest Revitalization Program there are potential options for communities to apply for a license	¤ Initial costs will be high and timeline is over years not months	¤ Long term community economic development resulting in the increased self-reliance of rural communities, local employment, local level decision making , increased potential to resolve conflicts over timber harvesting in watersheds, protection of drinking watersheds, and other values that are important to the community, opportunities for education and research (eco-certification etc.)	¤ See notes in next column	¤ New Community Forest Guidebook in the office ¤ Require strong local desire to manage local forests, enthusiasm for community forestry, leadership, local and technical knowledge ¤ Must have evidence of an appropriate forest land base, evidence of community support and involvement, sound business plan, democratic and pratical administrative authority and structure in place, stewardship and management objectives ¤ Must be realistic (not a "get rich quick scheme"), requires a lot of work and time ¤ The Community Forest Advisory Committee (CFAC) stated that proposals produced by community members stood out from those produced by external consultants, access to sufficient financial capital to cover start-up costs, political support and business sense, a meaningful forest tenure with sufficient duration, security and scope with a an area based long term license with a financially viable allowable annual cut (balanced age-class distribution)
B. Coordinate Community "Milfoil Pull" day	**¤ Coordinate community volunteers to pull milfoil from heavily infested areas**	**¤ Little to no cost**	**¤ Increase public awareness about milfoil problem**	**¤ Native vegetation may be mistaken for non-native milfoil**	**¤ CLSS, RDKB and Volunteers**
C. Coordinate Lake Clean Up Day event	**¤ Coordinate an event to get local residents and lake users involved in community clean up activities ¤ Provide BBQ lunch, prizes**	**¤ Donation by local grocers for juice and prizes, Chamber of Commerce for hotdogs etc., garbage pick up local business donation ¤ Boat and volunteers to do north end of lake, diving club, RDKB waives dump fees**	**¤ Community involvement, makes community more visually appealing for locals and tourists**	**¤ Requires several volunteers**	**¤ CLSS and Partners (Pitch in Canada Application supplies garbage bags and stickers)**

D. Coordinate BC River's Day event	¤ Coordinate an event in conjunction with BC River's Day	¤ Unknown at this time	¤ Review options, Kettle River is on the endangered Rivers List	¤ Requires several volunteers	¤ MWLAP/CLSS/Partners
E. Coordinate Lake Awareness Day event	¤ Coordinate local lake awareness day activities ¤ Invite other groups to participate ¤ Booth set-up, draw prizes	¤ Little or no cost	¤ Educational forum on a vast array of topics	¤ Requires several volunteers and the involvement of all partners ¤ Community participation and interest?	¤ CLSS, Businesses and Partners
F. Promote land acquisition and conservation of DL 498				¤ Requires several volunteers and the involvement of all partners ¤ Community participation and interest?	¤ CLSS, Businesses and Partners

Objective 3.4: Develop and deliver school programs

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Develop and deliver school program about fisheries issues	¤ Coordinate with local schools to deliver fisheries education programs to various grade levels	¤ Some time involved in gathering resources and developing lesson plans	¤ Countless educational resources available online	¤ No apparent disadvantages	¤ CLSS/Partners ¤ Some funding required for incentive prizes etc.
B. Develop and deliver school program about water quality	¤ Coordinate with local schools to deliver water quality education programs to various grade levels	¤ Some time involved in gathering resources and developing lesson plans	¤ Countless educational resources available online	¤ No apparent disadvantages	¤ CLSS/Partners ¤ Some funding required for incentive prizes etc.

Goal 4: Create and maintain a locally-based resource library that will be accessible to the public.

Objective 4.1: Establish a data retrieval system

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Establish a method of receiving and updating data	¤ Work with WLAP, Interior Health, DFO, etc. to establish a method of receiving data as it is available	¤ Time required to organize method of data exchange/delivery	¤ Current data will be available to residents wishing to review it ¤ Data from various sources will be available for comparison	¤ There may be a significant delay between data collection and reporting	¤ It is essential to have a long term custodian of all the CLMP data and this data must be updated as new information is received - CLSS, Selkirk, RDKB, MWLAP, CMN

B. Seek out long term funding sources to sustain Community Stewardship Resource Centre (CSRC)	**¤ The CSRC provides a central location from which recommended actions may be coordinated** **¤ The CSRC provides space to house local data/information**	**¤ Funds for office rental, services (phone, fax, Internet), etc. are required**	**¤ Coordinating CLMP projects from a central location makes it easier to monitor success** **¤ The CSRC houses a vast array of local data that will be useful in implementing action items**	**¤ Long term funding sources may be difficult to find**	

Goal 5: Sustain the Christina Lake community and local economy within the context of a healthy watershed.

Objective 5.1: Sustain the CLMP through volunteerism and an annual review process

Action	Description	Cost/Time Estimate	Advantages	Disadvantages	Notes
A. Secure core funding to support Community Stewardship Resource Centre (CSRC)	¤ The CSRC houses an extensive data library and is the most logical place from which to coordinate CLMP implementation projects	¤ Long-term/multi year funding is required to ensure that CSRC stays open ¤ CLSS should consider establishing an endowment fund to ensure funding for CSRC	¤ see description notes	¤ Funding may be difficult to secure for long term	
B. Build and maintain a constituency of involved citizens	¤ Successful implementation of recommendations will require committed volunteers	¤ Some time required for volunteer recruitment	¤ Generates local interest and gives area residents/tourists the opportunity to learn more about local issues	¤ Maintaining an adequate volunteer base is a challenge	
C. Secure a Memorandum of Understanding-type agreement to ensure long term commitment by CLMP participants	¤ An agreement should be reached between the CLSS and CLMP participants to determine future level of involvement in the annual review process, consultation, and funding potential for various types of projects	¤ Some time to draft an agreement that suits each participant	¤ Ensures commitment of participants in future CLMP initiatives	¤ Some participants may not be willing to commit to future work	
D. Produce an annual CLMP progress report	¤ An annual report should be drafted to update participants, the public, etc. on the success of implemented actions and the future focus of activities related to the CLMP	¤ Time and salary money required	¤ Reporting on progress is an important	¤ Will require time commitment by CLSS appointed/hired individual	

Table 9. Water Licenses within the Christina Lake Watershed (LWBC, 2004)

Source	Licence #	Purpose	Quantity	Unit
Ann Spring No. 1	C108339	Domestic	500	gal/day
Ann Spring No. 1	F039827	Domestic	500	gal/day
Ann Spring No. 1	F109664	Domestic	500	gal/day
Ann Spring No. 2	C108339	Domestic	500	gal/day
Ann Spring No. 2	F039827	Domestic	500	gal/day
Ann Spring No. 2	F109664	Domestic	500	gal/day
Aquarius Brook	C040756	Irrigation	40	acre feet
Baker Creek	C022856	Domestic	2000	gal/day
Bart Creek	C047158	Domestic	500	gal/day
Christina Lake	C040308	Domestic	500	gal/day
Christina Lake	C052493	Domestic	500	gal/day
Christina Lake	C059373	Domestic	1500	gal/day
Christina Lake	C062855	Domestic	500	gal/day
Christina Lake	C070135	Domestic	500	gal/day
Christina Lake	C103754	Domestic	500	gal/day
Christina Lake	C114849	Waterworks Local Auth	9125000	gal/yr
Copper Creek	C046150	Domestic	500	gal/day
Copper Creek	C046150	Irrigation	25	acre feet
Copper Creek	F066253	Domestic	1000	gal/day
Dyson Spring	C026701	Domestic	500	gal/day
Dyson Spring	C044357	Domestic	500	gal/day
Dyson Spring	C066416	Domestic	500	gal/day
Dyson Spring	C066417	Domestic	500	gal/day
Dyson Spring	C114634	Domestic	500	gal/day
Dyson Spring	F039726	Domestic	500	gal/day
Dyson Spring	F039728	Domestic	500	gal/day
Dyson Spring	F041114	Domestic	500	gal/day
Earhart Creek	C053779	Domestic	500	gal/day
Earhart Creek	C059416	Domestic	500	gal/day
Ferraro Spring	C064204	Domestic	500	gal/day
Gill Creek	C023680	Domestic	1500	gal/day
Gill Creek	C025442	Domestic	500	gal/day
Gill Creek	C041542	Domestic	500	gal/day
Gill Creek	C045607	Domestic	1000	gal/day
Gill Creek	C111710	Domestic	500	gal/day
Gill Creek	C111711	Domestic	500	gal/day
Hofer Creek	C058081	Domestic	500	gal/day
Italy Creek	C042709	Domestic	500	gal/day
Lighthouse Creek	F018168	Domestic	500	gal/day
Maida Creek	C120259	Irrigation	20	acre feet
Maida Creek	F039946	Domestic	500	gal/day
McRae Creek	C064235	Domestic	500	gal/day
McRae Creek	C064235	Irrigation	50	acre feet
McRae Creek	C066603	Ponds	0.001	cubic feet/sec
McRae Creek	C115221	Irrigation	4	acre feet
Moody Creek	C018809	Waterworks Local Auth	3650000	gal/yr
Moody Creek	C028819	Waterworks Local Auth	14600000	gal/yr

Moody Creek	C038036	Waterworks Local Auth	73000000	gal/yr
Moody Creek	C059417	Irrigation	20	acre feet
Moody Creek	C059418	Storage	20	acre feet
Moody Creek	C066319	Irrigation	5	acre feet
Moody Creek	C119885	Domestic	500	gal/day
Moody Creek	C119885	Irrigation	5	acre feet
Moody Creek	F013272	Domestic	1000	gal/day
Moody Creek	F019280	Waterworks Local Auth	2190000	gal/yr
Moody Creek	F041001	Waterworks Local Auth	3467500	gal/yr
Murphy Spring	C039658	Domestic	1000	gal/day
Palma Spring	C119746	Domestic	1500	gal/day
Palma Spring	C119747	Domestic	1500	gal/day
Parson Creek	C039990	Domestic	500	gal/day
Parson Creek	C047785	Domestic	500	gal/day
Parson Creek	C106310	Domestic	500	gal/day
Red Ochre Creek	C112785	Domestic	500	gal/day
Red Ochre Creek	C113101	Domestic	500	gal/day
Robinson Spring	C115812	Domestic	500	gal/day
Robinson Spring	C115812	Stockwatering	500	gal/day
Spooner Creek	C049757	Domestic	500	gal/day
Spooner Creek	F015282	Domestic	1000	gal/day
Spooner Creek	F019573	Domestic	1000	gal/day
Stepkinson Brook	F017838	Domestic	500	gal/day
Stepkinson Brook	F017972	Domestic	500	gal/day
Stepkinson Brook	F019539	Domestic	500	gal/day
Stepkinson Brook	F019707	Domestic	500	gal/day
Stepkinson Brook	F061827	Domestic	1000	gal/day
Stewart Creek	C024431	Domestic	500	gal/day
Stewart Creek	C031939	Domestic	500	gal/day
Stewart Creek	C032012	Domestic	500	gal/day
Stewart Creek	C039900	Domestic	500	gal/day
Stewart Creek	C043333	Domestic	500	gal/day
Stewart Creek	C052996	Domestic	500	gal/day
Stewart Creek	C060475	Domestic	500	gal/day
Stewart Creek	C062151	Domestic	500	gal/day
Stewart Creek	C105106	Domestic	500	gal/day
Stewart Creek	C117269	Domestic	500	gal/day
Stewart Creek	F018307	Domestic	500	gal/day
Stewart Creek	F019120	Domestic	500	gal/day
Stewart Creek	F067373	Domestic	500	gal/day
Stewart Creek	F067373	Domestic	500	gal/day
Stewart Creek	F067374	Domestic	500	gal/day
Sutherland Creek	C045606	Waterworks Local Auth	27375000	gal/yr
Sutherland Creek	C046151	Domestic	2000	gal/day
Sutherland Creek	C057724	Domestic	500	gal/day
Sutherland Creek	C058667	Domestic	500	gal/day
Sutherland Creek	C058668	Domestic	500	gal/day
Sutherland Creek	C058669	Irrigation	3	acre feet
Sutherland Creek	C058670	Domestic	1000	gal/day
Sutherland Creek	C058672	Irrigation	3	acre feet

Sutherland Creek	C058673	Domestic	500	gal/day
Sutherland Creek	C059201	Irrigation	12.5	acre feet
Sutherland Creek	C059202	Irrigation	31.25	acre feet
Sutherland Creek	C060449	Domestic	500	gal/day
Sutherland Creek	C060449	Irrigation	7.5	acre feet
Sutherland Creek	C060450	Domestic	500	gal/day
Sutherland Creek	C060450	Irrigation	30	acre feet
Sutherland Creek	C060451	Domestic	500	gal/day
Sutherland Creek	C060451	Irrigation	7.5	acre feet
Sutherland Creek	C060452	Domestic	500	gal/day
Sutherland Creek	C060453	Domestic	500	gal/day
Sutherland Creek	C060453	Irrigation	25	acre feet
Sutherland Creek	C060454	Irrigation	10	acre feet
Sutherland Creek	C060456	Domestic	500	gal/day
Sutherland Creek	C060456	Irrigation	2.5	acre feet
Sutherland Creek	C060457	Domestic	500	gal/day
Sutherland Creek	C060457	Irrigation	2.5	acre feet
Sutherland Creek	C060473	Waterworks Local Auth	27375000	gal/yr
Sutherland Creek	C062261	Domestic	500	gal/day
Sutherland Creek	C066372	Domestic	500	gal/day
Sutherland Creek	C106880	Domestic	500	gal/day
Sutherland Creek	C108743	Irrigation Local Auth	14.75	acre feet
Sutherland Creek	C108744	Irrigation Local Auth	10.875	acre feet
Sutherland Creek	C109696	Domestic	500	gal/day
Sutherland Creek	C115810	Irrigation	17.5	acre feet
Sutherland Creek	C116551	Domestic	500	gal/day
Sutherland Creek	C118458	Domestic	500	gal/day
Sutherland Creek	C119939	Domestic	500	gal/day
Sutherland Creek	C120014	Domestic	500	gal/day
Sutherland Creek	C120014	Irrigation	17.5	acre feet
Sutherland Creek	F017086	Domestic	500	gal/day
Sutherland Creek	F019082	Domestic	500	gal/day
Sutherland Creek	F046485	Domestic	500	gal/day
Swetland Springs	C040567	Domestic	1000	gal/day
Swetland Springs	C040567	Irrigation	40	acre feet
Swetland Springs	C040567	Domestic	1000	gal/day
Swetland Springs	C040567	Irrigation	40	acre feet
Szimmer Slough	C024548	Irrigation	42	acre feet
Texas Creek	F013311	Domestic	1000	gal/day
Texas Creek	F015276	Domestic	1000	gal/day
Texas Creek	F019080	Domestic	1000	gal/day
Treadmill Creek	C105326	Domestic	500	gal/day
Treadmill Creek	C115146	Domestic	500	gal/day
Walker Creek	C039901	Domestic	500	gal/day
Woodley Creek	C036605	Domestic	500	gal/day
Woodley Creek	C047157	Domestic	500	gal/day
Woodley Creek	C047455	Domestic	500	gal/day

Table 14. Common Breeding Birds

Mallard	Wood Duck	Common Goldeneye
Common Merganser	Killdeer	Spotted Sandpiper
Common Snipe	Sharp-shinned Hawk	American Kestral
Ruffed Grouse	Blue Grouse	Wild Turkey
Mourning Dove	Common Nighthawk	Black-chinned Hummingbird
Rufous Hummingbird	Calliope Hummingbird	Northern Flicker
Red-naped Sapsucker	Downy Woodpecker	Hairy Woodpecker
Pileated Woodpecker	Eastern Kingbird	Western Kingbird
Western Wood-pewee	Dusky Flycatcher	Hammonds Flycatcher
Cordillian Flycatcher	Tree Swallow	Belted Kingfisher
Violet-green Swallow	Northern Rough-winged Swallow	American Crow
Black-capped Chickadee	Mountain Chickadee	Red-breasted Nuthatch
House Wren	Winter Wren	Ruby –crowned Kinglet
Golden-crowned Kinglet	Mountain Bluebird	Very
Swainson's Thrush	American Robin	Varied Thrush
Grey Catbird	Solitary Vireo	Red-eyed Vireo
Warbling Vireo	Nashville Warbler	Orange-crowned Warbler
Yellow-rumped Warbler	Yellow Warbler	MacGillvray's Warbler
Wilson's Warbler	Northern Waterthrush	Common Yellowthroat
American Redstart	Black-headed Grosbeak	Lazuli Bunting
Spotted Towhee	Song Sparrow	Chipping Sparrow
Dark-eyed Junco	Red-winged Blackbird	Brewer's Blackbird
Brown-headed Cowbird	Bullock's Oriole	Western Tanager
American Goldfinch	Cassin's Finch	House Finch

Table 15. Resting and Feeding Habitats for Migrating Birds (Spring and Fall)

Tundra Swan	Green-winged Teal	Blue-winged Teal
Cinnamon Teal	American Wigeon	Common Goldeneye
Barrow's Goldeneye	Bufflehead	Hooded Merganser
Lesser Yellowlegs	Solitary Sandpiper	Sora Rail
American Coot	Olive-sided Flycatcher	Alder Flycatcher
Hermit Thrush	American Pipit	Magnolia Warbler
Townsend's Warbler	Tennessee Warbler	Savanna Sparrow
Tree Sparrow	White-crowned Sparrow (rare)	Fox Sparrow
Lincoln's Sparrow	Common Redpoll	

Table 16. Birds that are None –Breeding Visitors

Great Blue Heron	Ring-billed Gull	Herring Gull
Turkey Vulture	Golden Eagle	Bald Eagle
Red-tailed hawk	Rough-legged Hawk (rare)	Northern Goshawk (rare)
Northern Harrier	Merlin	Peregrine Falcon (rare)
Short-earred Owl (rare)	Long-eared Owl (rare)	Great Horned Owl
Northern Pygmy Owl	Saw-whet Owl (uncommon winter visitor)	Vaux's Swift
Black Swift (irregular)	Cliff Swallow	Barn Swallow
Steller's Jay	Grey Jay (winter visitor)	Clark's Nutcracker
Black-billed Magpie	Common Raven	Chestnut-backed Chickadee (winter visitor)
Brown Creeper (uncommon)	White-breasted Nuthatch	Western Bluebird
Townsend's Solitaire	Northern Shrike (winter visitor)	European Starling
Western Meadowlark	House Sparrow	Red Crossbill
Pine Grosbeak	Evening Grosbeak	

Table 17. Mammals that have been reported within DL 498

Mammals reported seen within Lot 498. Studies have not been done on shrews, Bats, Mice, and Voles. The ones listed could very well be present as reported in Mammals of British Columbia by Cowan and Guiguet, British Columbia Provincial Museum, Victoria, Canada – 1956.

Short-tailed Shrew	Common Shrew	Wandering Navigator
Big Brown Bat	Little Brown myotis	Silver-haired Bat
Western Big-eared Bat	Yuma Bat	Snowshoe Rabbit (Hare)
Marmot (on upper slopes)	Columbia Ground Squirrel	Mantled Squirrel (rare)
Northwestern (Yellow Pine) Chipmunk	Red Squirrel	Flying Squirrel (almost as common as the Red Squirrel
Pocket Gopher	Beaver (plentiful)	Deer Mouse
Bushy-tailed Pack Rat (Wood)	Meadow Vole	Mountain Vole
Long-tailed Vole	Muskrat	Meadow Jumping Mouse
Porcupine	Coyote	Black Bear
Racoon	Martin (rare)	Short-tailed Weasel
Long-tailed Weasel	Mink (occasionally)	Striped Skunk
River Otter (transient)	Cougar (rare)	Bobcat (occasionally)
White-tailed Deer	Mule Deer (occasional transient)	Moose (rare)

Table 18. Reptiles

Alligator Lizard	Rubber Boa (uncommon)	Blue Racer (uncommon)
Gopher Snake (uncommon)	Garter Snake	Painted Turtle

Table 25. Mean sampling overturn nutrient concentrations (ug/L) and Nitrogen-Phosphorus (N:P) ratio for deep sampling sites at Christina Lake.

Site	Year	Month	T.P	T.D.P.	T.N.	K.N.	NO_3	NH_3	N:P
0200078 (South Basin)	1973	May	6					<10	
	1978	April	6	<3		95		8	16:1
	1981	April	8	5.5	55	55		16	7:1
	1983	March	9.5	5	140	140		<5	15:1
	1984	April	10.5	5	120	70	<20	<5	11:1
	1986	April	8	3		70		<5	9:1
	1988	April	7.5	3.5		105		<5	14:1
	1990	March	3	<3		90		<5	30:1
	1991	May	4	<3	55	50		<5	14:1
	1992	April	3.5	<3		135		6.5	13:1
	1992	May	4	<3	95	90		5	39:1
	1993	April	4	3	120	110		16	24:1
	1994	March	5	4	110	90		5	30:1
	1995	March	3	3	110	100		5	22:1
	1996	April	16	17	90			<5	37:1
	1997	April	14	13.5	90			<5	6:1
	1998	March	12	9	85			5	6:1
	1999	March	13	10.5	130			5	10:1
	2000	March	16	12.5	75			5	5:1
	2001	April	8.5	6.5	110			5	13:1
	2002	April	4.5	3.5	80			5	18:1
	2003	March	5.5	5.5	95	85		5	17:1
	2004	April	4	2.5	85	80			21:1
0200520 (English Point)	1978	April	5.5			120		8.5	22:1
	1981	April	8	5	85	85	<20	16	11:1
	1983	March	9	5.5	130	110	40	9	14:1
	1984	April	16	3	115	115	<20	<5	7:1
	1986	April	9	3		70	<20	<5	8:1
	1988	April	5	3		70	<20	<5	14:1
	1990	March	5	<3		90	<20	<5	30:1
	1991	April	4.33	<3		95	<20	<5	22:1
	1992	April	6.5	<3		85	<20	<5	13:1
	1993	April	11	4		95	<20	<5	9:1
	1994	March	6	4	100	80		<5	17:1
	1995	March	6	3	135	135		5	23:1
	1999	March	12	10.5	90			5	8:1

Table 25. cont'd. Mean sampling overturn nutrient concentrations (ug/L) and Nitrogen-Phosphorus (N:P) ratio for deep sampling sites at Christina Lake.

Site	Year	Month	T.P	T.D.P.	T.N.	K.N.	NO_3	NH_3	N:P
E215758 (North Basin)	1991	May	3.5	<3		55	<5	5.5	16:1
	1992	April	4	<3		80		<5	20:1
	1992	May	4	<3		50	<4	<5	13:1
	1993	April	3	5	100	80		8	33:1
	1994	March	4	3	100	80		5	25:1
	1995	March	7		85				12:1
	1995	March	4		130				33:1
	1995	March	3		120				40:1
	1996	April	13.5	15.5	80			<5	6:1
	1997	April	16	13.5	70				4:1
	1998	March	12	8.5	120			7	10:1
	1999	March	13	10	100			5	8:1
	2000	March	13	13	75			5	5:1
	2001	April	8	5.5	110		<5	5	14:1
	2002	April	5	5.5	80			5	16:1
	2003	March	4	5.5	90	85			23:1
	2004	April	3	2.5	90	85			30:1

T.P. = Total phosphorus

T.D.P. = Total dissolved phosphorus

T. N. = Total nitrogen

K.N. = Kjeldahl nitrogen

NO_3 = Nitrate

NH_3 = Ammonia

N:P = Nitrogen to phosphorus ratio

No entry = No data

Table 26. Seasonal total phosphorus concentrations (ug/L) in Christina Lake (deep sites combined) 1994.

Month	Epilimnion	Metalimnion	Hypolimnion
Mar		4.67	5.00
Jun	4.33	5.33	7.00
Jul	3.33	3.25	4.67
Aug	3.00	3.33	3.33
Sep	4.67	3.67	3.33
Oct	4.00	3.33	3.00

E= Epilimnion

M=Metalimnion

H=Hypolimnion

Table 27. Nitrogen concentrations in Christina Lake at deep sites, March through June 1994

Site	DATE	UPPER DEPTH	LOWER DEPTH	Ammonia Dissolved (mg/L)	N.Kjel:T (mg/L)	Nitrate + Nitrite Diss. (mg/L)	Nitrogen - Nitrite Diss. (mg/L)	Total Organic ($TNK+NH_4^+$)
200078 (South Basin)	29-Mar	20	20	0.005	0.09	0.02	0.005	0.10
	29-Mar	1	10	0.005	0.08	0.02	0.005	0.09
	7-Jun	24	24	0.005	0.10	0.02		0.11
	7-Jun	5	5	0.005	0.14	0.02		0.15
	7-Jun	0.5	0.5	0.005	0.13	0.02		0.14
	12-Jul	24	24	0.005	0.09	0.02		0.10
	12-Jul	6	6	0.011	0.07	0.02		0.08
	13-Jul	0.5	0.5	0.005	0.06	0.02		0.07
	15-Aug	8	8	0.005	0.16	0.02		0.17
	15-Aug	24	24	0.005	0.10	0.02		0.11
	16-Aug	0.5	0.5	0.009	0.12	0.02		0.13
	12-Sep	26	26	0.005	0.10	0.02	0.005	0.11
	12-Sep	10	10	0.005	0.10	0.02	0.005	0.11
	13-Sep	0.5	0.5	0.005	0.12	0.02	0.005	0.13
	3-Oct	24	24	0.005	0.12	0.02	0.005	0.13
	3-Oct	8	8	0.005	0.10	0.02	0.005	0.11
	3-Oct	0.5	0.5	0.005	0.10	0.02	0.005	0.11
	Average for Epilimnion			**0.006**	**0.103**	**0.020**	**0.005**	**0.11**
	Average for Metalimnion			**0.005**	**0.120**	**0.020**	**0.005**	**0.13**
	Average for Hyplimnion			**0.005**	**0.100**	**0.020**	**0.005**	**0.11**
0200520 (English Point)	29-Mar	20	32	0.005	0.08	0.02	0.005	0.09
	29-Mar	1	10	0.005	0.12	0.02	0.005	0.13
	7-Jun	48	48	0.005	0.08	0.02		0.09
	7-Jun	10	10	0.005	0.08	0.02		0.09
	7-Jun	0.5	0.5	0.005	0.08	0.02		0.09
	12-Jul	8	8	0.005	0.07	0.02		0.08
	12-Jul	36	36	0.005	0.07	0.02		0.08
	13-Jul	0.5	0.5	0.005	0.11	0.02		0.12
	15-Aug	9	9	0.005	0.14	0.02		0.15
	15-Aug	36	36	0.005	0.10	0.02		0.11
	16-Aug	0.5	0.5	0.005	0.04	0.02		0.05
	12-Sep	36	36	0.005	0.12	0.02	0.005	0.13
	12-Sep	10	10	0.005	0.10	0.02	0.005	0.11
	13-Sep	0.5	0.5	0.005	0.09	0.02	0.005	0.10
	3-Oct	34	34	0.005	0.11	0.02	0.005	0.12
	3-Oct	11	11	0.005	0.10	0.02	0.005	0.11
	3-Oct	0.5	0.5	0.005	0.11	0.02	0.005	0.12
	Average for Epilimnion			**0.005**	**0.092**	**0.020**	**0.005**	**0.097**
	Average for Metalimnion			**0.005**	**0.098**	**0.020**	**0.005**	**0.103**
	Average for Hyplimnion			**0.005**	**0.093**	**0.020**	**0.005**	**0.098**
E215758 (North Basin)	29-Mar	20	45	0.005	0.08	0.02	0.005	0.09
	29-Mar	1	10	0.006	0.08	0.02	0.005	0.09
	7-Jun	48	48	0.005	0.09	0.02		0.10
	7-Jun	8	8	0.005	0.09	0.02		0.10
	7-Jun	0.5	0.5	0.005	0.11	0.02		0.12
	12-Jul	8	8	0.005	0.08	0.02		0.09
	12-Jul	48	48	0.005	0.16	0.02		0.17
	13-Jul	0.5	0.5	0.005	0.04	0.02		0.05
	13-Jul	8	8	0.005	0.08	0.02		0.09
	15-Aug	10	10	0.005	0.17	0.02		0.18
	15-Aug	48	48	0.005	0.08	0.02		0.09
	16-Aug	0.5	0.5	0.005	0.09	0.02		0.10
	12-Sep	10	10	0.005	0.13	0.02	0.005	0.14
	13-Sep	0.5	0.5	0.005	0.09	0.02	0.005	0.10
	12-Sep	50	50	0.016	0.12	0.02	0.005	0.14
	3-Oct	0.5	0.5	0.005	0.09	0.02	0.005	0.10
	3-Oct	48	48	0.005	0.12	0.03	0.005	0.13
	3-Oct	11	11	0.005	0.08	0.02	0.005	0.09
	Average for Epilimnion			**0.005**	**0.08**	**0.02**	**0.01**	**0.09**
	Average for Metalimnion			**0.005**	**0.11**	**0.02**	**0.01**	**0.11**
	Average for Hyplimnion			**0.007**	**0.11**	**0.02**	**0.01**	**0.12**

Table 28. Epilimnetic chlorophyll-*a* concentrations (*u*g/L) for Christina Lake 1993-2004.

Date	Station 200078	0200520	E215758
15-Apr-93	1.5	1.8	
5-Oct-93	2.2	2.0	
29-Mar-94			
3-Oct-94	1.1	0.6	0.5
22-Mar-95	2.5	2.3	2.3
3-Oct-95	0.9		0.9
25-Apr-96	1.4		1.6
3-Oct-96	0.6		0.7
29-Apr-97	1.5		2.4
30-Sep-97	1.6		1.1
10-Mar-98			3.4
1-Oct-98	1.5		3.2
10-Oct-98	5.7		
31-Mar-99	2.8	3.8	3.7
28-Sep-99	0.7		0.5
9-Mar-00	2.7		2.2
5-Oct-00	5.4		2.4
1-Apr-01			2.2
10-Apr-01	3.4		
2-Oct-01	0.8		0.5
9-Apr-02	1.6		1.9
3-Oct-02	1.5		1.3
31-Mar-03	1.1		0.9
30-Sep-03	0.7		0.5
1-Apr-04	2.4		2.4
25-Sep-04	0.5		
28-Sep-04			0.5

Table 29. Chlorophyll-*a* concentrations at Christina Lake during 1994 sampling March - October.

Station	DATE	UPPER DEPTH	LOWER DEPTH	Chlorophyll-*a* (*ug*/L)
200078	29-Mar-94	1	10	0.50
200078	7-Jun-94	0.5	0.5	1.60
200078	13-Jul-94	0.5	0.5	0.50
200078	16-Aug-94	0.5	0.5	0.70
200078	13-Sep-94	0.5	0.5	0.80
200078	3-Oct-94	0.5	0.5	1.10
			Seasonal Average	**0.87**
			Stdev	**0.42**
200520	29-Mar-94	1	10	0.50
200520	7-Jun-94	0.5	0.5	1.70
200520	13-Jul-94	0	0	0.50
200520	16-Aug-94	0.5	0.5	0.50
200520	13-Sep-94	0.5	0.5	1.00
200520	3-Oct-94	0.5	0.5	0.60
			Seasonal Average	**0.80**
			Stdev	**0.48**
E215758	29-Mar-94	1	10	0.70
E215758	7-Jun-94	0.5	0.5	2.30
E215758	13-Jul-94	0	0	0.50
E215758	16-Aug-94	0.5	0.5	1.00
E215758	13-Sep-94	0.5	0.5	1.40
E215758	3-Oct-94	0.5	0.5	0.50
			Seasonal Average	**1.07**
			Stdev	**0.69**

Table 30. Concentrations of chlorophyll *a* in epilithic periphyton in Christina Lake 1998-2001.

			Chlorophyll *a* concentrations mg/m^2						
Site Name	Site Number	Date	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average	Stdev
Left of Sander Creek	E246100	Aug-98	0.94	3.07	3.07	1.11	1.86	2.01	1.03
right of Texas Creek	E246101	Aug-98	1.01	1.46	2.67	0.025	0.22	1.08	1.06
Gabana Residence	E246102	Aug-98	3.04	2.48	0.3	2.92	2.13	2.17	1.11
North of McRae Creek	E246103	Aug-98	0.54	1.34	0.72	0.64	1.31	0.91	0.38
South side of English Cove	E246104	Aug-98	1.63	0.45	2.77	2.25	1.93	1.81	0.87
Colville Cove	E246105	Aug-98	0.69	0.45	1.19	0.42	0.57	0.66	0.31
Kelly Court Public Access	E246106	Aug-98	0.01	0.32	0.12	0.05	0.1	0.12	0.12
Sutherland Creek	E246183								
Sandner Residence, South er d	E246184	Aug-98	5.99	2.2	0.05	0.01	2.87	2.22	2.46
South end at Provincial Park	E246185	Aug-98	0.52	1.81	0.92	0.45	0.67	0.87	0.55
Tambellini Residence	E246186	Aug-98	1.21	0.27	2.8	0.04	2.48	1.36	1.25
Little Tadanac	E246187	Aug-98	1.24	1.31	1.26	2.48	3.44	1.95	0.99
Stewart Creek	E246188	Aug-98	0.42	0.01	0.27	0.54	3.32	0.91	1.36
Treadmill Creek	E246192	Aug-98	1.44	1.26	4.28	3.47	12.5	4.59	4.61
							Maximum	4.59	
							Minimum	0.12	
Left of Sander Creek	E246100	Aug-99	3.91	1.26	0.25	3.24	2.65	2.26	1.49
right of Texas Creek	E246101	Aug-99	4.18	3.04	0.72	3.42	1.71	2.61	1.39
Gabana Residence	E246102	Aug-99	1.49	2.87	1.76	1.19	2.85	2.03	0.78
North of McRae Creek	E246103	Aug-99	2	0.62	0.42	1.34	1.11	1.10	0.62
South side of English Cove	E246104	Aug-99	1.09	0.82	0.67	1.53	1.66	1.15	0.43
Colville Cove	E246105	Aug-99	5.45	2.5	1.01	1.81	0.72	2.30	1.89
Kelly Court Public Access	E246106	Aug-99	0.2	0.01	0.12	0.01	0.12	0.09	0.08
Sutherland Creek	E246183	Aug-99							
Sandner Residence, South er d	E246184	Aug-99	1.16	3.59	5.35	3.27	2.38	3.15	1.55
South end at Provincial Park	E246185	Aug-99	1.95	1.16	0.99	4.08	3.98	2.43	1.50
Tambellini Residence	E246186	Aug-99	1.56	0.17	4.95	4.85	3.14	2.93	2.08
Little Tadanac	E246187	Aug-99	2.87	5.25	1.98	3.14	4.9	3.63	1.39
Stewart Creek	E246188	Aug-99	0.77	0.15	0.54	0.1	0.32	0.38	0.28
Treadmill Creek	E246192	Aug-99	6.53	5.89	2.15	2.55	3.42	4.11	1.99
Trapper Creek	E246191	Aug-99	0.57	3.66	2.18	1.76	0.99	1.83	1.20
Ole Johnson Park	E246190	Aug-99	3.22	1.11	5.2	3.49	2.45	3.09	1.50
							Maximum	4.11	
							Minimum	0.09	
Left of Sander Creek	E246100	Aug-00		0.6	0.2	0.2	0.5	0.33	0.21
right of Texas Creek	E246101	Aug-00	0.8	9	1.1	0.8	0.9	2.93	3.62
Gabana Residence	E246102	Aug-00	3	2.9	2.1	1.3	1.9	2.24	0.71
North of McRae Creek	E246103	Aug-00	2.2	2	0.9	1.6	1.2	1.58	0.54
South side of English Cove	E246104	Aug-00	3.1	0.3	4.6	0.9	0.9	1.96	1.82
Colville Cove	E246105	Aug-00	2.7	1.1	0.4	12.4	0.1	3.34	5.16
Kelly Court Public Access	E246106	Aug-00							
Sutherland Creek	E246183	Aug-00							
Sandner Residence, South er d	E246184	Aug-00	1.9	1.9	1.5	2.7		2.00	0.50
South end at Provincial Park	E246185	Aug-00	0.9	1.7	1.8	2.5	1	1.58	0.65
Tambellini Residence	E246186	Aug-00	1.2	0.3	0.3	1.2	0.4	0.68	0.48
Little Tadanac	E246187	Aug-00	2.5	0.8	0.4	6.8	0.6	2.22	2.69
Stewart Creek	E246188	Aug-00	0.1	0.2	0.4	0.3	0.3	0.26	0.11
Treadmill Creek	E246192	Aug-00	2.8	16.3	14.9	9.4	7.9	10.26	5.48
Trapper Creek	E246191	Aug-00	1.6	1	0.5	2.6	2	1.54	0.82
Ole Johnson Park	E246190	Aug-00	0.5	2.4	3.4	2.5	1.3	2.02	1.13
							Maximum	10.26	
							Minimum	0.26	
Left of Sander Creek	E246100	Aug-01	0.17	3.24	1.41	1.91		1.68	1.27
right of Texas Creek	E246101	Aug-01	0.67	0.27	0.27	0.47	0.15	0.42	0.21
Gabana Residence	E246102	Aug-01	1.51	1.11	1.36	2.95	1.71	1.73	0.72
North of McRae Creek	E246103	Aug-01	4.16	3.17	3.98	2.15	2.52	3.20	0.88
South side of English Cove	E246104	Aug-01	0.15	0.79	0.15	0.84		0.48	0.38
Colville Cove	E246105	Aug-01	2.92	3.04	1.06	2.25	2.13	2.28	0.79
Kelly Court Public Access	E246106	Aug-01	0.05	0.01	0.05	0.17	0.05	0.07	0.06
Sutherland Creek	E246183	Aug-01	0.003						
Sandner Residence, South er d	E246184	Aug-01	2.4	8.54	2.85	1.58	2.75	3.62	2.79
South end at Provincial Park	E246185	Aug-01	0.82	0.1	0.45	0.82	0.59	0.56	0.30
Tambellini Residence	E246186	Aug-01	3.91	2.23	5.07	0.92	4.8	3.39	1.77
Little Tadanac	E246187	Aug-01	3.76	1.73	0.82	3.81	1.09	2.24	1.45
Stewart Creek	E246188	Aug-01	1.76	1.14	0.92	1.73	2.33	1.58	0.56
Seigl Creek		Aug-01	0.22	3.66	1.96	0.47	0.54	1.37	1.45
Ole Johnson Park	E246191	Aug-01	9.16	0.52	0.82	5	2.95	3.69	3.55
							Maximum	3.69	
							Minimum	0.07	

Appendix D

Pope & Talbot procedures

Forest Development Plan

1. 5 year Forest Development Plan (FDP) is developed. (This plan is amended regularly as fieldwork brings in new information or as events evolve, e.g. beetle and blowdown). Areas of proposed harvest and proposed access (ie: roads) are identified and mapped in FDP.
2. Required assessments to be completed are identified and associated with a particular harvest and/or access feature. (e.g.: terrain survey field assessments, visual impact assessment, archaeological assessments, etc.).
3. Advertisement in local newspaper for 60 days. Referrals are sent to stakeholders: first nations, range permittees, trapline holders, outfitters. Public review and comment may be given during this time at P&T office in Midway. Emergency salvage may receive a shortened review time.
4. FDP reviewed and approved by Ministry of Forests.

Site Plan

The site plan considers all of the following items:

1. Road locations and timing of use, Area (physical size of cut block), Soil sensitivities (surface erosion, compaction, and soil displacement hazards), Timing of harvest, Wildlife tree patch %, Stocking requirements mostly based on BEC and site series, with influences from disease, insects, visuals etc, Old growth constraints, Green-up dates, Grizzly bear habitat, Ungulate (Mule deer) winter range, Wildlife features/Endangered species assessment, Community/Domestic watersheds, Equivalent clearcut area (previous harvesting in the watershed), Recreation, Range for cattle, Visual impact, Pests – mostly diseases and insects, Archaeological assessments, Terrain stability assessments, Riparian assessments, Elevation, Aspect, Slope, Seed planning zone, Permanent access (roads and landings), Regeneration potential of existing stand.
2. Registered professional forester (RPF) signs site plan and is responsible for the contents

Cutting Permit

1. Timber cruise reviewed and approved by MoF (before and after cruising)
2. Compilation of timber cruise reviewed and approved by MoF.
3. Application for Cutting Permit (permission to harvest) for cutblocks identified in the finalized harvest plan:
    a. Must be consistent with the approved FDP
    b. Must have all assessments completed
    c. Must be consistent with Site Plan
4. Cutting Permit reviewed and approved by MoF
5. Appraisal Submission submitted for cutblocks identified in the Cutting Permit application and roads identified in the Road Permit application:
    a. Must be consistent with Site Plan and Road Permit

6. Stumpage appraisal reviewed and approved by MoF
7. Receive stumpage rate for a particular Cutting Permit from MoF.

Road Permit

1. Application for Road Permit (permission to cut right-of-way and build road) for roads identified in the finalized access plan:
    a. Must be consistent with the approved FDP
    b. Must have all assessments completed
    c. Must be consistent with objectives indicated by legislation
2. Road permit reviewed and approved by MoF
3. Receive Road Permit contract from MoF.

Harvest

1. Environmental management systems (EMS) pre-works done with each road and harvesting crew to identify key issues on each job location.
2. Startup notice provided to MoF.
3. Harvest must be consistent with the Site and Road plans.

Post Harvest

1. Rehabilitation of temporary trails and roads.
2. Deactivation of permanent access trails and roads.
3. Block and road completion signed off by road and logging foremen. Notice to MoF of completion.
4. Hazard abatement

Silviculture

1. Fire hazard assessments are done after harvest and hazard abatement is done as required.
2. Stocking standards achieved through dynamic treatment regimes that contain, but are not limited to: site preparation, destumping, planting, brushing, thinning, etc.
3. Regeneration surveys done to show that there is a proper species mix and density of trees to be able to achieve free-to-grow (FTG). Monitoring is done for up to 20 years until trees have reached specified heights, densities and species mixes.
4. FTG surveys done.
5. Registered professional forester is responsible for regimes applied and their success.
6. 15 months following the silviculture forester's declaration, responsibilities for the new forest revert to the crown. Road maintenance remains the responsibility of the Licensee in most cases.

Data Exchange Agreements

Data exchange agreements (DEAs) are necessary to obtain digital data (such as map layers) owned by any private or public agency. Data exchange agreements stipulate what the data may be used for and for what period of time. Currently there are 2 data exchange agreements in place for the CLMP project; one with Pope and Talbot Ltd. Who will review the DEA on an annual basis and one with the Ministry of Sustainable Resource Management[1] who allowed one-time use of their TRIM (Terrain Resource Inventory Mapping) data to create the CLMP Base Map. Selkirk College is named as data custodian on those agreements as all digital data is stored at the Castlegar campus. Brad Mason, with the Community Mapping Network (Department of Fisheries and Oceans) also has copies of all digital files so that the CLMP maps available online[2] may be updated as necessary. Copies of the DEA documents are on file at the Community Stewardship Resource Centre. Contact information for each party is provided below.

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Community Mapping Network
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[1] The Ministry of Sustainable Resource Management was reorganized and subsequently renamed the Ministry of Agriculture and Lands following the provincial election in May 2004. The agency currently responsible for arranging data exchange agreements is not known. Updated information will be provided as it becomes available. The contact information listed for MSRM above may or may not be accurate.
[2] The CLMP maps are currently available online at http://www.shim.bc.ca/.

Christina Lake Management Plan
Memorandum of Understanding

The *Christina Lake Management Plan* is a collaborative outcome produced primarily by the Christina Lake Stewardship Society with assistance provided by a wide range of representatives from:

- All orders of government, including federal, provincial, local, and First Nations;
- Land- and water-based user groups;
- Resource-based businesses and industries; and
- Non-profit organizations.

The plan's goal is to build cooperation and coordination to protect social, economic, and environmental values within the Christina Lake watershed by working toward addressing a number of identified priority issues.

Signatories to this Memorandum of Understanding endorse the plan's intent and thereby agree to uphold and espouse its goals. Signatories agree to participate on a CLMP Implementation Committee and/or help build leadership to work towards cooperative watershed-based management. Signatories are likewise expected to encourage other potential parties and individuals to work towards successful implementation of the plan over time.

Nothing in this Memorandum of Understanding obligates signatories to contribute financially to the Christina Lake Stewardship Society or any aspect of the plan's implementation although this may be done voluntarily on a project specific basis.

Name _____ Title _____

Organization _____

Signature _____ Date _____