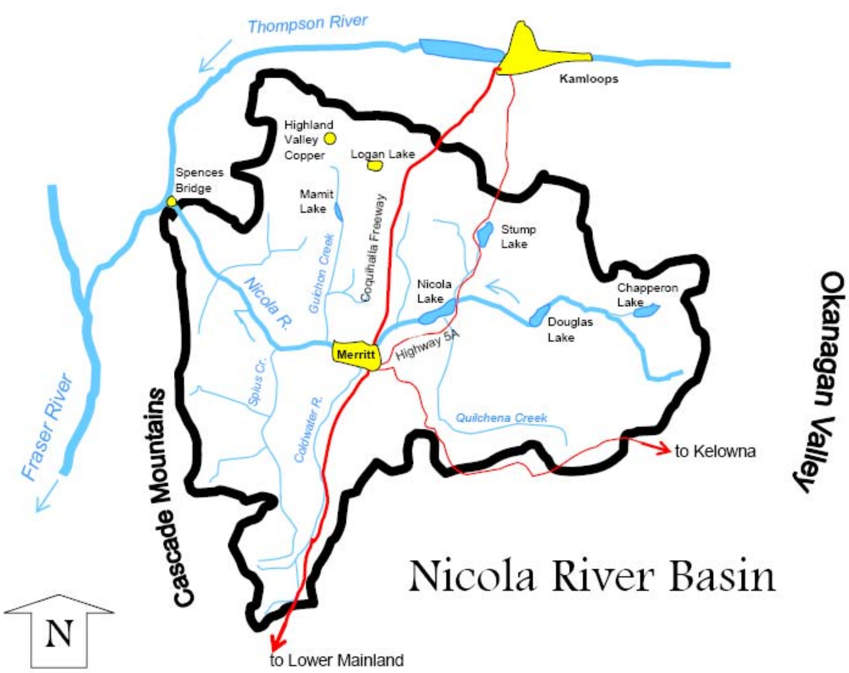
# Report

# NICOLA STOCK BREEDERS ASSOCIATION

## The Completion of the Nicola Lake Dam Project: Technical Feasibility Study






**March 2006**

File: 2503.0002.01

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March 20, 2006 File: 2503.0002.01

Nicola Stock Breeders Association
Box 1063
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**Attention: The President**

**RE: COMPLETION OF THE NICOLA LAKE DAM PROJECT: TECHNICAL FEASIBILITY STUDY FINAL DRAFT REPORT**

Herewith attached please find a copy of the final draft of the Feasibility Report that you have recently reviewed.

The study concluded that the completion of the Nicola Lake Dam project is technically feasible and that Agriculture and the Nicola River Fishery stand to benefit greatly from this community driven initiative. It is also believed that this option is probably the most cost effective means of creating additional water storage in the Nicola Valley, since most of the construction investment was already made in the late 1980's.

As a result of the recent drought conditions in the Nicola Valley, as well as concerns regarding the "drying out" effects of global warming and climate change in future, it will be imperative that additional water storage be created to avert serious water shortage problems that could threaten the survival of the Fishery and Agriculture downstream of the Nicola Lake Dam.

We would like to thank you for opportunity to support you in this technical feasibility study and look forward to you taking the findings in this report back to your membership and the Nicola Watershed Community Round Table (including First Nation representation).

Yours truly,

**URBAN SYSTEMS LTD.**

JC Cooke, P.Eng.
Team Leader

P. Coxon, P.Eng.
Partner

/sp

Attachment

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## EXECUTIVE SUMMARY

The Nicola Lake Dam Completion Feasibility Study has found that the completion of the Nicola Lake Dam project is technically feasible and that the Nicola River Anadromous Fishery and Agriculture stands to benefit greatly from this community driven initiative. It is also believed that this option is probably the most cost effective means of creating additional water storage in the Nicola Valley, since most of the construction investment was already made in the late 1980's.

### Background and Approach

In the 1980's a new concrete dam structure was put in place to access an additional 3 feet or one vertical metre of water storage on the Nicola Lake. This water was intended to support the development of new agricultural irrigation projects and fishery flows during the low flow, non-freshet period of the year.

The 1980's construction project stopped just short of removing a 470m highspot in the mouth of the lake between the dam structure and the deeper waters of the lake. In effect, the envisaged storage benefit has not been realized over the past 18 years. Resulting issues have included: an increase in the risk of water shortages for irrigation; a threat on the ecological integrity of the riverine environment, and consequently of fish habitat and their life cycle; and a hold on any new irrigation licences due to the water balance and flow shortages experienced during recent years.

As a result of the water shortage crisis experienced during these recent drought conditions, as well as concerns regarding the "drying out" effects of global warming and climate change, the local Nicola Valley Community have launched numerous water management initiatives, one of which was this study that has been sponsored by the Nicola Stock Breeders Association and the Canada-British Columbia Water Supply Expansion Program.

This feasibility study has been conducted to provide an objective assessment of the feasibility of dam completion to alleviate current river flow problems. Feasibility has been judged on technical engineering factors, impacts and a technical financial/economic analysis, and has been conducted using a fairly limited budget.

### Study Findings

It has been found that there will be sufficient water to refill the lake in most years up to a 1:15 year drought event. The additional storage is intended to support irrigation and fish flows during the months of July to September each year. After irrigation shut down, flow releases from this storage help maintain instream flow requirements, mainly to protect for fish values.

The accessible storage capacity to support river flows during these drier months will increase from the existing 28,500 acre-feet to a volume of 41,600 acre-feet which constitutes the 3 feet, or one metre, referred to above. This also means that the fluctuation in lake levels in dry climatic years could drop by an additional 0.5 metre vertically exposing more beach area as well as mudflats near the mouth of the lake. Mitigation regarding existing infrastructure (e.g. boat ramps) and aquatic environmental concerns will most likely need attention during the construction phase.

Twelve options of creating connectivity between the dam and the deeper waters of the lake have been reviewed in this study. Through a process of elimination, which included the interview of a focus group and a presentation to the Nicola Watershed Community Round Table, the focus was narrowed down to the recommended option number 11. This option would involve two main stages:

- Summer: by using a traditional excavator placed on a floating barge to dig out the 470 metres of main channel which is constituted of hardpan clay material. An additional 580 metres of existing channel will have to be dredged by swapping the excavator bucket for an agitating augur drill and suction nozzle. The suctioned material would be filtered off and remain on the barge.

- Winter at a very low lake level: An excavator working from constructed rock work pads will excavating the side channels to irrigation intakes. Trucks would then remove the material to specified dump sites. Note that various alternatives of piping water to some of the irrigation intakes could obviate the need for the excavation and future maintenance of these channels.

Option 12 was retained as a possible alternative. This option would include an expensive southshore channel excavated predominantly on “dryland”. Although technically not the best option, the results of the financial and economic analysis showed that the large benefit derived from this dam completion project would warrant some form of consideration when entering the design and social/environmental impact stage of this project. Option 12 does have a few environmental and land access concerns.

It has been demonstrated that for a relatively small investment (in the region of $2 million including further public consultation and required assessments), a reasonably large benefit to agriculture and fisheries can be achieved by completing the project. Benefits would include:

- Reducing the risk of water shortages to 4,892 acres (1,980 hectares) of existing licenced irrigation, including about 560 acres of restricted fish clause licences; it would allow a further 1,664 acres (673 hectares) of agricultural land to be put into production almost immediately; and it is believed that up to an additional 2,880 acres of irrigation land could be developed in the years that follow completion of the dam project. These benefits would accrue to about 55 properties in the valley.

- The additional water storage, combined with properly timed flow releases from the dam, would provide more sustainable flow conditions to support the natural fish life cycle in the Nicola River.
- Numerous other social-economic improvements to lakeshore owners, ecotourism, the City of Merritt and the regional economy, also exist.

It is recommended that the assessment now move on to the next stages and that as many of the following tasks be conducted concurrently:

- A public decision (via the NWUMP, including First Nations input) as to whether to proceed further or to put the dam completion debate to bed;
- The formation of a dam management partnership/institution. This is a crucial component of the success of this project. It is suggested that the Nicola Water Use Management Planning group appoint a champion to drive this process;
- Sourcing of interim financing;
- Conducting the selected level of social and environmental assessment including Public/First Nation consultation;
- Final selection of the dam completion option to be implemented;
- Design, specification and obtaining quotations for the selected dam completion option;
- Putting construction funding arrangements in place; and
- Agreeing on the future water allocations and ensuring that the storage and water diversion and flow licences are secured.

In conclusion, it has been found that the long overdue completion of this project will provide large economic benefits to the regional economy, and will also assist in improving the ecological integrity of the riverine environment below the dam. Given the potential effects of Climate Change, more water storage will have to be provided if the Nicola River Fishery and Irrigated Agriculture in the Valley are to survive in the future. It is believed that the completion of the Nicola Lake Dam project started in the 1980's will provide the most efficient means of creating this storage.

## TABLE OF CONTENTS

**APPENDICES**

# 1.0 INTRODUCTION

Agriculture, involving the irrigation of essential overwintering forage crops during the summer growing period, remains an important mainstay in the Nicola Valley Watershed. The Nicola River and some of it tributaries have been recognized as an important salmonoid fishery that needs to be preserved.

The Nicola Lake and the dam at its mouth is the main water storage unit in the watershed (Figure 1.1). Without the dam there would be very little assurance of supply for instream (fish) and offstream (agriculture) water users during the low flow periods of the year (February-March and August-November), especially during dry climatic/low precipitation years.

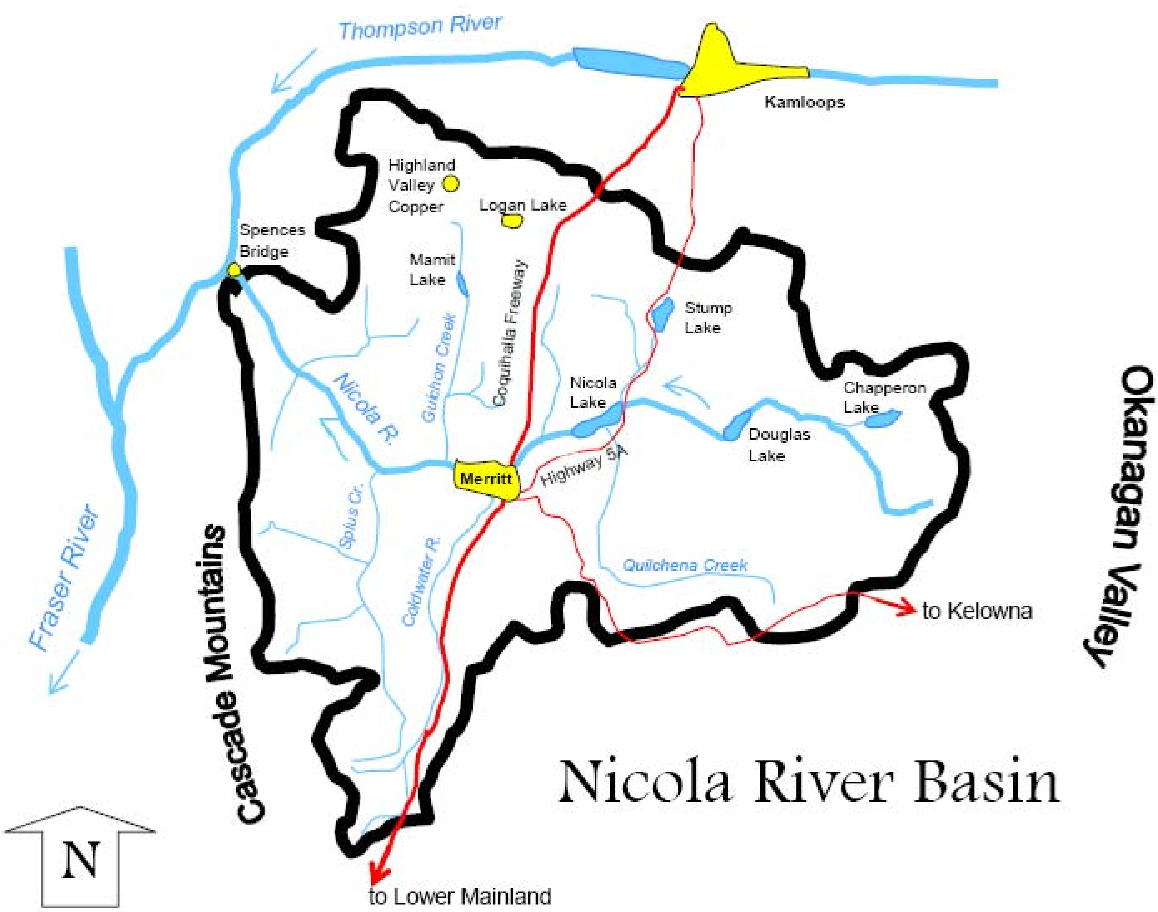


***Figure 1.1 – Location of Nicola Lake in the Centre of the Watershed***

1927 Dam

1986 Dam

***Figure 1.2 – Photographs of Dam***

A cross section through the mouth of the Nicola Lake is shown in Figure 1.3.

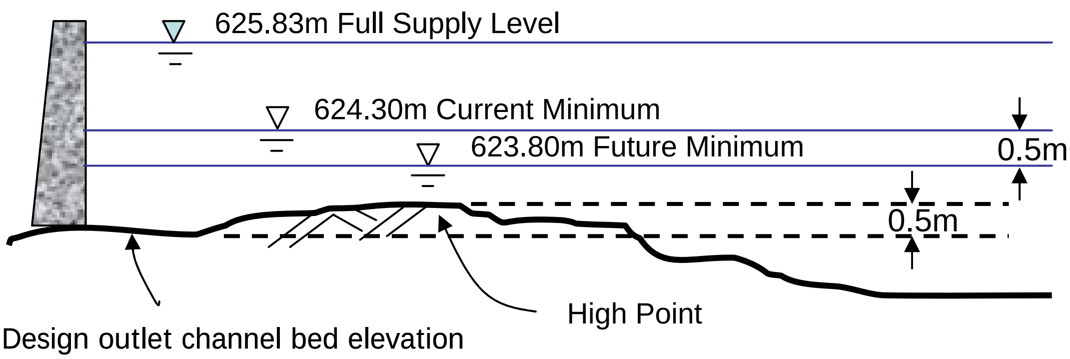


***Figure 1.3 – Cross Section through Shallow West End of Nicola Lake***

Having a lower sill meant that that a high spot just upstream of the dam structure had to be excavated out to be able to access the water storage in the main lake via a main outlet channel. Construction of the new dam project was 95% complete in 1986/87. At this stage, the cutterhead suction dredge method of channel excavation being used through the high spot clay material proved to be ineffective. Despite an additional financial allocation, the dam construction budget reached an end and the dredging was stopped with about 470 metres (1,420 feet) of main channel route remaining. A few irrigation intakes and boat ramp side channels were also not lowered to be functional at the lower, planned, lake levels. Figure 1.4 shows an aerial view of the immediate study area.

The main consequence of not completing this section of the project was that about 13,100 acre-feet (16,159,000 cubic metres) of the envisaged total accessible storage volume of 41,600 acre-feet (51,313,000 cubic metres) was not realized. In other words, for the past 18 years, only 28,500 acre-feet (35,154,000 cubic metres) of storage, or two thirds of the potential storage during the non-freshet period of the year (July to March), has been accessible to agriculture downstream of the Nicola Lake, the Lower Nicola River Fishery and other water users. The loss in income and environmental integrity has been considerable due to the fact that the project was not completed.

Since the late-1980's numerous attempts have been made by the Dam Advisory Committee (comprised of local stakeholders) and Government officials to complete the project. In the latest effort, the Nicola Stock Breeders Association (NSBA), with the financial backing of the Canada-British Columbia Water Supply Expansion Program (CBCWSEP), commissioned a study in 2004 that provided an inventory of all watershed attributes and issues related to water management in the Nicola Watershed (See Scoping Report – Nicola Stock Breeders Association, 2005). This process helped to navigate through and identify the sensitivities and hidden conflict surrounding the flows in the Nicola River. It also assisted in maintaining the momentum already generated by the Nicola Watershed Community Round Table (NWCRT) in its broad mandate of bringing the community together to sustainably manage land and natural resources in the Nicola River Watershed. The Scoping Study also recommended that the completion of the dam should be given serious attention as this would more than likely provide the most lucrative return (i.e. benefits) for the money invested in water resource development.

At a Nicola Water Use Management Plan (NWUMP) workshop that was hosted by the NWCRT in October 2004, one of the main issues that arose was the completion of the Nicola Lake Dam. The NWUMP recommended that a study be launched to investigate whether the community should proceed towards dam completion, or to follow the alternative path of shelving the idea once and for all. It was felt that new water storage is the main requirement to support existing and new irrigation development and that the completion of the dam would provide the lowest cost per unit of water of all alternatives. The "do nothing" option could potentially put fishery flows and agriculture at risk in future if climate change predictions materialize.

The NSBA then commissioned the Feasibility Study documented in this report. Specific terms of reference were provided to the consultants, which limited this initial stage of the dam completion decision-making process primarily to a technical evaluation. Public involvement would be the responsibility of the NWUMP.


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***Figure 1.4 – Aerial Photograph of Immediate Study Area***

## 2.0 GENERAL APPROACH TO THE STUDY

The bulk of the feasibility work was conducted between July and December 2005 with a cash budget of $64,000 sourced from the Canada-British Columbia Water Supply Expansion Program (CBCWSEP). It should be noted that the funder's mandate is focused on assisting Canadian agricultural producers to develop and enhance long-term agricultural water supplies that will lower the risk of water shortages. Linking this with environmental sustainability is an important part of this approach.

The CBCWSEP would therefore like to see a solution developed (in this case, water storage) that would start increasing the assurance of water supply to irrigators in the Nicola Valley, so helping agriculture in the valley to prosper and grow. The added benefit of increasing the assurance of supplies to fishery resources and the riverine environment also meets the CBCWSEP's mandate of environmental sustainability.

In other words, the objective of this assignment has been to provide sufficient information on the technical viability of the proposed Nicola Lake Dam Completion Project, with the view to the Government owner (the BC Ministry of Environment), the Nicola Stock Breeders Association (NSBA) and the Nicola Watershed Community Round Table, being able to make an initial decision to proceed, or not to proceed, with next phase of the project en-route to constructing the channel, or an alternative means of accessing water from the deeper part of the lake.

The purpose of the investigation and specific scope of work called for by the Nicola Stock Breeders Association is listed *ad verbatim* from the terms of reference as follows:

***Purpose of Study***

The purpose of the study is to conduct an objective assessment of the feasibility of dam completion for alleviating current river flow problems. Feasibility is to be judged by technical engineering factors, impacts, and technical financial/economic analysis.

***Project Scope***

In this study, the Consultant will:

- Compile existing technical engineering, social, environmental and economic information regarding dam completion.
- A public involvement program will utilize the Nicola Water Use Management Plan (NWUMP) process to relay information to the communities and gather public input. In



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addition, contact will be made with individuals listed in lists B and C below.

- Technical engineering information will be gathered as required, including an assessment of the lake bottom that could be dredged. It is realized that these additional inputs will be generally unknown until existing information is compiled and preliminary design evaluations conducted.
- Conduct a Water Resource System Analysis based on water availability, offstream water allocation, instream, or fish, flow requirements, and dam operating rules. Inputs with regard to instream flow requirements and potential system operating rules for these flows will be provided by work that the Pacific Salmon Foundation (PSF) will be undertaking as part of this study. This work will be funded by the PSF.
- Conduct a preliminary evaluation of technical engineering options for dam completion.
- Summarize impacts anticipated from dam completion based on available information.
- Estimate of technical and resource-based costs of dam completion options.
- Conduct a technical financial/economic analysis (which will include a cost–benefit analysis) of the dam completion project options.
- Institutional arrangements and potential implementation considerations will be reviewed.
- Evaluate the options and make recommendations regarding the feasibility of dam completion based on the above information.
- Produce a final report on the feasibility of dam completion that summarizes all information gathered in the study, recommends future steps, and lists estimated costs of any future steps required.

In initiating this study in June 2005 Mr Cooke, P.Eng. (on contract to Urban Systems Ltd.) and Mr Bob Costerton, P.Eng. (of BC Rivers Consulting) collated existing information on the various aspects of dam completion. The 1982 Bergman project feasibility report and the documentation that accompanied the almost completed dam project were used as the basis of the current study. Public involvement was limited to a few key interviews with specific stakeholders, as well as testing technical options with a NWUMP Focus Group on 22nd of September 2005 and a public forum hosted by the NWUMP on the 23rd of November 2005. Detailed public involvement will take place through the NWUMP once the draft of this report is finalized and presented to this forum.

Mr Costerton conducted various interviews with lakeshore owners adjacent to the proposed works as well as dredging contractors, in addition to conducting field tests to confirm certain technical inputs.

Mr Doyle, P.Eng. (of Doyle Engineering) conducted a water resource assessment to confirm the availability of water that can be stored behind the Nicola Lake Dam. This assessment was conducted to update the hydrology from that which was estimated in the 1982 study (i.e. more years of climatic data available). This latest study also included inputs on future hydrologic projections in the light of potential changes in climate and global warming.

Note that the PSF study referred to in the terms of reference has been initiated, but will only be completed after the draft technical report has been submitted. The NSBA has excluded this deliverable from the consultant's current assignment. The instream flow requirements for fish currently used in the existing operating rule for water flow releases from the Nicola Lake Dam were adopted in the assessment. The PSF and other Nicola River instream flow requirement study findings will provide information which can further improve the operation of the dam. It is not believed that this water flow information will affect the decisions that need to be made between various technical options in the dam completion study at this stage. This information could affect how the "new water" will be split between instream fish flows and offstream irrigation use in future.

Mr Costerton then proceeded to evaluate the various technical/engineering options for dam completion in a fair amount of detail. These findings make up the heart of this report.

During the course of his feasibility investigation, Mr Costerton also identified various impacts associated with the proposed dam completion work. The team received some input from Ms Gizikoff, M.Sc. P.Ag. as to other potential social and environmental impacts. The intention of this study was to only summarize these impacts based on available information. Depending on the required balance between vested rights to complete the dam (by virtue of the 1986/87 construction) and current environmental legislation, some level of social and environmental impact assessment may have to form part of the formal design and specification process in preparing to implement the project.

Mr Costerton produced reasonably detailed feasibility level cost estimates attributable to each of the twelve technical dam completion options considered. Where possible, other project cost items were quantified as part of the financial and economic analysis.

The terms of reference called for a technical financial/economic analysis of the dam completion options. Given the limited budget available to this study only a basic least cost, net present value, internal rate of return, sensitivity analysis and a financial benefit/cost analysis was conducted in evaluating the various options. A rudimentary economic assessment provided an insight into the overall project viability when compared with the "do nothing" option.

Since institutional arrangements are cardinal to the successful implementation of this project, these considerations were reviewed and suggestions made in this regard.

In conclusion, project implementation was reviewed and recommendations made regarding the feasibility of the dam completion.

The following report provides a summary of the findings in this study. More detailed stand alone reports that contributed to this main report have been archived in a project file that will be housed in the NSBA offices, along with some of the reports and documentation referred to in the next section.

## 3.0 BACKGROUND

### 3.1 Existing information

As mentioned above, existing information pertaining to this dam completion project was compiled from various sources.

- Technical files associated with the project during the 1970's and 1980's were obtained. The boxes of information are housed in the BC Ministry of Environment in Kamloops and include:
  - General files, including: memos, correspondence, meeting minutes, etc;
  - Structure documentation, including: original design, progress reports, incident reports, cost overrun reports, as-constructed reports, surveys and drawings, soils investigations in plan and profile (i.e. core samples along the route of the proposed main channel), etc;
  - Operations, including: select annual operating reports, plans, etc;
  - Operations and Maintenance, including: notes, costs, individual lakeshore owners required works, maintenance procedure documentation, etc;
  - Nicola Dam Advisory Committee, including: Meeting minutes, operation plans, reports, etc;
  - Technical committee information, including: correspondence, meeting minutes, etc;
  - Feasibility reports, including: Nicola Valley Strategic Plan, Dam reconstruction feasibility report, fisheries inventory of resources, problems, etc;

  - Contracts, including: main components of dam construction, dredging, fencing and safety features, storage shed, vertical turbine pump modifications required, etc;

- The original Bergman Feasibility Report (1983) that summarized the work conducted up to 1982 and that laid the foundation for the project. By rights, we are completing the project that was approved, started and almost finished in the 1980's.
- The Nicola Lake Operating Plan (1987) that is still in use today. A more recent analysis of this operating rule has been started by Mr Ball of the Ministry of Environment.
- NSBA Scoping Report (2005) that provides an inventory and background to the water situation in the Nicola River Watershed. A preliminary review of water use and fish flow requirements was conducted during the scoping study. This scoping report highlighted the completion of the Nicola Lake Dam as community priority and the most significant positive impact that can be achieved for the amount of input that will be required.
- Historical photographs and information gleaned from archives as well as interviews with stakeholders who stay in the immediate vicinity of the dam completion work.

Some of the key background information is presented below for the reader who is unfamiliar with the Nicola River Basin.

### 3.2 Water Situation

The annual flow regime in the Nicola River Basin is typical of the Southern Interior of British Columbia with a sustained snowmelt volume starting in April, peaking in June, and followed by streamflow recession throughout the summer. Cooler, wetter weather in the fall usually brings streamflow back slightly, which then remains fairly steady until the spring freshet starts again.

This cycle can change from year to year as has been proven during living memory where some seriously low precipitation years have been experienced. The consequences of this climatic swing have caused below normal low flows in the Nicola River and some of its tributaries (especially the Coldwater River) during July to September and again in February of some years. This has in turn caused a stressful situation for fish (instream requirements) and irrigators (offstream requirements) with ensuing conflict developing. The NWUMP process has fortunately provided a forum where this conflict can be acknowledged, dealt with by opening dialogue, and implementing ways in which all parties can benefit.

Water has to be provided from currently accessible storage in the Nicola Lake to support flows during the non-freshet nine month period of the year. From July to August there is a critical overlap in the requirement for water between fish and irrigation. Since there is not enough water storage to support both instream and offstream requirements during these low flow months during very dry climatic years, both sectors experience water shortage problems that threaten their existence.

This sensitivity associated with low fish flows occurs during both late summer as well as during freeze up of the river during the colder months. Water temperature issues also affect the fish (e.g. warmer water associated with shallow water running over cobbles and riffles).

In dry low flow years some irrigators have to shut down their irrigation systems due to fish clauses constraining them to do so if there is not enough water flowing in the river. This puts their multi-year forage crops at risk of drying out.

In most cases, issues such as these are usually solved by providing additional water storage. By properly regulating releases from these storage units, river flows become more sustainable so providing higher levels of assurance of supply to both instream and offstream water users. It is a commonly held belief that if the existing Nicola Lake Dam was not in place, river flows during the drier times of some years could be close to non-existent. Similarly, irrigation would also only be able to be practiced during the first few months of spring/summer.

If the Nicola Valley agricultural industry is to maintain its role in the regional economy and if it is to grow in future, it needs a more sustainable source of water storage to see it through the latter parts of the growing season in order to produce enough feed to sustain its overwintering cattle herds. Alternatively, this sector could diversify and move towards more intensive crops that yield a higher return per cubic metre of water used for irrigation.

In a similar vein, the Nicola River Fishery needs to optimize its flow regime requirements to achieve a better spread of annual flows of water to help its fish populations survive and preferably increase its production/recruitment numbers.

In other words, at least three strategies are needed to achieve a more reliable supply of water and to reduce the risk of water shortages to all users, namely:

- To improve water management practices (e.g. refine dam operating rule; implement water conservation and water demand management measures, etc.);
- To design and implement a drought water use management plan that caters for very severe droughts in excess of the 1:15 year recurrence interval; and

- To ensure that the Nicola Lake Dam project can be completed. This would create a significant "bank account" of water that can be used to improve the level of assurance of water supplies for fish and agriculture.

## 3.3 Institutions Concerned with Water Management in the Nicola River Valley

The operation and ownership of the Nicola Dam now resorts under the MOE's Water Stewardship Division and more specifically under the Directorate Regional Operations for the Southern Interior.

The Nicola Dam Advisory Committee (NDAC) is made up of local stakeholders that liaise with the Director of Regional Operations (who was formerly known as the Regional Water Manager) and his management team. The NDAC would be the logical starting point from which to build a more formal water user association or similar management institution that can help the Provincial Government in managing the dam in future.

From a local perspective, the Community is well represented via the Nicola Watershed Community Round Table, which is currently involved in setting up its Nicola Water Use Management Plan (NWUMP). The NWUMP has a Planning Committee of ten people that meet regularly to guide the process. The 2005 monthly NWUMP meetings have also been well attended both in representation (of the various sectors) and numbers (usually 40 to 50 people, with major workshops reaching over 100 attendees).

Numerous representatives from Federal and Provincial Government Departments have been active participants in the NWUMP. Hydrologists from the BC Ministry of Environment have been involved in debating Nicola Lake storage volumes and flow rates that formed a critical part of the water availability assessment.

The Nicola Stock Breeders Association (NSBA) has spearheaded the initial scoping phase that produced a watershed inventory that has been used by the NWUMP. Both the scoping study and this current feasibility study has been funded through the Canada-British Columbia Water Supply Expansion Program (CBCWSEP) via the NSBA.

## 3.4 State of Agriculture and Anadromous Fishery Sectors in the Nicola Watershed

As in the rest of British Columbia there is a significant economic upswing in Merritt and the surrounding Nicola Valley. More and more people are discovering the Valley both from a recreational perspective and the desire to buy lakeshore property and hobby farms. This is placing a strain on the natural surface and groundwater resources. All indications are that this pressure will not abate, which in turn emphasizes the need for additional water storage in the Valley.

Ranching is just surfacing from a few years of difficulty due to the USA border being closed to Canadian Beef. Furthermore, no new water licences have been approved since the late 1970's and all irrigation licences granted since 1971 have fish clause restrictions placed on them.

This uncertainty in water supplies (mainly due to a lack of reliable water storage), has a major negative effect on the local ranching industry. Growth in irrigation practices has therefore stagnated in the Nicola Valley. Additional water storage would go a long way to supporting our Canadian beef industry.

It is a Provincial Government objective to support agriculture with the view to enhancing the potential for rural growth. This sentiment is captured in the CBCWSEP mandate and guidelines for this feasibility study.

The Department of Fisheries and Oceans in their Salmon Overview of October 2004, state: that Pacific salmon serve as a food for First Nations and are a source of their cultural identity; they provide jobs and income to individual Canadians, business and coastal communities; they also provide recreation and enhance our quality of life; and they serve as a measure of our environmental health and well being.

Numerous efforts have been launched in recent years to conserve the Pacific Salmon Fishery, which has shown signs of a reduction in the abundance of fish. The DFO, the Pacific Salmon Foundation, the Steelhead Society of British Columbia and the BC Ministry of Environment have been very active in the Nicola River Watershed as they move to help recover this fishery. Large Government and private sector investments have been made in recovery programs and other similar initiatives in the Nicola River Watershed to date. Completion of the Nicola Lake Dam will provide a higher level of assurance of water supply to support these efforts and ecological integrity as a whole.

### 3.5 Development, Social and Environmental Objectives

The Ranching Community would like to see water supplies that have a higher level of assurance of supply. They would also like to see more storage created that could lead to new water licences being granted.

First Nations downstream of the Nicola Dam do have existing licences but do not fully utilize them. They do have the desire to reinstate their irrigation lands. The First Nations also realize the importance of looking after the Fishery, and together with the Provincial and Federal regulators responsible for fish and the riverine environment, they would like to see a higher assurance of supply to adequately provide sufficient river flow rates to provide for the various spawning and rearing stages of the Nicola River Fishery.

The City of Merritt would like to see the Nicola Lake Dam provide more flood control capacity (i.e. draining lake just before the spring freshet), but the lake's capacity to attenuate major floods is very small. Floodplain management is required (e.g. limiting development within a natural floodplain buffer zone). They would also like to see open standing water (caused by floods) to be better managed in order to help control the proliferation of mosquitoes.

Lakeshore owners around the Nicola Lake want to see a balance between aesthetics (i.e. lake levels not too low) and sufficient beach area for recreation purposes. With more and more people purchasing subdivided farms in the valley and around the numerous lakes in the watershed, water conflicts could increase in future.

### 3.6 Community's Proposed Way Forward

The Community through the NWCRT (and its NWUMP process) has actively engaged sustainable water stewardship planning and management practices. This Dam Completion Feasibility Study was backed by a joint decision at the NWUMP workshop in October 2004. A large portion of the Community would like to see the dam completed as they believe that it can only help in sustaining flows in the river, with benefits to the survival of agriculture and fish values far outweighing any negative impacts.

It is believed that the money spent in the 1980's has not yielded the benefits it was meant to deliver. They feel that further protracted studies will only continue to disadvantage agriculture and other sectors in the Nicola Valley. Hence, they would like to see this dam completion project brought to its conclusion as expeditiously as possible.

To summarize, the Community has decided to support this technical feasibility study to assess the viability of the project. If the project proves to be technically viable, then it will decide if there is sufficient community and political will, and financing to move on towards implementation.

## 4.0 THE PROJECT AREA

The physical and other features of the Nicola Valley are described in the NSBA Scoping Study (2005). The more site specific descriptions are provided in the Bergman Report (1983). Figures 4.1 to 4.4 provide a photographic perspective of the study area. Figures 7.1 and 7.2 in Chapter 7 will show more project related details associated with the various technical options to completing the dam project.

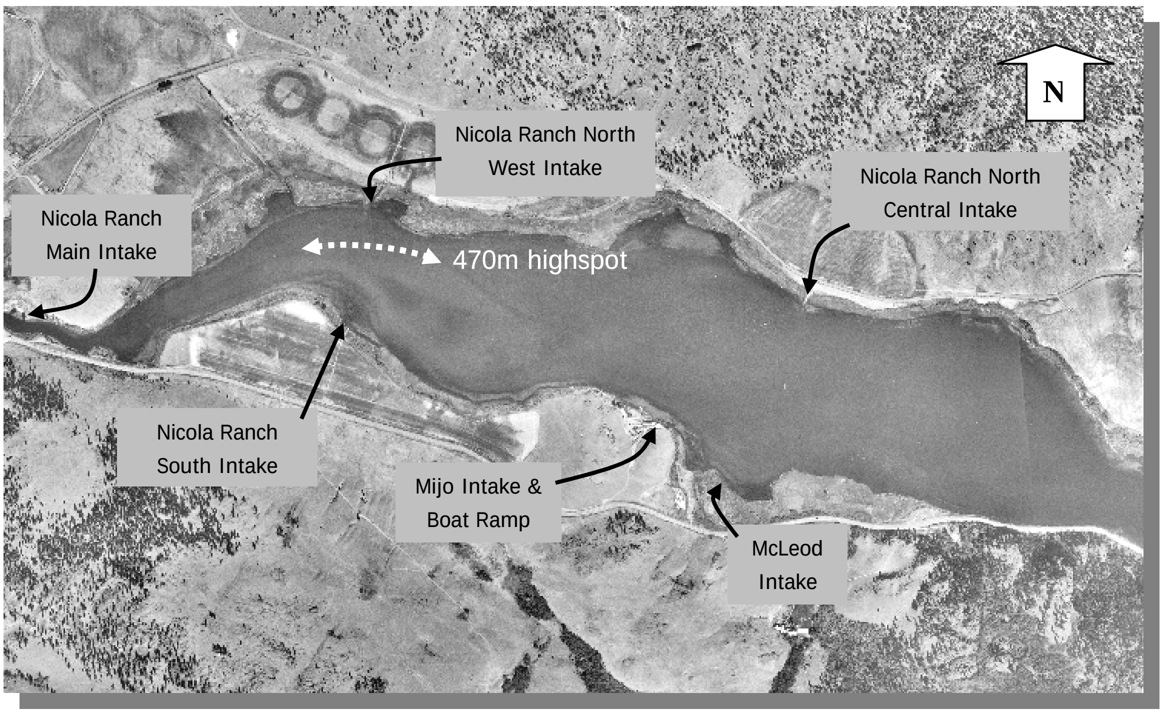



*Figure 4.1 – View of the Nicola Lake Dam looking towards the west*

***Figure 4.2 – Photograph of the lake outlet narrows taken from the road just upstream of the dam structure***

***Figure 4.3 – Taken slightly further east looking towards the deeper part of the lake***

***Figure 4.4 – Same place as Figure 4.3 but looking north across the area where the channel has not been excavated***

# 5.0 WATER ALLOCATIONS AND USE

## 5.1 Irrigation (Main Portion of Offstream Water Requirements)

Since the Nicola Lake Dam was constructed with a certain storage in mind, it is important to first understand what went into determining these in the early 1980's before we revisit the current 2005 values.

### *a) 1983 Feasibility Study Values*

The following numbers were assumed by Bergman (1983 Feasibility Report) in the calculation of storage required (i.e. 7.08 vertical feet or 2.16 metres on the lake), as well as in the 1983 benefit-cost analysis. It should be noted that a drought return period of 1:15 years was assumed for agricultural and fishery flows alike, even though agriculture can adopt a much lower level of assurance of supply. The rationale for this choice was documented in the Nicola Basin Strategic Plan (July 1983), which included public consultation.

Relatively little irrigation was, and still is, allowed directly from the lake onto surrounding lakeshore agricultural fields. Bergman estimated that about 659 acres (267 ha), currently irrigated from tributaries such as the Quilchena Creek, could be changed over to using the Nicola Lake as a water source. He also indicated that a further 2,351 acres (951 ha) around the lake could potentially draw on the lake as well.

Continuing, Bergman noted that 4,100 acres (1,660 ha) of downstream irrigation land was dependent on the lake as its source in 1982. In other words this was the land area being irrigated directly from the Nicola River. A further 1,451 acres (588 ha) was irrigated from tributaries that brought the total to roughly 5,551 acres (2,246 ha) in total.

He also estimated, that of the area being irrigated from these tributaries, about 1,272 acres (515 ha) of irrigation land below the Nicola Lake could be switched over to the lake as a source. A large portion of this "switch over" included the reduction of the reliance on the Clapperton Creek by shifting the irrigation water source over to the lake. Since the 1980's, this switch over was not realized and the irrigator has constructed storage in the upper reaches of the Clapperton Creek. In other words, it is unlikely that this Clapperton switch over will occur.

Bergman also estimated that a further 3,925 acres (1,588 ha) of irrigation land could be put into production between the dam and the Nicola River's confluence with the Thompson River at Spences Bridge.

His ultimate design acreage therefore totalled to 12,307 acres (4,980 ha) of existing and new irrigation land that would utilize the Nicola Lake as its main water source (see Table 5.1).

***Table 5.1: Design Acreages as Utilized in the 1983 Bergman Feasibility Report***

| | Around Nicola Lake (acres) | Downstream of Nicola Lake (acres) | Totals (acres) |
|---|---|---|---|
| Land already irrigated in 1982 | 0 | 4,100 | 4,100 |
| Land irrigated from tributaries in 1982 | 659 | 1,272 | 1,931 |
| Potentially irrigable land in 1982 | 2,351 | 3,925 | 6,276 |
| Ultimate design acreage used in 1983 feasibility study assessments | 3,010 | 9,297 | 12,307 |

Based on these numbers, Bergman determined the required storages based on hydrological work done by the Planning Branch of the Ministry of Environment in the early 1980's. These values have been shown in Table 5.2 below. This storage was only meant to support irrigation and fish flows during the critical months of the year (irrigation = July to September; fish = July to March). It should be noted that the storage for the ultimate "build-out" of irrigation land and fish maintenance flows (Fishery Resource Maintenance (FRM)) was based on a conservative 1:15 year drought recurrence interval. Anything less (e.g. an average 1:2 year) would require significantly less storage to bridge the non-freshet period.

***Table 5.2: Required Storage on Nicola Lake Under Various Conditions of Runoff and Demand (depth in feet on lake)***

| Runoff Condition | Existing 1982 Irrigation Demand plus FRM flows | Ultimate Irrigation Demand plus FRM flows |
|---|---|---|
| 1:2 return period (average) | 0.64 | 2.44 |
| 1:5 through irrigation period plus 1:2 through the remainder of year | 3.12 | 4.90 |
| 1:5 year return period | 4.09 | 6.17 |
| 1:15 year return period | 5.01 | 7.08 |

### *b) 2005 Feasibility Study Values*

Mr. Cooke has spent time revisiting the licences and irrigation areas that were recorded by Bergman in 1983 and tracked the changes in ownership and areas. This assessment was based on the MOE database for all current and pending licences diverting water off the mainstem of the Nicola River. He has also viewed the outstanding applications that are awaiting signature/approval, as it is believed that there has not been enough storage to approve this usage. Based on this research, the licensed irrigation abstractions from the Nicola River downstream of the Nicola Lake Dam amount to the values shown in Table 5.3. All of these licences are run-of-river or baseflow irrigation licences. Please note that only about 65% of these water requirements (i.e. irrigation requirement during July, August and September) would need to be backed by storage.

***Table 5.3: Current Irrigation Requirements***

| Status of Irrigation Licence | Area (acres) | Area (ha) | Volume (AF) | Volume (million $m^3$) |
|---|---|---|---|---|
| Current licences | 4,892 | 1,980 | 8,990 | 11.1 |
| Apportionment pending | 717 | 290 | 1,778 | 2.19 |
| Outstanding applications | 947 | 383 | 2,560 | 2.97 |
| **Totals** | **6,556** | **2,653** | **13,328** | **16.26** |

## 5.2 Fisheries Resource Maintenance Flows (Instream Flow Requirements)

Bergman also provided an overview of the conservation water requirements for the fishery in the Nicola River (1983: pages 23 to 39).

In 1983, the desired Fisheries Resource Maintenance (FRM) or instream flow requirements for the Nicola River were recorded as shown in Table 5.4 below.

***Table 5.4: FRM Flow Rates***

| Reach of Nicola River | August to November | | December to April | |
|---|---|---|---|---|
| | (cfs)[1] | ($m^3/s$)[1] | (cfs) | ($m^3/s$) |
| Nicola Lake to Coldwater River | 60 | 1.7[2] | 40 | 1.13[2] |
| Coldwater to Spius Creek | 110 | 3.1 | 110 | 3.1 |
| Spius to Thompson River | 200 | 5.7 | 200 | 5.7 |

*Note 1 cfs = cubic feet per second; $m^3/s$ = cubic metres per second flow rate.*
*Note 2 Bergman used 1.8 $m^3/s$ and 1.2 $m^3/s$ respectively in their analyses.*

The sequence of releases to achieve these values are detailed in the 1987 Nicola Lake Operating Rule (R.Y. McNeil, 1987). It is believed that this FRM can be refined to mimic the natural flow conditions that are required by fish as has been successfully implemented at the Okanagan Lake outlet. In parallel to this study the Pacific Salmon Foundation has commissioned a reconnaissance study to identify what the scope of work would be to refine these instream flow requirements. At time of writing, these results and recommendations were not yet available. This information will be fed into the NWUMP process.

## 5.3 Summary of Water Requirements Used in the Water Availability Assessment

The volumes and flow rates used in the water availability assessment were based on the full build-out of arable land assumed by Bergman in his 1983 Feasibility Report.

### *a) Current Dam*

The total annual water requirement that needs to be released from the current Nicola Lake Dam amounts to 46,500 AF. This is broken down into three main periods of the year, namely:

- Freshet Period (April, May and June)

  A minimum flow volume of 11,500 AF or 14,185,000 cubic metres for irrigation, fish and other requirements. To put this in context, in an average year approximately 80,300 AF of water spills over the dam during this period. In a 15 year drought return period, about 16,900 AF of water spills over the dam during the same timeframe.

- Summer Low Flows (July, August and September)

  A flow volume of 17,000 AF or 20,970,000 cubic metres for irrigation, fish and other requirements.

- Non-irrigation period

  A flow volume of 18,000 AF or 22,203,000 cubic metres for fish flow requirements.

***b) Completed Dam***

According to Bergman (1983) values, the total annual water requirement that needs to be released from a “completed” Nicola Lake Dam amounts to 57,200 AF that may be divided up as follows:

- Freshet Period (April, May and June)

  A minimum flow volume of 15,100 AF or 18,625,000 cubic metres for irrigation, fish and other requirements needs to be released from the dam during this period.

  Summer Low Flows (July, August and September)

  A flow volume of 24,100 AF or 29,727,000 cubic metres for irrigation, fish and other requirements. Fish flows alone amount to around 10,296 AF during this period.

- Non-irrigation Period

  A flow volume of 18,000 AF or 22,203,000 cubic metres for fish flow requirements.

In other words, a total of 28,296 AF would be required for instream flow requirements for fish during the non-freshet period of July through March.

Bergman assumed that the total required for irrigation during the period July to September would amount to 13,804 AF in the completed dam scenario.

The reason why we focus on the non-freshet period above is due to the fact that the storage we are creating has to maintain these water releases during this period of the year in a 15 year drought flow sequence. This conservatively assumes that there is no use of any inflow into the Nicola Lake during this period.

### 5.4 Storage Allocations

There are only two storage licences on the Nicola Lake, one held by the MOE (License C64717 for an annual 31,634 AF or 39,020,000 cubic metres), and the other by the Department of Fisheries and Oceans (DFO; License C64716 for 10,000 AF or 12,335,000 cubic metres). Note that the uncompleted dam only yields storage of around 28,500 AF or 35,154,000 cubic metres, which is only about two-thirds of the total licensed storage of 41,634 AF.

During the non-freshet period, the DFO licence is not adequate to meet the minimum flow requirements. Furthermore, irrigation below the Nicola Lake is not backed by a storage licence and relies on run-of-river flows. As a result of water shortages during drier than average years, the MOE has over the years released additional water from its storage licence to back fish flows and to provide a bit more security for irrigation requirements.

The relative financial contributions made towards the intended creation of the additional storage on behalf of each sector, were:

- The DFO contributed $450,000 at 1986 prices;
- Agriculture, $311,944 through the Federal/Provincial ARDSA program;
- With the Provincial Government (BC Ministry of Environment and Parks (BCELP)) contributing the lion’s share at $1,532,552.

Domestic, mining and industrial water use is very small in comparison to irrigation requirements.

## 6.0 AVAILABILITY OF WATER

### 6.1 Introduction and Description of Lake and River Hydrological Regime

The original “incomplete dredging” operating rule curve, with minor improvements, is still followed today. This operating rule is described in the official 1987 MOE report prepared by R.Y. McNeil.

It is felt that this operating rule can be optimized by holding back certain releases and by utilizing new fish or instream flow requirement input as well as operating the dam on a more day to day basis in the same way as the Okanagan Lake Dam is successfully managed. This task does not form part of the current feasibility assessment of various dam completion options.

Mr Ball of the MOE in Kamloops, has commenced work on a detailed review of the operation of the Nicola Lake Dam over the period 1987 to 2005. It will be most helpful to the NWUMP process for this work to be integrated with all the water management assignments that will take place during the period 2006 to 2008.

## 6.2 Water Resource Evaluation and Water Balance

A water availability analysis was conducted by Mr Doyle, P.Eng., to determine whether there will be enough residual inflow into the Nicola Lake to fill the Nicola Lake reservoir both now and in 50 years time. The following section provides an abbreviated version of Mr Doyle’s report summarized by the project team leader. The original report may be found in the project file in the NSBA offices.

### *a) Methodology Employed*

Mr Doyle worked with actual Nicola River and tributary water flow data obtained from Environment Canada and other sources in order to analyze the inflow and outflow characteristics of the Nicola Lake. He also built in the potential future reduction of inflows due to climate change scenarios as have been predicted by numerous experts in the neighbouring Okanagan Valley.

After discussions with MOE officials, an identified constraint was the fact that an increase in actual water usage upstream of the lake could have a negative impact on the inflow into the lake, and that this uncertainty should be acknowledged. It should however also be realized that uncertainty exists in any hydrological analyses. Even though these are the best predictions given the current data and assumptions, further refinements of these flow availability values will take place in the NWUMP process in future as more information becomes available.

The possibility of an increase in “mudflat exposure’ during lake draw-down levels associated with the completed dam was also considered.

It must be noted that the completed dam analyses included the “full build-out of arable land” as put forward by Bergman in his 1983 report and shown in Table 5.1 in the previous chapter. Conclusions have been drawn from the result of these analyses.

### *b) Summarized Findings*

i. The following estimates were obtained (Table 6.1).

***Table 6.1: Best Estimates of Nicola Lake Outflows for Different Drought Return Periods for the Entire Year, Freshet, 7-day Summer Low Flow and the Non-irrigation Period in the year 2000.***
***(cms = cubic metres per second; AF = acre-feet)***

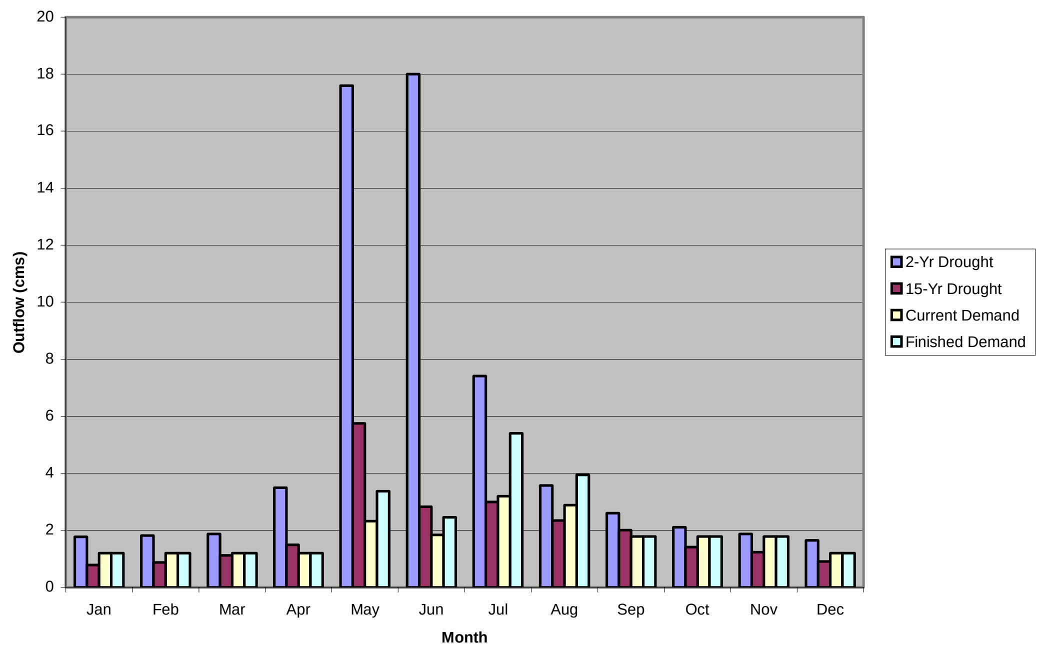
| | ⇨ | Drought events get drier | | | ⇨ | | ⇨ | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Period** | **Drought Return Period** | | | | | | | | **Current dam Required Outflow Volume* (AF)** | **Completed dam Required Outflow Volume* (AF)** |
| | **2-Yr Discharge (cms)** | **Volume (AF)**** | **5-Yr Discharge (cms)** | **Volume (AF)** | **15-Yr Discharge (cms)** | **Volume (AF)** | **50-Yr Discharge (cms)** | **Volume (AF)** | | |
| <u>Entire Year</u> | | | | | | | | | | |
| *Annually* | 5.32 | 137,000 | 3.32 | 85,600 | 1.98 | 51,000 | 1.04 | 26,800 | 46,500 | 57,200 |
| *Monthly* | 4.92 | 127,000 | | | 1.32 | 34,000 | | | | |
| <u>a) Freshet</u> | | | | | | | | | | |
| (Apr-May-Jun) | | | | | | | | | | |
| no dam | 16.5 | 106,000 | 10.8 | 69,400 | 6.75 | 43,400 | 3.8 | 24,400 | | |
| current dam | | 80,300 | | 37,800 | | 16,900 | | 7,400 | 11,500 | |
| completed dam | | 76,700 | | 34,200 | | 15,100 | | 7,400 | 15,100 | 15,100 |
| b) 7-day Mean | | | | | | | | | | |
| <u>Summer LF</u> | | | | | | | | | | |
| (Jul-Aug-Sep) | | | | | | | | | 17,000 | 24,100 |
| no dam | 0.59 | N/A | 0.36 | N/A | 0.25 | N/A | 0.2 | N/A | Jul - 3.2 cms | Jul - 5.4 cms |
| current dam | 2.16 | | 1.61 | | 1.25 | | 1.01 | | Aug -2.9 cms | Aug -3.9 cms |
| completed dam | 2.85 | | 2.3 | | 1.34 | | 1.01 | | Sep - 1.8 cms | Sep - 1.8 cms |
| <u>c) Non-irr. Period</u> | | | | | | | | | | |
| (Oct-Mar) | 1.59 | 20,400 | | | 0.615 | 7900 | | | 18,000 | 18,000 |
| | | | | | | | | | Oct - 1.8 cms | Oct - 1.8 cms |
| | | | | | | | | | Nov - 1.8 cms | Nov - 1.8 cms |
| | | | | | | | | | other 4 months - 1.2 cms | |
| | | | | | | | | Storage Vol. of Lake with <u>Existing</u> Dam | 28,500 | |
| | | | | | | | | <u>Completed</u> Dam | 41,600 | |

* Based on full build-out of arable land
** 1 AF or acre-foot equals to 1233.482 cubic metres of water.

In an average year approximately 137,000 acre-feet (AF) of water flows into Nicola Lake, most of which enters during the months of May to June as part of the annual snowmelt freshet. During a relatively dry climatic year a volume of 51,000 AF flows into the lake. Since the storage that can currently be released from the lake only amounts to 28,500 AF, the rest of this water usually spills downstream towards the Thompson River.

ii. Other ways of depicting the results of water availability at the dam are shown below.

***Figure 6.1: Current Monthly Supply/Demand Comparisons at Outlet of Nicola Lake for 2-yr and 15-yr Droughts***




Note that median (2-yr) drought flows far exceed current or future demands but that a 15-yr drought barely matches current demand and does not meet "completed dam" demand. During the drier portions of the year it has been assumed that the 1:15 year dought flows are supplied exclusively from storage.

The following diagram demonstrates the expected change in hydrological regime over the next 50 years.

***Figure 6.2: Comparison of Avg. Monthly Inflows to Nicola Lake for a 2-yr Drought for 2000, 2020, and 2050***

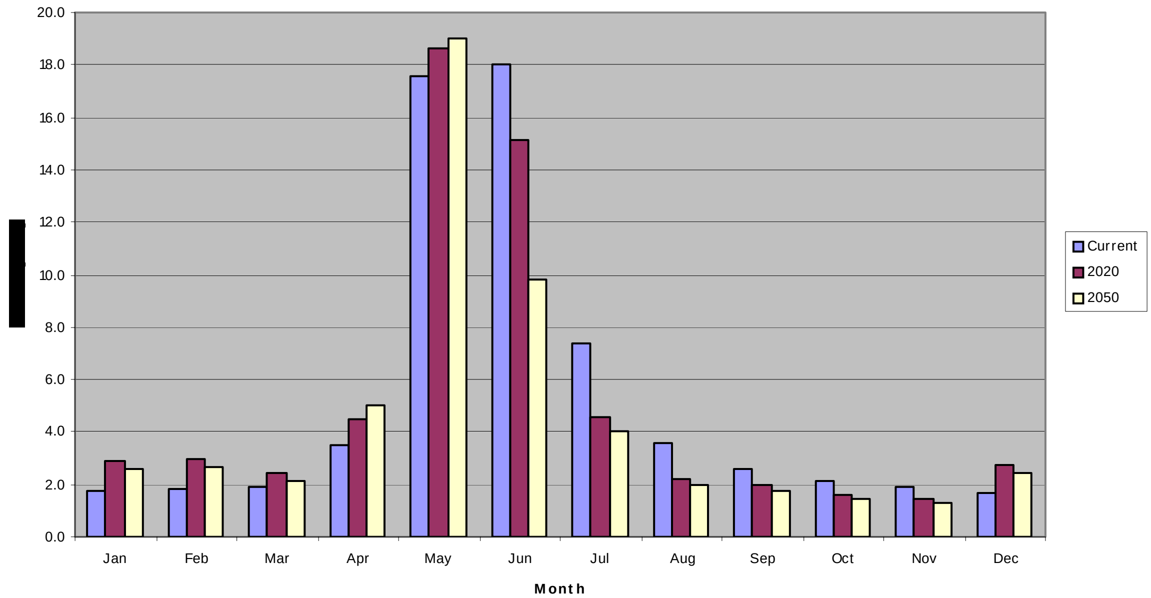



***Figure 6.3: Comparison of Avg. Monthly Inflows to Nicola Lake for a 15-yr Drought for 2000, 2020, and 2050***

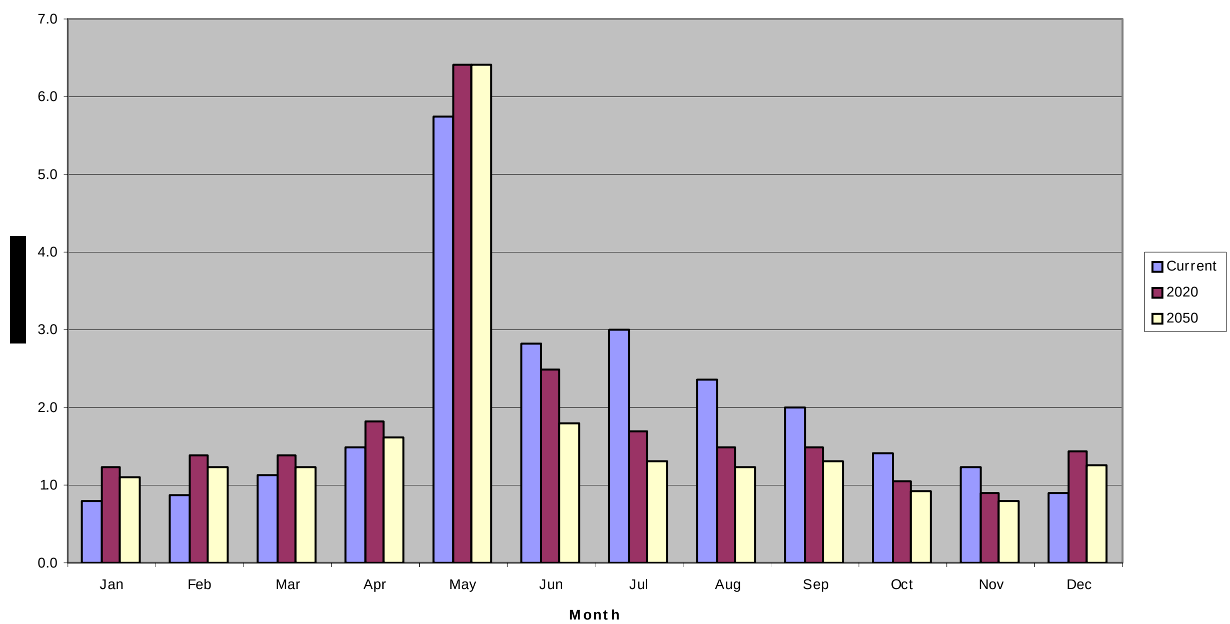


Figure 6.2 and 6.3 indicate that the following trends in the hydrological regime into the Nicola Lake will be observed:

- The Spring freshet may be smaller and earlier;
- Summer and Fall flows would be smaller;
- Winter flows would be larger at first, but then will begin to decrease by mid-century;
- Annual flows will decrease.

The bottom line here is that it seems likely that annual runoff into the Nicola Lake will decrease through the present century if the forecast consequences of climate change/global warming become a reality. Water stored in Nicola Lake (and other reservoirs) will therefore become more and more valuable as the decades pass because of a continuing reduction in summer and fall flows. Figure 6.3 shows that flows could become especially critical for fish during the months of June to November if additional storage is not created.

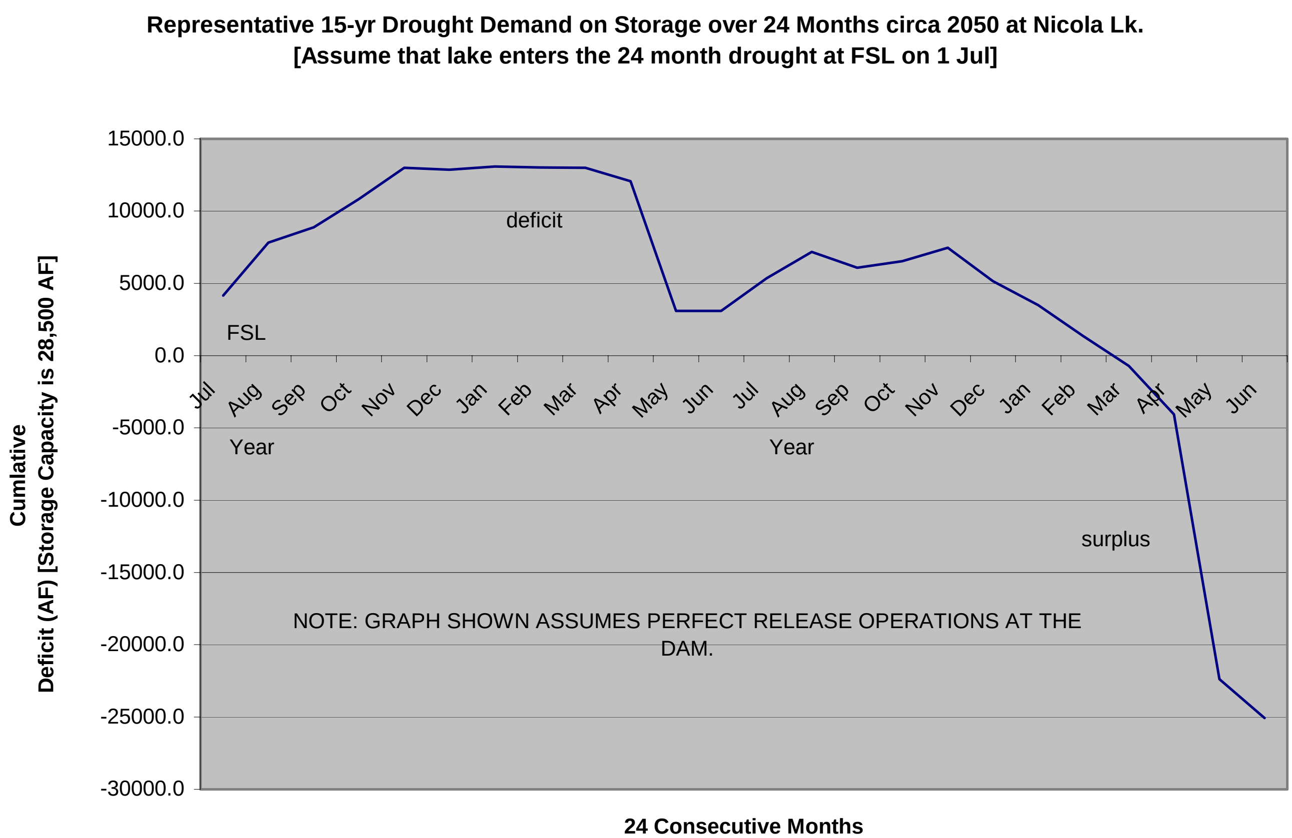
iii. As part of this study it was deemed necessary to put the meaning of envisaged annual shortages of storage in the Nicola Lake into the context of storage capacity and the resulting flows at the dam control structure over multi-year periods. Simply put, because the lake does not refill from one year to the next does not mean that required outflows cannot be met in a water-short year or the succeeding year. Figure 6.4 illustrates this point.

Figure 6.4 presents the cumulative deficit (surplus) on a monthly basis in lake storage over a 2-year period during a 15-yr drought using the existing operating regime in the year 2050.

In the first year of the drought (assumed to be the worst year of the 2 year long drought) the storage deficit never exceeds 13,000 AF (lake storage capacity is 28,500 AF so live storage in the lake is always more than 50% of full storage) and lake storage at the end of this year is about 3000 AF shy of full.

In the second year of the drought, the maximum deficit is only a little more than half that of the first year and the lake refills by early March despite starting the year at less than full supply.

***Figure 6.4: Example of Storage Volume Changes in Nicola Lake on Monthly Basis During a 2-year long 15-yr Drought in 2050 with Current Dam***




These results are based on the following assumptions:

- That the capacity curve shown ignores the operating rule curve (that helps to reduce chance of flooding at the other end of hydrologic spectrum) and also the potential problem of low lake levels going into winter (i.e. very low lake levels going into winter pose a real threat of significant ice blockage in the shallow channel leading from the main lake to the dam if a prolonged cold snap occurs).
- Two further important assumptions made when constructing the curve shown in Figure 6.4 were: that year 1 of the drought starts in July with the lake full; and that no releases from the dam beyond the required minimums are made over the 2 years. For argument sake, if twice the amount of water required for minimum releases

happened to be released that first year, then there would be a real danger of no lake outflow over the winter (2 x 13,000 = 26,000 AF ~ 28,500 AF capacity) and again the following summer. As this century progresses, operating the dam during significant drought years will require close monitoring of lake levels and timely gate operations when change is required so that little stored water is wasted.

All in all, even though the lake will not quite refill in a 15 year drought event of two years duration, it is believed that there will be adequate water to meet current demand at the lake outlet.

iv. The analysis followed the existing level of risk of water shortage principle that was adopted in the 1983 feasibility study, namely that a 1:15 year drought condition was used to determine the volume of storage required for agriculture and fish interests. In the case of agriculture, this assumes a very high level of assurance of supply for the cultivation of the forage crops.

v. It is important to note that the water availability results presented above do not include an additional demand for greater releases for fish during the freshet period each and every year to better mimic the natural hydrograph. The reason for adopting this approach was due to the fact this new demand would require that all the lake inflow from April to June be passed through the lake during a 15 year drought. Certain levels of risk and trade-offs will have to be made in drought years.

vi. One issue that became important during the course of this feasibility study was the impact of more frequent exposure of the "mud flats" in the lake outlet channel associated with the ability to lower lake levels as much as 0.5 m below what is now possible.

A review of the historic exposure of the mud flats based on a rough estimate of lake levels that produce a "noticeable exposure of mud flats" and a "large exposure of mud flats" over the period 1987-2002 was conducted. This was followed by a rough calculation of how often the lake level in a completed project might be drawn down lower than it currently can be in anticipation of heavy runoff in the spring and again in the late summer to meet downstream demand in dry years.

*Current Dam*

Results of the review indicated that, annually, the mud flats have been "largely exposed" for about 2 days and "moderately exposed" for about 40 days on average with present operations.

It is only in recent years that lake levels have dropped so low over winter to result in "large exposure". The longest period of this type of exposure occurred in 2002 and lasted about 40 days.

Preliminary 2003/2004 lake level data show that the mud flats were "largely exposed" from late October 03 to late April 04 during and after the 2003 drought. "Moderate" exposure was obviously even longer during that same winter.

*Completed Dam*

Operations under a completed dam would likely result in "large exposure" periods of 35 days and "moderate exposure" periods of 70 days as annual averages.

The simple answer to a difficult question is that the mud flats, under the existing hydrologic regime, would likely be "greatly exposed" for a long-term average of an additional month each year more than the current couple of days and also "moderately exposed" for an average of one additional month each year more than the current 6 weeks with a completed dam when compared to the present dam.

A worst-case scenario of annual mud flat exposure with a completed dam is 2 additional months more than both the current average annual "large exposure" and "moderate exposure" durations. Exposure of the mud flats can be partially controlled by dam operating rules if that is a critical concern.

### c) Water Balance

The work in this feasibility study has focused on the additional storage capacity that can be released during the July to September summer low flow period from a completed dam project.

*No Dam*

What has become clear from the Bergman work (1983) and the more recent Doyle work (see Table 6.1) is that both the fishery and irrigation have benefited greatly from having the dam in place. The freshet would normally flow through in the April to May period, leaving very little storage capacity. The 7-day low flow in the July to September period river flow would only be a fraction of what the current and completed dam could deliver. This proves the universal need for water storage to back water usage and to help maintain the ecological integrity of the riverine system at the same time.

*Current Dam*

If we consider the water use and water availability values presented in the sections above, it has been deduced that the current water supply deficit during July to March in a 15 year drought amounts to a negative water balance of 6,500 AF (i.e. storage of 28,500 AF less the non-freshet water requirement of 35,000 AF).

*Completed Dam*

Completion of the dam project would increase the accessible storage capacity available to around 41,600 AF (i.e. an increase of 13,100 AF). The water balance therefore increases to a positive value of 6,600 AF if the lake is assumed full at the end of June.

The following instream, or fish, flow requirement volumes were assumed:

- From July to September (10,296 AF);
- From October to March (18,000 AF).

Taking these instream flow requirements into account in addition to the irrigation requirements for the July to September portion of the growing season, a calculation was made to determine how much additional irrigation could be accommodated in a 1:15 year return period drought. Use was made of actual water licences, apportionments pending, existing applications and their existing duties. Using a water supply duty of 2.5 feet per acre per annum for potential new irrigation land, it is believed that the following water allocations can be supported in a 15 year drought period for a completed dam:

- Current irrigation licences (4,892 acres; 8,990 AF; 5,844 AF for July to September);
- Apportionments pending (717 acres; 1,778 AF; 1,156 AF for July to September);
- Outstanding licence applications (947 acres; 2,560 AF; 1,664 AF for July to September);
- 280 acres of new irrigation around the Nicola Lake (700 AF; 455 AF for July to September);
- 2880 acres of new irrigation downstream of the lake (7,208 AF; 4,685 AF for July to September).

The values for new irrigation are based on conservative assumptions, which include:

- All the licenced water usage, existing and new, is supported solely by Nicola Lake storage during the months of July, August and September. This assumes that no water flows into the lake from the Upper Nicola River and the lake's tributaries during this period, which is unlikely even in 1:15 drought;
- A drought with a 1:15 year return period. There should be more water available in drought periods with less severity and ample water in an average to good climatic year. Any business in the real world assumes a certain level of risk. In other words, it is believed that more water could be made available to irrigators in developing land if they are willing to cut back drastically on irrigation in dry, low flow years when water is required to meet old licence and instream fish flow requirements;
- Since this water availability assessment was limited in its scope ($14,000), it should be remembered that the purpose of this analysis was to determine whether there was enough residual inflow into the Nicola Lake to fill an expanded Nicola Lake reservoir now and in 50 years time. The actual determination of new irrigation licences will have to be based on a more thorough water resources system analysis that encompasses the whole Nicola River watershed above and below the lake (i.e. taking the main tributaries contributions to meeting the required offstream and instream flow requirements).
- The water availability assessment assumed the full "build-out" values adopted by Bergman (i.e. 12,307 acres). In today's terms this amounts to around 10,000 acres as listed above.

### *d) Conclusions*

Water requirements for fish and irrigation are usually catered for during these three freshet months with the exception of very severe drought periods.

The problem arises during the remaining nine non-freshet months of the year during low flow/dry climatic periods. Water from the 28,500 AF of storage has to be released downstream to meet the irrigation <u>and</u> fish flow needs (approximately 17,000 AF) between July and September. Climate Change is expected to exacerbate these shortages.

An additional minimum of 18,000 AF is required for fish flows during the remaining months from October to March. A small freshet flow to support an important part of the fish life cycle in April is currently not met.

Based on this "current dam" situation in a 15 year drought sequence, the Provincial Government has not approved outstanding licence applications that have been in the works for almost two decades.

This emphasizes the need for the completion of the dam to make more water storage available. There is an urgent need to complete the hydraulic connection between the deeper waters of the lake and the dam itself. Completing the dam would create a storage capacity of 41,000 AF which could provide just more than 13,000 AF of additional storage that can be utilized during the non-freshet period for fish and irrigation assuming that the lake is full at the end of June. During very serious dry years (i.e. much greater that the 1:15 year drought return period), this may not be the case and a special drought management plan will have to be implemented.

The total irrigation area that can be supported by completing the dam amounts to around 10,000 acres, which is lower than the Bergman values. This decrease is due to the fact that he included a substantial volume of water for switch over from tributaries as the source of water (i.e. probably not all of it will be realized), and he assumed a lot of new irrigation around the lake.

The full fishery allocation referred to in Section 6.2 would be met in most cases. Some additional water may be required for a freshet flow in April. The Pacific Salmon Foundation will be conducting a study to start evaluating what needs to be done to determine more accurately what flow regime will be optimum for the Nicola River Fishery. This regime along with other instream flow requirement determinations will then need to be worked into a revised dam operating rule so as to conserve as much water as possible for use during the non-freshet, low flow period.

## 7.0 ENGINEERING OPTIONS

The following technical assessment was prepared by Bob Costerton, P.Eng., of BC Rivers Consulting for Urban Systems Ltd.

### 7.1 History of Works Completed and Those Requiring Completion

In 1986 and 1987 the Nicola Dam structure was replaced with a new concrete and earth fill dam. All work on the dam (structure, fishway, power canal, etc) was completed as planned. The new dam design intended that more water be accessed from the storage in the lake by lowering the minimum level to which the lake could be drawn down. The dam at the outlet is capable of passing flows at the design minimum supply level of 623.78 m.

The other portion of the required work was to cut a channel through the shallow, western portion of the lake (3 km long) to allow the lake to be drawn down to the minimum supply level. This channel will be referred to as the main outlet channel. Other works around the lake would also have to be modified to operate at lower lake levels, such as irrigation pumps, channels to those pumps from deep water, boat ramps and domestic wells.

In 1987 and 1988 the main outlet channel was cut using a hydraulic cutterhead suction dredge that grinds up the lake bed soil and sucks it up using a pump and floating pipe that carries the dredged soil and water to a settling pond on land. The soil particles are then settled out and the clean water released to the lake.

The cost of the dredging went over-budget due to hardpan clay that was encountered in the lakebed, which was much slower to dredge than anticipated. Additional funding was secured, but the operation was called to a halt as the dredge production slowed further and the costs rose under the existing contractual arrangement with the dredge contractor. The intent at that time was to complete the dredge under a more favourable contract in the future. No additional funds were ever secured for completing the work, despite numerous attempts.

The other related works around the lake were not finished as the lake could not be lowered to the minimum supply level, and all available funding was used on the dredging portion of the project.

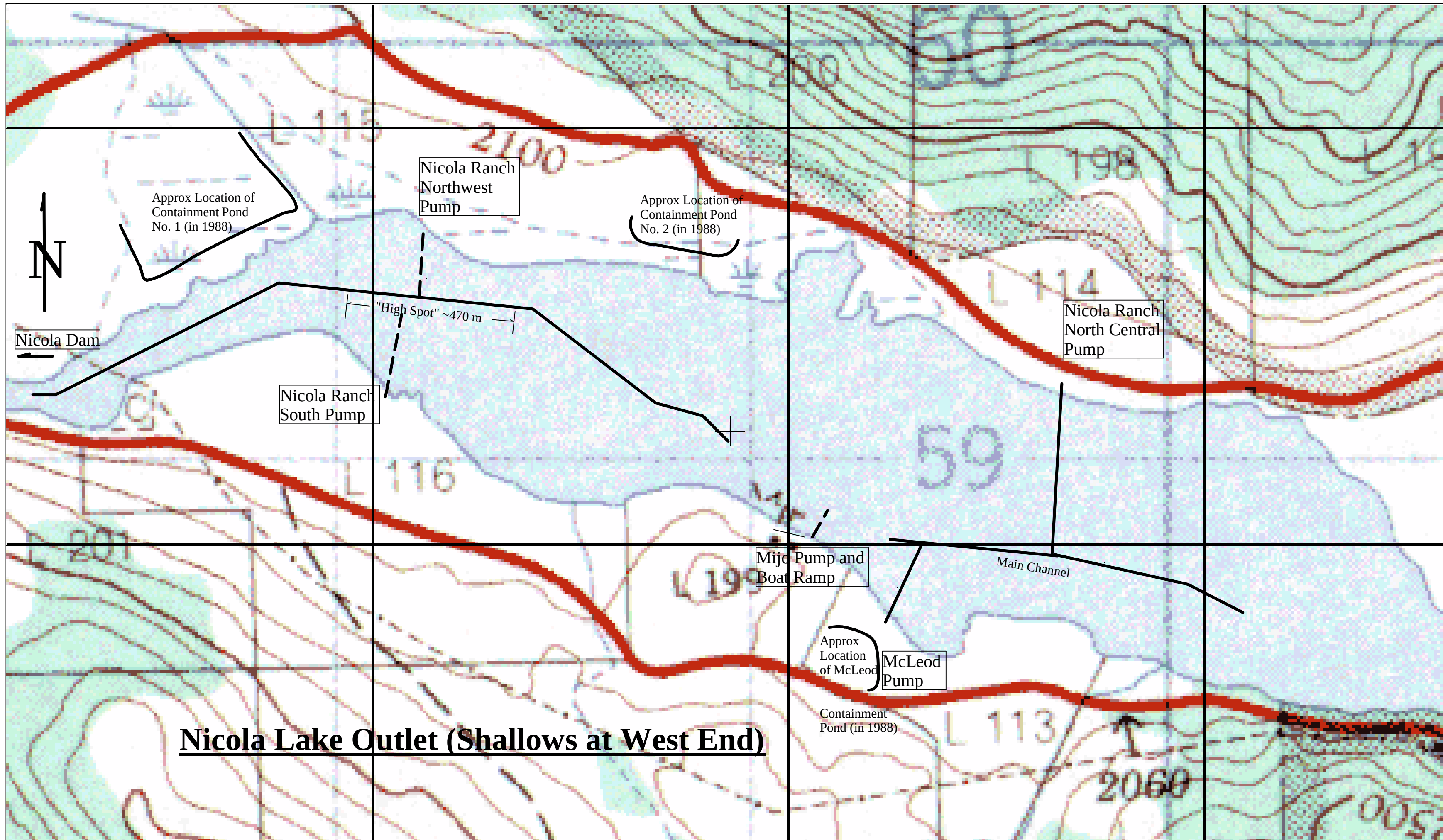
Figure 7.1 shows the required works in the shallow portion of the lake and also the related works around the lakeshore. Figure 7.2 shows greater detail of the works required on the main outlet channel and the side channels to irrigation pumps, along with an August 2005 update on lakebed levels. Table 7.1 itemizes the required works and provides details for each work item with regard to costs, etc.

The following comments can be made regarding the works that remain to be completed:

- The majority of the work (cost) is involved in removing the high spot in the main outlet channel, and providing water (in channels that are effective at low lake levels) to each of the 6 intakes around the shallow, west, end of the lake;

- Other lakeshore works are related to the modifications required to pumps, boat ramps and wells to enable them to function at lake levels near the design minimum supply level;
- The hydraulic cutterhead suction dredge was efficient when soft sediments (silt, organics, sand, etc) were encountered, but highly inefficient in the blue clay (hardpan) encountered;
- Due to the high cost and slow progress using this method, it was decided to change the design to widen the channel and reduce its depth over a 470 m long section that contained mostly hardpan clay. This design change enabled the costly dredging contract to be completed, but leaves restrictions on the amount of water that can be moved through the channel at low lake levels. There is also the risk of ice blocking the main outlet channel during the winter if lake levels drop too low;
- When this work was suspended in 1988 it was assumed that when the channels started to infill over time (assumed to be every 5 years) that maintenance dredging of each channel would be required, and that the remainder of the main channel dredging would be completed at that time, under a more cost effective contract;
- In the 1990s cost estimates were prepared using an alternate technique of excavating the channels using conventional hydraulic excavators working off of temporary, rock, work berms. The costs were thought to be lower using this technique, but funds were still not available;
- During this assessment of the engineering feasibility of completing the storage project the dredged/proposed channels were resurveyed. The result was a significant infilling of the excavated side channels and a significant filling in of the main channel east (upstream) of the high spot. The hardpan clay high spot was relatively unchanged. This infilling was anticipated to happen, and that maintenance dredging would be required approximately every 5 years. The documented infilling has occurred over the past 17 years, but had never been shown to be significant in the past. This roughly doubles the amount of work required to complete the project, over that envisioned in the 1980s or 1990s.

Focusing on creating the required channels in the shallow end of the lake, several new options are considered, beyond the cutterhead suction dredge and excavation from work berms considered in the past. These are discussed in detail below. The fact that the channels were never completed places restrictions on the storage that can be accessed in Nicola Lake. Depending on the operation of the dam and assumption regarding winter ice thickness, roughly 0.5 m of storage cannot be accessed without increasing the risk of having winter ice block the outlet channel and restrict / cut off flow at the outlet of the lake. This has occurred at two times in the past, impacting water use and fish downstream (Doyle and Kosakoski, 1993).





**Notes:**

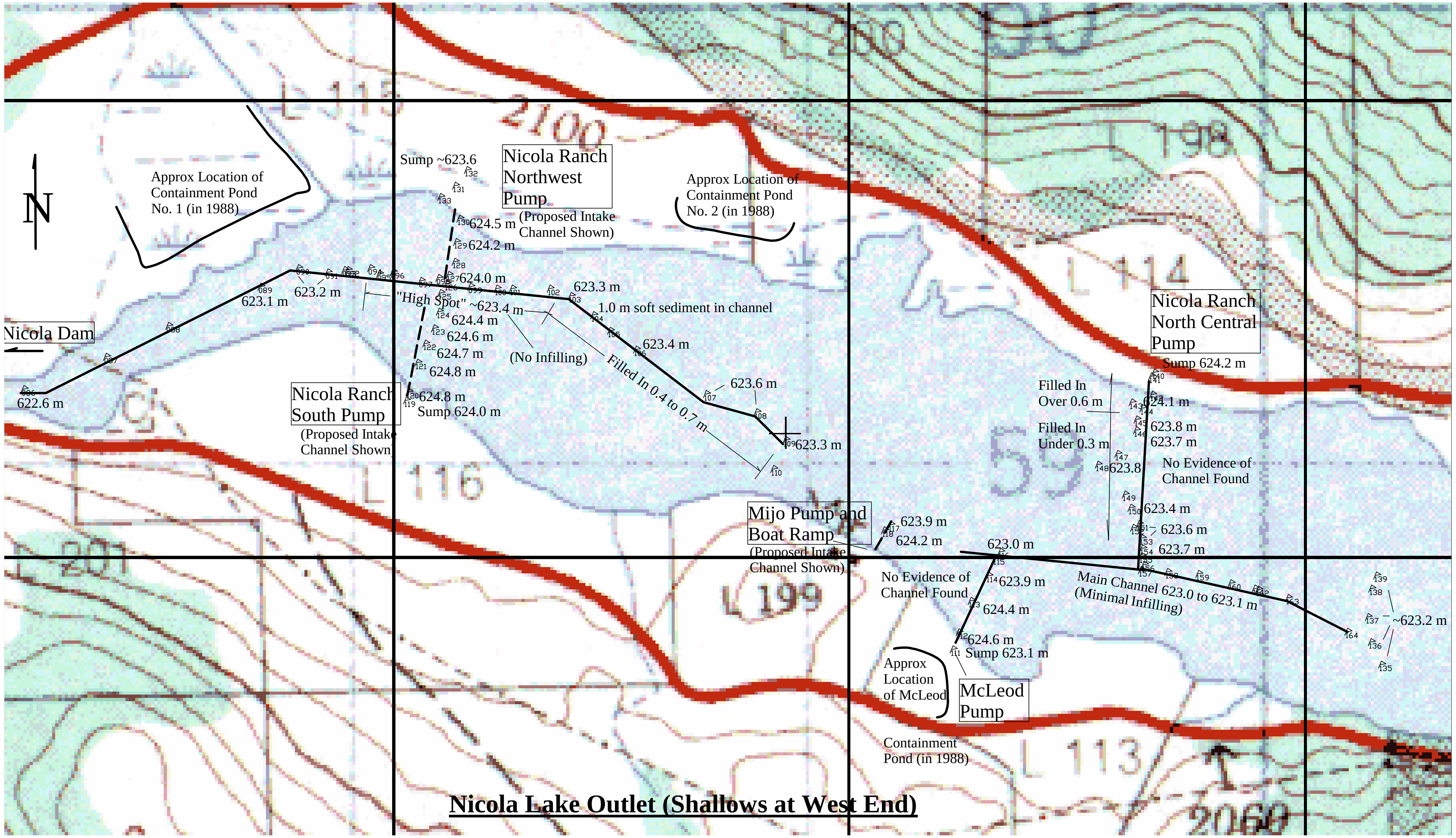
- For a complete list of works required see table in text
- Lake outlet map shows:
  - Main outlet channel high spot
  - Intake channels to pumps for:
    - Nicola Ranch NW, N Central and South
    - McLeod
    - Mijo
- Smaller scale map of Nicola Lake shows:
  - MoT boat ramps
  - Monck Park boat ramp
  - Location of other boat ramps in case work was required there
  - Domestic wells
  - Huber intake
  - Nicola Ranch NE intake

Nicola Dam Completion Feasibility Study

Figure 7-1 - Locations of Required Works for Completion of Storage Project
(As presented in 1988 and 1998 assessments of required works)

BC Rivers Consulting

Drawn By: Bob Costerton, P.Eng. Date: 4 Aug 2005

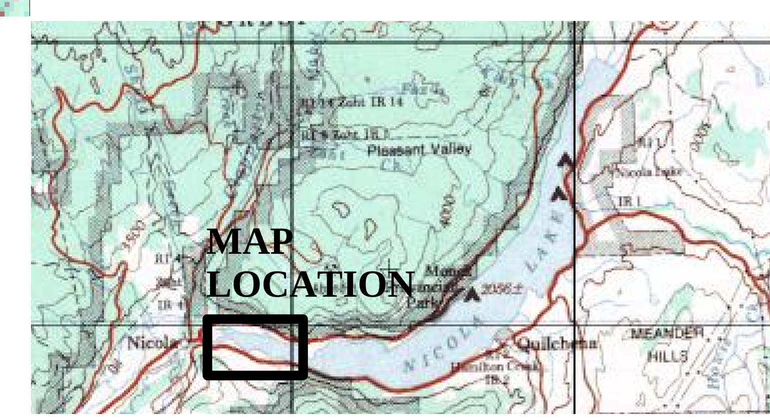



**Nicola Lake Outlet (Shallows at West End)**

**Observations:**

- Main outlet channel has not infilled significantly over the ~470 m length of the "high spot", which averages approx 0.5 m above design level of 622.9 m
- Channel east of high spot has filled in between 0.4 and 0.7 m. The length of channel affected is 580 m
- Total "High spot" is now 1.05 km long, varying between 0.4 and 0.7 m above the design elevation
- Original high spot will be largely made of firm clay, with some loose sediments on top, particularly near the edges
- Infilled channel east of original high spot will be composed largely of loose sediments as consolidated material was dredged out in 1988
- Separate portion of main outlet channel to the east (north of McLeod property) has only filled in 0.1 to 0.2 m
- Two side channels were dredged in 1988: one to McLeod's intake and one to the Nicola Ranch's central intake on the north lake shore - both with 623.5 m inverts
- McLeod side channel has filled in by 0.4 to 0.9 m with soft sediments - its original location is not visible. Maintenance dredging is required
- Nicola Ranch North Central pump intake side channel has filled in by 0.3 to 0.8 m - its original location is not visible. Maintenance dredging is required.
- Average lake bed elevations for the proposed side channels are as follows:
  - Nicola Ranch NW intake: 624.3 m
  - Nicola Ranch N Central: 624.2 m
  - Nicola Ranch S intake: 624.7 m
  - Mijo boat / water intake: 624.2 m
  - McLeod intake: 624.4 m
- Other specifics are noted on the map.

**Key Map**




**Survey / Drawing Notes:**

- Lake bed elevations were surveyed relative to a known lake level on 2 August 2005
- A 0.2 m disc was placed on the base of the survey rod to determine the lake bed level
- Only top of soft sediment elevations are shown
- Depth of soft sediments were noted at select locations, where standard survey rod was pushed into lake bed
- Elevations shown are estimated thalweg levels (deepest part of channel). Thalweg was located by probing periodic depths in a cross-section and returning to the deepest location and recording depth and GPS location
- GPS locations are approximate (stated to be within 10 m). Mapping of locations is very approximate as surveyed locations are crudely superimposed on a lake map.
- Do not rely on locations of features shown on map. Distances are not to be scaled off of map. Channel lengths given are based on original GPS data and are more accurate than the visual representation of the data here.
- Map grid is 1000 m; annotations are approximately the same scale

| | | |
|---|---|---|
| Nicola Dam Completion Feasibility Study | Figure 7-2 - August 2005 Survey of Existing and Proposed Channels | BC Rivers Consulting<br>Drawn By: Bob Costerton, P.Eng. Date: 3 Aug 2005 |

**Table 7-1 - Nicola Dam - 2005 Summary of Works Requiring Completion**

Prepared By: Bob Costerton, P.Eng.
BC Rivers Consulting
Date: 15-Nov-05

Cost Estimates and Details are Given for the Prefered Option with Notes on Assumptions and Uncertainties.
Option Evaluations for Items 1 and 2 are Provided in Table 2.

| Item | 1988 Work Item Description | 1988 and 1998 Comments | Original (1988) Cost Estimate | 1998 Cost Estimate | 2005 Cost Estimate | Contract Required? | 2005 Assessment of Work Required | Environmental Assumptions | Landowner Issues | Uncertainties |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Main Channel Hight Spot**: Including Nic. Ranch NW and S intake channels | Original plan was using a cutterhead suction dredge; 1998 plan used excavator on work berms | $288,000 | $200,000 | $0.6 M to $1.0 M depending on final option feasibility (Costs assume in-kind design and construction supervision by MoE staff)<br><br>Future maintenance costs will have to be added to this capital cost | Yes (2005 equipment rental rates assumed - actual contract would more likely be lump sum, with contractor's taking on entire finacial risk, further increasing cost) | - 470 m long "High Spot" was surveyed to be 0.5 m above design in 1990 (and 2005)<br><br>- Significant channel infilling will require the removal of soft sediments for ~580 m in main channel<br>- The removal of the hardpan clay high spot is most efficient with hydraulic excavators<br>- The removal of soft sediments is inefficient and messy with excavators due to high loss of material into the lake waters and their later migration into the channel<br><br>- Hydraulic suction dredge relatively clean for removing soft sediments, but inefficient for hardpan clay<br>- see options assessment | - see option summary for work timing and lake levels<br><br>- most methods assume use of silt curtains around clay / silt excavation / dredging, but not soil handling areas (off barge / dredge etc)<br>- plan to use the same isolation for rock work berm, if one is required to be placed along proposed channel(s) and removed following channel excavation<br><br>- Fisheries impacts will vary depending on option chosen (see option summary). No financial compensation package is assumed to be required, only the impact mitigation efforts identified. | - Nicola Ranch was supportive of project in 1980s and 1990s,<br><br>- In 2005 Nicola Ranch refused access for planning or construction<br><br>- various cost estimates assume full access or no access from Nicola Ranch | - depth of soft soils on which work berm will be built. Increased soft soil greatly increases volume of work berm and costs<br><br>- exact extent / consistency of hardpan clay (soil profile is available from 1988 work is included in appendix)<br><br>- acceptability of isolation plan; associated isolation and fish salvage costs are very approx.<br><br>- Nicola Ranch access currently denied<br>- The Aug 2005 survey shows that extensive "maintenance dredging" of infilled channels is now required in addition to the work planned in the 1980s and 1990s. A detailed survey would be required during the year the work would actually be done<br><br>- MoE involvement in design, construction supervision, environmental monitoring, approval process, etc |
| 2 | **Pump Intake Channels (6):** | | | | | | | | | |
| | Nicola Ranch - NW | See item 1 | $1,000 | $1,450 | Incl. item 1 | Add to item 1 | See item 1 | See above | See above | See above |
| | Nicola Ranch - N Central | Mostly done - sump exc only | $1,000 | $1,450 | Included in item 1 | Add to item 1 | Infilled and requires removal of soft sediments | | | |
| | Nicola Ranch - NE | Short - sump exc only | $1,000 | $1,450 | Incl. item 1 | Add to item 1 | See item 1 | | | |
| | Nicola Ranch - S | See item 1 | $1,000 | $1,450 | Incl. item 1 | Add to item 1 | See item 1 | | | |
| | McLeod | Mostly done - exc shoreward 45 m | $1,000 | $1,450 | Incl. item 1 | Add to item 1 | Infilled and requires removal of soft sediments | | | |
| | Huber | Buried pipe req'd (or other method) | $13,500 | $19,575 | ~$5000 capital plus $5000 every 5 years | Yes | Temporary channel would be excavated only if / when req'd - likley only during severe drought | Excavation would take place in dry at low water - all soil would be hauled out | A tentative agreement on method acceptable to Huber has been established | Frequency of temporary channel excavation required will be investigated. |
| 3 | **Irrigation Pump Intakes (6):** | | | | | | | | | |
| | Nicola Ranch - NW | No pump modifications req'd | $0 | $0 | $0 | No | No update as landowner denies access | | | Cost should be refined with site inspection (no access allowed) |
| | Nicola Ranch - N Central | Vertical turbine modifications req'd | $16,500 | $23,925 | ~$35,000 | Contract No 6 prepared | as above | | | As above |
| | Nicola Ranch - NE | Vertical turbine modifications req'd | $16,500 | $23,925 | ~$35,000 | Contract No 6 prepared | as above | | | As above |
| | Nicola Ranch - S | No pump modifications req'd | $0 | $0 | $0 | No | as above | | | As above |
| | McLeod | No pump modifications req'd | $0 | $0 | $0 | No | No change | | | |
| | Huber | No pump modifications req'd | $0 | $0 | $0 | No | No change with channel option | | | |
| 4 | **Boat Ramp Extensions (4):** | | | | | | | | | |
| | Monck Park | 140 m fill req'd | $8,000 | $11,600 | ~$20,000 | Yes | No sig change | | | some debate in 1988 regarding length of extension req'd |
| | MoT x 2 | | $4,000 | $5,800 | ~$10,000 | Yes | No sig change | | | Site inspection done - detailed cost estimate required |
| | Mijo | Excavation req'd to 623.5 m | $6,000 | $8,700 | ~$10,000 | Add to item 1 | No sig change | | | Site inspection done - detailed cost estimate required |
| 5 | **Domestic Wells:** | | | | | | | | | |
| | Mijo | Done | $0 | $0 | $0 | No | | | | |
| | Others (Armstrong)? | 5 others may need modifications to avoid priming problems; replace small diameter 1 | $5,000 | $7,250 | ~$10,000 | Yes | Further investigation req'd | | | Site inspections required along with detailed cost estimates |
| 6 | **Extending Domestic Intakes:** | | | | | | | | | |
| | Rose | Done by owner in 1987 | | | $0 | No | | | | |
| | Whitecross | Done by owner in 1987 | | | $0 | No | | | | |

| Totals: | | | Original (1988) | 1998 | 2005 | Recommended / Most Likely Scenario (Using Option 11): | |
|---|---|---|---|---|---|---|---|
| | **High Spot and Intake Channels** | | $306,500 | $226,825 | ~$0.6 M to $3.1 M | | $ 700,000 |
| | **Lakeshore Works** | | $56,000 | $81,200 | ~$125,000 | | $ 125,000 |
| | **Construction Supervision / Surveys / As-constructed Drawings** | Originally planned to be done by government, later assumed to be privately done (in 8 weeks at $2500 plus $2000 drafting work) | | $22,000 (plus in-kind support) | $0 to $180,000 depending on in-kind by MoE or others | Assume no in-kind support from MoE | $ 180,000 |
| | **Environmental Protection (silt curtains, fish salvage, etc)** | None originally planned. | | $20,000 | Included in item 1, plus ~$30,000 | | $ 30,000 |
| | **Grand Total:** | | **$362,500** | **$328,025** | **~$0.75 M to $3.4 M** | Total Capital Cost | **$1.035 Million** |

## 7.2 Current Assessment of Dam Completion Options

The following notes are made regarding the options analysis for completion of the works described above, that are required to complete the Nicola Dam storage project as originally designed:

- Lakeshore works (lowering of pumps, wells and boat ramps) are considered somewhat separately from the "dredging" of channels in the shallow end of the lake. Options for the completion of the lakeshore works are summarized in Table 7.1;
- Focusing on creating the required channels in the shallow end of the lake, several new options are considered, beyond the cutterhead suction dredge and excavation from work berms considered in the past. Several floating / barge mounted excavators, shoreline channel excavation and water pipeline options were considered;
- Numerous internet searches were made to investigate alternative options, not considered in the past. These options were pursued through discussions and meetings with contactors on the coast and in the interior of BC;
- Most options were assessed with and without the cooperation of the predominant lakeshore property owner, who has recently withdrawn support for the project until further scientific studies are conducted;
- Photographs and diagrams have been included in the next section to portray the options;
- The options assessed are summarized in Table 7.2, along with environmental considerations, uncertainties, and notes and conclusions as to the feasibility of each option;
- This list of options was reviewed with small focus group at the 23 Sept 2005 meeting in Merritt. Several options were eliminated at that time, either because they were not feasible, or because a more cost effective, similar option existed. The full list is included as Table 7.2. The short list of options worthy of further consideration is included here, as Table 7.3;
- Detailed cost estimates have been prepared for the preferred option short-list. The cost estimates provided are based on numerous assumptions that have been described in the tables.

### 7.3 Brief Description of Dam Completion Options

Each major option has an alternative which caters for the additional work required to implement the option if the major lakeshore owner does not allow construction access. Access would have to be from distant shores and the main body of the lake, which is owned by the Crown.

A description of each option is provided in Table 7.2 below. The following options developed during the course of this technical assessment starting from the original methodology employed in the late 1980's.

***Figure 7.3: Option 1- A Cutterhead Suction Dredge Off a Floating Barge***

***Figure 7.4: Option 2 - Working with excavators and trucks from berms pushed out into the lake at lower lake levels. (Various other sub-options exist.* Please refer to Table 7.2 for descriptions of these sub-options).**

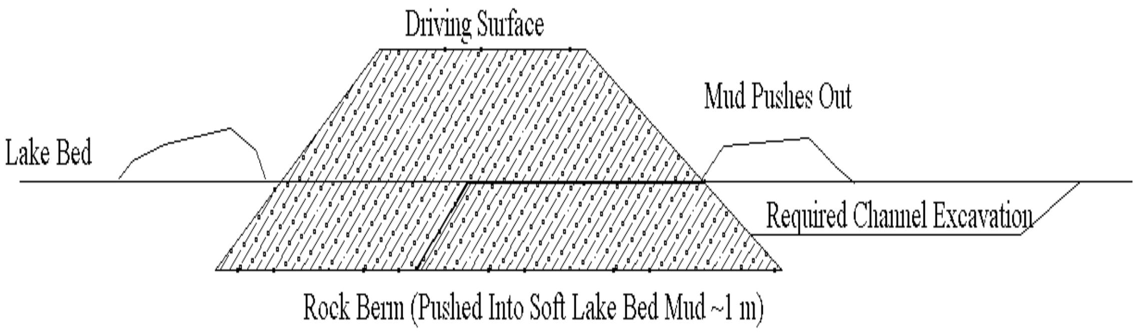
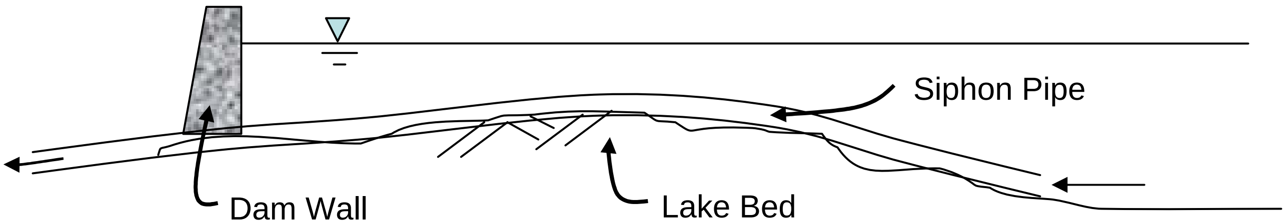



***Figure 7.5: Option 3 - Excavator on a Barge, Loading Materials Onto a Second Barge to be Dumped Elsewhere***

***Figure 7.6: Option 4 - An Amphibious Dredger (Excavator)***

**Figure 7.7: Option 5 - A South Shore Channel Excavation**

***Figure 7.8: Option 6- Siphon Pipe(s)***




Although not mainstream options, the following three refinements could have an impact of the project, especially from the perspective of long-term maintenance:

Option 7: The possibility of doing away with side channels to irrigation intakes by piping water to irrigation fields from the existing Nicola Ranch main pump station near the dam structure.

Option 8: Individual pipes from each irrigation intake down into the main channel.

Option 9: The Combination of the Mijo and McLeod Intakes/Boatramp

As the options were refined it became clear that a combination of various techniques would probably be the most effective way of delivering the solutions required.

***Figure 7.9: Option 10 - The combination of cutterhead suction dredging taking out loose material from the already excavated and now filled in channels, and excavation (for harder materials in main and side channels) from a barge and berm.***

***Figure 7.10: Option 11 - Combination of excavator on barge for main channel (summer) utilizing excavator bucket for hardpan material and augur-suction head for softer material; plus an excavator on work pads during low lake levels (winter)***

***Figure 7.11: Option 12 - South Shore Excavation Through Nicola Ranch fields – Away from the Lake and in the "Dry".***

**Table 7- 2 - Nicola Dam - 2005 Full Option Listing for Completing "Dredging" Work (Work Items 1 and 2 from Table 1 – High Spot and Irrigation Pump Intake Channels)**

Cost Estimates and Details are Roughed Out for All Options. Only construction equipment / materials costs given. No allowance for engineering or environmental design or supervision.
Detailed Cost Estimate Is Provided for the Recommended Option Only.

| Option | Description | Comments | 2005 Cost Estimate | Details of Method / Assumptions | Environmental Considerations | Uncertainties | Feasibility Notes | Conclusions |
|---|---|---|---|---|---|---|---|---|
| 1a (With Primary Landowner Co-operation) | Cutterhead Suction Dredge – continuation of the two dredging efforts made in 1988 | Cost overruns were incurred due to the increased time required to dredge the hardpan clay encountered. The clay was of greater extent and higher density than anticipated. Production from dredge averaged 27 cubic metres per hour as opposed to 61 to 77 cubic metres per hour claimed in tender submission. Work was halted after several shifts of producing only 8.3 cubic metres / hour in hardpan clay | ~$0.8 M | Barge mounted dredge would pipe dredgate to constructed containment pond on nearest available flat land. Once pond dries out it can be spread. The resulting field is non-productive without soil enhancement. | Greater sediment containment and fish salvage may be required than during dredging in 1986 and 1988. This adds to cost, but is likely feasible.<br>Work could likely be done, in part, during the normal instream work window (mid-Jul to mid-Aug) at an increased cost, if that is an environmental benefit.<br>Relatively clean in soft sediments; messy in hardpan clay during clearing of "gummed up" cutterhead | Cost estimate is affected by wide range of bids received for original work – 2nd low bid was twice the lowest, which was later the subject of significant overage claims. Current cost estimates are based on this knowledge of slow dredging progress and should be higher and more accurate as a result. | Access through primary landowner property and finding a suitable dredgate disposal site are major stumbling blocks. McLeod may take dredgate, but available area is small and may be required when overall outlet channel maintenance dredging is required. Now that we know the channel maintenance dredging is required (after 17 years) this flat land is at a premium and is not likely to be adequate for both the longer high spot and side channels. Other lands could be sought at much greater cost. Not currently feasible to do all work using this method due to disposal area limitations. | Not feasible, unless primary landowner takes dredgate (or McLeod property can be made to accommodate the required quantity). |
| 1b (Without Primary Landowner Co-operation) | Cutterhead Suction Dredge – as above) | As above | N/A | As above | As above | As above | Not currently feasible to do all work using this method due to disposal area limitations. This would be feasible for a portion of the work only. | Not feasible, unless additional dredgate disposal site found. |
| 2a (With Primary Landowner Co-operation) | Constructed Work Berms in Lake | Work to be done at low water levels (during late winter / very early spring) | ~$1.3 M | Work berms would be constructed by end-dumping coarse rock (talus or shale) to build a berm along each of the channels requiring excavation. A long-reach hydraulic excavator would work from the berm and load excavated clay into tandem dump trucks, which would haul the material to a disposal site on dry land. Only the portion of the work berm above the surrounding lakebed would be removed. | The placing of rock would be relatively clean, but the excavation of clay and the removal of the work berm would generate substantial fine suspended sediments. It is assumed that all work would be conducted within an area confined by silt curtains (2) to reduce the sediment movement downstream. This is anticipated to be highly effective in calm water, but not completely effective in the main outlet channel unless the water is directed around the main channel into the shallow (0.3 to 1.0 m deep) portion of the lake on either side of the outlet channel. Excavation of hardpan relatively clean; soft mud messy with high losses of loose fines. | The extent to which the rock forming the work berm will sink into the soft organic sediments on the lakebed is not known exactly, but is estimated to average 1.0 m. This will "squish" soft sediments out which will then add to the material to be excavated by some unknown quantity. High percentage loss of excavated fines will reduce effectiveness of work and start to infill excavated channels. | The environmental impacts and exact costs have some uncertainty, but the method is deemed to be feasible, although not completely effective. Costs and impacts can be better assessed during initial discussions with regulatory agencies and final method design. Full cooperation from primary landowner is assumed for access, use of rock (talus slide) material, and disposal of clay and dirty rock. Work program takes over 2 months unless more than 2 long reach excavators brought in. Fisheries may not approve due to sediment generated and duration of instream work (and difficulty isolating work area in January when work would likely start. | Feasible, but not recommended due to high silt losses (which infill channel or move downstream). |
| 2b (Without Primary Landowner Co-operation) | Constructed Work Berms in Lake | Work to be done at low water levels (as above) | ~$1.8 M | As above, but work berms would have to enter the lake on the Mijo or McLeod property and would use alternate site for sourcing coarse rock and disposing of rock and clay. | Longer work berms would increase the area impacted by the work and the chances of an accident. | As above | Not feasible, even at much higher cost, as access is required to excavate intake channels to 3 primary landowner pumps. | Not feasible. |

| Option | Description | Comments | 2005 Cost Estimate | Details of Method / Assumptions | Environmental Considerations | Uncertainties | Feasibility Notes | Conclusions |
|---|---|---|---|---|---|---|---|---|
| 2c (With Primary Landowner Co-operation) | Constructed Work Berms in Lake With Islands Left in Lake | As with Option 2a, but with Islands of excavated soil left in the lake shallows. | ~$1.0 M | As with Option 2a, but cost of work would be reduced by leaving potions of the work berms and excavated clay in the lake to provide diversified fish and waterfowl habitats. | It is not known if such islands could be designed to provide a "net benefit" to fish habitat and waterfowl. For example, closed ring shaped berms could retain water for fall / winter waterfowl habitats but could also strand fish and therefore may not be acceptable. High sediment production off islands by waves. | As with Option 2a. Also, the risk and liability of creating navigation hazards in the middle of the lake where none existed before may not be manageable with normal navigational warning buoys. It is not known how much this method would accelerate the infilling of the channel with soft sediments. | As with Option 2a, work is technically feasible. Liability concerns and low likelihood of environmental approval make option unattractive. | Feasible, but not recommended. |
| 2d (With Primary Landowner Co-operation) | Constructed Work Berms in Lake at High Water Levels | As with Option 2a, but work would be conducted at high lake levels around the time of the summer instream work window | ~$2.1 M | As with Option 2a, but extent of work would be increased by constructing the work berms 1.0 m higher (626.1 m) | The area impacted by the work berms would be greater, but the timing during the summer work window may theoretically reduce the impact to fish during construction. The height of the work berms would increase the risk of an accident. The higher wind / waves in the summer may necessitate a further increase in berm height and erosion resistance of rock used in the berm. Better isolation of sediment may be possible as current in channel is less | As with Option 2a. The wider footprint of the work berms would increase the impact of variations in the extent to which rock berm material sinks into the soft sediments of the lakebed. | As with Option 2a, work is technically feasible. Increased cost / risk of the higher berms and an uncertain environmental benefit of working during the summer instream work window make option unattractive. | Not feasible. |
| 2e (With Primary Landowner Co-operation) | Constructed Work Berms on Frozen Lakebed / Low Berms | As with Option 2a, but work would be conducted during the coldest period of the year. | ~$0.6 M | As with Option 2a, but extent of work would be decreased by constructing the work platforms of ice and rock on a frozen lakebed. | The required extreme cold weather would complicate the use of silt curtains to the extent that the work would likely have to be done without isolation. This could introduce sediment to downstream locations and local fish habitats during salmon egg incubation. | As with Option 2a, with the added uncertainty of how will frozen the lakebed sediments would be. As the success of this method would entirely rely on a cold snap of –20 degrees C for approx three weeks it is highly unreliable (for planning the work, or once started). | Great uncertainties make this method infeasible. | Not feasible. |
| 3a (With Primary Landowner Co-operation) | Excavator on Barge | Conventional hydraulic excavator or permanently mounted excavator on a low draft barge | Similar to below | Excavated clay would be loaded onto an adjacent barge and taken to a convenient site to be unloaded – then moved by loader or tandem to disposal site | The amount of excavation in the lake would be much less than if work berms were constructed. Silt curtains are still assumed to be required around the barge excavator barge (only – not around transport barge or unloading site). Work could take place (partly) during summer instream work window. Clay exc likely to be relatively clean; soft sediments likely to be dirty with high losses to lakebed. | Fewer unknowns than for other options as the work does not depend on support of lakebed sediments. Source of barge-mounted excavator is not known at this time. Flat barge in Kelowna and likely in Vancouver (?) Difficulty in handling wet soil (off barge) important unknown. | Likely feasible and cost effective. One concern is getting a barge to Nicola Lake (but many barges can be transported by highway). Also minimal dependence on primary landowner access (except for pump house modifications, as with all options). Excavation of soft soils may be too mess and losses to lake bed too high to be effective at keeping channels clear. | Feasible, but not as effective as some methods due to high sediment loss to lakebed. |
| 3b (Without Primary Landowner Co-operation) | Excavator on Barge | Conventional hydraulic excavator or permanently mounted excavator on a low draft barge | ~$0.6 M (preliminary estimate) | As above, but disposal site must be off Primary landowner property | As above | As above<br>As with other excavation options, high loss of fines reduces effectiveness as lost soil migrates to channel bed. Additional siltation during and post construction. . | Feasible and cost effective (as above).<br>Note minimal cost increase for using lake access off of Primary landowner property | Feasible, but not as effective as some methods due to high sediment loss to lakebed. |
| 4a (With Primary Landowner Co-operation) | Amphibious Dredger (Excavator) | A small hydraulic excavator with a centre pontoon and three legs with floats / wheels, such as the Smalley 6808 | Somewhat higher than above, due to reduced efficiency (as excavator not well anchored without "spuds"). | Excavated clay would be loaded onto an adjacent barge and taken to a convenient site to be unloaded – then moved by loader or tandem to disposal site | The amount of excavation in the lake would be much less than if work berms were constructed. Silt curtains are still assumed to be required around the barge excavator barge only – not around transport barge or unloading site. Work during window. | Fewer unknowns than for other options as the work does not depend on support of lakebed sediments. Source of amphibious excavator is not known at this time (Vancouver?) Work may not be possible in hardpan if excavator is not well anchored (using "spuds" as on a barge). | May be feasible and cost effective. Amphibious excavator can be transported by highway. Need to confirm that we can get clay transport barges to Nicola Lake (should be OK as size is negotiable). Also minimal dependence on Primary landowner access (except for pump house modifications). | Less efficient than 3a. Not recommended. |

| Option | Description | Comments | 2005 Cost Estimate | Details of Method / Assumptions | Environmental Considerations | Uncertainties | Feasibility Notes | Conclusions |
|---|---|---|---|---|---|---|---|---|
| 4b (Without Primary Landowner Co-operation) | Amphibious Dredger (Excavator) | A small hydraulic excavator with a centre pontoon and three legs with floats / wheels, such as the Smalley 6808 | Slightly higher than 3b. | As above, but disposal site must be off Primary landowner property | As above | As above | Feasible and cost effective (as above).<br>Note minimal cost increase for using lake access off of Primary landowner property | Less efficient than 3B. Not recommended. |
| 5 (With Primary Landowner Co-operation) | South Shore Channel Excavation | Excavate a new channel along the south shore of Nicola Lake, past the high spot, and tie into the existing channel ASAP | ~$1.4 M | When the original dredging contract was planned this was an alternate proposal suggested. A channel would be run along the south shoreline, constructed using conventional hydraulic excavators, working from a constructed road. Provided the work was done when the lake was low, most of the length would be excavated away from the water, but in / near the riparian area along the shore. All work would be on primary landowner property | Extensive damage to the riparian area would be sustained, although vegetation may be able to regenerate. Permanent road would be left in place and would impact riparian are long-term, but would provide access for maintenance of channel in future. Overall channel length required to meet up with existing main channel is only slightly higher then mid-lake channel deepening now that high spot is found to be 1.05 km. Overall increased environmental impact over other options. | Greater uncertainties regarding environmental approval of impact on riparian areas. Great reliance on primary landowner approval of plan on their property, which is not likely at this time. | Feasible but not likely cost effective or environmentally attractive. Primary landowner approval essential, but unlikely. Long-term maintenance would be better, especially given the rate of side channel infilling and lack of dredgate disposal sites.<br><br>Alternate method of constructing a berm in the lake (off primary landowner property), using the excavated soil, is not likely to be environmentally acceptable and would likely violate Primary landowner's riparian right of access to deep water. | Feasible, but not recommended. |
| 6 | Pipe / Siphon | Install a pipeline from the deep portion of Nicola Lake to the dam (3 km) | Very High (Cost estimate not prepared) | This option has been discussed in the past because of the high cost of dredging and the desire to moderate high summer water temperatures in the Nicola River downstream | Extensive work required as pipeline is 3 times longer than remaining high spot. Fish passage when pipeline in operation is problematic. Unknown impacts of cold water release in river downstream. Loss of siphon could cease lake outflow when lake level low. | Exact method of anchoring pipeline not examined due to high materials cost. Method of keeping intake clear is unknown, but thought to be problematic. | Not feasible or cost effective, so not pursued to completion of cost estimate. Required pipe is very large to release drought flows, let alone high flows to draw lake down prior to large freshet runoff. | Not feasible due to size / cost of pipe and maintenance issues. |
| 7 | Use New Primary landowner Intake and Pipe Water to Other Intakes | Instead of excavating the side channels to primary landowner NW, N Central and S intakes install a pipe from the intake by the dam to each existing pump house | ~$600,000 for intake works only | Due to observed infilling of side channels a pipe alternative would be used during low water. All intakes would be used at normal water levels to save Hydro costs | Significant reduction of in-lake disturbance due to reduction of "dredged channel" length by 880 lineal m (200 +230+450 m). Water licensing changes required is alternate points of diversion used at different times. | Primary landowner cooperation is essential, but not currently offered. Pipe construction work has less uncertainty than in-lake work. | Feasible only with primary landowner cooperation. Capital cost is likely high, but ongoing costs are reasonable when compared to the increasingly difficult matter of finding disposal sites for channel maintenance dredgate, and the high rate of infilling of side channels (compared to main) | Not cost effective or likely to receive necessary cooperation of primary landowner |
| 8 | Pipes to Each Water Intake | Install a pipe from the main channel to each intake to avoid maintenance dredging of side channels | ~$150,000 for intake work only | Pipe would only be used during low water to save Hydro costs. | Long-term reduction of in-lake excavation for maintenance of side channels | Maintenance of mid-lake intake could be problematic with weeds, etc. Increased pumping costs, sedimentation, and priming problems not investigated yet | Feasible only with the cooperation of all landowners. Some resistance from all likely – all due to maintenance problems becoming theirs, and Mijo and McLeod due to lack of boat access. | Not feasible to keep system in working order for years between uses. |
| 9 | Combined Intake / Boat Access for Mijo and McLeod | Construct one intake / deep water access point for both along the property line to reduce maintenance costs | N/A | One access may be able to meet the needs of both (at low water only) | Reduction of in-lake excavation attractive | Landowner agreement not likely if individual access an option | Feasible with landowner agreement, which is has not been investigated yet. May be feasible in conjunction with option 8. | Not feasible; not Acceptable to Mijo |
| 10 | Combination of Cutterhead Suction Dredging and Excavtion from Barge / Berm | A combination may be best, and will be investigated more fully | ~$1.0 M | Excavate hardpan clay and use suction dredge on soft sediments. | The cleanest option is likely to use an excavator on the original high spot and suction dredge elsewhere. | As above. | Feasible, at a high cost, if sufficient dredgate disposal sites available. McLeod's property is the only one available to handle dredgate. It can likely handle the volume with some modifications (might be slower). | Likely feasible, assuming McLeod's property can be made to handle dredgate vol. |
| 11 | Combination of Excavator on Barge for Main Channel (Summer) and Excavator on Work Pads (Winter) | Once the lake level could be drawn down to minimum supply level the side channels would be excavated from work berms. | ~$0.7 M | The work berms would be very low (small volume) and would be done in the dry. | Main channel in summer work window and most of winter work in the dry so the least impact of all options. | Less then with other options as barge could "dredge" or "excavate" the soft / hard soils encountered. | Feasible, and uses preferred method of handling each type of soil cleanly and efficiently. | Feasible and likely most cost effective option. |

| Option | Description | Comments | 2005 Cost Estimate | Details of Method / Assumptions | Environmental Considerations | Uncertainties | Feasibility Notes | Conclusions |
|---|---|---|---|---|---|---|---|---|
| 12 | South Shore Channel Excavation Though Nicola Ranch Fields | Construct a new outlet channel, past high spot, similar to option 5. Channel would go through the adjacent field to avoid riparian area and allow for future maintenance. Some in-lake work is required to tie-in to existing outlet channel and to avoid known bedrock on shoreline. | $3.0 M | Most of the work would be in primary and secondary landowner hay fields. Estimated cost of land purchase and compensation ($0.5 M + $0.2 M) is included in budget. | Riparian disturbance and instream work reduced, although some still required to tie-in to existing outlet channel and avoid bedrock along shoreline | Landowner agreement not likely due to loss of field use or access problems to remnant field / lake. No bridge included in cost estimate. Channel would fill in more quickly due to separation from main flow at all but lowest water levels. | Feasible with landowner agreement, which is not likely. Cost is very high due to high excavation quantity and land costs. Future maintenance uncertain as new channel will fill in more quickly due to split flow during normal lake levels. | Feasible with landowner OK; not recommended due to very high capital cost and uncertain future costs. |

**Table 7- 3 - Nicola Dam - 2005 Short List of Options (for Future Consideration) for Completing "Dredging" Work (Work Items 1 and 2 from Table 1 – High Spot and Irrigation Pump Intake Channels)**

Cost Estimates and Details are Roughed Out for All Options. Only construction equipment / materials costs given. No allowance for engineering or environmental design or supervision.
Detailed Cost Estimate Is Provided for the Recommended Option Only.

| Option | Description | Comments | 2005 Cost Estimate | Details of Method / Assumptions | Environmental Considerations | Uncertainties | Feasibility Notes | Conclusions |
|---|---|---|---|---|---|---|---|---|
| 1a (With Primary Landowner Co-operation) | Cutterhead Suction Dredge – continuation of the two dredging efforts made in 1988 | Cost overruns were incurred due to the increased time required to dredge the hardpan clay encountered. The clay was of greater extent and higher density than anticipated. Production from dredge averaged 27 cubic metres per hour as opposed to 61 to 77 cubic metres per hour claimed in tender submission. Work was halted after several shifts of producing only 8.3 cubic metres / hour in hardpan clay | ~$0.8 M | Barge mounted dredge would pipe dredgate to constructed containment pond on nearest available flat land. Once pond dries out it can be spread. The resulting field is non-productive without soil enhancement. | Greater sediment containment and fish salvage may be required than during dredging in 1986 and 1988. This adds to cost, but is likely feasible. Work could likely be done, in part, during the normal instream work window (mid-Jul to mid-Aug) at an increased cost, if that is an environmental benefit. Relatively clean in soft sediments; messy in hardpan clay during clearing of "gummed up" cutterhead | Cost estimate is affected by wide range of bids received for original work – 2nd low bid was twice the lowest, which was later the subject of significant overage claims. Current cost estimates are based on this knowledge of slow dredging progress and should be higher and more accurate as a result. | Access through primary landowner property and finding a suitable dredgate disposal site are major stumbling blocks. McLeod may take dredgate, but available area is small and may be required when overall outlet channel maintenance dredging is required. Now that we know the channel maintenance dredging is required (after 17 years) this flat land is at a premium and is not likely to be adequate for both the longer high spot and side channels. Other lands could be sought at much greater cost. Not currently feasible to do all work using this method due to disposal area limitations. | Not feasible, unless primary landowner takes dredgate (or McLeod property can be made to accommodate the required quantity). |
| 1b (Without Primary Landowner Co-operation) | Cutterhead Suction Dredge – as above) | As above | N/A | As above | As above | As above | Not currently feasible to do all work using this method due to disposal area limitations. This would be feasible for a portion of the work only. | Not feasible, unless additional dredgate disposal site found. |
| 2a (With Primary Landowner Co-operation) | Constructed Work Berms in Lake | Work to be done at low water levels (during late winter / very early spring) | ~$1.3 M | Work berms would be constructed by end-dumping coarse rock (talus or shale) to build a berm along each of the channels requiring excavation. A long-reach hydraulic excavator would work from the berm and load excavated clay into tandem dump trucks, which would haul the material to a disposal site on dry land. Only the portion of the work berm above the surrounding lakebed would be removed. | The placing of rock would be relatively clean, but the excavation of clay and the removal of the work berm would generate substantial fine suspended sediments. It is assumed that all work would be conducted within an area confined by silt curtains (2) to reduce the sediment movement downstream. This is anticipated to be highly effective in calm water, but not completely effective in the main outlet channel unless the water is directed around the main channel into the shallow (0.3 to 1.0 m deep) portion of the lake on either side of the outlet channel. Excavation of hardpan relatively clean; soft mud messy with high losses of loose fines. | The extent to which the rock forming the work berm will sink into the soft organic sediments on the lakebed is not known exactly, but is estimated to average 1.0 m. This will "squish" soft sediments out which will then add to the material to be excavated by some unknown quantity. High percentage loss of excavated fines will reduce effectiveness of work and start to infill excavated channels. | The environmental impacts and exact costs have some uncertainty, but the method is deemed to be feasible, although not completely effective. Costs and impacts can be better assessed during initial discussions with regulatory agencies and final method design. Full cooperation from primary landowner is assumed for access, use of rock (talus slide) material, and disposal of clay and dirty rock. Work program takes over 2 months unless more than 2 long reach excavators brought in. Fisheries may not approve due to sediment generated and duration of instream work (and difficulty isolating work area in January when work would likely start. | Feasible, but not recommended due to high silt losses (which infill channel or move downstream). |
| 2b (Without Primary Landowner Co-operation) | Constructed Work Berms in Lake | Work to be done at low water levels (as above) | ~$1.8 M | As above, but work berms would have to enter the lake on the Mijo or McLeod property and would use alternate site for sourcing coarse rock and disposing of rock and clay. | Longer work berms would increase the area impacted by the work and the chances of an accident. | As above | Not feasible, even at much higher cost, as access is required to excavate intake channels to 3 primary landowner pumps. | Not feasible. |

| Option | Description | Comments | 2005 Cost Estimate | Details of Method / Assumptions | Environmental Considerations | Uncertainties | Feasibility Notes | Conclusions |
|---|---|---|---|---|---|---|---|---|
| 3a (With Primary Landowner Co-operation) | Excavator on Barge | Conventional hydraulic excavator or permanently mounted excavator on a low draft barge | Similar to below | Excavated clay would be loaded onto an adjacent barge and taken to a convenient site to be unloaded – then moved by loader or tandem to disposal site | The amount of excavation in the lake would be much less than if work berms were constructed. Silt curtains are still assumed to be required around the barge excavator barge (only – not around transport barge or unloading site). Work could take place (partly) during summer instream work window. Clay exc likely to be relatively clean; soft sediments likely to be dirty with high losses to lakebed. | Fewer unknowns than for other options as the work does not depend on support of lakebed sediments. Source of barge-mounted excavator is not known at this time. Flat barge in Kelowna and likely in Vancouver (?) Difficulty in handling wet soil (off barge) important unknown. | Likely feasible and cost effective. One concern is getting a barge to Nicola Lake (but many barges can be transported by highway). Also minimal dependence on primary landowner access (except for pump house modifications, as with all options). Excavation of soft soils may be too mess and losses to lake bed too high to be effective at keeping channels clear. | Feasible, but not as effective as some methods due to high sediment loss to lakebed. |
| 3b (Without Primary Landowner Co-operation) | Excavator on Barge | Conventional hydraulic excavator or permanently mounted excavator on a low draft barge | ~$0.6 M (preliminary estimate) | As above, but disposal site must be off Primary landowner property | As above | As above<br>As with other excavation options, high loss of fines reduces effectiveness as lost soil migrates to channel bed. Additional siltation during and post construction. . | Feasible and cost effective (as above).<br>Note minimal cost increase for using lake access off of Primary landowner property | Feasible, but not as effective as some methods due to high sediment loss to lakebed. |
| 5 (With Primary Landowner Co-operation) | South Shore Channel Excavation | Excavate a new channel along the south shore of Nicola Lake, past the high spot, and tie into the existing channel ASAP | ~$1.4 M | When the original dredging contract was planned this was an alternate proposal suggested. A channel would be run along the south shoreline, constructed using conventional hydraulic excavators, working from a constructed road. Provided the work was done when the lake was low, most of the length would be excavated away from the water, but in / near the riparian area along the shore. All work would be on primary landowner property | Extensive damage to the riparian area would be sustained, although vegetation may be able to regenerate. Permanent road would be left in place and would impact riparian are long-term, but would provide access for maintenance of channel in future. Overall channel length required to meet up with existing main channel is only slightly higher then mid-lake channel deepening now that high spot is found to be 1.05 km. Overall increased environmental impact over other options. | Greater uncertainties regarding environmental approval of impact on riparian areas. Great reliance on primary landowner approval of plan on their property, which is not likely at this time. | Feasible but not likely cost effective or environmentally attractive. Primary landowner approval essential, but unlikely. Long-term maintenance would be better, especially given the rate of side channel infilling and lack of dredgate disposal sites.<br><br>Alternate method of constructing a berm in the lake (off primary landowner property), using the excavated soil, is not likely to be environmentally acceptable and would likely violate Primary landowner's riparian right of access to deep water. | Feasible, but not recommended. |
| 7 | Use New Primary landowner Intake and Pipe Water to Other Intakes | Instead of excavating the side channels to primary landowner NW, N Central and S intakes install a pipe from the intake by the dam to each existing pump house | ~$600,000 for intake works only | Due to observed infilling of side channels a pipe alternative would be used during low water. All intakes would be used at normal water levels to save Hydro costs | Significant reduction of in-lake disturbance due to reduction of "dredged channel" length by 880 lineal m (200 +230+450 m). Water licensing changes required is alternate points of diversion used at different times. | Primary landowner cooperation is essential, but not currently offered. Pipe construction work has less uncertainty than in-lake work. | Feasible only with primary landowner cooperation. Capital cost is likely high, but ongoing costs are reasonable when compared to the increasingly difficult matter of finding disposal sites for channel maintenance dredgate, and the high rate of infilling of side channels (compared to main) | Not cost effective or likely to receive necessary cooperation of primary landowner |
| 10 | Combination of Cutterhead Suction Dredging and Excavtion from Barge / Berm | A combination may be best, and will be investigated more fully | ~$1.0 M | Excavate hardpan clay and use suction dredge on soft sediments. | The cleanest option is likely to use an excavator on the original high spot and suction dredge elsewhere. | As above. | Feasible, at a high cost, if sufficient dredgate disposal sites available. McLeod's property is the only one available to handle dredgate. It can likely handle the volume with some modifications (might be slower). | Likely feasible, assuming McLeod's property can be made to handle dredgate vol. |
| 11 | Combination of Excavator on Barge for Main Channel (Summer) and Excavator on Work Pads (Winter) | Once the lake level could be drawn down to minimum supply level the side channels would be excavated from work berms. | ~$0.7 M | The work berms would be very low (small volume) and would be done in the dry. | Main channel in summer work window and most of winter work in the dry so the least impact of all options. | Less then with other options as barge could "dredge" or "excavate" the soft / hard soils encountered. | Feasible, and uses preferred method of handling each type of soil cleanly and efficiently. | Feasible and likely most cost effective option. |
| 12 | South Shore Channel Excavation Though Nicola Ranch Fields | Construct a new outlet channel, past high spot, similar to option 5. Channel would go through the adjacent field to avoid riparian area and allow for future maintenance. Some in-lake work is required to tie-in to existing outlet channel and to avoid known bedrock on shoreline. | $3.0 M | Most of the work would be in primary and secondary landowner hay fields. Estimated cost of land purchase and compensation ($0.5 M + $0.2 M) is included in budget. | Riparian disturbance and instream work reduced, although some still required to tie-in to existing outlet channel and avoid bedrock along shoreline | Landowner agreement not likely due to loss of field use or access problems to remnant field / lake. No bridge included in cost estimate. Channel would fill in more quickly due to separation from main flow at all but lowest water levels. | Feasible with landowner OK, which is not likely. Cost is very high due to high excavation quantity and land costs. Future maintenance uncertain as new channel will fill in more quickly due to split flow during normal lake levels. | Feasible with landowner OK; not recommend-ed due to very high capital cost and uncertain future costs. |

## 7.4 Site Inspections and Assessments

The following summary is provided of the fieldwork undertaken to assess the work required and the practicality of each option:

- Site inspections have been made for the following items: all boat ramps, all in-lake channels and all pump intake channels. Rough elevations have been surveyed (using boat access, surveyed depths and known lake level) for the above works to confirm the extent of the required works;
- Site inspections were not possible for the predominant landowner's pumps, possible material supply sites or dredgate/clay/shale disposal sites on the predominant lakeshore owner's property due to the refusal of access for the investigation or construction phases of this work;
- Logsheets of boreholes drilled along the existing channels and high spot in the 1980's have been reviewed in this study;
- No site inspections were made of wells adjacent to the lake that may require modification to function at lower lake levels. This cannot be assessed based solely on a visual inspection. An amount has been included in the budget to allow for modifications to a few wells, should they fail to perform adequately if the lake is lowered, following completion of the dredging works;
- Various construction methods have been thought through, and costs estimated based on the site conditions, and materials and equipment required.

## 7.5 Environmental Considerations

The terms of reference for this study called for a summary of the impacts anticipated from dam completion options based on existing information. Three levels of social and environmental impacts were identified. Firstly, the environmental management costs that can be included in construction costs are listed on Table 7.2. Secondly, the environmental and social issues associated with each engineering option that cannot be costed at this time are listed in Table 7.4 and Table 7.5 to enable a relative comparison of each option. Finally, costs associated with social and environmental impact assessment potentially required for obtaining regulatory approval to proceed are summarized in Appendix B.

### *7.5.1 Environmental Management Costs*

For all options, there are technical works that will have to be accomplished as a result of the envisaged further vertical fluctuation in lake level that can be expected in dry years. These may include:

- Extending boat ramps around the lake;
- Deepening a few shallow domestic wells; and,
- Extending domestic water intakes around the lake.

The costs of completing the technical works are estimated at around $125,000 (2005 prices) and have also been included in cost estimates for each option listed in Table 7.2.

Environmental management costs that could be quantified at this time were included in the 2005 Cost Estimate (Table 7.2). These costs include:

- Fish salvage during operations;
- Containment of siltation during operations; and,
- Remediation of dredgeate/excavate on lakeshores or elsewhere.

All options that include dredging, excavation, and work berms would have direct impacts on fish during operations and require catchment netting for salvage prior to and during operations. Options that include dredging (Options 1, 4, 6, 10) require reclamation of dredgeate disposed of on adjacent lands and these costs have been included in Table 7.2; however, costs of compensation to land owner, if required, have not been included at this time. Similarly, costs for reclamation of excavate (Options 2,3,4,5,6,10,11,12) included in Table 7.2, are assumed to be lower than dredgate reclamation due to the ability to haul away to a fill site on non-agricultural land. Workberm options (Options 2, 11) include reclamation costs of talus slope borrow area.

### *7.5.2 Potential Environmental Impacts*

There are numerous other environmental costs that can not be quantified at this time as they are highly dependent upon agency approval of detailed construction designs and an assessment of compensation. A summary of potential items requiring compensation, mitigation, or other action for each technical option are listed in Table 7.3.

There are 19 species of fish listed for Nicola Lake including Bull Trout, currently blue-listed, and burbot, one of the few freshwater fish that spawn under the ice in winter. Dredging, excavation and work berms are expected to have impacts on benthic and fisheries values. Compensation and mitigation costs associated with lakebed disturbance have not been costed at this time but would be identified following detailed construction design and submittal for regulatory approval. Option 12 (Dryland Channel Excavation) could have a lower impact on benthic and fisheries values. Dredging and excavation options have repeat impacts due to channel maintenance requirements. Workberms have long-term impacts for those alternatives suggesting berms be permanent features.

Costs associated with containment of siltation during operations are included in Table 7.2; however, activities resulting in siltation may also required compensation for downstream siltation impacts. Compensation costs for downstream siltation impacts on fish would be identified following detailed construction design and submittal for regulatory approval. Options 10 (Combination of Dredging and Excavation) and 5 (Dryland Channel Excavation) are considered to have the lowest siltation impact. Dredging and excavation options are expected to have recurring siltation impacts during maintenance operations. Permanent workberm options avoid recurring siltation impacts to some degree; however, workberm alternatives requiring rock removal from the lakebed are likely to have higher siltation impacts than dredging or excavation.

Option 6 (Pipe/Siphon) incurs the same impacts as dredging and excavation as these activities are required prior to pipe placement. In addition, piping may result in impacts of cold water release on fish and fish habitat, and impacts on fish passage are currently unknown. This option has potentially lesser impacts over long-term compared to dredging and excavation as less maintenance is required.

All options include some disturbance to the riparian zone required for access. Reclamation of the riparian area and foreshore is not costed in Table 7.2. Compensation and mitigation for areas with rare waterfowl/avian, amphibian, and plant habitat are not included. There are currently 16 species of birds that are red and blue listed for the bunchgrass and ponderosa pine zones, of which 4 are associated with wetlands and riparian habitat types. Listed amphibians and reptiles associated with the Nicola Lake riparian zone may include the Great Basin Spadefoot Toad and Great Basin Gopher Snake. In addition, there are rare plants, non-marine mollusks and butterflies blue-listed for the district that are associated with riparian/wetland habitat. Riparian impacts are expected to be high for Option 5 (South Shore Channel Excavation).

**Table 7.4. Impact Evaluation of Technical Engineering Options**

| Option | Description | Environmental Management Costs Included in Table 7.2 | Additional Environmental Considerations | Additional Social Considerations |
|---|---|---|---|---|
| 1 | Cutterhead Suction Dredge | Fish salvage during operations<br>Sediment containment during operations;Soil remediation costs of dredgeate on agricultural land | Compensation for temporary loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for riparian impact<br>Repeated impacts during channel maintenance | Landowner consultation/ negotiation critical for obtaining access<br>Landowner compensation costs for dredgeate disposal |
| 2 | 2a - Constructed Work Berms in Lake (installed at low water levels) | Fish salvage during operations<br>Sediment containment during operations of workberm installation and removal<br>Reclamation of clay and dirty rock from talus excavation<br>Soil remediation costs of excavated material | Compensation for permanent loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for permanent riparian impact in access area<br>Repeated impacts during channel maintenance | Landowner consultation/ negotiation for access<br>Landowner compensation costs for disposal of clay and dirty rock from talus excavation and excavate from lakebed<br>Liability and risks associated with public and recreational safety with regard to workberms |
| | 2c Alternative - Permanent Islands Left in Lake | | Possibly compensation for increased, permanent loss of benthic and fisheries values<br>Possibly reduced compensation for downstream siltation impacts<br>Design and restoration costs associated with developing habitat and/or recreational values | Increased public safety and liability issues<br>Potential loss of recreational values |
| | 2d Alternative – Constructed during High Water Levels | Reduced impact on fish during construction but salvage still required<br>Siltation containment costs reduced | Siltation impacts reduced<br>Reclamation of clay and dirty rock from talus excavation potentially higher as more material is utilized. | Increased compensation costs for higher volumes of clay and dirty rock disposal. |
| | 2e Alternative – Constructed on Frozen Lakebed | Potentially higher sediment control costs | Potentially higher compensation for downstream siltation impacts | |
| 3 | Excavator on Barge | Fish salvage during operations<br>Sediment containment during operations<br>Soil remediation of excavate | Compensation for temporary loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for temporary riparian impact in loading area<br>Repeated impacts during channel maintenance | Landowner consultation/ negotiation for access<br>Landowner compensation costs for excavate disposal |
| 4 | Amphibious Dredger (Excavator) | Fish salvage during operations<br>Sediment containment during operations<br>Soil remediation of excavate | Compensation for temporary loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for temporary riparian impact in loading area<br>Repeated costs during channel maintenance | Landowner consultation/ negotiation for access<br>Landowner compensation costs for excavate disposal |

| | | | | |
|---|---|---|---|---|
| 5 | South Shore Channel Excavation | Fish salvage during operations<br>Sediment containment during operations<br>Soil remediation of excavate | Compensation for temporary loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Repeated impacts during channel maintenance<br>Mitigation/ compensation costs for permanent riparian impact | Landowner consultation/ negotiation for access<br>Landowner compensation costs for shoreline impact and for excavate disposal |
| 6 | Pipe / Siphon (dredging or excavation also required) | Fish salvage during operations<br>Sediment containment during operations<br>Soil remediation costs of excavate | Compensation for permanent loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for permanent riparian impact in loading area and pipeline access areas<br>Minimal maintenance costs of channel | Landowner consultation/ negotiation for access. Landowner compensation costs for excavate disposal |
| 7 | Use New Nicola Ranch Intake and Pipe Water to Other Intakes | | Mitigation/ compensation costs for permanent riparian impact in pipeline access area | Consultation required with landowners for access and with water users for water license changes required |
| 8 | Pipes to Each Water Intake (alternative to dredging/ excavating side channels) | | Impacts for dredging/excavating main channel remain<br>Compensation for permanent loss to benthic and fish values in side channel area<br>Reduced maintenance costs | Landowner consultation/ negotiation required as per dredging/ excavation<br>Potential increase in public safety and liability issues |
| 9 | Combined Intake / Boat Access for Mijo and McLeod | | impacts for dredging/excavating main channel remain<br>Reduced compensation for permanent loss to benthic and fish values in side channel area | Landowner consultation/ negotiation required |
| 10 | Combination of Cutterhead Suction Dredging and Excavation from Barge / Berm | Fish salvage during operations<br>Sediment containment during operations ;Soil remediation costs of dredgeate on agricultural land and excavated material | Compensation for temporary loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for riparian impact in access area<br>Repeated costs during maintenance | Landowner consultation/ negotiation critical for access and potentially compensation costs for dredgeate and excavate disposal |
| 11 | Combination of Excavator on Barge for Main Channel (Summer) and Excavator on Work Pads (Winter) | Fish salvage during operations<br>Sediment containment during operations<br>Soil remediation costs of excavated material | Compensation for permanent (work berms) loss of benthic and fisheries values<br>Compensation for downstream siltation impacts<br>Mitigation/ compensation costs for riparian impact in loading area<br>Repeated costs during maintenance | Landowner consultation/ negotiation for access and potentially compensation costs for disposal of clay and dirty rock from talus excavation and excavate from lakebed; Liability and risks associated with public and recreational safety due to workberms |
| 12 | Alternative – Dryland Channel | | Benthic and fisheries impacts significantly reduced<br>Siltation impacts reduced<br>Sediment containment and excavate reclamation costs repeated during channel maintenance<br>Lesser mitigation/ compensation costs for riparian impact | Landowner compensation for land resource |

### *7.5.3 Potential Social Issues*

Public communication, education and consultation will be required for any option selected due to real or perceived issues by lakeshore owners and local residents arising from construction, such as:

- Reduced aesthetics;
- Reduced air quality (odour and dust);
- Increased noise;
- Public safety concerns (with regard to truck traffic congestion during construction); and,
- Perceived impact on recreation and tourism.

A public education and communications program as part of the social and environmental assessment process prior to and during construction has been estimated to cost $80,000 (see Appendix B). These costs have not been included in Table 7.2, but will need to be considered as a project implementation cost and will have to be confirmed by requesting proposals after detailed terms of reference are drawn up. Specific consultation relative to each technical option is listed in Table 7.3.

The level of cooperation, or lack thereof, received from the predominant landowner may strongly affect the cost and feasibility of many options. Ultimately, further discussions regarding access, either to allow crossing of their property for channel excavation or to modify their pumps intakes, will have to be completed. One option looks at a water distribution pipeline system to provide water to the predominant landowner and other fields around the lake and downstream, without the need to excavate the side channels in the shallow end of the lake. The ultimate costs of this option merge the cost of completing the storage project and the costs of upgrading the water supply system to many properties. Similarly, if work is being done to provide access to deep water in Nicola Lake for Mr Huber, it may make sense to consider modifications to Mr Rose's intake at the same time, even if it is beyond the scope of the works required to complete the storage project.

### *7.5.4 Summary*

Properly funded, the environmental and social issues associated with each of the technical options could be dealt with satisfactorily. Through completion of detailed construction designs and an environmental assessment, issues will be better understood and quantified, specific construction solutions identified to reduce impacts, and remaining compensation and mitigation costs identified. Some fisheries issues remain to be discussed before any approval is possible from the approving agencies. This future, detailed discussion of approval conditions will provide a more reliable assessment of cost and feasibility implications of the fisheries interests.

Not having firm costs for compensation and mitigation at this time limits the ability to compare the potential environmental and social impacts associated technical options. For the purpose of evaluating the technical options at this phase, a relative comparison of potential environmental and social impacts have been prepared in a matrix (Table 7.4). This matrix provides a relative ranking of technical options against each other for various categories of potential impact. Depending on the communities' values or governing agencies feedback, varying weights can be applied to each impact category to determine an overall rating of the technical option. For the task at this time, no weighting has been applied.

With regard to environmental issues, the digging a channel on the south shore of the lake along the edge of the hay field (Option 12) would obviate having to enter the lake and impacting fisheries values, which the other options incur both during channel construction and maintenance. Appendix A provides a little more insight into the issues surrounding Option 12. Construction methods employed in Option 11 may have the least impact of all the options related to excavating the channels in the lake itself. This could be further mitigated by installing a series of irrigation pipelines from a central pump station (Option 7).

With regard to social issues, consultation, landowner negotiation and compensation requirements are likely similar for all options with the exception of the excavation options from a barge or amphibious support (Options 3 and 4). Social costs for these two options is lower due to the lesser requirements for access and land base for disposal of excavate; however, siltation impacts incurred from these two techniques likely result in these options being considered undesirable.

### 7.6 Evaluation of Options

In the course of this study many options were considered. Each option was evaluated on the following basis:

- Cost;
- Practicality of construction procedures;
- Likelihood of being able to perform the work in a environmentally acceptable manner,
- Identification of any significant unknowns;

- Implications for the longer term costs and environmental impacts associated with the maintenance of the excavated channels; and
- Other relevant construction issues, such as material sources, risks, etc.

Options were eliminated if they were deemed to be technically infeasible (i.e. siphon, pipes to each intake, excavator working of frozen lake bed, etc.), or if a similar option existed that was clearly preferable (i.e. excavator on barge better than amphibious dredge as it can anchor itself and work more efficiently).

The short-list of options is shown in Table 7.3.

## 7.7 Recommended Solution from a Technical Perspective

At this time, the preferred approach is Option 11. This method would use a barge mounted excavator/auger dredge for the main outlet channel during the summer instream work window.

This method would utilize a piece of equipment, similar to that viewed at Fraser River Pile and Dredge Ltd in New Westminster. The barge supports a long reach excavator that would use a conventional digging bucket to remove the hardpan clay from the “high spot”. This material would be loaded onto the excavator barge, or an adjacent barge, and transported to shore where it could be unloaded and hauled to a disposal site.

The same excavator would then be used with its auger dredge attachment to pump a slurry of soft sediment and water from the infilled portion of the main channel onto the barge, where a series of containers (ponds) would be used to dewater the mud and the relatively clean water would be allowed to flow back into the lake beside the barge. When the barge had a full load of soil it would be moved to shore and unloaded into trucks for soil disposal (as with the clay). A separate barge could be used to ferry soil back and forth for disposal if that was deemed to be more efficient.

This system would allow the most efficient/cost effective technology to be used for each material to be removed: soft sediments to be removed using the cleaner, more efficient method of dredging, while the hard clay would be removed by excavator as it is not readily lost from the bucket, which would result in siltation and infilling of the lakebed and recently excavated channel. The side channels would be excavated during the following winter, working off of very low work berms (pads) at very low lake levels. Conventional hydraulic excavators would work off shale work pads along each side channel. The pads would not extend above the surrounding lakebed and would not create a navigation hazard. The pads would however be available in the future to be used (every 5 years) to perform the maintenance dredging of the side channels, which tend to fill in more readily than the main outlet channel that has a definite current.

The side channels would be excavated in the winter, after the main channel was dredged and the lake level lowered to the minimum supply level. This would enable most of the work to be completed in the dry, with only a quick tie-in required to the flowing main outlet channel. This method would greatly reduce the volume of shale required over constructing work berm at higher lake levels, and be provide excellent value when compared to the future cost of bringing in a dredge for the side channel maintenance and the associated uncertainty regarding future funding. Each component of the work would be done in the cleanest possible manner, with the maximum possible amount of the work done in the dry.

It may be possible to implement Option 7 instead of excavating the side channels. Water would then be pumped from the main Nicola Ranch pump station near the dam structure back up through new pipelines to the various irrigation fields on the lake shore. It would also obviate the need to have to clean out side channels every time they are filled with debris and silt.

Option 11 is the method that appears to be the most likely to gain environmental approval and provide reasonable efficiency.

There are a couple of slightly cheaper options, but these options provide less long-term value in terms of facilitating the side channel maintenance dredging. The cheaper options are also compromised by having high sediment losses during channel excavation, resulting in higher environmental impacts and greater infilling of the channels with fine sediments immediately after construction.

Other options are kept on the short-list as well, as all approval considerations have not been investigated, and this could influence the final method selection.

### 7.8 Conclusion and Recommendations of the Technical Assessment

From an engineering point of view the completion of the Nicola Dam storage project is feasible. Other factors, including social, environmental, institutional, financial and operational considerations will have to be examined in more detail before it can be determined if the project can proceed. These tasks will have to be conducted in parallel to ensure that a final decision is reached expeditiously.

If the completion of the dam is to be pursued further, it is recommended that Option 11 may provide the best short and long-term value and environmental acceptability. This option includes a combination of a normal digging bucket and auger dredge attachment on an excavator working from a barge to complete the main outlet lake channel excavation. The construction of low work pads along the side channels would enable future maintenance of these channels as they fill-in in the future. The cost of this option is just over $1.0 million, the details of which will be presented in the next chapter. Other options should be retained "on the table" for further consideration, in case insurmountable obstacles are found with some aspect of the work using Option 11.

When the project is closer to final approval, it is recommended that the cost estimates be updated following confirmation of environmental, institutional and social conditions under which the work will proceed.

## 8.0 FINANCIAL ANALYSIS OF TECHNICIAL OPTIONS

The following approach has been used in this brief financial analysis:

- Assembling the project cost estimates produced in the technical assessment described in the previous section;
- Forecasting incremental project cashflows;
- The adoption of a project discount rate of 6%. Also assumed rates of 2, 4 and 8% to test sensitivity in a changing environment; and
- The comparison of the various technical options by adopting a discounted cash flow analysis.

### 8.1 Cost Estimates

Key assumptions regarding the manner in which the work will be carried out and administered will affect the cost significantly. For example, it is could be assumed that the BC Ministry of Environment (MOE) would provide in-kind engineering design and supervision of all construction works as they currently have the mandate to operate the dam and have water resources engineers on staff. If this work were to be carried out by consultants working on behalf of MOE, or another agency in charge of the dam, this additional cost would have to be added to all estimates.

Table 8.1 above provides a range of costs for all options/levels of in-kind support for engineering and construction related environmental work. In the analysis it was assumed that consultants will oversee the engineering and environmental work.

Also the manner in which a contract for the dredging work was let would affect the costs. The costs given are based on standard government equipment rental rates. Under this type of contract the government carries most of the risk of cost increases, as opposed to the contractor. More realistically, the contract would be let on a lump sum basis, in which case the contractor would assume more risk and demand a proportionally higher price to compensate for this risk.

The costs are based on 2005 construction and equipment rental rates. It is not known when the work would take place, and updates to construction costs will be required in future. Depending on the institutional/administration structure envisioned in the operation and maintenance of a completed dam, these cost estimates may have to be revised during detailed design and construction.

Appendix A attached to this report provides detailed cost estimation worksheets for options 11 and 12 to indicate what assumptions were made in deriving these feasibility level estimates. Since it has been mentioned that Option 12 could be more environmentally friendly in the long-term, the various costs associated with this option are presented in the appendix as well.

### *8.1.1 Capital Cost*

Capital cost estimates of all the options are provided in Table 7.2 above. Table 8.1 below provides a summary of the construction related costs associated with the selected options presented in Table 7.3. The second column refers to the capital costs of the specific options. The third column adds in the other related costs (e.g. lakeshore works; design, contract management, environmental review and other construction related services; and environmental protection measures during construction).

It does exclude any other unknown technical, environmental and social assessments, and mitigation/compensation measures that will be required as part of the eventual project. The total cost also excludes any costs associated with the water management practices that will be implemented in parallel with the completion project (e.g. refinement of the operating rule, water conservation, downstream fish habitat rehabilitation, ground surface water management, etc).

***Table 8.1: Approximate Cost Estimates Associated with Various Short-Listed Options***

| Option and Alternative | Capital Cost (CAD $) | Other Costs (CAD $) | Total Cost (CAD $) |
|---|---|---|---|
| Option 1a: Cutterhead with lakeshore owner co-operation | $ 800,000 | $355,000 | $1,155,000 |
| Option 2a: Constructed work berms in lake with lakeshore owner co-operation | $1,300,000 | $355,000 | $1,655,000 |
| Option 2b: Constructed work berms in lake without lakeshore owner co-operation | $1,800,000 | $372,000 | 2,172,000 |
| Option 3a: Excavator on barge with lakeshore owner co-operation | $ 550,000 | $335,000 | $885,000 |
| Option 3b: Excavator on barge without lakeshore owner co-operation | $ 600,000 | $335,000 | $935,000 |
| Option 5: South shore channel excavation with lakeshore owner co-operation | $1,400,000 | $355,000 | $1,755,000 |
| Option 10: Combination of cutterhead suction dredging and excavation from a barge | $1,000,000 | $355,000 | $1,355,000 |
| Option 11: Combination of an excavator on a barge for main channel/excavator on work pads | $ 700,000 | $ 335,000 | $1,035,000 |
| Option 12: South shore channel excavation through Nicola Ranch fields | $3,100,000 | $517,000 | $3,617,000 |

The current estimate of total capital costs for Option 11 is $1.03 million. Some savings may be possible if MOE or others can contribute in-kind engineering and environmental design and construction supervision (and contract administration, tendering, as-constructed documentation, etc.).

Only qualitative comments are provided regarding the balance between the capital and maintenance costs associated with different construction methods.

### *8.1.2 Recurrent Cost*

There are known future costs that are influenced by the method chosen to complete the capital portion of the work. The most significant is the required side channel maintenance dredging. The recommended option incurs additional up-front capital costs to build work pads adjacent to each side channel to facilitate the required maintenance clearing of these channels, approximately every 5 years. The anticipated cost of this side channel maintenance is $60,000 every 5 years. It has been mentioned that the responsibility for maintenance of these intake channels will rest with the owners of the irrigation intakes.

It is not known if the main outlet channel will fill in with soft sediments once the high spot has been removed. In the past, this high spot has clearly held back sediment behind it. When the lake level is drawn down to its lowest level there will be a marked current in the outlet channel, which may well keep it clear of sedimentation. Some further comments on expectations regarding the possibility of this self-cleaning phenomenon are provided in Appendix A.

If maintenance dredging of this channel is required it will be a much larger cost than the side channels as there will be no easy way of accessing the channel. The total cost would be similar to the capital cost of the side and main channel work assessed herein, and would be in the order of $600,000.

This larger extent of work may not be required very often, if ever. In part, the ultimate need for this work will depend on the operation of the dam, and the frequency of high flows at low lake levels, which will tend to clear the channel.

For planning purposes, it would be reasonable to assume that the side channel maintenance costs will be $60,000 every 5 years, and that the main channel will have to be dredged less frequently, say every 20 years.

Option 12 was formulated to get away from the five- and twenty-year main channel maintenance events in the lake. The cost of maintenance of the south shore channel in Option 12 will however need maintenance as well, albeit slightly less in monetary value. Projected costs (see Appendix A) would still be in the region of $60,000 every 5 years for side channels, but only $150,000 every 20 years.

#### *8.1.3 Contingencies*

Contingencies of 20% are included in construction and consulting cost estimates due to the large number of uncertainties such as: details of the method of construction, soils encountered, approval conditions, location of material sources and disposal sites, etc.

#### *8.1.4 Need to Re-examine Costs at a Later Date*

The cost estimates provided are based on certain assumptions, including 2005 dollar prices. Current construction supply and demand forces are making it very difficult to predict actual costs. Cognizance must be taken of this fact. When the environmental, social, institutional and other arrangements are known more fully, the costs should be reassessed for the construction method selected. Future cost increases will also change this assessment and will necessitate re-evaluation when the work schedule is known.

### 8.2 Simple Least Cost Evaluation

By initially ignoring the traditional financial and economic considerations, we can start to see a trend in the cost of each engineering option. Taking the above-mentioned capital and recurring costs into account and discounting them at 6% over a 20 year period, we see that the two least cost options are numbers 3a and 3b. As described above, the problem with these two options is that the excavator bucket will not be able to efficiently remove the loose material from the existing filled in channels. It was with this in view that the technical focus shifted to Option 11's auger suction dredge for soft material and an excavator for hardpan material. Option 11 then comes in at the next least cost option. Option 12 however still remains the most expensive alternative to Option 11 mainly due to the fact that a much longer and deeper channel will have to be excavated in the case of Option 12.

Given this preliminary assessment, the analysis moved on to a more in-depth financial evaluation of the options.

### 8.3 Summary of Cash Flows Associated with Dam Completion Project

Results from the stand-alone technical financial/economic report have been summarized below. It must be noted that the current feasibility study budget did not allow for an in-depth analysis, especially since institutional arrangements and cost recovery were not decided on in a public forum in the study. Direct benefits to the Nicola Fishery have not been included since they are not easily determinable. These benefits are included in the economic analysis discussions below.

The following cash flows associated directly with the dam completion infrastructure were identified in this analysis (Option 11 was used to illustrate the cash flow below):

- The initial capital expenditure for each option to create the hydraulic connection between the deeper part of the Nicola Lake and the dam structure, as indicated in Table 9.1 above. Option 11 would therefore be $1,035,000 in the year 2005 Canadian Dollar terms;
- Although not accurately known at the moment (i.e. no detailed social and environmental assessment conducted), a very rough estimate of costs associated with environmental investigations and actual mitigation/compensation has been assumed as part of this planning process. Consequently, this number has been assumed at $400,000 per year as an initial cost in years 1 and 2;
- Operation and maintenance costs associated with the maintenance of the channels. $60,000 every 5 years for the side channels with the exception of the 20th year. Every 20 years it has been conservatively assumed that an expenditure of $600,000 would have to be entered into to maintain the main and side channels;
- Administrative and dam maintenance costs associated with managing the completed dam (e.g. staffing costs, dam structure maintenance, etc, averaged out over the years) have been assumed as $40,000 per annum;
- The financial input associated with the previous construction of the project in the late 1980's has been treated as a sunk cost and has not been included in the financial and economic analyses;
- The cost to establish new irrigation has been included in the analysis. It has been assumed that an investment of $782,800 would be made in year 1 and a further $598,500 per annum for the four ensuing years to year 5;
- Production costs associated with the new acreage and the existing land that will benefit from the new storage total to approximately $295,000 in year 1 and up to $614,000 in year 5;
- No residual value on dam and systems at the end of 20 years;
- The possibility of obtaining a one third capital cost government subsidy has been assumed in this case. This would emanate from the Canada-British Columbia Water Supply Expansion Program. In the case of Option 11 this could amount to $480,000 paid out in Year 1 and $133,000 in Year 2;
- A further assumption has been made that the balance of the capital cost and the environmental work would be sponsored one third by a fund such as Living Rivers and the remaining one third from the Provincial Government, the DFO and other sources;
- An income from current tariffs for irrigation use and conservation (fish) storage has been assumed at just more than $10,000 per annum. This is based on the latest year 2006 rates

of $0.60 per 1000 cubic metres of irrigation use and a fraction of a dollar per 1000 cubic metres of water for conservation storage;

- A new institution who would manage a completed dam will more than likely have to impose new additional tariffs for water usage over and above these MOE taxes in order to help pay for operation and maintenance costs annually and in the long-term. The channel dredging in future years would resort under this category for example. These tariffs, which would be a positive cashflow are not included in the initial financial analyses.
- The financial net benefit to the agriculture sector due to the creation of the new storage (i.e. financial benefit derived from a higher level of assurance of supply and new irrigation land), grows from $1,838,000 in year 2 to $3,833,000 per annum in year 5 to year 20. It has been assumed that there is no net benefit to agriculture in the first year during construction.

## 8.4 Findings of Financial Analysis

The following Net Present Values (NPV's) were obtained in analyzing the financial cash flow.

***Table 8.2: NPV Results Using 6% Over 20 Year Discounting Period***

| Option and Alternative | NPV of Cash Flow (CAD $) |
|---|---|
| Option 1a: Cutterhead with lakeshore owner co-operation | +$26,221,000 |
| Option 2a: Constructed work berms in lake with lakeshore owner co-operation | +$25,721,000 |
| Option 2b: Constructed work berms in lake without lakeshore owner co-operation | +$25,204,000 |
| Option 3a: Excavator on barge with lakeshore owner co-operation | +$26,491,000 |
| Option 3b: Excavator on barge without lakeshore owner co-operation | +$26,441,000 |
| Option 5: South shore channel excavation with lakeshore owner co-operation | +$25,621,000 |
| Option 10: Combination of cutterhead suction dredging and excavation from a barge | +$26,021,000 |
| Option 11: Combination of an excavator on a barge for main channel/excavator on work pads | +$26,341,000 |
| Option 12: South shore channel excavation through Nicola Ranch fields | +$23,899,000 |

Although Option 3 has the highest NPV of income over 20 years, it is very close to the other options. Option 12 is slightly less due to the higher initial construction cost. Sensitivity in the discount rates (i*) indicated values ranging from $41 million for an i* of 2% rate down to $21 million for an i* of 8%. Since these are straight financial values using the cost of construction, ongoing operation and maintenance of the dam completion project and irrigation infrastructure, and estimates of financial returns associated with the net increase in irrigation land, it can be seen that for a relatively small investment, a large benefit can be realized in the Nicola Valley. The economic evaluation will indicate a much larger benefit when considering the intangible benefits associated with this project.

Furthermore, it was found that the discounted payback period using an i* of 6% would be around 3 to 4 years for all the technical options.

The Capital Efficiency factor (KE), which is a measure of the present value added to the collective water users group by every dollar invested in the project, range between 1.70 for Option 12 and 2.30 for Option 3. By normal project standards this is a very high measure. Again the reason for this is that the major portion of the project was completed in the 1980's. The investment to finish off the work is small in comparison with the large benefit in eventually unlocking the full storage potential behind the Nicola Lake Dam.

Having said this, the Financial Internal Rate of Return (i.e. the discount rate at which the NPV for the project option is zero) is abnormally high.

A Financial Benefit/Cost Analysis yields values of 3.3 for Option 11 and 2.7 for Option 12.

The financial challenges and risks associated with this project refer to the sourcing of capital funding to carry out construction and social and environmental mitigation/compensation. The way in which this money will be raised (via government subsidy and otherwise) will depend on the institutional model adopted in proceeding with the dam completion project (see Chapter 11).

Since it has been estimated that fifty five properties would benefit directly from the increase in water supply, it is assumed that the cost of new irrigation infrastructure would be defrayed between these water users incrementally over a period of five years.

Without proceeding to further detailed financial and economic analysis, and treating the initial construction costs invested in the 1980's as sunk costs, it is believed that the relatively small investment associated with any of the technical options will yield very large dividends for the agricultural community around the Nicola Lake and downstream on the main stream of the Nicola River.

Based on these findings, it is believed that either Option 11 or 12 could be selected if the initial construction capital can be raised. Other considerations as raised in Appendix A and later in this report would have to be brought into consideration when making the final decision regarding which option should be selected to complete the Nicola Lake Dam Project.

# 9.0 ECONOMIC EVALUATION OF OPTIONS

## 9.1 Background to Evaluation

Given the nature and scope of this Nicola Lake Dam Completion Feasibility Study, it has not been possible to delve into the economic and resource-economic benefits and dis-benefits of the project.

Based on the outcome of the financial analysis however, the economic prospects should be more significant.

The following economic considerations were taken into account in briefly exploring the overall benefit to the rural economy of the Nicola Valley and the intrinsic value added to the Nicola River Fishery.

- *Agriculture*

  The financial benefits referred to in the previous chapter only included the net increase in forage production. This forage is however utilized to maintain Beef Cattle during the winter season. The economic value added in this conversion of foodstuff to meat for human consumption has not been quantified in this analysis.

  Even though forage cropping will most likely constitute the largest portion of the irrigation water usage, other higher value crops (e.g. potatoes, corn and other vegetables) could be farmed instead if the risk of water shortages is reduced by creating more available storage capacity behind the Nicola Lake Dam. This would increase the economic input in the valley.

  Another positive impact of a higher level of assurance of irrigation water supply would be an increase in the resale value of irrigation land/farms.

- *Fisheries*

The importance of the Nicola Watershed as a fishery has been realized and large initiatives (Pacific Salmon Foundation and Government Ministries) have been funded in this river basin.

The positive benefits to the Nicola River Fishery associated with dam completion would include making more water available at critical times of the year (i.e. August through March). In the original Bergman Feasibility Report, a rudimentary estimate of the net benefits associated with increased fish production ranged from a Net Present Value of $2 to 4 million (in 1982 dollar terms; i*= 10%; 25 years).

The straight use of commercial fishing value (income minus cost) in fish harvested at sea should not be the only basis on which to quantify this benefit. Intrinsic and resource based values associated with First Nation rights and good custodianship requirements (i.e. future costs related to rehabilitation if the river habitat is degraded to a point where fish cannot survive and public nuisances such as mosquitoes proliferate; or where mine leachate and pollutants cause severe water quality problems due to low streamflow), all play a role in determining the benefits to the fishery.

Cost items to do with fish values (e.g. Burbot) may be associated with the potentially larger fluctuation in lake water levels (0.5 metres lower than the current allowable or minimum draw down level). These costs cannot be determined at this stage as the environmental assessments have not commenced. A present value of $800,000 has roughly been estimated to provide for investigations, compensation and mitigation measures.

- *Other*

Costs and benefits associated with the following are very hard to quantify without more significant investigation:

*Lakeshore Owners*:- On the positive side it has been assumed that more beach area will be available to holidaymakers in late summer due to lower lake levels in some years. Other benefits may accrue when the social assessment is conducted. Economic costs have not yet been identified as a more in-depth public involvement and the full social and environmental study have not been conducted. Intangibles such as the perceived deterioration in aesthetic values associated with mudflat exposure in dry, low flow years have not been quantified.

*Eco-Tourism*:- A completed dam would allow more water to be released from the lake. This should provide better quality water and higher flow rates for recreational activities such as kayaking and canoeing during certain times of the year. Again no value has been placed on these benefits at this stage. Some form of social accounting matrix methodology could be used in the social and environmental assessment that would follow.

*Water Quality*:- Already alluded to in the fisheries section the increased flow releases from a completed dam should have a positive impact on the quality of water over a longer period each year, giving the Nicola River a higher capacity to dilute the inevitable nutrient and other waste products that find their way into the river with increased development.

*Supporting Economic Development*:- It is envisaged that development will continue apace as more and more Lower Mainland people discover the Valley. The improved certainty of water supplies that would be associated with dam completion, as well as the implementation of good water stewardship practices, would make a positive impression on potential investors.

*Flood Damage Control*:- Although a completed dam will allow more capacity to contain small to medium floods passing through the dam (i.e. assisting in reducing bankfull conditions in Merritt and affecting irrigation intakes), this capacity will by no means have much effect on the larger floods that will inevitably come through in future. No cost or benefit has been accounted for here. The City of Merritt should urgently address this situation as the potential threat on human life and property is reasonably great (e.g. reversing development on the river floodplains or building dykes or other flood control measures).

## 9.2 Conclusions Associated with Economic Considerations

In this economic evaluation it has been realized that benefits accrue to both agriculture and fisheries. Only the most apparent benefits and costs have been identified. Even so, it seems that benefits far outweigh the costs associated with finishing this project.

In this assessment we have also ignored the sunk costs associated with the original construction of the dam, which in 1986 prices cost $2,294,466 to reach the stage that we find in the field today. In today's dollar terms, this would be significantly more.

Since the storage that should have been created was not developed at that time, the full benefits will be realized at a relatively small cost in the dam completion project currently under review.
Options 11 and 12 still remain viable in economic terms due to the large benefit that would be derived from the investment.

An update of the economic analysis can be conducted in the next phase of the study after the engineering design and the environmental/social assessments are completed. Apart from updating the analyses, other economic tools could be employed (e.g. a social accounting matrix). Resource economics to quantify the cost and benefits to the natural environment may be considered to fully understand the implications of the project.

## 10.0 INSTITUTIONAL ARRANGEMENTS

An extremely important element in the feasibility process leading towards dam completion is the matter of who will champion such a project and guide it through the various project stages that remain.

A formal entity or agency will have to be in place to pull together financing, to implement other arrangements and to start cost recovery procedures. As already mentioned, the type of institutional model adopted will influence the eventual cost of the dam completion project. Mr Bergman (1983) put forward some possibilities in his work in the early 1980's.

Various models exist ranging from the current status-quo of pure Provincial Government ownership (Ministry of Environment), through to a Provincial/Regional District/Community Water User group (e.g. Bonaparte River), through to a form of public private sector partnership, a community owned water authority, or even to the extreme of private ownership.

More information on Water User Communities, including practical suggestions re the start-up and running of these institutions may be found on land and Water BC (now MOE) website at http://www.lwbc.bc.ca/03water/licencing/wuc/index.html. The existing water user's group in the Bonaparte River Watershed may be a good model to learn from.

Judging by contact with NWUMP members (including Government authorities), no one entity (Government or private) really wants to shoulder the full responsibility of the Nicola Lake Dam in the future. This component of the dam completion project needs urgent attention!

Strong leadership, which is not reluctant to tackle conflict head-on and find win-win solutions, and that can make timely decisions, is a pre-requisite, as the window of opportunity to complete the dam will start closing not long after the beginning of the year 2007. In 2008, the Federal Government funding program (one third of capital cost) will more than likely not be available after that date.

Construction costs are also escalating due to the shortage of skilled workers, machinery and construction materials in the build-up to the 2010 Winter Olympics in British Columbia.

It is also envisaged that lakeshore development will continue in the near future, with more and more influential people building homes in the new development areas. This could influence a decision regarding dam completion further in the years to come.

If the decision is made to proceed beyond this feasibility study, it will be crucial that a champion be identified at the earliest opportunity, and that institutional capacity is built with the view of implementing the project and then successfully operating and maintaining it in future.

# 11.0 PROJECT IMPLEMENTATION CONSIDERATIONS

## 11.1 The Lead-Up to Construction

Based on input received at the NWUMP meeting in late September 2005, this feasibility assessment needs to be taken back to the Nicola Water Use Management Planning (NWUMP) process for a decision as to whether or not the Nicola Valley Community wishes to proceed any further with implementation of the project.

If the decision is affirmative, then a champion or institution needs to be formed that can take responsibility for the implementation of the project. This organization could take on the form of a Public Private Sector Partnership with the Ministry of Environment.

It will have to formalize its business approach and may also have to charge water tariffs in order to fund the maintenance and operation of the dam. Water licencing associated with the new storage also should be prepared during this period and the dam operating rule must be refined. All these mechanisms must be put in place before construction begins. Once this institution has clear direction, it will need to source funding for the dam completion project implementation assessment.

This next phase in the project cycle would ideally incorporate a project design/specification stage along with a specially tailored social and environmental assessments that deal with mitigation regarding specific issues and First Nation consultation. The exact scope of these assessments will need to be determined at an early stage in this implementation process. Some notes in this regard have been presented in Appendix B.

All these assignments mentioned above should run in parallel so as to ensure that the process is expedited in order to allow the full benefits of this dam completion project to be realized at the earliest opportunity.

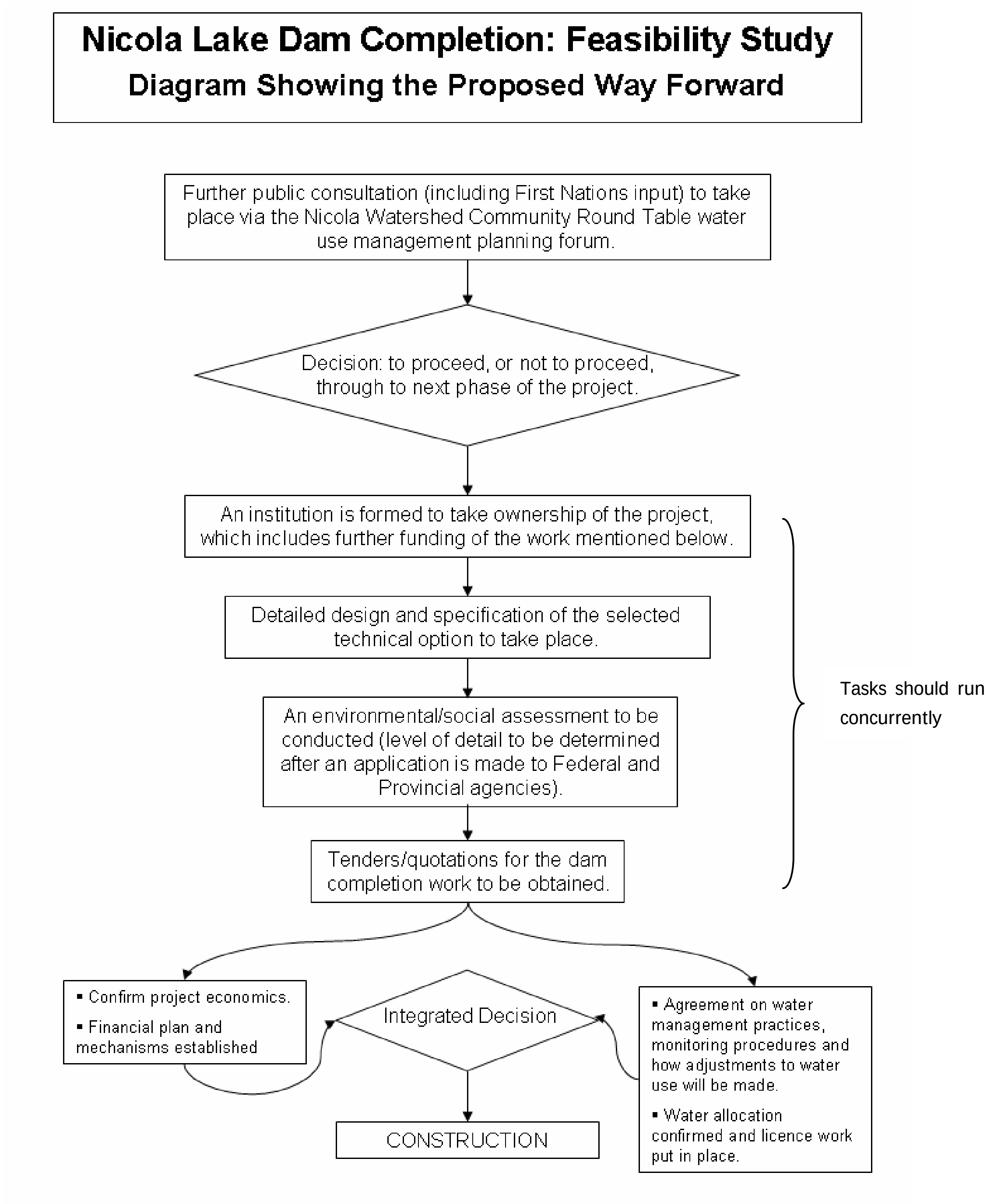
The Pacific Salmon Foundation Reconnaissance Study into identifying the most suitable approach to determining instream fish flow requirements and the corresponding operation of the Nicola Dam, will be conducted during mid-2006.

It is hoped that this initial study will be followed by a larger investigation into these matters. It is hoped that this input will streamline the flow regime to hold back water for when it really is needed for fish and other values.

Project costs and economics need to be confirmed at this stage. NWUMP would have to intervene in the process to obtain public buy-in to the final proposals.

Funding arrangement also need to be put in place. This stage should culminate in an agreed upon price with a contractor.

***Figure 11.1: The Proposed Way Forward Towards Construction***



## 11.2 Construction

The next phase of the project will be to implement the construction work as described in Section 7 above and to mobilize the contractor to do the work.

At this time, the preferred approach is Option 11. This method would use a barge mounted excavator/auger dredge for the main outlet channel during the summer instream work window. This method would utilize a piece of equipment, similar to that viewed at Fraser River Pile and Dredge Ltd in New Westminster. The barge supports a long reach excavator that would use a conventional digging bucket to remove the hardpan clay from the "high spot". This material would be loaded onto the excavator barge, or an adjacent barge, and transported to shore where it could be unloaded and hauled to a disposal site.

The same excavator would then be used with its auger dredge attachment to pump a slurry of soft sediment and water from the infilled portion of the main channel onto the barge, where a series of containers (ponds) would be used to dewater the mud and the relatively clean water would be allowed to flow back into the lake beside the barge. When the barge has a full load of soil it will be moved to shore and unloaded into trucks for soil disposal (as with the clay). A separate barge could be used to ferry soil back and forth for disposal if that was deemed to be more efficient.

The implementation of Option 7 (i.e. irrigation pipelines from Nicola Ranch pump station to irrigation fields) still remains as a viable alternative to excavating the side channels to the existing irrigation intakes.

If Option 7 is not selected, then the side channels would be excavated during the following winter, working off of very low work berms (pads) at very low lake levels. Conventional hydraulic excavators would work off shale work pads along each side channel. The pads would not extend above the surrounding lakebed and would not create a navigation hazard. The pads would however be available in the future to be used (every 5 years) to perform the maintenance dredging of the side channels, which tend to fill in more readily than the main outlet channel that has a definite current.

Since the side channels would be excavated in the winter, this would enable most of the work to be done in the dry with only a quick tie-in required to the flowing main outlet channel. This method would greatly reduce the volume of shale required over constructing work berm at higher lake levels, and would provide excellent value when compared to the future cost of bringing in a dredge for the side channel maintenance and the associated uncertainty regarding future funding. Each component of the work would be done in the cleanest possible manner, with the maximum possible amount of the work done in the dry.

Option 12 would require some excavation in the lake to tie in the “dryland” channel to the deeper part of the lake on the upstream side and the existing channel on the downstream end. Large excavators/trucks or earthmoving scrapers would move in and excavate a fairly deep channel on the northern side of the hayfield along the edge of the southern shore of the lake. Option 7 would have to be implemented to allow irrigation pumps on the lakeshore to operate.

At the same time, the dam management organization will have to implement all the other associated works and tasks as referred to above (e.g. confirmation of old and new water licence allocations; environmental mitigation and compensation measures; etc).

### 11.3 Summary of Costs Associated with Project Implementation

Until such time as a dam management institution is formed and a decision made as to who will conduct the dam completion work (i.e. MOE or private consultants/contractors), it is very difficult to provide accurate cost estimates for the work that needs to be conducted. Preliminary cost estimates that need to be firmed up on early in the next stage of the project are as follows:

i. Formation of champion organization together with Provincial Government. Scope and cost unknown at this stage. Have assumed that the Provincial Government would financially support this initiative;

ii. It has been assumed that initial public consultation within the NWUMP process;

iii. Public consultation, including First Nation involvement, during the design and assessment phase could amount to around $80,000, but this will need to be confirmed after a detailed terms of reference is prepared for this work

iv. Social/environmental assessments and mitigation and compensation measures during implementation have been assumed at around $800,000 over the first two years of project implementation. These numbers will have to be substantiated during the design and environmental assessment phase and negotiated out with the relevant government authorities.

v. The construction cost of Option 11 has been estimated at around $700,000 plus an additional $335,000 in engineering design, contract administration and other construction related costs. This totals to $1,035,000. Corresponding costs associated with could be in the region of $3,617,000. A contingency of 20% (2005 dollar prices) has been included in these estimates. This could be higher in future due to an unfavourable balance between factors in the construction industry in British Columbia. Estimates will have to be revised during the next phase of this assessment.

vi. Other fees associated with the management of the implementing institution have not been estimated.

vii. This study has been more focused on the technical feasibility of the project and hence surrounding monitory values mentioned above are tentative at the moment. Having said this though, it can be expected that Option 11 may cost in the order of $2 million to construct and option 12 in the vicinity of $4.5 million. These ballpark values have to be placed in the context of the much larger financial and economic returns that will be achieved by creating the additional storage.

## 12.0 CONCLUSIONS & RECOMMENDATIONS REGARDING DAM COMPLETION FEASIBILTY

In 1983, the Bergman Feasibility Report (1983) evaluated the project and found it to be viable based on the assumptions made in that era.

A similar conclusion has been reached in this current 2005 Feasibility Study.

### 12.1 Background

The original project was substantially finished in the late 1980's (i.e. dam structure completed and only about 470 metres of main channel and three relatively short side channels remaining incomplete). Unfortunately the full water storage benefit has not been realized as almost no additional water storage was created by the 1980's intervention.

The majority of local residents of the Nicola Valley want to see the project completed, since for a relatively small investment, a very large potential would unlocked that will greatly benefit the regional economy and improve the ecological integrity of the Nicola River below the lake.

### 12.2 Water Availability and Water Requirements

The current storage remains at roughly 28,000 AF which was close to the lake's accessible storage volume behind the original dam. This storage is still significant if one compares it with the no dam option which would place a major strain on fish flows during the non-freshet period. Irrigation would realistically only be able to be practiced during a much shorter period of the growing season. Irrigation and especially fisheries have benefited from releases made by the BC Ministry of Environment from their storage licence during the drier times of the year.

In the study it was observed that the water requirements adopted in the early 1980 studies to determine lake and storage levels required when constructing the new dam were more than what would be expected today. These large values have been used in the current water availability analysis to maintain consistency.

The fact that the water availability analyses showed that there would be sufficient water to support releases at the dam during a drought return period of 1:15, means that current estimates of water requirements remain on the "safe" side of allocating too much water.

Continuing on from this it was assumed that a 1:15 year return interval was required for irrigation of forage crops, which is a much higher level of assurance of supply than is usually required. Ranchers could assume higher levels of risk by using water when it is there and cutting back significantly when it is not. This could unlock more potential for both agriculture and fish flows. The implementation of water conservation measures, a refined operating rule for the dam, and other water stewardship measures could improve the situation further when additional storage is created. These aspects will have to be explored more fully in future.

### 12.3 Benefits to the Valley

The benefits to the environment and society have been demonstrated in this report. The main new benefits may be summarized as follows:

- One additional cut of forage crop on 560 acres of land in the late season on various portions of land from the lake down to the Thompson River (i.e. by providing higher level of assurance of supply to fish clause licences that are usually restricted in the late season);
- 280 acres of new land being cultivated around the Nicola Lake upstream of the dam;
- Water supplies to 717 acres of "new apportionment pending" land would be provided if the dam where completed;

- Water supplies to 947 acres of "new awaiting signature" land would also be secured;
- Up to 2,880 acres of new irrigation land downstream of the Nicola Lake Dam;
- Flow rates required for fish flows would be met helping the fishery to approach more favourable habitat conditions;
- Lakeshore owners may potentially experience more beach more often during later summer, than has been the case to date;
- Use of the river and ecotourism (including fishing, kayaking and canoeing) may benefit from more and better quality water in the Nicola River;
- Economic development and investor confidence may be enhanced (e.g. higher security of water supply and improved irrigation land prices)

Existing First Nation irrigators who would like to reinstate their irrigation land would also benefit from a more secure supply of water.

### 12.4 Engineering Options

A reasonably detailed feasibility assessment has been conducted on the various technical options that could be employed to create the connectivity between the deeper part of the lake and the dam structure.

Option 11 proved to be the most suitable option. This would include an excavator on barge that would use a bucket to excavate hardpan clay material and an augur attachment to suck up loose material in the main channel. This operation would take place in summer. The side channels would be conventionally excavated in the "dry" during winter from pre-constructed gravel workpads.

The option of reducing these side channel excavations (Option 7) by investing a bit more in irrigation water supply infrastructure to feed the lakeshore irrigation fields, could save on having to dredge these channels every 5 years in future.

Option 12, although coming with a much higher initial price tag, would also help obviate entering the lake for future maintenance works. The current lakeshore owner is however not in favour of allowing this construction over his land. Some environmental impact uncertainties could also make this option less favourable that it seems.

## 12.5 Social and Environmental Considerations

During the course of this assignment, known social and environmental issues associated with the dam completion project have been identified. With the exception of burbot fish life cycle concerns, no unusual issues have been found.

These concerns and the development of adequate mitigation/compensation measures will have to be addressed in the next stage of this project implementation cycle. The extent of these upcoming assessments will have to be determined with the relevant government authorities, if the decision is made to proceed with the dam completion project immediately.

## 12.6 Financial and Economic Considerations

It has been assumed that all the original costs involved in building the 1987 dam structure and getting the dredging to where it is now, are history (i.e. sunk costs).

Fifty-five agricultural properties could benefit directly from this extra water storage and the regional economic benefit would be greater. If operated properly, it is believed that the new storage would enhance fishery values significantly.

The financial analysis conducted in this study demonstrated that for a relatively small initial investment by government and others will provide a significant benefit to the Nicola Valley and the Pacific Salmon Fishery.

## 12.7 Institutional and Project Implementation Considerations

It has been stated in this report that the formation of a mutually acceptable organization between the MOE and local stakeholders that will champion the project, is crucial to the success of this project.

Strong political will and commitment will be required to move the project through to design and specification, public consultation, the conducting of social and environmental assessments, finding suitable funding, constructing the project, allocating water use, and operating and maintaining the dam in future.

The estimated costs associated with these project stages have been presented in order to guide this future work.

### 12.8 Recommendation

The conclusions drawn above confirm the general sentiment of the people of the Nicola Valley that completing the dam makes sense. Some community members still remain skeptical and would like to see due process and diligence followed in assessing all the environmental and social issues in more detail. Although these people's views should be respected, it must be realized that protracted study could cost as much as the dam completion project if it drags on for another two years or more.

Most of the people interviewed via the NWUMP process agreed that, in public decision-making, there are times that the decisions must be made for the greater good of, and the economic well-being of, the community and the environment. In this case, if the dam is operated carefully and water allocations are made wisely, the anadromous fishery and agriculture downstream of the Nicola Lake stands to benefit greatly by the additional water storage. Special mitigation and compensation measures may however still need to be put in place to minimize the impacts of negative social and environmental issues that are a concern.

The majority of stakeholders that have attended Nicola Watershed Community Round Table Workshops, and more recently a presentation on the technical options being put forward by this Feasibility Study, echo the need to finish what was started. They feel that the benefits both to fish and agriculture far outweigh any negative impacts associated with an additional fluctuation of 0.5 metres vertically on the Nicola Lake during the non-freshet period of the year.

In response to terms of reference followed in this study, it can be stated that the dam completion project has been found to be viable based on technical engineering factors, impacts and a technical financial/economic analysis.

It is recommended that the assessment now move on to the next stages and that as many of the following tasks be conducted in parallel:

i. A public decision (via the NWUMP) as to whether to proceed further or to put the dam completion option to bed indefinitely;
ii. The formation of a dam management partnership;
iii. Sourcing of interim financing;
iv. Conducting the selected level of social and environmental assessment including Public/First Nation consultation;

v. Selection of the dam completion option to be implemented;

vi. Design, specification and obtaining quotations for the selected dam completion option;

vii. Putting construction funding arrangements in place; and

viii. Agreeing on the future water allocations and ensuring that the storage and water diversion and flow licences are secured.

## 13.0 REFERENCES

1. BC Ministry of Environment and Parks, Planning and Resource Management Division. L.A. Bergman P.Eng. March 1983. *Engineering Feasibility Study on Rebuilding the Outlet of the Nicola Lake*.

2. Urban Systems Ltd. January 2005. *Nicola River Basin Management Strategy - Phase 1: Scoping Study*. Prepared for the Nicola Stock Breeders Association.

3. BC Ministry of Environment and Parks, Water Management Branch, Hydrology Section. R.Y. McNeil. May 1987. *Nicola Lake Operating Plan*.

4. BC Ministry of Environment and Parks. July 1983. *Nicola Basin Strategic Plan*.

# APPENDIX A

## *Some Notes on Options 11 and 12*

## ANNEXURE A: SOME ADDITIONAL NOTES ON OPTIONS 11 AND 12

A detailed feasibility level cost estimate for Options 11 and 12 are attached to this appendix below.

Option 11 has been described in detail in the main text. Although significantly more expensive initially, Option 12 still yields a major return when compared to this capital investment. Since Option 12 holds benefits associated with future maintenance and access to the lake itself, it has been left in as an option if the Client wishes to pursue it further. Option 7 (irrigation pipeline system instead of side channels) would have to come into play.

Some considerations about Option 12 should be borne in mind when considering it further. These considerations as well as some notes on channel cleaning in both options are as follows:

- The existence of 2 channels (i.e. existing main channel plus new side channel) will reduce the normal water velocities in the south channel to well below that of the existing main outlet channel. This will reduce the tendency for the flowing water to keep the channel from infilling This may also result in certain fish passage concerns;
- The rate at which soil is washed from the banks of the channel will depend on soil type, wave action and vegetation stabilizing the slopes. We have no information to suggest the soil types will be different in the south field. We know wave action will be reduced because of a lower fetch. Vegetation will help to stabilize the slopes in the south channel, but the slopes will always be subject to wave action, whereas the mid-lake channel sides are only really subject to the full force of waves when the lake is low. Overall, the rate of sediment loss from banks will be comparable in both channels;
- The bank height is assumed to be 6.9 m in the 900 m long south field channel. This gives plenty of opportunity for slope stability problems, including surface sloughing, or deep-seated rotational slope failures. This could easily be a much larger source of infilling and maintenance than the low banks of the mid-lake outlet channel. The side slopes are assumed to be 1.5 to 1 above high water and 2 to 1 below. This may provide stable slopes, but like on the Coquihalla highway road cuts, there may be regular maintenance required to keep the channel unobstructed. No geotechnical analysis has been done, and no soils information is available for the south field. Both would be required before the assumed side-slopes could be confirmed as feasible. This represents a risk for the south channel that is not a factor for the mid-lake channel;
- These large cuts may create a public safety concern
- The operation of the dam will ultimately determine how well the outlet channel(s) are kept clear of fine sediments;

- If the reservoir is operated in such a way as to produce high outflows at times of low lake level (i.e. vacating storage prior to freshet) the rate of infilling may possibly be very low, and maintenance "dredging" may not be required, or at least very infrequently;
- If the lake is not operated in such a fashion, or it is deemed environmentally unacceptable to wash fine sediments downstream prior to freshet, the rate of infilling will be comparable to that seen in the past 18 years. In such case a reasonable expectation would be to have 6000 cu m (0.6 m x 10 m wide x 1000 m long = 6000 cu m) of sediment to remove from the mid-lake main outlet channel every ~20 years, plus an additional volume of ~6500 cu m in the side channels, at a cost of ~$500,000 to $600,000 (in 2005 dollars including dredge mobilization/demobilization, etc).
- The amount of sediment to be removed from a south shore channel would in all likelihood be higher, but would cost less to remove as the access would be better for the majority of the channel length. The south shore channel is of comparable length to the mid-lake channel that currently requires "dredging". There is an additional 0.5 km of mid-lake channel that may require dredging in the future, but has only filled in ~0.1 to 0.2 m so far in 18 years. Assuming only the south shore channel required clearing the volume may be in the order of 9000 cu m (0.75 m x 10 m x 1200 m) plus 6500 cu m for the side channels. This may cost in the order of $10/cu m for the south shore channel ($90,000) plus the cost of the side channels. This cost is thought to be $60,000 every 5 years provided a work pad (shale) is left in the lake bed to provide access. The cost of maintenance would therefore be $60,000 every 5 years and $150,000 every 20 years, or an average of $16,500 / year.
- The costing associated with Option 12 which pushes the construction cost up, has been rechecked and the numbers still turn out in the same ballpark. This option includes work in the lake as well as a long and deep on-shore channel.

**Cost Estimate Spreadsheets for Nicola Dam Channel Excavation Options**

1 This is a copy of the output from a calculation spreadsheet used to estimate costs for various options that could be used to complete the channel excavation portion of the Nicola Dam storage project.

2 The spreadsheets were used as a tool and document the assumptions used in making the estimates. The component costs cannot be used independantly as they were assembled on the basis of the overall estimate.

3 Hourly rates used for equipment rental are shown and could be updated when a final cost estimate is prepared prior to construction.

4 The overall cost estimates include a standard contingency of 20 %. All relevant cost factors have been attempted to be explicitly included in the estimate. The total cost is rounded up to the nearest $100,000. Consideration was given as to whether the contingency plus rounding amount provide a sufficient allowance for the unknowns specific to the method used.

5 A number of factors not known at this time will affect final costs, such as environmental approval conditions, tendering method and contract admimistration, etc. This is discussed in the report in detail.

6 Hourly equipment and production rates used were standardized to the extent possible.

7 Final estimates will be required when the details of the construction conditions / timing are known. This more detailed estimate will reflect the method chosen, the most up-to-date survey information, environmental approval conditions, institutional arrangements, in-kind contributions from partners, economic climate factors, profit for contractor, etc.

# Cost Estimate and Work Performed for Nicola Dam Channel Excavation Options

## Option 11 - Barge Mounted Excavator / Auger Dredge WITHOUT Nicola Ranch Cooperation

| Hourly Rates for Equipment: | Rate | Number | Cost Per Hour | Cu. m/load | | |
|---|---|---|---|---|---|---|
| Barge Mounted Excavator / Auger Dredg | $ 400 | 1 | $ 400 | Excavate 1 cu m/minute in soft; 0.5 in clay | | |
| Tandem Dump Truck Hauling Clay | $ 70 | 4 | $ 280 | 6 | 60 | 30 (transport |
| Tandem Dump Truck Hauling Rock | $ 77 | 3 | $ 231 | 8 | 30 | 30 |
| Hitachi EX220 Excavator (load or spread | $ 135 | 1.0 | $ 135 | | | |
| 966 Loader | $ 145 | 1 | $ 145 | Production | | |
| Extra Barges for clay | $ 60 | 2 | $ 120 | 8 cu m /hr in hardpan clay | | |
| | | | | 65 cu m /hr in soft silt | | |

Truck Round-trip Time (General):

| Task | Load Talus Rock Dist (km) | Load Talus Rock Minutes | Dump Clay at Disposal Site Dist (km) | Dump Clay at Disposal Site Minutes | |
|---|---|---|---|---|---|
| Load | | 5 | | 5 | |
| To berm | 1 | 3 | 5 | 7.5 | to disposal site |
| Dump | | 4 | | 4 | |
| To pit | 1 | 3 | 5 | 7.5 | |
| Standby | | 5 | | 5 | |
| Total | | 20 | | 29 | |

| Item | Description | Amount (cu. m) | Production (cu. m/hr) | Equipment | Rate ($/hr) | Costs: Excavation | Costs: Isolation | Costs: Total |
|---|---|---|---|---|---|---|---|---|
| 1 | Work berm from shore to channel | 0 | 72 | LR Exc, rock tandems, EX220 | | $ - | | $ - |
| 2 | Removal | 0 | 50 | LR Exc, rock tandems, EX220 | | $ - | | $ - |
| 3 | Work berm along main channel | 0 | 72 | LR Exc, rock tandems, EX220 | | $ - | | $ - |
| 4 | Removal | 0 | 50 | LR Exc, clay tandems, EX220 | | $ - | | $ - |
| 5 | Hardpan clay (high spot) excavation | 2585 | 30 | Exc+3Barges, 2 tandems, 966, EX | $ 940 | $ 80,997 | $ 30,000 | $ 110,997 |
| 6 | Main channel soft sediment removal | 3190 | 30 | Auger on Barge, 2 tandems, EX220 | $ 820 | $ 87,193 | $ 30,000 | $ 117,193 |
| 7 | Berm install for NW chan | 1495 | 72 | 3 rock tandems, 2 EX220 | $ 501 | $ 10,403 | | $ 10,403 |
| 8 | Berm removal for NW chan | 0 | 50 | LR Exc, rock tandems, EX221 | | $ - | | $ - |
| 9 | Excavation NW Intake | 846 | 64 | 4 tandems, EX220x2 | $ 550 | $ 7,274 | $ 1,000 | $ 8,274 |
| 10 | Dredge half NW Intake | 0 | 65 | Dredge | | $ - | | $ - |
| 11 | Berm install for N chan | 2925 | 72 | 3 rock tandems, 2 EX220 | $ 501 | $ 20,353 | | $ 20,353 |
| 12 | Berm removal for N chan | 0 | 50 | LR Exc, rock tandems, EX221 | | $ - | | $ - |
| 13 | Excavation N Intake | 1386 | 64 | 4 tandems, EX220x2 | $ 550 | $ 11,911 | $ 1,000 | $ 12,911 |
| 14 | Dredge half N Intake | 0 | 65 | Dredge | | $ - | | $ - |
| 15 | Berm install for NE chan | 144 | 72 | 3 rock tandems, 2 EX220 | $ 501 | $ 1,000 | | $ 1,000 |
| 16 | Berm removal for NE chan | 0 | 50 | LR Exc, rock tandems, EX221 | | $ - | | $ - |
| 17 | Excavation NE Intake | 250 | 64 | 4 tandems, EX220x2 | $ 550 | $ 2,148 | $ 1,000 | $ 3,148 |
| 18 | Dredge half NE Intake | 0 | 65 | Dredge | | $ - | | $ - |
| 19 | Berm install for S chan | 1625 | 72 | 3 rock tandems, 2 EX220 | $ 501 | $ 11,307 | | $ 11,307 |
| 20 | Berm removal for S chan | 0 | 50 | LR Exc, rock tandems, EX221 | | $ - | | $ - |
| 21 | Excavation S Intake | 1620 | 64 | 4 tandems, EX220x2 | $ 550 | $ 13,922 | $ 1,000 | $ 14,922 |
| 22 | Dredge half S Intake | 0 | 65 | Dredge | | $ - | | $ - |
| 23 | Berm install for McLeod | 1560 | 72 | 3 rock tandems, 2 EX220 | $ 501 | $ 10,855 | | $ 10,855 |
| 24 | Berm removal for McLeod | 0 | 50 | LR Exc, rock tandems, EX221 | | $ - | | $ - |
| 25 | Excavation McLeod Intake | 1037 | 64 | 4 tandems, EX220x2 | $ 550 | $ 8,910 | $ 1,000 | $ 9,910 |
| 26 | Dredge half McLeod Intake | 0 | 65 | Dredge | | $ - | | $ - |
| 27 | Berm install for Mijo | 455 | 72 | 3 rock tandems, 2 EX220 | $ 501 | $ 3,166 | | $ 3,166 |
| 28 | Berm removal for Mijo | 0 | 50 | LR Exc, rock tandems, EX221 | | $ - | | $ - |
| 29 | Excavation Mijo Intake | 559 | 64 | 4 tandems, EX220x2 | $ 550 | $ 4,800 | $ 1,000 | $ 5,800 |
| 30 | Dredge Mijo Intake | 0 | 65 | Dredge | | $ - | | $ - |

| Calculations: Length | WL | Berm Top | Bed Level | Firm Bed | S. Slope | Width | Unit Vol | Volume | Description |
|---|---|---|---|---|---|---|---|---|---|
| | 624.8 | 625.1 | 624.0 | 623.0 | 1.5 | 5 | 17.1 | 0 | Work berm from shore to channel |
| | 624.8 | 625.1 | 624.0 | 623.0 | 1.5 | 5 | 17.1 | 0 | Removal |
| | 624.8 | 625.1 | 624 | 623.2 | 1.5 | 5 | 14.9 | 0 | Work berm along main channel |
| | 624.8 | 625.1 | 624 | 623.2 | 1.5 | 5 | 14.9 | 0 | Removal |
| 470 | | 623.4 | | 622.9 | 2 | 10 | 5.5 | 2585 | Hardpan clay (high spot) excavation |
| 580 | | 623.4 | | 622.9 | 2 | 10 | 5.5 | 3190 | Main channel soft sediment removal |
| 230 | 623.8 | 624.3 | 624.3 | 623.3 | 1.5 | 5 | 6.5 | 1495 | Berm install for NW chan |
| 0 | 624.8 | 625.1 | 624.3 | 623.3 | 1.5 | 5 | 13.9 | 0 | Berm removal for NW chan |
| 230 | | 624.3 | | 623.5 | 2 | 3 | 3.7 | 846 | Excavation NW Intake |
| 0 | | 624.3 | | 623.5 | 2 | 3 | 3.7 | 0 | Dredge half NW Intake |
| 450 | 624.8 | 624.2 | 624.2 | 623.2 | 1.5 | 5 | 6.5 | 2925 | Berm install for N chan |
| 0 | 624.8 | 625.1 | 623.9 | 622.9 | 1.5 | 5 | 18.3 | 0 | Berm removal for N chan |
| 450 | | 624.2 | | 623.5 | 2 | 3 | 3.1 | 1386 | Excavation N Intake |
| 0 | | 623.9 | | 623.5 | 2 | 3 | 1.5 | 0 | Dredge half N Intake |
| 50 | 623.8 | 624.0 | 624.5 | 623.5 | 1.5 | 5 | 2.9 | 144 | Berm install for NE chan |
| 0 | 624.8 | 625.1 | 624.5 | 623.5 | 1.5 | 5 | 11.8 | 0 | Berm removal for NE chan |
| 50 | | 624.5 | | 623.5 | 2 | 3 | 5.0 | 250 | Excavation NE Intake |
| 0 | | 624.5 | | 623.5 | 2 | 3 | 5.0 | 0 | Dredge half NE Intake |
| 250 | 623.8 | 624.7 | 624.7 | 623.7 | 1.5 | 5 | 6.5 | 1625 | Berm install for S chan |
| 0 | 624.8 | 625.1 | 624.7 | 623.7 | 1.5 | 5 | 9.9 | 0 | Berm removal for S chan |
| 250 | | 624.7 | | 623.5 | 2 | 3 | 6.5 | 1620 | Excavation S Intake |
| 0 | | 624.7 | | 623.5 | 2 | 3 | 6.5 | 0 | Dredge half S Intake |
| 240 | 623.8 | 624.4 | 624.4 | 623.4 | 1.5 | 5 | 6.5 | 1560 | Berm install for McLeod |
| 0 | 624.8 | 625.1 | 624.4 | 623.4 | 1.5 | 5 | 12.8 | 0 | Berm removal for McLeod |
| 240 | | 624.4 | | 623.5 | 2 | 3 | 4.3 | 1037 | Excavation McLeod Intake |
| 0 | | 624.4 | | 623.5 | 2 | 3 | 4.3 | 0 | Dredge half McLeod Intake |
| 70 | 623.8 | 624.2 | 624.2 | 623.2 | 1.5 | 5 | 6.5 | 455 | Berm install for Mijo |
| 0 | 623.8 | 624.2 | 624.2 | 623.2 | 1.5 | 5 | 6.5 | 0 | Berm removal for Mijo |
| 70 | | 624.2 | | 623.5 | 2 | 10 | 8.0 | 559 | Excavation Mijo Intake |
| 0 | | 624.2 | | 623.5 | 2 | 10 | 8.0 | 0 | Dredge Mijo Intake |

| | | | Excavation | Isolation | Total |
|---|---|---|---|---|---|
| Sub-Total | | | $ 274,240 | $ 66,000 | $ 340,240 |
| | Time: 13902 side channels | | Mob / demob of barges | | $ 75,000 |
| | 5775 main channel | | Access and disposal site constr and rehab | | $ 75,000 |
| | 19677 cu m | 38 days | ·alties @ $2/cu m x 2 sites | | 78,706 |
| Contingency (20 % - To cover costs not anticipated or specifically included in this work plan.) | | exc in summer | 54,848 | 13,200 | 68,048 |
| | | 38 days | | | |
| **Total** | | | **$ 329,088** | **$ 79,200** | **$ 636,994** |

Total material moved 19677 cu m

Actual channel excavation 8329 cu m

Rounded up to **$0.7 M** with soils and any uncertainties.

| | | |
|---|---|---|
| Side Channel Maintenanc | $ | 54,965 |
| mob and demob | | 5000 |
| 5 year maintenance cost | $ | 59,965 |

Assumptions:

1 Nicola Ranch will not allow access, or take the excavated clay to fill a low area; assume other disposal site within 8 km
2 Royalties are $2/cu m for talus rock and $2/ cu m for placing clay on property.
3 Rock pit development costs are included in equipment time in pit
4 Lake level is 624.8 m
5 Top of berm is 0.3 m higher at 625.1 m (no allowance for large waves)
6 1.0 m of soft organic soil on lake bed, which rock will push down through
7 Soft sediments pushed up will have to be excavated to avoid infilling channel(s)
8 Organics, clay and dirty talus can be excavated at only 6 cu m / load due to wet conditions. All require a disposal royalty and can't be reused.
9 No design or supervision cost included in this estimate. Assume MoE does work.
10 Barge mounted exc costs $250/hr; 2 barges are another $150/hr or $400/hour for equipment in water.
11 All of each side channel is excavated from the barge
12 Loader would unload barges and pile wet soil; later the drier soil would be loaded into tandems and moved to disposal site within 8 km

**Cost Estimate and Work Performed for Nicola Dam Channel Excavation Options**

**Option 12 - South Shoreline Channel Excavation IN NICOLA RANCH FIELDS with Nicola Ranch Cooperation**

Use option 5 estimate with addition of overburden removal using scrappers at $5/cu m

| | | |
|---|---|---|
| Option 5 cost | $ | 1,400,000 |
| Additional excavation with scrappers | $ | 700,000 |
| Land purchase cost for 900 m x 39 m of waterfront plus disposal of soil on property covering an area greater than the excavation | $ | 500,000 |
| Mijo compensation for loss of riparian rights. | $ | 200,000 |
| No bridge over this channel for lake access in future | $ | - |
| **Total** | $ | 2,800,000 |
| Contingency 20 % of amount in excess of Option 5 | $ | 280,000 |
| Total | $ | 3,080,000 |

Rounded up to **$3.1 M** with soils and env uncertainties.

Assumptions:

1 Nicola Ranch will allow full access, use of talus material for constructing berms, and will take the excavated clay to fill a low area within 5 km**and allow overburden to be spread on the same lot (with scra**
2 Royalties are estimated in land purchase cost (for placing soil on property).
3 Rock pit development costs are included in equipment time in pit
4 Lake level is 624.8 m (I.e. late fall work)
5 Top of berm is 0.3 m higher at 625.1 m (no allowance for large waves)
6 1.0 m of soft organic soil on lake bed, which rock will push down through
7 Soft sediments pushed up will have to be excavated to avoid infilling channel(s)
8 Organics, clay and dirty talus can be excavated at only 6 cu m / load due to wet conditions. All require a disposal royalty and can't be reused.
9 No design or supervision cost included in this estimate. Assume MoE does work.
10 Approach section of main channel and all of side channels are excavated from a talus work berm.
11 Berm along shoreline would be left in place for future use in maintenance channel clearing
12 AVERAGE AFFECTED FIELD LEVEL IS 4.0 M ABOVE FSL or 629.8 m. THIS WAS NOT SURVEYED BUT ESTIMATED FROM PHOTOS ONLY!!!!!
13 Can't excavate in field on Mijo property because of bedrock (and opposition
14 Scrappers used above 624.5 m at cost of $5/cu m. Excavators used below 624.5 m at equipment rental rates
15 2 to 1 side slopes below 626.0 m (FSL plus 0.2 m); 1.5 to 1 above.
16 5 m wide bench cut for access road so long reach excavator can reach bottom and so future access is possible for maintenance dredging
17 Note: top width is 39 m, depth is 7 m, length is 900 m. Total overburden volume is 137,000 cu m (in addition to option 5 work
18 NO BRIDGE OVER THIS 39 M WIDE CHANNEL FOR FUTURE LAKE ACCESS (RIPARIAN LAND OWNERS RIGHT OF ACCESS TO DEEP WATER!)
19 Mijo has opposed this in the past and would likely again. This is assumed to be a problem with him under this cost estimate and $200,000 compensation is assumed.
20 Nicola Ranch would lose approximately 35,000 sq m of lakeshore land from long-term use. Purchase of this land is assumed to cost $500,000.

**Cost Estimate and Work Performed for Nicola Dam Channel Excavation Options**

**Option 12A - South Nicola Ranch Field Channel Excavation WITH Nicola Ranch Cooperation**

| | | | | |
|---|---|---|---|---|
| Option 5 | Rounded up to | **$1.4 M** | $ | 1,400,000 |
| Additional: | 120,000 cu m exc with scrappers at $5/cu m for vol above 624.5 m | | $ | 600,000 |
| | 17,100 cu m exc with scrapers for additional vol for road on sideslope | | $ | 85,500 |
| | gravel road on bench | | $ | 15,000 |
| | Note: channel length is 900 m in field plus tie-in to deep water in lake | | | |
| | Area exc in field in 39 m wide x 900 m long = 35,100 sq m "ditch" | | | |
| | Compensation for 35,100 sq m waterfront land to Nicola Ranch | | $ | 500,000 |
| | Compensation for loss of waterfront land to Mijo | | $ | 200,000 |
| | Contingency on amount over option 5 (1.4 M x 20%) | | $ | 280,000 |
| | | | $ | 3,080,500 |
| Less: | Environmental savings of reducing in-lake excavations | | $ | 100,000 |
| | Total | | $ | 2,980,500 |
| Assumptions: | **Say** | | **$** | **3,000,000** |

1 Same as option 5, except:
2 land costs as shown
3 1.5:1 side slopes above 626 m (high water level)
4 2:1 side slopes below 626 m in water
5 land elevation in field averages 4 m above the FCL of 625.8 m, or land is 629.8 m (ESTIMATE FROM PHOTOS, NO SURVEY OR ADDITIONAL PROPERTY INSPECTION)
6 Access road is required along cut at 626 m to allow excavator to reach to bed of channel; road is 5 m wide for exc turning and stable truck access.
7 Environmental cost reduced from option 5, but still have some in-lake work to tie in to deep water channel; plus all side channels so savings is not dramatic
8

# APPENDIX B

## *Ideas on the Way Forward Regarding Social/ Environmental Assessments*

## APPENDIX B: POTENTIAL SOCIAL AND ENVIRONMENTAL ASSESSMENTS REQUIRED FOR DAM COMPLETION

There are basically three scenarios that could play out with regards to what level of investigation will be required as part of the implementation of the Nicola Lake Dam Completion Project:

- It could be argued that there is a vested right to complete the dam without any further social and environmental assessment. This vested right emanates from the fact that we are completing the original 1987 project.
- A limited social and environmental assessment that is mutually agreed to by government agencies and stakeholders alike. These assessments would be tailored to achieve the most cost effective study options with the view of saving scarce financial resources for the actual implementation of the project including mitigation/compensation measures. The time scales associated with this option would also be shorter than the full assessment referred to in the next option.
- A full-scale social and environmental assessment that would be expensive and that would take a minimum of 18 months to complete from the time of project initiation.

It is hoped that the second option will receive favourable consideration, as the cost of a full environmental study would likely be comparable to the construction of Option 11. Timing is also crucial at this stage since the potential government subsidy via the National Water Supply Expansion Program will only be valid until the end of 2007.

The third option of a full assessment study may be required. An environmental assessment has not previously been conducted for this project: in the mid-1980s during dam construction, an environmental assessment process was not in place in BC. The Environmental Assessment office and regulations through the Environmental Assessment Act was established in 1995. In 2005, large project criteria exist for determining the environmental assessment review process. The *Reviewable Projects Regulation* of the British Columbia Environmental Assessment Act (BCEAA) and *Inclusions List Regulations* of Canadian Environmental Assessment Act (CEAA) identify the possible triggers from environmental assessment:

> ***BCEAA*** – shoreline modification project that results in changes in or about a stream, marine coastline or estuary, and entails dredging, filling or other direct physical disturbance of > 1000m of linear shoreline or > 2 hectares of submerged land or combination.
>
> ***CEAA*** – alternation/ destruction of fish habitat by means of (a) physical activities carried out in a water body, including dredge or fill operations or (b) draining or altering the water levels of a water body.

It is possible that the project will not trigger a BCEAA review process if the footprint of disturbance is less than 2 hectares. Recent calculations by Bob Costerton indicate that the dredging and/ or excavation required may be close to 2 hectares. It must be noted here that the south shore channel excavation (Option 12) would be less likely to trigger a BCEAA review.

It is with a fair degree of certainty that a CEAA review process will be triggered by any of the technical options proposed due to the altering of the water levels in Nicola Lake, if not by dredging or excavation of the lakebed. Triggering of the CEAA occurs when a final construction plan is received by the Department of Fisheries and Oceans (DFO) and Harmful Alteration, Disruption or Destruction (HADD) of fish habitat is determined. At this time, Fisheries Act authorization would be initiated and the CEA would be triggered. Once a CEAA process is triggered by the Fisheries Act, referral to other Federal agencies for their comment on issues begins. Other Federal, Provincial and Local Government Acts brought into the review process at this time are listed as follows:

- Fisheries Act
- Water Act
- Canadian Navigable Waters Protection Act
- Species at Risk Act
- Forest and Range Practices Act
- Fish Protection Act
- Wildlife Act
- Waste Management Act
- Local Government Bylaws
- Local Government Act
- Drainage, Ditch and Dyke Act

A CEAA review has a narrower scope focusing primarily on environmental impacts and less on socio-economic impacts or public consultation in comparison to the BCEAA review process. Although this may indicate to some that the cost of the environmental assessment would be lower, this is not guaranteed, as the timeframe for environmental review completion through a CEAA is less certain. The Federal process may stall for an undetermined period of time as the DFO reviews the application package and requests additional technical information and design work on the proposed works (Figure B1, Step 2). This could significantly delay the triggering of the CEAA review and project approval.
It may be advantageous, therefore, to request BCEAA review in conjunction with the CEAA, broadening the scope of the environmental assessment but ensuring completion within a set time period. When a

project is subject to the CEAA as well as the BCEAA, the project review is coordinated under the Canada-BC Environmental Assessment Cooperation Agreement and follows the BCEAA timeframe.

The next steps for achieving regulatory approval for dam completion through coordinated BC/CEAA process would be to:

- Identify the proponent group for dam completion (indications are that this has to be the BC Ministry of Environment as holders of the storage license and dam operating license);
- Hold meetings with Federal and Provincial governments and necessary consultants regarding dam completion and future steps;
- Conduct issue scoping analysis which identifies potential impacts and identify those that can be mitigated through an environmental management plan by the contractor and those that require an assessment to discern the possibility, nature and/or extent of potential impacts;
- Rank significant (H, M or L) of each potential impact;
- Determine scope of impact assessment required and associated costs. (Identify the overlap with Nicola Water Use Management Planning (NWUMP) process in gathering technical information and filling knowledge gaps. There are technical information items that need to be addressed as part of or prior to a Nicola Dam Completion Project through an environmental assessment process that overlap with those required to be addressed by the NWUMP);
- Evaluate alternatives to Dam Completion in terms of effectiveness, risk, and environmental/ social costs;
- Conduct a Project Viability Assessment to- compare Dam Completion costs/ benefits and risks against alternative;
- Complete community and First Nations consultation.

Ballpark costs for various steps of the EIA process are listed in Table B.1:

***Table B1: EIA/SIA – Potential Scope and Cost Estimate***

| ***Component*** | ***Approximate Cost*** |
|---|---|
| **Step 1. Issues Scoping** – First Nations, Waterfront Owners, Ranchers, General Public | (Already underway through WUMP Process) **$5,000** |
| **Step 2. Initial Regulatory Consultation –** EAO, DFO, MLAP (now MOE) | **$15,000** |

| | |
|---|---|
| **Step 3. Assessment of Project Need and Viability (ie. Project Rationale)**<br>• Options<br>• Viability<br>• Comparative Costs Assessment<br>• Risk Management<br>• Water Quality Benefit<br>• Environmental Benefit (Fisheries)<br>• Economic Benefit<br>• Social Benefit<br>*Additional dollars added here in likelihood of a need to develop water balance model to assess need and alternatives* | (Partially completed – 1983 alternative storage study needs to be revisited)<br>**$30,000**<br>**$50,000** |
| **Step 4. Engineering Designs and Technical Assessment of Potential Impacts – for (a) Construction phase, (b) Operational phase and (c) Cumulate effects.**<br>• Construction designs – (Dredging operations, upland infrastructure required, dredgeate disposal, maintenance dredging, sediment control, fish salvage) potential impacts mitigated by routine management practices vs those subjected to Environmental Management Analysis | **$100,000** |
| • Physical Site Description and Impacts<br>a. Lake Bathymetry<br>b. Hydrology – groundwater, surface water<br>c. Water quality<br>d. Sediment geochemistry | (Groundwater / surface water interactions - a large study previously recommended)<br>**$150,000** |
| • Biological Descriptions and Impacts:<br>a. Fish – Bull trout, burbot<br>b. Benthic Invertebrate and Plankton communities<br>c. Vegetation - Rare Plants<br>d. Wildlife – Mammals, Birds, Butterflies, Amphibians<br>e. Other land resources | **$125,000** |
| • SIA Settings and Impacts –<br>a. Economic, Social, Health,<br>b. Cultural – Heritage Settings (non-First Nations)<br>c. First Nations Traditional and Other Interests – aboriginal interest, traditional use, archaeological<br>*(First Nations do be done as an independent effort because of high priority and need for focus)* | **$25,000**<br>**$50,000** |
| **Step 5. Summary of Impacts, Cumulative Impact Assessment, Mitigation** | **$30,000** |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| | |
|---|---|
| **Step 6. Risk Assessment –** Natural hazards (floods, hydrological and water quality earthquakes, climate change, forest management) | **$50,000** |
| **Step 7. Environmental Management Plan**<br>Partially completed in Step 4, finalized after Step 5 and 6. | **$20,000** |
| **Step 8. Consultation**<br>During project review, pre-construction, during construction, First Nations, Government | **$30,000** |
| **Total** | **$680,000** |

*Note: Burnaby Lake Rejuvenation Project is the only other dredging project of any significant scale to go through BCEAA process and documentation can be viewed on BC Environmental Assessment Office website.*