Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

KINBASKET RESERVOIR
FISH AND WILDLIFE INFORMATION PLAN

- **CLBMON55 – Revelstoke Reservoir Macrophyte Assessment Program**

03 December 2008

Monitoring Study No. CLBMON-55
Revelstoke Reservoir Macrophytes Assessment Program

1.0 MONITORING PROGRAM RATIONALE

1.1 Introduction

The Columbia River Water Use Plan (Columbia WUP)[1] objectives are to balance competing uses of water for fish, wildlife, recreation, heritage, flood control and power generation (BC Hydro 2005). It was developed through a consultative process involving representatives from BC Hydro, provincial and federal government agencies, municipal government, industry, First Nations and local stakeholders (BC Hydro 2005). This resulted in a Consultative Committee (CC) Report and Draft Water Use Plan. The Columbia WUP included a recommendation whereby the addition of a turbine unit at the Revelstoke Dam would trigger a review of those aspects of the Columbia WUP that could potentially be affected by changes to the operation of the facility.

When BC Hydro applied to install a fifth generating unit at Revelstoke, a joint environmental assessment and a Columbia WUP review were undertaken. This resulted in amendments to the BC Comptroller of Water Rights' order to implement the Columbia WUP, as specified in the Revelstoke Unit 5 Core Committee report and WUP Addendum. These amendments did not include any operational constraints but emphasized the implementation of additional physical works and monitoring programs in lieu of operational changes.

Vegetation responses to water levels were of concern during the REV5 consultative process, as it was recognized that submersed macrophytes play an important role for fish and wildlife habitat in Revelstoke Reservoir. Macrophytes also anchor soft bottom sediments and remove particles and nutrients from the water column (Madsen et al. 1996). Moreover, their range can be limited by water level fluctuations and temperature (Madsen et al. 2004), both potential impacts of a new operating unit. It was further acknowledged that there was a lack of data regarding vegetation tolerance of the timing, duration and depth of inundation (BC Hydro 2005). One program recommended to the BC Comptroller of Water Rights to address this lack of information on vegetation was to:

"*monitor, at an overview level, macrophytes in Revelstoke Reservoir prior to and following the commencement date of Revelstoke Unit 5*"" (BC Comptroller of Water Rights, 2007, p.3).

These Terms of Reference (ToR) describe the works to be undertaken to complete the above-referenced monitoring program in Revelstoke Reservoir.

1.2 Description of Facility and Area of Influence

Revelstoke Dam and Generation Station are located on the Columbia River, 5 km upstream from the town of Revelstoke and 130 km downstream from the Mica

[1] The Columbia WUP was ordered under Section 88 of the *Water Act* on January 26, 2007.

Project. Revelstoke Dam impounds the 130 km long Revelstoke Reservoir, licensed to store 1.5 Million Acre Feet (MAF). The reservoir is normally kept within 1.5 m of the maximum elevation (573 m) by regulating output at Mica Dam and Revelstoke Dam.

The Revelstoke Project, completed in 1984, consists of a concrete gravity main dam with an earthfill wing on the west bank, a gated spillway, a powerhouse and a switchgear building. The main concrete dam includes the power intakes in the middle and the spillway facilities to the right. The powerhouse is located directly downstream of the power intakes, and currently has four operating units with a total generating capacity of 1,980 MW, with space to install two additional units – the Revelstoke Dam was originally designed as a six turbine unit facility, with the installation of units 5 and 6 being deferred until additional capacity was needed. The addition of a fifth unit in 2010 will add 500 megawatts (MW) of capacity, bringing the dam's total capacity to 2,480 MW (BC Hydro EARG 2007).

Reservoir operations are market driven and do not strictly reflect climatic conditions (BC Hydro 2006). The reservoir is normally kept within 1.5 m of the maximum elevation throughout the year by regulating output at Mica Dam and Revelstoke Dam. Although Revelstoke Reservoir is rarely drafted below El. 571.5 m (1875 ft), operational or weather-related emergencies may occasionally result in drafting the reservoir beyond the normal limit to the emergency limit of El. 568.76 m (1866.0 ft). In the event of prolonged periods of basin drought or an outage at the Mica Powerhouse, the reservoir could be drafted by 15.2 m to El. 557.78 m (1830 ft) (BC Hydro 2005).

The geographic area of concern for this project encompasses Revelstoke Reservoir (Figure CLBMON-55-1).

1.3 Overview of Baseline Conditions

Prior to impoundment, the Mica-Revelstoke portion of the Columbia River contained 4,460 ha of floodplain habitat (3,780 ha of forested area, 680 ha of non-forested area) (Moody et al. 2006). The vegetation of the area can be described as coniferous forest, characteristic of the Interior Cedar-Hemlock Biogeoclimatic Zone (ICH), containing a mixture of conifer, deciduous and mixed forests, and shrub thickets. Wetland habitats have been noted to be restricted in occurrence along the river and its lower tributaries. Overall, there is a lack of information regarding the pre-reservoir valley bottom habitats. The only habitat mapping for this area is a 1:250 000 vegetation map produced by the province (RL&L 2001).

While there have been no vegetation surveys or mapping of Revelstoke Reservoir, aquatic macrophytes have been observed to considerable depths in various locations of the reservoir (Karen Bray, BC Hydro Revelstoke, pers. comm.; Figure CLBMON-55-2).

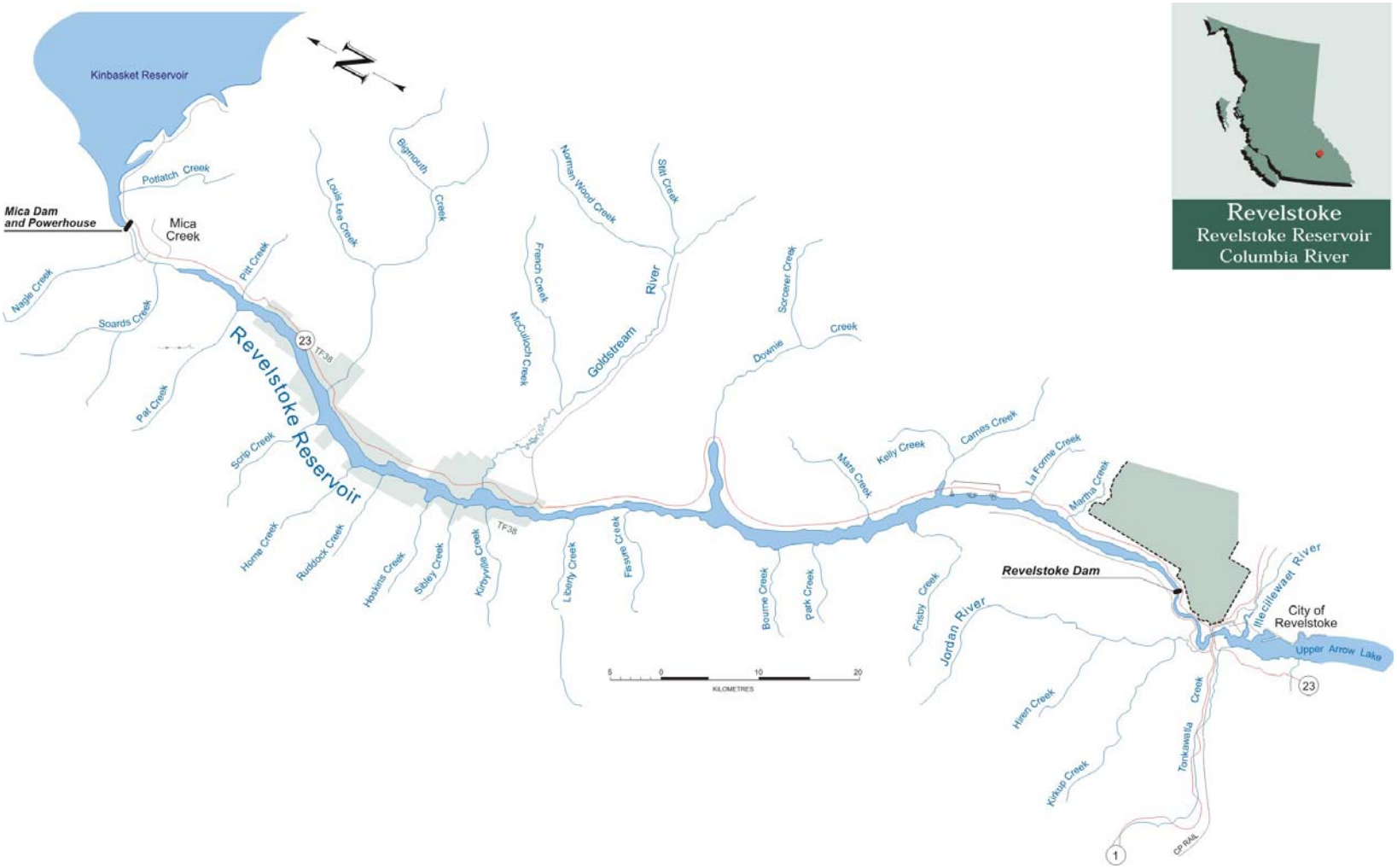

Figure CLBMON-55-1: Revelstoke Reservoir

Figure CLBMON-55-2: Macrophyte patch, likely *Potamogeton sp.*, near Martha Creek, October 2006. Photo courtesy of Karen Bray.

1.4 Potential Impacts of Five-Unit Operations on Macrophytes

The operating range of Revelstoke Reservoir after installation of the fifth unit is projected to be the same as under current operation with four units. The reservoir fluctuations following the start of Revelstoke Unit 5 operations are estimated to be less than 0.25 m over 90 per cent of the time, within the range of normal wave action during wind events (BC Hydro 2006). Changes in water levels could, nevertheless, affect the inundation regime, which in turn could affect productivity of macrophytes.

Based on a comparison of average daily elevations of Revelstoke Reservoir, the frequency of experiencing moderate drawdown (to ~ 572.5 m or about 0.5 m) would be higher with five operating units than currently experienced with four units although the frequency of experiencing low drawdowns (to 571.5 m or less or about 1.5 m) would be less. Any additional drafting of Revelstoke Reservoir could result in exposure and possible dessication of some macrophyte communities. However, a reduced frequency of low drawdowns with Unit 5 operational may benefit these communities.

The potential impacts of altered daily variations in reservoir level no greater than 0.25 m to the littoral zone, productivity and macrophytes were assessed as low (BC Hydro 2006), but it was acknowledged that there was a lack of information about species, distribution and depth of macrophytes in Revelstoke Reservoir. This limited

a more detailed assessment of potential incremental effects and residual impacts of additional reservoir drafting during winter and spring stemming from five-unit operations. A pre- and post-project assessment of macrophytes was, therefore, recommended to verify these predictions of low impacts.

1.5 Potential Adverse Impacts of Macrophytes

The preceding subsection addresses potential deleterious effects of dam operations on macrophytes. Uncontrolled macrophyte growth could in turn have negative hydrodynamic effects on impounded waters by increasing water levels and detention time (ponding) in shallow waters (changes in channel friction and blockage) and also remove nutrients from the water column and sediments (Berger and Wells 1999). Such impacts, however, are very unlikely due to the temperature regime, depth, topography and overall productivity of Revelstoke Reservoir.

1.6 Management Questions

The key management questions to be addressed by this program are:

1. What are the diversity and distribution of macrophytes in Revelstoke Reservoir?
2. Would the changes in drawdown amplitude and frequency due to five-unit operations at Revelstoke Dam have any impact on aquatic macrophytes in Revelstoke Reservoir?

Should potential impacts be confirmed, other management questions will arise:

3. Which species of aquatic macrophytes are most likely to be affected by the operation of REV5?
4. What are the best mitigating strategies to minimize any impact to or from aquatic macrophytes?

1.7 Management Hypotheses

The primary goal of this program is to provide baseline information on macrophytes in Revelstoke Reservoir before and after the start of operations of the fifth generating unit[2] at Revelstoke Dam, and to eventually relate this information to forecasted changes in reservoir operations. Once macrophytes distribution and biodiversity are quantified, a likely management null hypothesis will be:

1. Implementation of normal post-REV5 operations does not result in measurable impacts on aquatic macrophytes distributions and biodiversity in Revelstoke Reservoir.

BC Hydro realizes that the present work would likely not be sufficient to falsify the management null hypothesis. Such a study may be addressed in future, separate Terms of Reference.

[2] The Revelstoke Dam fifth unit is slated to start operating between August and November, 2010.

1.8 Key Water Use Decision Affected

This program will add to the information needed to assist decisions about balancing storage in Revelstoke Reservoir and power generation at Revelstoke Dam. The information collected will help support decisions related to future operating regimes or modify operations to protect aquatic resources. This may therefore have implications on the operation of the fifth generating unit at the Revelstoke powerhouse.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The primary objective of this macrophyte survey is to assess aquatic macrophyte biodiversity and map the distribution of the main species in Revelstoke Reservoir. A secondary objective is to determine the best locations for possible long-term monitoring stations of macrophyte extent and biodiversity.

This integrates with the overall objective of ensuring that changes in reservoir elevations and drawdown frequency due to the operation of REV5 do not impact biological and abiotic environments in the area of influence of the project.

For the purpose of this work, 'macrophyte' includes both vascular and non vascular plants, native and non native (sometimes referred to as invasive) species visible to the naked eye. Aquatic refers to a strong association with water – floating, emergent or submersed. Thus *Potamogeton sp., Marsupella sp.* and *Didymosphenia sp.* are all considered aquatic macrophytes in this study. Refer to Table CLBMON-55-1 for other examples. Species occurring above normal reservoir levels are not included as their distribution is likely more influenced by micro edaphic conditions than by water levels.

Table CLBMON-55-1 Non-exhaustive list of macrophytes potentially occurring in Revelstoke Reservoir. Red- and blue-listed macrophytes from B.C. Conservation Data Centre (2006).

	Notes
Chara sp.	
Didymopshenia geminata	Diatom colony
Elodea nuttallii	Blue listed
Marsupella sp.	Bryophyte
Myriophyllum sp.	
Myriophyllum ussuriense	Blue listed
Nuphar sp.	
Potamogeton nodosus	Red listed
Potamogeton oakesianus	Blue listed
Ranunculus sp.	

The study will involve the mapping of macrophyte presence, and the collection of relevant data on their biodiversity and distribution in Revelstoke Reservoir over two

separate years, before and after implementation of Revelstoke Dam Unit 5. It will also include the mapping and monitoring of potential entry points for early detection of invasive species such as boat launches and popular angling locations.

2.2 Approach

The program will be comprised of three components:

1. Information review.

2. Site overview, mapping and ground truthing.

3. Report – assessment of macrophyte diversity and distributions, maps and recommendations for potential long term monitoring sites.

2.3 Tasks

2.3.1 Task 1: Project Management

Project management will involve the general administrative and technical supervision of the program. This will include, but not be limited to: 1) budget management, 2) study team management, 3) logistic coordination, 4) technical supervision of field and analyses, and 5) facilitation of data transfer among other investigations associated within the REV5 area of influence and Revelstoke Reservoir.

A safety plan must be developed and submitted to the BC Hydro contact for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required.

2.3.2 Task 2: Summary of Existing Information

Existing information on macrophytes (species and their relative abundances, distribution, etc.) in Revelstoke Reservoir will be collected and summarized from the grey and peer-reviewed literature, and from queries directed to agencies and consultants working or having worked in Revelstoke Reservoir (a list of consultants and their main contacts will be provided by BC Hydro). Aerial photographs and flight videos may also be available for review from BC Hydro and government agencies.

2.3.3 Task 3: Site Overview, Mapping and Ground Truthing

The purpose of this task is to determine the extent of macrophytes distribution (locations, depth, relative abundance, approximate cover) and alpha biodiversity (species richness) within Revelstoke Reservoir before and after the start of operation of the Revelstoke fifth unit. This task is divided into two components:

1. Overview survey of Revelstoke Reservoir; and

2. Establishment of potential long-term monitoring sites for macrophyte biodiversity and abundance.

Overview surveys may be most efficiently conducted from helicopter or boat (BC Hydro is in the process of reformulating its policy for helicopter use and the proponent will need to consult the BC Hydro project manager prior to scheduling flights). The use of Compact Airborne Spectrographic Imagery (CASI) may be investigated. The best time of the year is probably in early fall when macrophyte biomass is at its yearly maximum and when water clarity is improving. TRIM maps are available from the BC Hydro Department of Photogrammetry Services. Some old orthophotos of Revelstoke Reservoir (before 2000) may also be available.

It will be necessary to assess species composition within representative polygons. Sites on the eastern side of the reservoir can be accessed from a paved road (Hwy 23; Figure CLBMON-55-1), whereas access to sites on the western side may require the use of a boat. Some of these ground truthing stations may be proposed as long term monitoring stations. Any assessment of abundance should take into account the fact that Revelstoke Reservoir is not a homogenous water body (c.f. section on Data analyses).

Data expected from these surveys are:

- Flight lines
- Geo-referenced polygons
- Lowest possible taxonomic level of macrophytes present in each polygon
- Areal extent / cover of macrophyte species
- Approximate depths (average and maximum) of macrophyte beds
- Substrate type
- Water clarity
- Habitat type and gradient (shallow bay, deep embankment, etc.)
- Geo-tagged photographs (videos are optional)

Long-term monitoring stations will have a dual purpose: they may be part of future studies to monitor the impacts of planned generating units at Mica and Revelstoke dams on macrophyte biodiversity and distribution. They may also act as early warning stations for detection of invasive species (primarily aquatic macrophytes; the proponent may elect to propose stations suitable for additional phyla). Potential sites include, but are not limited to, locations with shallow slopes and sites such as Downie Arm, Carnes boat launch, and north of Kirbyville Creek (Figure CLBMON-55-1).

Alternative cost-effective methods may be proposed instead of the methods outlined above.

2.3.4 Task 4: Voucher Specimens and Reference Collection

The proponent will collect voucher specimens of all species present and provide BC Hydro with a reference collection. All specimens will be identified to the closest possible taxonomic level and preserved according to accepted museum standards. A taxonomic key of the specimens may be generated if budget allows. A first reference

collection will be provided with the first report. Only specimens not included in the first reference collection need to be provided in the second one with the final report.

2.3.5 Task 5: Data Entry

The proponent will ensure that the databases used for data entry (biophysical variables or GIS measures) are compatible with BC Hydro's databases (either Microstation or shape files are acceptable). A photographic database will also be provided of the monitoring sites, significant or unusual geographical or biological features, and macrophyte species (the latter to be linked to the reference collection), all with suitably descriptive titles, tags and keywords.

2.3.6 Task 6: Data Analyses

Macrophyte distributions should be related to local conditions (the upper portion of Revelstoke Reservoir presents more riverine conditions, is located at a higher altitude and is usually subjected to lower air temperatures than the lower portion). Possible variables to assess changes between years include area of vegetation communities (m^2), species richness, biodiversity indices and taxonomic distinctness.

Potential long-term monitoring sites will be mapped and a short rationale explaining each choice (ease of access, high biodiversity, potential entry point for invasive species, sensitive or blue/red listed species, etc.) will be provided.

2.3.7 Task 7: Reporting

Due to the extended time between the two field assessments, two formal reports are required, one following each year of the study. The first year report will summarize the information collected on macrophyte distribution (high abundance areas, species, approximate cover, unusual findings, etc.) prior to implementation of REV5, provide printed and digital maps, a list of potential monitoring stations, and a first reference collection (c.f. Task 4 for details on the latter).

Both reports will follow the standard format developed for WUP monitoring programs. They will include:

- an executive summary of the project of not more than 300 words;
- a summary of existing information on macrophyte distributions highlighting areas of concern and justification of the choice of proposed long term monitoring sites;
- description of data collection methods;
- digital maps;
- analyses of macrophytes distributions relating them to REV5 operations;
- summary of the findings as they relate to the management question;
- recommendations for mitigation methods to minimize impacts to or from macrophytes (if needed);
- raw data, to be provided in an Excel spreadsheet, Microstation or ArcGIS shape files, and other suitable format acceptable to BC Hydro;

- hard copy and digital maps, in an acceptable format, showing the area topography, flight lines, sampling sites summarizing areal extents per species, and proposed long term monitoring sites.

All reports will be provided in hard-copy and as Microsoft Word and Adobe Acrobat (PDF) format, and all maps and figures will be provided as embedded objects in the Word file and as separate GIS files (acceptable formats described above). Photographs will be embedded in the final report and also provided separately in a searchable photography database with suitable titles, keywords and tags. Minimum resolution for photographs in the database should be 2816 × 2112 pixels.

2.4 Interpretation of Results

The data will be used to identify the extent of aquatic macrophyte presence and diversity in Revelstoke Reservoir before and after start of operations of the Revelstoke Dam fifth unit. The analyses will help to assess potential impacts of REV5 operations on macrophytes distribution and biodiversity. Should the impacts to or from macrophytes be found to be of significant concern, the results will further help to propose adequate mitigation measures.

2.5 Schedule

This project is scheduled over two years spanning the year before and some time after implementation of REV5 (Table CLBMON-55-2). Note that although Year 3 is given a specific date, BC Hydro may elect to sample at a different interval – e.g., the second year of the survey could be other than 2014. Information review and first survey will occur in Year 1 of the program.

Table CLBMON-55-2: Schedule for the macrophyte survey by implementation year.

Task / Milestone	2009 Y1	2010 Y2	2014 Y3
Information review	✓		
Monitoring sites selection	✓		✓
Survey of macrophytes	✓		✓
REV5 starts operating		✓	
First report / data summary	✓		
Data analyses			✓
Reference collection	✓		✓
Final report			✓

2.6 Budget

The estimated total cost for the project is $119,167 (including 2% inflation plus 5% contingency).

3.0 REFERENCES

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