Columbia River Project Water Use Plan

Monitoring Program Terms of Reference

COLUMBIA RIVER WHITE STURGEON MANAGEMENT PLAN

- CLBMON-20 Mid Columbia River White Sturgeon Spawning Habitat Assessment

22 February 2008
TERMS OF REFERENCE FOR THE COLUMBIA RIVER
PROJECT WATER USE PLAN

COLUMBIA RIVER WHITE STURGEON
MANAGEMENT PLAN

1.0 OVERVIEW

This document presents Terms of Reference for white sturgeon monitoring studies being delivered under the Columbia River White Sturgeon Management Plan. These programs will monitor sturgeon populations and their habitats in the upper, mid and lower Columbia River. To the extent possible, these programs will also aim to address concerns related to the potential effects of five-unit operations at Revelstoke Dam on sturgeon habitat.

This document provides detailed Terms of Reference for the following programs:

1) CLBMON-19 Kinbasket Reservoir White Sturgeon Inventory and Habitat Use Assessment: a 3-year investigation into the status and habitat use of white sturgeon in Kinbasket Reservoir and the Columbia River upstream. The study is descriptive in nature, and will include surveys at key locations to capture adult and/or juvenile sturgeon and record habitat characteristics important to the white sturgeon life cycle.

1) CLBMON-20 Mid Columbia River White Sturgeon Spawning Habitat Assessment: a 2-year study to assess hydraulic and substrate conditions in locations of known sturgeon spawning immediately below Revelstoke Dam, relate hydraulic condition to discharge from the dam and water elevation of Arrow Lakes Reservoir, and assess operations in providing suitable spawning conditions and incubation for white sturgeon.

2) CLBMON-28 Lower Columbia River Adult Sturgeon Monitoring and Broodstock Collection: a 10-year program to describe changes in age structure and population estimates, provide information on movements, habitat use, and population interactions through telemetry, provide periodic spawn monitoring to measure trends in the numbers of spawning events, population demographics and reproductive potential, and provide an annual broodstock contribution to the conservation culture program.
### Table 1  Columbia River White Sturgeon Management Plan Monitoring Program Terms of Reference Submission Information

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<tr>
<th>Name of Monitoring Program</th>
<th>Order Clause Fulfilled</th>
<th>Submitted with this Package</th>
<th>Previously Submitted To CWR</th>
<th>Submission Date</th>
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Monitoring Study No. CLBMON-20
Mid Columbia River White Sturgeon
Spawning Habitat Assessment

1.0 MONITORING PROGRAM RATIONALE

Canadian Columbia River populations of white sturgeon were listed as endangered under the Species at Risk Act (SARA) in 2006. Habitat for white sturgeon in the Canadian Columbia River has been altered and fragmented by the construction of dams and reservoirs. Current population estimates are in the order of 900 to 1400 fish upstream of the border, with the great majority residing downstream of Hugh Keenleyside Dam. The population residing in Arrow Lakes Reservoir is currently estimated at approximately 50 individuals (Golder Associates Ltd. 2006a), all older than the 1968 year-class. Based on the small size of this population and the advanced age of these individuals, there appears to be a lack of recruitment from these fish.

In 1999, a small number of white sturgeon were tracked to the Columbia River downstream of Revelstoke Dam in the vicinity of Steamboat Rapids (Figure CLBMON-20-1). The presence and sexual maturity of these fish was interpreted as being related to spawning activity (RL&L Environmental Services Ltd. 2000, Golder Associates Ltd. 2003). Capture of eggs and larvae confirmed successful spawning. Spawn monitoring in 2003 and 2006 also resulted in collection of fertilized eggs and confirmation of spawn timing in late July/early August.

Although construction and operation of dams have been implicated in the decline of white sturgeon in the Columbia River, the precise mechanisms responsible for recruitment failure have been difficult to ascertain. Hypotheses are wide ranging (UCWSRI 2002), not necessarily mutually exclusive and, in general, are difficult to test due to the species’ longevity and the influence of other concurrent impacts. During development of the Columbia River WUP, this uncertainty made it difficult for the WUP CC to evaluate the benefits of operational changes (i.e., alternative flow regimes) specifically aimed at supporting sturgeon spawning and recruitment in the mid Columbia River. The Committee, therefore, agreed to a 10-year work plan designed to inform on key hypotheses regarding potential habitat changes in the mid Columbia River that may have contributed to recruitment failure.

As part of the monitoring plan recommended for the Arrow Lakes Reservoir sturgeon population, the WUP CC identified the need to better understand spawning habitat capability in the mid-Columbia River, and how dam and reservoir operations influence the quality and quantity of this habitat. It was recommended that detailed hydrometric surveys be undertaken in the mid-Columbia River in locations of known white sturgeon spawning and other locales, as appropriate, to:

1) validate assumptions used to decide on and set white sturgeon spawning flow treatments, and

2) determine spawning habitat objectives for sturgeon for future rehabilitation activities.
Revelstoke Dam is operated as a load-following facility. As a result, discharge from the dam can vary over a 24-hour period from minor leakage, when no water is passing through the generating units, to more than 1700 m$^3$/s when all units are operating at full capacity. Hydraulic conditions in the riverine section below Revelstoke Dam are therefore highly variable and complex. Adding to this complexity is a backwatering effect caused by Arrow Lakes Reservoir. This flooding effect is greatest from June to August when the reservoir is near or at full pool level, extending over 40 km from Shelter Bay to just downstream of the Revelstoke Dam. Sturgeon spawning habitat can, therefore, be affected by both discharge from the dam and reservoir water surface elevation. Characterizing the suitability of this habitat for sturgeon spawning will require exploring the effects of both these operational factors on hydraulic conditions within the river.
1.1 Management Questions

Key management uncertainties encountered during development of the Columbia River Water Use Plan related to how current operation of Revelstoke Dam and Arrow Lakes Reservoir affects the quantity and quality of white sturgeon spawning habitat in the Columbia River below Revelstoke Dam. Given the endangered status of white sturgeon in the upper Columbia River, this habitat is considered of major importance.

The fundamental management questions to be addressed through this monitoring program are:

1) What are the depth, hydraulic properties (velocity/turbulence) and substrate conditions in the known or identified white sturgeon spawning and incubation area(s) below Revelstoke Dam?

2) How do Revelstoke Dam and Arrow Lakes Reservoir operations affect hydraulic conditions in this/these area(s)?

3) How do these hydraulic conditions relate to spawning habitat suitability (quality and quantity) for white sturgeon?

4) Can modifications be made to operations of Revelstoke Dam and/or Arrow Lakes Reservoir to protect or enhance mid Columbia River white sturgeon spawning habitat?

1.2 Management Hypotheses

The approach of the monitoring program will be descriptive rather than experimental and, as such, will provide baseline information rather than test specific management hypotheses or measure biological response to different treatments. Nevertheless, results of the study are expected to inform future decisions regarding changes in operation and its effect on white sturgeon spawning and incubation habitat. Habitat data collected from spawning and incubation areas may be used in conjunction with proposed flow tests to determine whether current operations reduce spawning habitat availability and suitability, and whether modified operations can be expected to improve conditions.

1.3 Key Water Use Decision Affected

The WUP CC explored several alternative minimum flow scenarios to benefit white sturgeon spawning and incubation in the mid Columbia River. The performance of these alternative operations was evaluated based on predictions of water depth and velocity for a given discharge under a range of Arrow Lakes Reservoir elevations to provide an index of spawning habitat suitability based on published sturgeon spawning habitat suitability relationships (Korman and Lin 2003). The performance measure reported on suitability estimates for an area of the mid Columbia River located 300 m upstream and 300 m downstream of the confluence with the Jordan River. This area has been used for spawning by white sturgeon, and performance measures were calculated for the period of 15 July to 15 August, which approximately coincides with the timing of the two reported spawning events in 1999 and 2003.
Based on results of modeling, it was suggested that a minimum discharge of 850 m$^3$/s (30 kcfs) from Revelstoke Dam would be needed to achieve suitable spawning habitat for sturgeon in the mid Columbia River. However, it was recognized that a number of assumptions regarding spawning habitat requirements and reservoir elevation effects were built into the modeling, which would require validation through future assessment work.

The WUP CC agreed to a seasonal release of 850 m$^3$/s from Revelstoke Dam in years when sturgeon spawning in the mid Columbia River was probable. However, there was concern related to the need for harmful capture, handling and tagging of adult sturgeon for detecting possible spawners and triggering implementation of the flow treatment. Underwater videography was proposed as a non-invasive method of spawner detection; however, the feasibility of this technology was uncertain. Consequently, the Committee recognized the need for flexibility in selecting the magnitude and timing of the flow treatment within a maximum funding level based on results of research and monitoring. A water budget was proposed with an economic cap of $5M per 10 years, which will provide a volume of water that can be allocated in a manner best suited to spawning and incubation needs of white sturgeon. Subsequently, as part of a review of the program prompted by the Revelstoke Unit 5 (REV5) project, the UCWSRI TWG recommended that implementation of flow changes be deferred until after start up of Unit 5 (post 2010). As a result, the first 4 years of the work plan (2007-2010) will be used to collect background information needed for allocating the water budget.

The proposed monitoring program is part of this background data collection effort, and will provide information to validate the assumptions used in setting sturgeon spawning flows, and to support decisions related to selection of a water allocation schedule for sturgeon spawning during implementation of the Water Use Plan.

### 2.0 MONITORING PROGRAM PROPOSAL

#### 2.1 Objective and Scope

The primary objectives of this monitoring program are to:

1) Assess hydraulic and substrate conditions in locations of known sturgeon spawning immediately below Revelstoke Dam.

2) Relate hydraulic conditions to discharge from the dam and water elevation of Arrow Lakes Reservoir.

3) Assess operations of the dam and the reservoir in providing suitable spawning conditions and incubation for white sturgeon.

4) Provide recommendations for selection of a water allocation schedule for white sturgeon spawning in the mid Columbia River.

The scope of the program is limited to empirical measurement of hydraulics, observations of substrate conditions, post-measurement analysis, and professional judgment. The study will be undertaken over a 2-year period (one year pre-REV5 and one year post-REV5) to allow collection of data over a range of dam discharges and reservoir elevations.
Development of a hydraulic model that relates discharge and reservoir elevation to suitability of white sturgeon spawning and incubation habitat in the mid Columbia River is a necessary tool for making decisions related to possible flow treatments. The data collected in this study will be used to upgrade the existing habitat suitability model (Korman and Lin 2003).

2.2 Approach

The general approach of this monitoring program will be to collect depth and velocity measurements over a range of dam discharges and reservoir elevations to improve understanding of the effect of hydraulic conditions in the mid Columbia River on sturgeon spawning habitat suitability. The study will involve three components:

1) direct measurements of depth, velocity, and bathymetry of river section transects below Revelstoke Dam,
2) analysis of hydraulic conditions in relation to dam discharge and reservoir elevation, and
3) assessment of spawning habitat suitability in relation to hydraulic conditions with recommendations for a water allocation schedule for flow augmentation during white sturgeon spawning and incubation.

Detailed bathymetric maps of the area below Revelstoke Dam, which were completed as part of the Revelstoke Dam tailrace excavation project, are available from BC Hydro. These will reduce the bathymetric data requirements under this project to that associated with transect sampling.

The approach of the monitoring program will be descriptive rather than experimental and, as such, the program will provide baseline information rather than measure biological response to different treatments.

2.3 Tasks

2.3.1 Task 1: Project Planning and Coordination

Project coordination will involve the general administrative and technical oversight of the monitoring program, which will include, but not be limited to: 1) budget management, 2) study team selection 3) logistic coordination, 4) technical oversight in field and analysis components, and 5) facilitation of data transfer among other projects in the Columbia River White Sturgeon Management Plan. Liaison between BC Hydro, First Nations, the regulatory agencies and especially the UCWSRI TWG will be instrumental during planning and coordination.

A safety plan must be developed and submitted to the BC Hydro contact authority 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: Study Design

To facilitate the collection and analysis of data for instream flow studies, flows in regulated systems are often held constant during data collection. However, given the need for Revelstoke Dam to be operated as a load-following facility and the high costs that would be incurred by constraining flows for sampling purposes, flow regulation for sampling purposes may not be feasible especially during the summer. In developing the sampling design, opportunities should be explored to take advantage of planned flows over fixed time periods or maintenance outages at the facility during the sampling process. Design and implementation of this study will require coordination and communication between Water License Requirements (WLR) management (the implementation stage of WUPs), the selected contractor, BC Hydro Operations Planning and Revelstoke Dam. One way of testing the feasibility of maintaining discharge for sampling is to work with the REV Operations Planner to identify work windows and then see if these can be provided during a year prior to field sampling starting. This could at the very least identify periods when discharge control is most feasible.

The assessment program should consider changes in hydraulic conditions at the spawning and incubation site(s) during and immediately after the spawning period. A HEC-RAS model has been developed (Korman and Lin 2003) for the mid Columbia River from Revelstoke Dam to below the confluence with the Akolkolex River, approximately 37 km downstream of the dam, which includes the area where spawning and incubation have been documented in the past. Data obtained during the monitoring program will be used to calculate Wetted Usable Areas (WUA) under different hydraulic conditions, and comparison of hydraulic and other habitat conditions at known white sturgeon spawning and incubation locations.

The study design (timing and sampling locations) will rely on adult movement information collected from CLBMON-21 Mid Columbia River Juvenile Sturgeon Detection and Habitat Use and Tracking of Existing Sonic Tagged Sturgeon, as well as location and egg stranding information collected during CLBMON-23 Egg Mat Monitoring and Underwater Videography Feasibility Study, to locate spawning areas. Data may also be available from studies monitoring physical and biological parameters in the same reach of the mid Columbia River. For example, CLBMON-15a Physical Habitat Monitoring is expected to collect physical measurements, including temperature, stage, total gas pressure, and electrochemical and nutrient information from the same area to contribute to comparisons with other spawning locations. Similarly, CLBMON-15b Ecological Productivity Monitoring will monitor periphyton and benthic invertebrates, while CLBMON-16 Fish Population Index Surveys and CLBMON-17 Juvenile Fish Habitat Use will provide data on fish species found in the reach. Efficiencies that may result from utilizing data collected as part of these other studies should be considered in the study design.

2.3.3 Task 3: Field Studies

An area around the identified spawning locations will be described according to depth, bathymetry, substrate conditions, velocity and turbulence distribution, and basic water quality (e.g., temperature and turbidity/TSS). Changes in these parameters over the period of spawning and during variations in hydrology should be
measured directly or estimated through the hydraulic models. Water quality parameters may also include total gas pressure and a standard sweep of basic water quality parameters. Some of the physical data may be collected as a component of Mid-Columbia Physical Habitat Monitoring (CLBMON-15a) and should offset the amount of data required for collected during this study.

A boat-mounted velocity meter will be used to obtain velocity profiles along select transects at the habitat sites over a range of dam discharges and reservoir elevations. The preferred technique is a boat-mounted broadband acoustic Doppler current profiler (ADCP) which has been used to define detailed hydraulic velocity conditions at sturgeon spawning locations in the lower Columbia River (Shields and Rigby 2005).

Differential GPS should be used to track geographic coordinates and the elevation of the habitats. Water depths can be measured using onboard sounding equipment, while substrate conditions can be assessed by active analysis (especially during low flow periods) or through remote passive observation techniques.

An estimated flow from the Jordan River will also be necessary to verify calculations, since it was included in the earlier modeled WUA results. A level logging station is planned for installation on the Jordan River in 2008 which should provide for this requirement.

2.3.4 Task 4: Data Analysis and Reporting

The primary aim of the analysis is to characterize known sturgeon spawning habitats, to compare physical habitat conditions to habitat suitabilities from the literature, and to assess the influence of operations at Revelstoke Dam and Hugh L. Keenleyside Dam (through levels of Arrow Lakes Reservoir) on these habitats. The analysis should emphasize identified and known sturgeon spawning areas. Habitat assessments will include WUA calculations with the verification data incorporated for comparison with the predictions of the HEC-RAS model. A power analysis or similar technique may help provide context for the results and associated inferences for future studies.

Project reporting will consist of one data report at the conclusion of Year 1 (scheduled for 2009), which will summarize the year’s activities and findings. The data report will include a brief description of methods, present the data collected that year, and report on the results of all analyses. A detailed technical report will be prepared at the conclusion of Year 2 (scheduled for 2011), which will provide:

a) an executive summary;
b) a description of the methods employed;
c) a data summary;
d) a comparison of results between years;
e) a detailed summary of the findings as they relate to the ecological hypotheses and the key management questions; and
f) recommendations with regard to potential next steps.
Decisions on next steps will follow consultation with the regulatory agencies and TWG. Draft versions of reports should be submitted in Microsoft Word for ease of editing.

Reports will follow the standard format that is being developed for WUP monitoring programs. 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 either as embedded objects in the Word file or as separate files.

2.4 Interpretation of Study Results

Results from this study will be used to characterize white sturgeon spawning habitat below Revelstoke Dam. Because the monitoring program is designed to be descriptive rather than experimental, it will provide baseline information rather than measure biological response to different treatments. The aim of the study is to expand on earlier sampling efforts to understand the hydraulic conditions under which sturgeon are spawning and the impacts caused by operation of Revelstoke Dam and Arrow Lakes Reservoir on these habitats. The study should allow an evaluation of the sensitivity of these habitats to dam operations, within the context of known habitat suitability for white sturgeon. Alternative explanations for study results should be considered which could aid in future management response discussions.

2.5 Schedule

This monitoring program was initially recommended by the UCWSRI TWG for Years 1 and 2 of the four-phase, 10-year sturgeon management plan to validate assumptions in setting spawning flows, and to determine habitat requirements for future rehabilitation activities. In the modified approach provided as part of the Revelstoke Unit 5 project plan, the study is scheduled during 2009 as part of the four-year background data collection period, and again during one year after the Revelstoke 5 Project and minimum flow provisions are initiated. The timing of the background portion of the study could be initiated as early as 2008 but must be completed by 2010. For the purposes of budget planning for this Terms of Reference, the work is scheduled for 2009 and 2011.

A proposed annual schedule for mid-Columbia sturgeon monitoring activities is provided below. Bullets 1) and 2) are not part of this project and are not incorporated into this Terms of Reference, but instead are incorporated into the Juvenile Sturgeon Detection and Habitat Use and Tracking of Existing Sonic Tagged Sturgeon (CLBMON-21). Bullet 3) will be delivered by the Egg Mat Monitoring and Underwater Videography Feasibility Study (CLBMON-23). These deliverables are included here to show the potential full annual sequence of events during those years when the spawning habitat assessment work is conducted.

1) Installation and maintenance of VR2 receivers – installed in April as part of the juvenile monitoring work and retrieved following the winter sample period.

2) Adult telemetry monitoring from April to winter when the VR2 receivers are retrieved.

3) Egg mat and videography system installation, monitoring from May to September.
4) Spawning and incubation habitat assessment during June to October (the exact timing will depend on when the required range of discharges and reservoir levels can be provided).

5) Data analyses from November to December.

6) Report preparation from December to March (draft reports should be submitted at least one month prior to the due date for a final report).

The modified program recommended by the UCWSRI TWG as a result of the Revelstoke Unit 5 project has three scheduled reviews of mid Columbia sturgeon data. The first review in 2011 will consider results and implications of the background data collected from juvenile monitoring and habitat assessments, spawn/incubation monitoring and habitat assessments, adult sonic telemetry, and incubation experiments. The second review in 2014 will consider similar results associated with minimum flow provision and potential spawning flow tests, while the final review in 2017 will assess the results associated with spawning flow tests, if a decision is made to implement these flows. Depending on the study results, the review process may decide to maintain the existing program in the mid-Columbia, redirect recovery work upstream to Kinbasket Reservoir, and/or rely on conservation culture to maintain the mid-Columbia sturgeon stock.

### 2.6 Budget

The total annual budget for the monitoring program is estimated at $132,145 (in 2004 dollars). Table CLBMON-20-1 provides annual budget estimates assuming a 2% rate of inflation and a 5% contingency for the duration of the program. This budget includes at least a 30% contingency in field time to accommodate potential problems with providing suitable discharge and reservoir water level conditions. Contractors will be asked to submit proposals to deliver this work assuming suitable conditions can be provided, and this contingency will be released if it is shown they are unable to do so because of operational constraints.

As previously mentioned, the program is scheduled for 2009 and 2011. However, the first year of the work could be conducted any time during 2008 to 2010. This decision should be based on the value of background information in designing the final study, the availability of staff experienced in the conditions of the reach, and efficiencies in delivery.

### 3.0 REFERENCES


