Columbia River Project Water Use Plan
Monitoring Program Terms of Reference
HERITAGE MANAGEMENT PLAN

- CLBMON-50 Arrow Lakes Reservoir Heritage Monitoring Wind and Wave Erosion

23 October 2007
HERITAGE MANAGEMENT PLAN
TERMS OF REFERENCE

1.0 OVERVIEW

This document presents Terms of Reference for an erosion monitoring program for the Heritage Management Plan (Table 1). This program will implement archaeological and erosion monitoring focused on the effects of both normal reservoir operations and the Rev 5 project on archaeological resources associated with significant landforms situated within Arrow Lakes reservoir and mid Columbia River drawdown zones, that were identified by the Culture and Heritage Subcommittee as having archaeological sensitivity.

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

1) CLBMON-50 Arrow Lakes Reservoir Heritage Monitoring Wind and Wave Erosion: a 5-year non-intrusive erosion monitoring program for archaeological resources located in Arrow Lakes reservoir and mid Columbia River drawdown zones.

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Terms of Reference for the Columbia River Project
Water Use Plan Monitoring Programs
Heritage Management Plan

1.0 MONITORING PROGRAM RATIONALE

The Columbia River Water Use Plan Consultative Committee (WUP CC) recognized the significance of heritage resources, particularly to the First Nations with an interest in the area. There are a number of known heritage sites within the Columbia River system and it is expected that other heritage sites of significance exist within areas affected by reservoir operations. The WUP CC was not able to fully evaluate the potential effects of operations on archaeological sites due to the lack of existing information.

A Heritage Management Plan (HMP) was recommended by the WUP CC to a), address the knowledge gap regarding the number, location, content, condition of archaeological sites within the Arrow Lakes, Kinbasket and Revelstoke Reservoirs that make up the Columbia system, and b), identify appropriate means of addressing those effects on archaeological sites that are a result of reservoir operations. The WUP CC recommended that the HMP be implemented over a ten-year timeline beginning with archaeological inventory work and the development of management strategies that would determine appropriate mitigation measures for the identified sites. Erosion monitoring and active intervention aimed at protecting archaeological sites from effects of reservoir operations are additional components of the recommended HMP. A key observation made by the WUP CC was that the revegetation physical works proposed within the reservoirs could be used as a means of archaeological site stabilization and protection.

Subsequently, the Comptroller of Water Rights (CWR) clarified that only non-intrusive heritage work could be included in an Order issued under the Water Act, thereby excluding any study that would require a permit under the Provincial Heritage Conservation Act (e.g. inventories involving subsurface testing or the collection of artifacts for analysis). As a result, the scope of the HMP has been significantly revised from the original WUP CC recommendation to reflect this new understanding. Most of the recommended HMP plan would require Provincial heritage inspection or investigation permits and cannot be implemented through Water Licence Requirements (WLR); however, three studies were re-designed to fit within the CWR’s mandate, while still addressing key management questions that arose during the WUP.

CLBMON-50 Arrow Lakes Reservoir Heritage Monitoring Wind and Wave Erosion is a five-year study intended to assess the reservoir effects on significant landforms within the Arrow Lakes Reservoir. Landforms observed at the head of Lower Arrow Lake, referred to as the “Narrows”, and in the Revelstoke Reach were identified as having significant potential for intact, but eroding archaeological sites in an archaeological review commissioned during the WUP process (Choquette 2002). The detailed approach, methods and budget for this study is presented in the attached terms of reference.

CLBMON-51 Kinbasket and Revelstoke Reservoirs Archaeological Site Overview Assessment and CLBMON-52 Arrow Lakes Reservoir Archaeological Overview Assessment are intended to replace components of the Archaeological Site Survey and Inventory studies for Arrow Lakes, Kinbasket and Revelstoke Reservoirs recommended by the WUP CC. These two Overview studies each incorporate a preliminary field reconnaissance component and are designed to be non-intrusive. A primary focus of these Overview studies is to evaluate whether revegetation programs can be employed as a means of archaeological site protection. Information regarding documented archaeological sites gathered during these overview studies will be shared with the WUP physical works programs to ensure that impacts to archaeological sites do not occur as a result of these programs. Terms of reference for these two studies have been submitted previously.
1.0 Introduction

During the Columbia River Water Use Planning (WUP) process, the WUP Consultative Committee (WUP CC) recognized the significance of heritage sites, particularly to the First Nations with an interest in the area. The WUP CC was not able to fully evaluate the effects of reservoir operations on archaeological sites due to the lack of existing information from prior studies. As part of a program for additional information the WUP CC report recommended a study to directly monitor the effects of wind and wave erosion on the stability of a significant escarpment in Arrow Lakes Reservoir that is predicted to contain a large number of intact and actively eroding archaeological sites. The overarching goal of this study is to provide information that could be used to design appropriate management through mitigation of wind and wave effects.

Subsequent to the completion of the WUP CC recommendations, the Comptroller of Water Rights clarified that only non-intrusive heritage work could be included in an Order issued under the Water Act, thereby excluding any study that would require a permit under the Provincial Heritage Conservation Act (e.g. the placement of a physical works structure for the purpose of measuring erosion or subsurface testing within an archaeological site). As a result, the Order stipulates non-intrusive erosion monitoring of archaeological resources located in Arrow Lakes Reservoir and mid Columbia River drawdown zones. This document provides detailed Terms of Reference for a 5-year non-intrusive erosion monitoring study of archaeological resources that are in association with significant landforms situated within the Arrow Lakes Reservoir and mid Columbia River drawdown zones.

A separate program of archaeological work aimed at achieving compliance with the Heritage Conservation Act is in development with the Archaeology Branch and is expected to address many of the archaeological concerns raised by the WUP CC that are not addressed in these Terms of Reference. This Reservoir Archaeology Program will incorporate the results of this erosion monitoring study in the development of a comprehensive archaeological management plan for the Arrow Lakes Reservoir.

2.0 STUDY RATIONALE

2.1 Background

The Arrow Lakes Reservoir was impounded in 1968, prior to the establishment of current Provincial heritage law that requires systematic archaeological investigations for developments, including hydroelectric reservoirs. As such, the archaeological values of the original lakeshore and riverbank settings, along with the adjacent terrain, were never comprehensively identified, recorded, or subject to salvage data retrieval. A patchwork of individual archaeological studies was conducted within and adjacent to the reservoir in relation to various developments, including, the proposed reservoir in the 1960s and later parks, highways and forestry. To date, evaluations of the erosion effects related to ongoing reservoir operations (i.e. the raising and lowering of water levels) have been both sporadic and anecdotal. Consequently, effects related to wind and
wave erosion in the reservoir draw down zone are not well understood in terms of their magnitude, severity, rate of change or duration.

BC Hydro’s Generation Engineering Services (2006) conducted a review to determine the area potentially subjected to reservoir induced erosion, flooding, landslides and groundwater impacts along the shoreline of the Arrow Lakes Reservoir above the maximum normal reservoir level (MNRL) of 440.1 m asl. This review indicates that reservoir effects may occur within a 30 m horizontal distance above MNRL depending on the geology, geomorphology and configuration of the shoreline.

During the Columbia River WUP process, a preliminary assessment of archaeological resources in the Arrow Lakes Reservoir area, which included an assessment of the archaeological sensitivity of the landscape within and immediately adjacent to the reservoir was undertaken (Choquette, 2002). Choquette’s report includes an initial assessment of potential erosion effects on the various landforms existing within the study area. Analysis of the landscape within the reservoir allowed for the delineation of four “reservoir effect” zones:

- Year-round Reservoir Zone (below 419 m asl)
- Drawdown Zone - lower (419 to 436 m asl)
- Drawdown Zone – upper (436 to 440.4 m asl)
- Reservoir Shoreline Zone (above 440.4 m asl)

The Year-Round Reservoir Zone is predicted to be relatively stable, as it is consistently inundated, and no further work was recommended for this zone, unless the area were to be consistently exposed in the future. According to Choquette, the wave erosion effects within the Lower Drawdown Zone appear to be significant and have likely disturbed or removed cultural deposits that may have existed. The Upper Drawdown Zone and the adjacent Reservoir Shoreline Zone have less overall exposure to wave erosion and represent the most likely locations for intact archaeological resources.

Of particular interest to the WUP CC were “escarpment” landforms situated throughout the reservoir drawdown zone but most visible in the Narrows between the Upper and Lower Arrow Lakes and in the mid Columbia River in the upper elevations starting at around 436 m asl. Remnant early post-glacial period lacustrine landforms such as delta fans and terraces are described in Choquette’s report as potentially containing significant intact cultural deposits based on observations of artifacts and other cultural material eroding from existing banks and other exposures. Initial findings from CLBMON-52 an archaeological sites overview assessment currently underway in the Arrow Lakes reservoir, indicate even greater complexity to the landforms in the Revelstoke Reach area (Choquette 2007: report in progress). To ensure the capture of meaningful data, this monitoring study will endeavor to incorporate new information into its interpretation and not be limited to measuring erosion of the escarpment landform.

Erosion monitoring will provide an opportunity to ground truth assertions made in Choquette's 2002 report regarding:

1) the presence of intact archaeological resources within remnant escarpment landforms in the upper portion of the drawdown zone, and

2) the effects of wave and wind erosion on these resources.
For example, based on his observations, Choquette writes:

*It is apparent from these areas that as erosion progresses, more and more cultural deposits are exposed, those at lower elevations in the drawdown zone basically being almost to completely destroyed by repeated reworking by the waves and removal by collectors while the intact portions of upper landforms near the top of the reservoir pondage suffer the same fate but at a considerably slower rate (Choquette 2002; Section 4.3).*

### 2.2 Heritage Monitoring Purpose

The primary purpose of this erosion monitoring study is to provide information that can be used in future WUP processes. Two key management questions were raised during the WUP consultative process regarding archaeology. The first focused on collecting information regarding the nature of the archaeological resources that are present within the reservoir through inventory work. The second was aimed at understanding the effect reservoir operations may be having on these archaeological resources. This study is primarily concerned with the latter although new information on archaeological sites is also expected to be gained as a result of this work.

The condition of a documented archaeological site is typically assessed only once, at the time of recording, and few sites are formally re-assessed. Since erosion within a reservoir takes place in a complex environment involving landform, aspect, de-vegetation, surface debris, surficial geology, weather, and human or animal intervention in addition to reservoir operations, the cumulative effect can be difficult to interpret. In order to develop an understanding of taphonomic process (post-depositional effects on archaeological materials) related to reservoir operations, repeated visits to a site over time are required. An important feature of erosion monitoring is the application of quantitative measures on a scale and frequency appropriate to the effects.

### 3.0 ARCHAEOLOGICAL EROSION MONITORING PROPOSAL

#### 3.1 Objective and Scope

The objective of the planned erosion monitoring study is to collect quantitative measures of the magnitude, severity, rate of change and estimated duration of erosion effects caused by reservoir operations on selected portions of escarpment and other significant landforms situated within the drawdown zone of the Arrow Lakes Reservoir. As described in Choquette’s 2002 report, these remnant landforms are associated with ancient glacial lakeshore settings and are expected to contain intact portions of archaeological sites. These landscape features are visible at an elevation of approximately 436 m asl and occur in two main locations, which are the focus of this study:

1) the Narrows situated between Upper and Lower Arrow Lakes, and
2) in the Revelstoke Reach (mid-Columbia River) between Revelstoke and Shelter Bay (Figure 3-1).

In accordance with the Order, this erosion monitoring study will be conducted using non-intrusive methods.

#### 3.2 Approach

This project will involve research and analysis, as well as an in-field component for establishing monitoring stations and subsequent data collection. Erosion monitoring stations will be
established at a minimum of six locations within the Reservoir drawdown zone divided between the Narrows locale and the Revelstoke Reach. Archaeological sites identified in Revelstoke Reach during the CLBMON-52 Arrow Lakes Reservoir Archaeological Site Overview Assessment will be selected for monitoring to the extent possible to meet BC Hydro’s commitment to assess the effects of winter flows related to the Revelstoke 5 project.

Monitoring stations will be situated on both the east and west shorelines of the Reservoir in a variety of landscape contexts. Each monitoring station must include a portion of intact escarpment or other landforms of significance and should measure no less than 0.04 ha (e.g. 20 m x 20 m) and no greater than 0.25 ha (e.g. 50 m x 50 m) in area. Configuring the monitoring stations to capture a maximum amount of archaeological information within a landform setting that appears to be subject to erosion effects will be critical to the success of the study.

To ensure the capture of information specific to erosion effects on archaeological deposits locations with archaeological materials and/or features exposed on the surface will be selected. Locations with either documented or previously undocumented archaeological sites may be suitable. The limits of the monitoring station will be clearly defined and recorded. No intrusive materials will be placed within the station and no materials or equipment brought in for the purpose of the study will be left on site. As this study is not being carried out under a Provincial Heritage Inspection Permit, no artifacts or other cultural materials will be collected from the monitoring stations and no subsurface testing will be conducted.

The project will take a collaborative multi-disciplinary team approach directed by a professional archaeologist and including a survey engineer, a quaternary geologist and technical assistants throughout the project. The archaeologist will be responsible for monitoring station selection and for identification, recording, mapping and interpretation of cultural materials and features present on the ground surface within the limits of the station. The archaeologist will be responsible for collating all collected data and project reporting.

Using terrestrial-based LIDAR, the survey engineer will collect a complete scanned dataset of the selected monitoring station. This dataset will be geospatially tied to the UTM grid (NAD 83). The resulting point cloud will be converted into a detailed topographic map (DTM) at a suitable scale (eg. 1:500). The DTM will include a related (thematic) layer of information regarding the archaeological features, artifacts and other materials observed on the ground surface. In addition, a physical datum will be established offsite for elevation control and as a reference point to aid in re-location.

Despite its additional cost when compared to more traditional means (intrusive physical structures combined with GPS or photogrammetry) there are several advantages in using LIDAR for measuring erosion effects. Laser scanning technology is a highly accurate method for collecting geospatial information at a fine scale. The resulting point cloud can be similar to the pixels in a digital photographic image but in the case of LIDAR, each point is geo-referenced to a chosen grid, in this case UTM. Unlike GPS where geo-reference points are collected individually by the GPS operator while moving over an area, LIDAR can be positioned off-site and can collect millions of individual data points as close as 5 cm apart with one scan. Topographical undulations require that the scanner position be re-positioned for collecting multiple overlapping scans, which are stitched together to create a combined point cloud from which 3-dimensional surface representations can be generated. Subsequent data analysis is required to create a DTM and related sections or other products. Features, such as vegetation, can create interference during the scans and this should be considered and addressed to minimize “shadows” in the scans during the data collection.
Figure 3-1: Location of Arrow Lakes Reservoir and mid-Columbia River Archaeological Erosion Monitoring Stations.
LIDAR is a particularly appropriate technology for this erosion monitoring study because:

1) it is non-intrusive,

2) it has suitable resolution for recording spatial areas in fine detail,

3) detailed DTMs can be created from the data, lessening time required for field mapping, and

4) changes in volume (i.e. erosion or accretion) between comparable scans over time can be readily calculated.

In Year 1, the quaternary geologist will assist in the selection of monitoring stations and develop a geological (stratigraphic) model, including an assessment of erosion susceptibility, for each station. The geological models would be based on visual inspections of exposed soil layers with no excavation. The potential for extrapolation of the geological models to the rest of the reservoir draw down zone outside the study areas should be considered in the model development. In Year 5, the geologist will re-visit each monitoring station, inspect the changes to the exposed sections, review the collected geo-spatial (LIDAR) data and provide a section of the project report that compares the observed and measured effects with those predicted from the Year 1 model.

Local First Nations will be given the opportunity to comment on the erosion monitoring plan before it is carried out through a review of these terms of reference. All final annual reports will be shared with local First Nations.

The project team will conduct accurate surveys in accordance with BC Hydro’s General and Technical Standards for Reservoir Archaeological Work, meeting all relevant requirements.

3.3 Methods

The monitoring study will involve five basic tasks outlined below:

3.3.1 Task 1: Project Management

Project management will involve the general administrative and technical oversight of the project. This task will include, but not be limited to:

1) budget management,
2) study team management,
3) logistic coordination,
4) technical oversight of field and analysis components, and
5) facilitation of data transfer among other investigators, as required.

A safety plan must be developed and submitted to the BC Hydro study implementation lead for all aspects of the study involving field work, in accordance with BC Hydro’s procedures and guidelines. This safety plan must be submitted prior to any fieldwork being undertaken. Specific safety training may be required.

3.3.2 Task 2: Background Research

This task includes, but is not limited to:

1) a review of relevant published and unpublished reports, including Choquette 2002, 2007 and BC Hydro Engineering Services 2006,
2) a review of all documented archaeological sites within the Narrows and Revelstoke Reach sections in the Arrow Lakes Reservoir drawdown zones as described in Section 3.1.; and

3.3.3 Task 3: Monitoring Station Site Selection and Erosion Susceptibility Model Development

Preliminary selection of appropriate monitoring station locations will be based on a review of documentary information such as air photos and digital elevation models of the drawdown zone.

Final monitoring station selection will take place in the field to ensure that both archaeological and landform aspects are well represented and that each station is configured to capture data reflective of the geological and archaeological landscapes. The selection and establishment of monitoring stations in the field will be combined with the collection of baseline data during a single field trip in Year 1. An individual offsite datum will be established for each monitoring station.

Year 1 will also include the development of an erosion susceptibility model for each established monitoring station.

3.3.4 Task 4: Data Collection

Both archaeological and geospatial data collection will take place in each of the five years of this study. Baseline LIDAR scans will be established in Year 1, with successive LIDAR scans (epochs) in each of years 2-5, inclusive.

Within each monitoring station, the position, type and morphological characteristics of all surface artifacts, cultural features and exposed sediments will be recorded by the professional archaeologist and technical support staff. Digital photographs with a minimum 300 dpi will be taken of the monitoring station and of all archaeological features and artifacts observed within. Information required for submitting or updating B.C. Archaeological Site Inventory Forms will be collected.

Geospatial data collection will include LIDAR scans of the entire monitoring station. Multiple overlapping scans may be required to account for all topographic undulations and to maximize the completeness of scanned ground. The position of each scan will be recorded using GPS and linked to UTM (NAD 83). A set of colour digital photographs will be collected from the same position as each LIDAR scan to capture the area covered in each scan.

3.3.5 Task 5: Analysis and Reporting

A draft interim report that summarizes the methods employed and study findings will be prepared shortly after the conclusion of the data collection each year. Final annual reports for the study will include:

- an executive summary;
- a description of the monitoring station set up and data collection methods;
- a detailed summary of the archaeological data collection findings for each monitoring station;
- a detailed summary of the geomorphologic data collection findings for each monitoring station;
- a detailed analysis of the observed measured erosion at each monitoring station as compared to the erosion susceptibility model(s);
- hard copy and digital maps, in an acceptable format, showing the monitoring station locations and the position of all surface archaeological features and artifacts per year;
- detailed scans (maps and sections) showing the recorded changes between successive
epochs; and

- a detailed quantitative analysis of the collected data regarding the effects of the reservoir on archaeological resources expressed in terms of magnitude (volumetric and dimensional changes), severity, rate of change and duration.
- an analysis of the effects relative to the position of the monitoring station (elevation, location, aspect, surficial geology) within the reservoir draw down.

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 as embedded objects in the Word file and as separate GIS files.

The preparation and submission of B.C. Archaeological Site Inventory Forms for all newly identified sites or updates to previously documented site data records is also required.

3.4 Schedule

The study will take place over five years with Year 1 taking place in spring of 2009. This schedule will allow for the collection of 2 years of base data prior to the installation and operation of the 5th unit at the Revelstoke generating station and 3 years of post-installation data. The exact timing will depend on site conditions, but it is expected that the greatest extent of the drawdown zone will be exposed in the spring. The Arrow Lakes Reservoir drawdown zone is typically accessible between March and June when the area is free from snow and ice but is not yet inundated from rising reservoir levels. Low water levels and minimal snow cover on the ground are needed for effective mapping. The field component of the project should take place before the end of June when reservoir levels start to rise.

3.5 Budget

The total annual budget for this study is estimated at $68,587 (in 2004 dollars). This exceeds the estimated cost provided by the WUP CC ($33,000/year). These increased costs are attributable to a number of factors, including:

1) the use of LIDAR technology to achieve non-intrusive accurate measures of surface erosion;
2) a more complete understanding of the measures and analysis required to obtain a meaningful assessment of erosion effects in the reservoir environment using the support of a survey engineer and quaternary geologist, and;
3) increased professional fees and expenses since the time of the WUP CC estimate.

Annual budget estimates assuming a 2% rate of inflation and a 5% contingency for the duration of the program is provided below in Table CLBMON-50-1.
3.6 References

