Cheakamus Project Water Use Plan

Cheakamus River Channel Morphology Monitoring

Implementation Year 7

Reference: CMSMON-8

Annual Progress Report

Study Period: 2014-2015

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March 16, 2016

Contents

Figures

Tables

Executive Summary

The Fisheries Technical Committee developed a comprehensive monitoring plan for the Cheakamus River to address critical points of scientific uncertainty and disagreement within the Consultative Committee, and to better inform the next Water Use Plan. CMSMON8 deals with questions related to channel morphology and tributary flows.

BC Hydro's Terms of Reference for CMSMON8 identify the following three management questions (MQs), which the Cheakamus River monitoring program is intended to answer:

1. Following implementation of the WUP, has there been a change in the overall availability of suitable fish spawning substrates from the present state? If so, can this change be clearly attributed to Daisy Lake Dam operations vs. other environmental or anthropogenic factor?
2. Following implementation of the WUP, has there been a change in the overall length, access and utility for fish of naturally occurring side channels from the present state? If so, can this change be clearly attributed to Daisy Lake Dam operations vs. other environmental or anthropogenic factors?
3. To what extent does the hydrology of Rubble Creek, Culliton Creek, and Swift Creek contribute to the general hydrology of lower Cheakamus River and how does it attenuate the effects of Daisy lake dam operations?

Years 1 through 5 of CMSMON8 were part of a previous monitor. BC Hydro awarded CMSMON8 Years 6 through 10 to KWL. Work on MQ3 was completed in Year 6. Work to address MQ1 and MQ2 is on-going.

The following work has been accomplished on CMSMON8 MQ1 during Year 7:

- Scope revision to better address MQ1 within the constraints of the available data and budget;
- Selection of field sites for the MQ1 analysis; and
- Collection of field data at MQ1 sites including surface grain size samples and temporary sediment traps.

Future work on CMSMON8 MQ1 will include:

- Additional fieldwork to empty temporary sediment traps following larger flow events and sieve the sediment;
- Analysis of grain size, hydraulic and hydrologic model data to estimate the threshold of movement and contrast whether the WUP resulted in likely changes to the distribution of flows that could initiate movement; and
- Summarizing the MQ1 work into a final report.

CMSMON8 MQ2 will be addressed in the final year of the monitor (Year 10).

1. Introduction and Background

1.1 Introduction

Kerr Wood Leidal Associates Ltd. (KWL) has been retained by BC Hydro (BCH) to conduct monitoring work for CMSMON8: Cheakamus River Channel Morphology Monitoring. BCH awarded CMSMON8 to KWL in August 2013.

This report documents the work performed in Year 7 of CMSMON8.

1.2 Background

Cheakamus River WUP

The Cheakamus River Water Use Plan (WUP) was accepted by the Comptroller of Water Rights, and implemented in February 2006. The Cheakamus Consultative Committee (CC) has agreed on six fundamental objectives for the Cheakamus Water Use Plan (in no particular order):

1. **Power:** Maximise economic returns from power generated at Cheakamus Generating System;
2. **First Nations:** Protect integrity of Squamish First Nation's heritage sites and cultural values;
3. **Recreation:** Maximise physical conditions for recreation;
4. **Flooding:** Minimise adverse effects of flood events through operation of the Cheakamus Generating system;
5. **Fish:** Maximise wild fish populations; and
6. **Aquatic Ecosystem:** Maximise area and integrity of the aquatic and riparian ecosystem.

Cheakamus River Monitoring Program

The Fisheries Technical Committee developed a comprehensive monitoring plan for the Cheakamus River to address critical points of scientific uncertainty and disagreement within the CC, and to better inform the next WUP. The CC recognised that it is essential to address critical scientific uncertainties that can affect future decision making, and to comprehensively assess the response of the system to operation of the Cheakamus Generating System.

The monitoring plan contains nine elements in total: CMSMON8 addresses one element of the monitoring plan dealing with channel morphology and tributary flows.

Management Questions (MQs) for CMSMON8

BC Hydro's Terms of Reference for CMSMON8 identify the following three management questions, which the Cheakamus River monitoring program is designed to answer:

1. **Following implementation of the WUP, has there been a change in the overall availability of suitable fish spawning substrates from the present state? If so, can this change be clearly attributed to Daisy Lake Dam operations vs. other environmental or anthropogenic factors?**
2. **Following implementation of the WUP, has there been a change in the overall length, access and utility for fish of naturally occurring side channels from the present state? If so, can this change be clearly attributed to Daisy Lake Dam operations vs. other environmental or anthropogenic factors?**
3. **To what extent does the hydrology of Rubble Creek, Culliton Creek, and Swift Creek contribute to the general hydrology of lower Cheakamus River and how does it attenuate the effects of Daisy Lake Dam operations.**

1.3 Results of First Monitor (2007-2012)

The Cheakamus River monitoring program has completed one 5-year cycle already, as follows:

- **Year 1 (2007-2008)**: "Post-WUP", Morphological Mapping and Hydrometric Monitoring;
- **Year 2 (2008-2009)**: "Post-WUP", Hydrometric Monitoring;
- **Year 3 (2009-2010)**: "Post-WUP", Hydrometric Monitoring;
- **Year 4 (2010-2011)**: "Post-WUP", Hydrometric Monitoring; and
- **Year 5 (2011-2012)**: "Post-WUP", Morphological Mapping and Hydrometric Monitoring.

Based on BC Hydro's Terms of Reference (BC Hydro, 2007), 2006 is identified as the only "pre-WUP" year but it is our understanding that the earliest morphological mapping is 2008, with follow-up mapping conducted in 2012.

Based on the Year 5 morphology report (NHC, 2014a), the following summary points may be made:

- wetted channel is the most common habitat type, by area, and the fraction of wetted channel did not change between 2008 and 2012 mapping;
- bare gravel bars became increasingly vegetated, and the increase in areas of young vegetation was statistically significant;
- wetted habitat areas (e.g., pools, riffles, rapids) showed changes between 2008 and 2012, but not above the level of statistical significance;
- to date, there has been no specific monitoring of changes to substrate size in the wetted channel or on individual bars;
- there was no change in the number, average area or areal variance of dry side channels. A decrease in the area of wetted side channels was noted, but was not statistically significant; and
- side channel habitat classification changes depending on the flow at which it is evaluated.

Based on the Year 5 hydrometric report (NHC, 2014b), the following summary points may be made:

- Three stations have been monitored to provide estimates of discharge:
    1. Cheakamus River at the Chance Creek Forest Service Road (Cheakamus FSR);
    2. Cheakamus River at the Pedestrian Bridge; and
    3. Culliton Creek at the Jack Webster Bridge Crossing.
- Rubble Creek flow is estimated by subtracting Daisy Creek flow releases from Cheakamus FSR flows. Culliton Creek flow is measured directly.
- Rating curve shifts are problematic at the Cheakamus River Pedestrian Bridge station, and somewhat less so at the other two stations.
- Flow measurements conditions are challenging, requiring a variety of approaches to obtain accurate measurements.

The Year 5 hydrometric report did not address the tributary flow management question.

1.4 Year 6 (2013-2014) Results

In July 2014, KWL presented interim results at the Cheakamus River Management Committee Meeting, including a preliminary evaluation of Management Question (MQ) 3 based on hydrometric data collected to that point. Following discussions with BC Hydro, regulators, and consultants responsible for other Cheakamus River monitors, it was decided to revise the scope of work for CMSMON8 to better address the three MQs.

Year 6 CMSMON8 work is documented in the Annual Report submitted by KWL (KWL 2014a).

As part of the revised scope, in Year 6 KWL also undertook an analysis of Year 1 through Year 5 hydrometric data to address CMSMON8 MQ3. Findings from this analysis are documented in the final report submitted to BC Hydro (KWL 2014b).

MQ3 is addressed by the Year 1-Year 5 flow synthesis in KWL (2014b). As work on MQ3 has been completed there was no need for additional hydrometric data to support MQ3 and data collection was discontinued in late 2014 at the three additional hydrometric stations associated with CMSMON8 (Cheakamus River at Chance Creek Forest Service Road, Cheakamus River at the Pedestrian Bridge and Culliton Creek at Jack Webster Bridge).

1.5 Current Report Scope

This report provides information on work carried out in 2015 to address MQ1 and provides a brief summary of the work that will be conducted in future years of the project to address MQ1 and MQ2.

2. Year 7 Work: MQ1

CMSMON8 Management Question 1 asks:

Following implementation of the WUP, has there been a change in the overall availability of suitable fish spawning substrates from the present state? If so, can this change be clearly attributed to Daisy Lake Dam operations vs. other environmental or anthropogenic factor?

The following sections describe work conducted in Year 7 to address MQ1.

2.1 Scope Revision

During the course of background information review and consultation with other Cheakamus River monitors it became evident that there is limited pre-WUP data available to support an approach to answer MQ1. In addition, consultants in charge of other Cheakamus River monitors were of the opinion that spawning habitat in the lower Cheakamus River is not limiting.

In response to these issues, BC Hydro proposed that an analysis be conducted to evaluate whether there has been degradation in spawning habitat via erosion following implementation of the WUP. This assessment would rely on the available record of flow releases from Daisy Lake dam to represent the pre-WUP vs. post-WUP condition (grain size information for the pre-WUP period is very limited).

KWL developed a revised scope of work to address MQ1 that involves the following main tasks:

- **Site selection**: select field sites representative of spawning habitat;
- **Field data collection**: characterize the surface grain size at selected sites, and install small sediment traps to sample the sediment being transported by the river;
- **Incipient motion analysis**: estimate the shear stress required to initiate bed sediment movement, and compare the frequency with which these shear stresses are experienced under pre-WUP vs. post-WUP conditions. Compare results of the analysis with sediment trap data; and
- **Reporting**: summarize the results of the field work and analysis to address MQ1.

KWL submitted a revised CMSMON8 scope of work to BC Hydro in April 2015. BC Hydro completed Terms of Reference Addendum 2 for CMSMON8 in June 2015.

2.2 MQ1 Site Selection

KWL conducted a desktop review to identify potential sites suitable for MQ1 analysis. The desktop review was based on data provided by BCH, including:

- 2012 orthophotos; and
- location of 2007 and 2012 channel bathymetry data used in the development of the existing BCH Cheakamus River hydraulic model.

Site selection criteria included:

- Suitability for spawning;
- Proximity to surveyed channel bathymetry; and
- Logistical considerations such as site access.

A number of potential site locations were identified based on the desktop review.

A field visit was conducted on September 15, 2015 by Erica Ellis, Chad Davey and Amir Taleghani (all KWL staff) to review potential MQ1 sites and finalize site selection. The discharge at the time of the field visit was about 36 m^3/s based on real-time provisional data from WSC 08GA043.

During the course of the field visit many spawning salmon were observed both in the wetted channel along the gravel bar edges, as well as carcasses. The presence of active spawners was used as confirmation of the suitability of potential MQ1 sites, in addition to the observed grain sizes at the sites in comparison with documented ranges of spawning gravel sizes.

Following review of a number of potential locations, two sites were selected for MQ1:

1. Pedestrian Bridge bar; and
2. Eagle Point bar (Cheakamus Centre).

The location of the sites is shown in Figure 2-1. Site layout is shown in Figure 2-2, including proximity to the 2011 surveyed channel bathymetry.

2.3 MQ1 Field Data Collection

Following site selection, a second day of fieldwork was conducted on September 16, 2015 to collect surface grain size samples and install sediment traps.

Two surface grain size samples were collected at each site: one to characterize the sediment in the immediate spawning location, and one to characterize the generally-coarser gravel bar sediments in the nearby vicinity. Sediment traps were installed to correspond with these locations also (see Figure 2-2).

Surface Grain Size Data

Surface grain size sampling followed the grid procedure (e.g., Kondolf et al, 2003), using a 30 m tape (Photo 1).

Photo 1: Sample Lines for Surface Grain Size Sample (Pedestrian Bridge, Sep. 16, 2015).

Approximately 100 points were collected for each sample and spacing between sampling points was determined as roughly three times the maximum grain size (based on visual observation of the sample area). Sample results were truncated below 4 mm prior to calculating the median.

Figures 2-3 and 2-4 show the observed grain size distributions for the Pedestrian Bridge and Eagle Point sites, respectively. Summary percentiles for the surface grain size samples are shown in Table 2-1.

Table 2-1: Surface Grain Size Percentiles

Site	Spawning Gravel		Gravel Bar, General Vicinity	
	D84 (mm)	D50 (mm)	D84 (mm)	D50 (mm)
Pedestrian Bridge	74	36	155	103
Eagle Point	93	45	100	60

Notes:
1. D84 is the size for which 84% of the sample is smaller. D50 is the median grain size: the size for which 50% of the sample is smaller.

Sediment Trap Data

Two temporary sediment traps were installed at each site. The traps are 30 L buckets with drainage holes to allow water and very fine sediment to drain. The intent of the traps is that as high flows move bedload along the channel bed, the material in motion will fall into the traps and be captured for later retrieval.

Sediment traps were dug into the gravel bar, set flush with the bar surface, and left empty (Photo 2). The sediment traps are located near, but not within, the area of active spawning.

Photo 2: Temporary Sediment Trap at Pedestrian Bridge Bar (Sep. 16, 2015)

On September 19-20, 2015 about 92 mm of rain was recorded at Squamish (Environment Canada station 10476F0), which resulted in about a 100 m³/s peak flow event at WSC 08GA043 (based on provisional data). A field visit was conducted on September 24, 2015 to empty and re-set the traps.

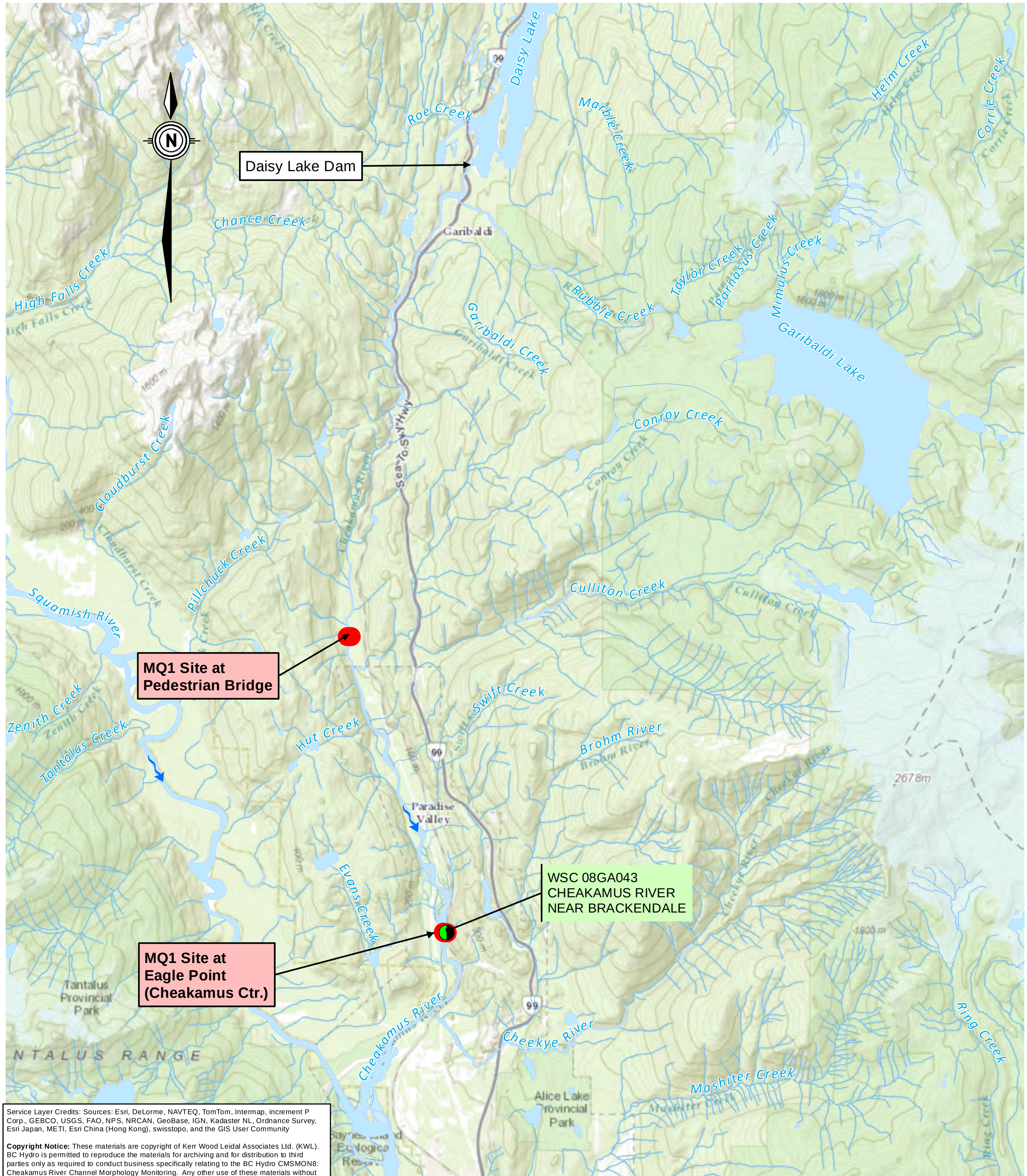
The following observations were made during the September 24 field visit:

- Pedestrian Bridge MQ 1 site:
  - The bar top trap could not be located, and may have been removed. A new trap was re-installed at the old location.
  - The trap near the spawning area was mostly empty except for organic matter (Photo 3): the small amount of sediment was removed from the bucket for later analysis and the trap was re-set.
- Eagle Point MQ 1 site:
  - The bar top trap was empty.
  - The trap near the spawning area was about 2/3 full with a mixture of sand and gravel (Photo 4). The trap was emptied and re-set.

Sediment from the traps was bagged and retained for later sieve analysis (see Section 2.2).

Photo 3: Mostly Organic Matter in Temporary Sediment Trap at Pedestrian Bridge Bar, near Spawning Area (Sep. 24, 2015).

Photo 4: Sediment in Temporary Sediment Trap at Eagle Point Bar, near Spawning Area (Sep. 24, 2015).



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consulting engineers
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BC Hydro
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Project No.	Date
478-164	November 2015

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MQ1 Field Site Locations

Figure 2-1

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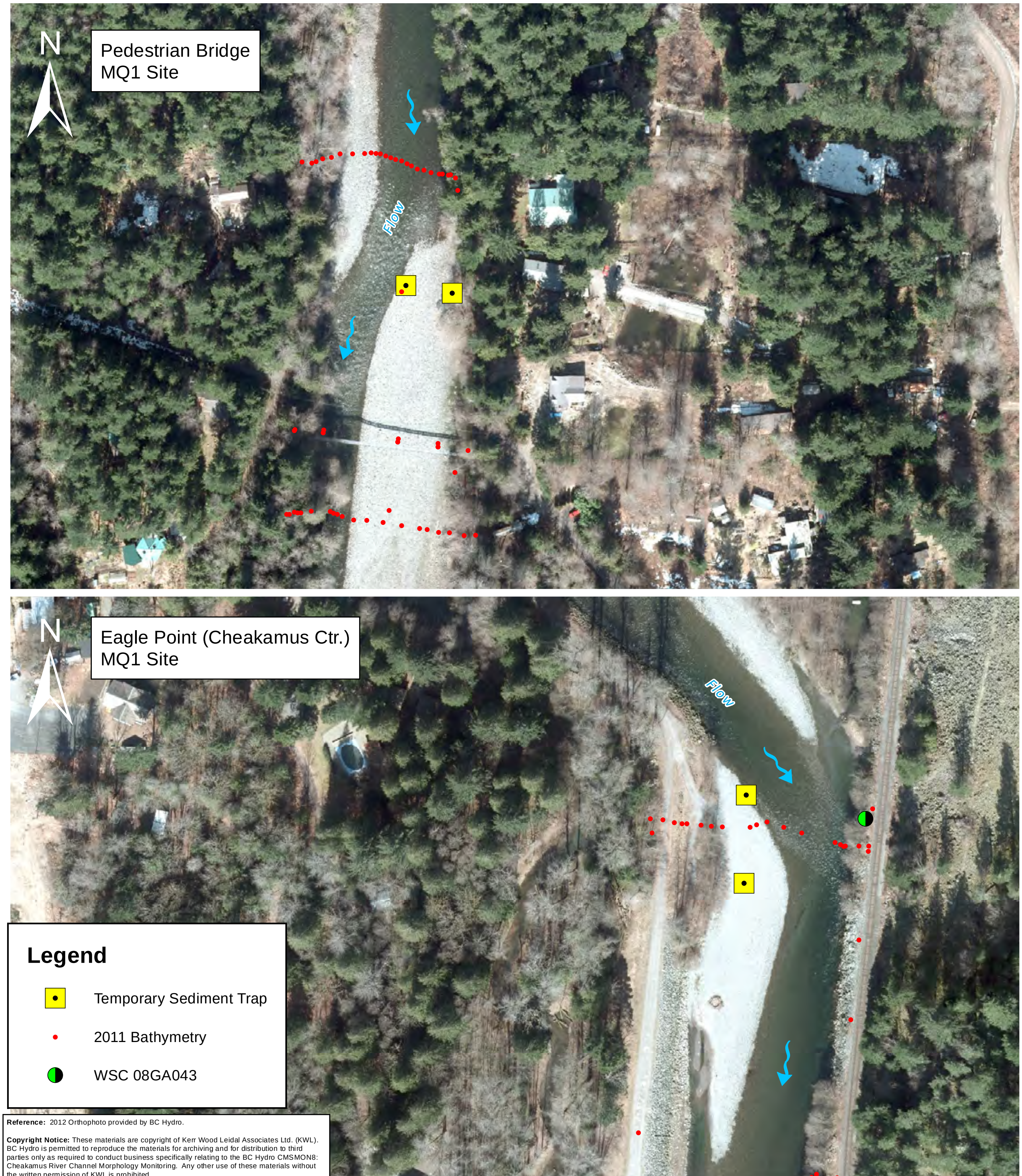

Reference: 2012 Orthophoto provided by BC Hydro.

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Project No. 478-164

Date November 2015

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MQ1 Field Site Layout

Figure 2-2

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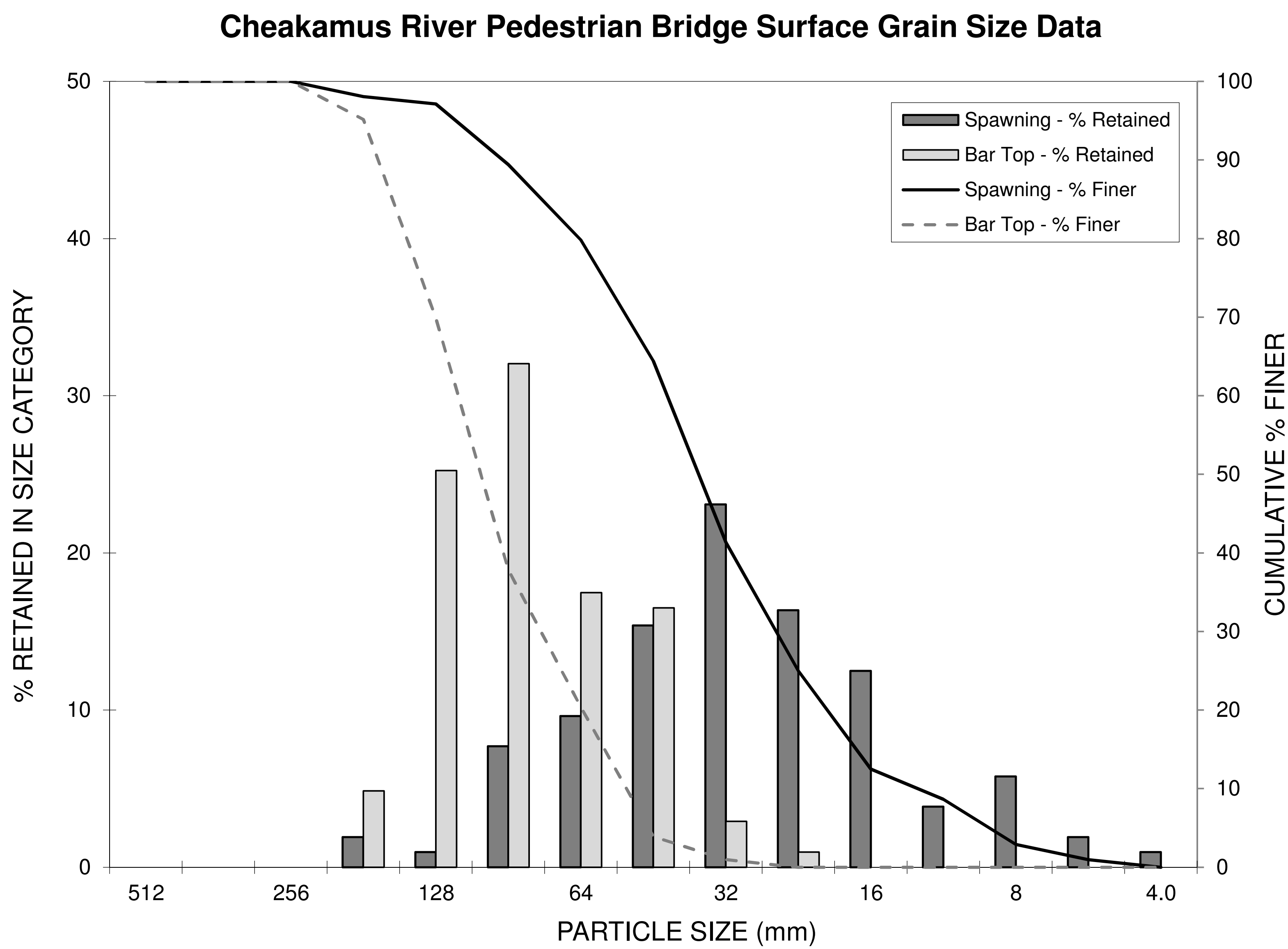

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Figure 2-3

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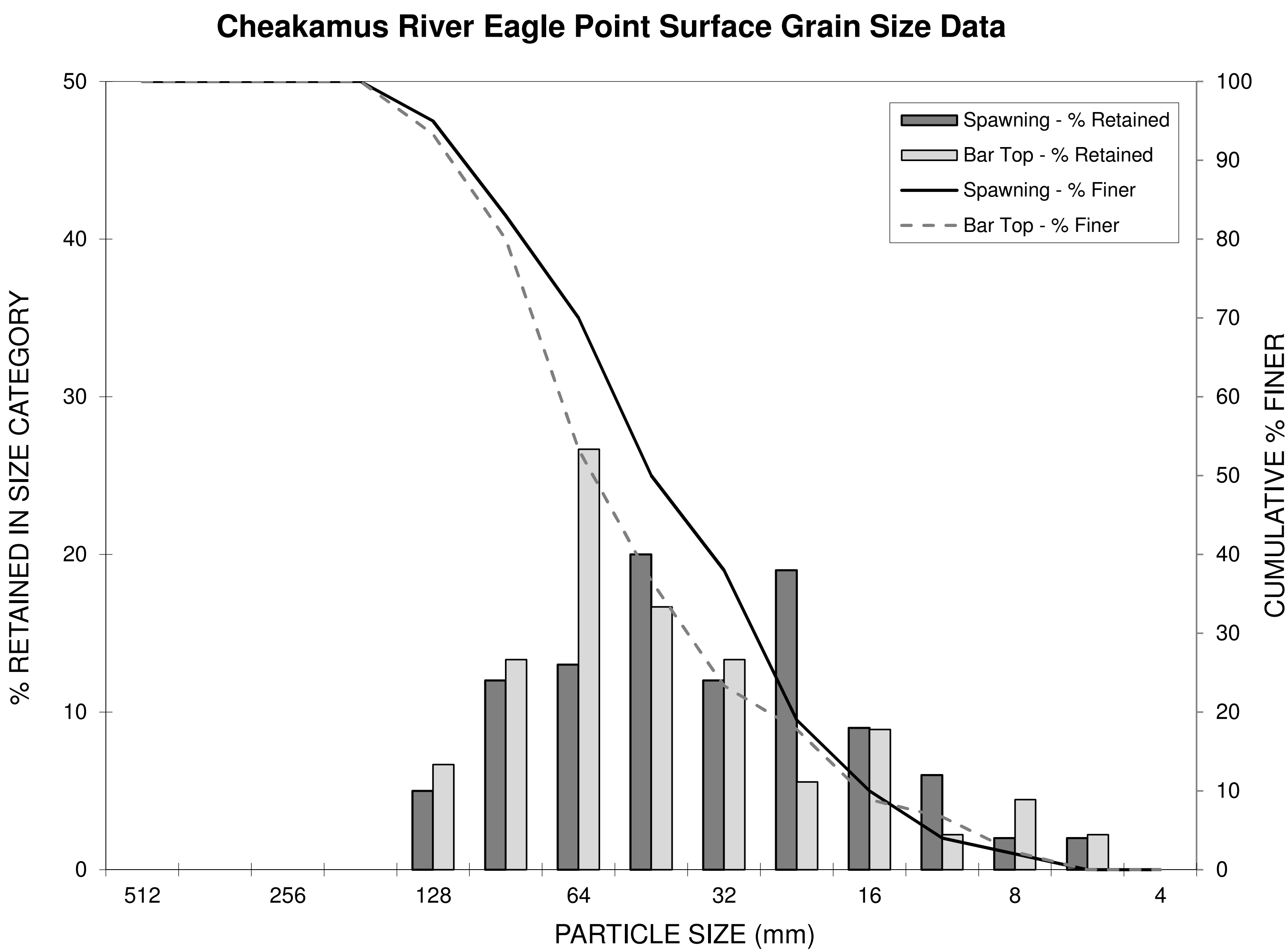

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Figure 2-4

3. Future Work

Preceding sections of this report have summarized work completed during Year 7 of CMSMON8. The following sections provide a brief summary of the work that will be conducted in future years of the project to address MQ1 and MQ2.

3.1 MQ1

Fieldwork

We will continue to monitor the real-time provisional data at WSC 08GA043 to identify when peak flows are likely to have mobilized sediment into the traps. Ideally, the traps will be emptied after a series of different magnitude peak flows. Following September 20 peak flow, there have only been similar-size or smaller peak flow events. Sediment trap monitoring will continue through to spring 2016 to allow for more opportunity to sample size different peak flow events (up to the maximum allowed for in the budget). Once the MQ1 fieldwork has been completed, a sieve analysis will be performed on the trap sediment to quantify the grain size distribution of the mobile sediment.

Analysis

An assessment will be conducted to estimate what size of sediment the shear stresses at the two MQ1 sites would be capable of mobilizing, and whether WUP operation has resulted in a different frequency of occurrence of these flows. The assessment will be supported by hydraulic and hydrologic modeling by BCH staff. The predicted size of mobile sediment at each site will be compared with observed mobile sediment from the trap data.

The final MQ1 report will provide a summary of the fieldwork and analysis, and will provide an answer to the question of whether there is likely to have been degradation in spawning habitat via erosion following implementation of the WUP. The final report addressing MQ1 is anticipated in Year 8 of the project (2015-2016).

3.2 MQ2

Work to address MQ2 will primarily occur in Year 10 of CMSMON8. For consistency, methods will be very similar to those applied in Years 1 and 5 of CMSMON8. Major tasks associated with MQ2 will include:

- Acquire background data, including new orthophotos.
- Perform GIS-based morphologic channel mapping.
- Compare new channel mapping to previous mapping and evaluate changes.
- Interpret results of channel mapping assessment in light of MQ2 and provide conclusions.

3.3 Report Submission

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Revision History

Revision #	Date	Status	Revision	Author
1	Mar. 16, 2016	Final	Final.	EE

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