

Peace Project Water Use Plan

Monitoring Program Terms of Reference

Peace Spill Protocol

- **GMSMON-4 WAC Bennett Dam Entrainment**

February 9, 2008

Terms of Reference for the Peace Project Water Use Plan Monitoring Programs Peace Spill Protocol

1.0 OVERVIEW

This document presents Terms of Reference for the effectiveness monitoring programs for the Peace Spill Protocol (Table 1). These programs will monitor and quantify the environmental effects of spills. Information collected through the Peace Spill Protocol will be used, if appropriate, in the revision of future spill strategies. This document provides detailed Terms of Reference for the following programs:

- 1) **GMSMON-3 Peace River Fish Stranding:** A conditional monitoring program to be implemented immediately following a spill event that will assess the magnitude of fish stranding in the Peace River.
- 2) **GMSMON-4 WAC Bennett Dam Entrainment Study:** A conditional monitoring program to be implemented for a spill event that will estimate the number of fish entrained through WAC Bennett Dam and the rate of mortality experienced by entrained fish. Formerly known as the GMS Entrainment Study. The original project title was misleading as the focus of the study is spillway entrainment and not turbine entrainment.
- 3) **GMSMON-6 Peace River Riparian Flooding:** A conditional 2-year monitoring program to be implemented in Years 9 and 10 of the Peace Project Water Use Plan should a spill event occur during the 10-period.
- 4) **GMSMON-7 Peace River Side Channel Fisheries:** A 10-year required program to provide baseline data on flow, fish use, and substrate changes in side channels as well as to assess the response of trial sites (a physical works project).
- 5) **GMSMON-8 Peace River Side Channel Response:** A conditional monitoring program to assess the response of side channels to spill events in terms of flow, fish use, and substrate.
- 6) **GMSMON-9 Peace River Spill Hydrology:** A conditional program to ensure the collection and reporting of hydrological data associated with a spill event.
- 7) **GMSMON-10 Peace River Spill Photos:** A conditional monitoring program that captures the Peace River at five different flows during a spill event.
- 8) **GMSMON-11 Peace River Spill TGP/Temp:** A conditional monitoring program that monitors TGP and temperature levels of the Peace River during a spill and two weeks following.
- 9) **GMSMON-12 Peace River Wildlife Survey:** A conditional monitoring program that assesses the impact of a spill event on ungulates, beavers, riparian birds, and toads.
- 10) **GMSMON-13 Williston Fish Index:** A study that will estimate the abundance of fish in the pelagic area of the Peace Arm of the Williston Reservoir to assist in assessing the impact of entrainment on fish populations during a spill.

Table 1 Peace Spill Protocol Monitoring Program Terms of Reference Submission Information

Name of Monitoring Program	Order Clause Fulfilled	Submitted with this Package	Previously Submitted To CWR	Ordered Submission Date
GMSMON-3 Peace River Fish Stranding	Schedule D 3(a)	Yes	No	February 2008
GMSMON-4 WAC Bennett Dam Entrainment	Schedule D 3(b)	Yes	No	February 2008
GMSMON-6 Peace River Riparian Flooding	Schedule D 3(c)	Yes	No	February 2008
GMSMON-7 Peace River Side Channel Fisheries	Schedule C 4(d)	Yes	No	August 2008
GMSMON-8 Peace River Side Channel Response	Schedule D 3(d)	Yes	No	February 2008
GMSMON-9 Peace River Spill Hydrology	Schedule D 3(e)	Yes	No	February 2008
GMSMON-10 Peace River Spill Photos	Schedule D 3(g)	Yes	No	February 2008
GMSMON-11 Peace River Spill TGP/Temp	Schedule D 3(f)	Yes	No	February 2008
GMSMON-12 Peace River Wildlife Survey	Schedule D 3(h)	Yes	No	February 2008
GMSMON-13 Williston Fish Index	Schedule D 3(i)	Yes	No	February 2008

Monitoring Program No. GSMON-4 WAC Bennett Dam Entrainment

1.0 MONITORING RATIONALE

1.1 Background

The Peace Water Use Plan Committee (hereafter known as the Committee) recognized that fish are entrained through the spillway during the spill events and consequently recommended that a monitoring program be implemented to track this fish entrainment issue during spill releases at the Williston Project.

The WAC Bennett Dam Entrainment study addresses two management plans, the Peace Spill Protocol (PSP) and the Peace River Flood Pulse Plan (BC Hydro 2003). Both positive and negative impacts are expected from a spill and this monitoring program will focus on the negative impact of fish loss through entrainment. As part of the PSP, this study will address the uncertainty of (i) the relative magnitude of fish entrained through the spillway, (ii) the relationship between discharge rate and numbers of fish entrained, (iii) acute fish mortality caused by spillway entrainment, and (iv) the relative impact to reservoir populations. As part of the PCR Flood Pulse Plan, the results from this monitoring program may act as a weighting against the ecological merits of flood pulses. The monitoring programs within both of these management plans will be conducted opportunistically as no planned spill release is proposed. Spill events on the Peace system exceeding generation capacity of 70,000 cfs are rare, occurring only four times since 1968. Four additional spills events have occurred for other reasons during this period (BC Hydro 2003). These eight spills, in total, roughly equate to a spill occurring on average once every five years.

Two previous studies, in 1996 and 2002, have attempted to quantify entrainment. The 1996 study consisted of two components: (i) hydroacoustic assessment and (ii) mark-recapture study. The single beam hydroacoustic assessment quantified number of fish moving through the spillway (average of 15,000/day), location where most fish in the water column (<10m), and the time of day when entrainment was greatest (twilight and evening hours) (Ebel 1996). The hydroacoustic assessment occurred in the last five days of a spill that extended over a two-month period. As a result, the study did not collect sufficient data to estimate the relationship between discharge and numbers of fish entrained as initial stages of the spill were not assessed nor was a wide range of spill discharges observed during the study. Additionally, the single beam hydroacoustic equipment was unable to provide adequate information to categorize entrainment by size class. The assessment, however, determined that fish could escape entrainment at spill discharges below 40,000 cfs. The second part of the study, the mark-recapture component was designed to estimate the number of fish killed by the spillway operation. Estimation of entrainment mortality in the system was difficult as assumptions of the mark-recapture program could not be met and netting of fish was limited to the water surface. The 2002 entrainment study (BC Hydro 2002) focused efforts on a mark-recapture program similar to the 1996 study. This study provided estimates of mortality but no estimate of entrainment rate. In both the 1996 and 2002 studies, lake whitefish experienced the greatest mortality.

1.2 Management Questions

The key management questions are:

- 1) What is the magnitude of fish entrainment through the spillway during a spill event?
- 2) Is there a relationship between spill discharge rate and numbers of fish entrained through the spillway?
- 3) What species and sizes of fish are entrained through the spillway?
- 4) What rate of mortality is occurring in fish entrained through the spillway?

This first management question will be addressed in this study by estimating the number of fish entrained and acquiring information from other studies within the Peace Water Use Plan (WUP) (i.e., Williston Fish Index); however, no ecological hypothesis will be tested to address this question. The purpose of the second management question is to establish a relationship between spill discharge rate and numbers of fish entrained, which would then be useful for predicting the impact of future spills on fish in Williston Reservoir. Also important is to establish if certain species or size classes of fish appear to be more susceptible to entrainment. Lastly, determining the mortality rate will establish if large numbers of fish are suffering acute mortality when entrained or if fish survive to then inhabit the environment downstream of the dam.

1.3 Detailed Hypotheses about the Ecological Impacts

The primary hypotheses¹ to be tested are:

- H₁: There is a correlation between spill discharge rate and number of fish entrained over the spillway;
- H₂: The diel distribution of fish entrained through spillway is not uniform;
- H₃: Spatial distribution of fish entrained through spillway is not uniform in the water column;
- H₄: Acute mortality results in fish entrained through the spillway.

The first hypothesis will test for a correlation between spill discharge rate and the number of fish entrained. If possible, the hypothesis can be examined more specifically (i.e., by species, life stage, etc.) based on the level of information gathered. The latter two hypotheses were investigated in the 1996 study, so analysis of new data will be an opportunity to substantiate the previous finding. Based on these previous findings, fish are expected to have higher entrainment rates in the twilight and evening hours and be entrained within the first 10 metres of the water column.

1.4 Key Water Use Decision Affected

The key water use decisions affected by the results of the monitoring program are the revision of future spill strategies and the necessity of flood pulse events to maintain side channel and riparian habitat. In addition to the information from this monitoring program, other studies within the Peace Spill Protocol and the Peace

¹ For clarity, the hypotheses are stated as the alternate hypotheses. Analyses will test the null hypotheses of no effect or difference.

River Flood Pulse Plan will influence these water use decisions. These decisions have important implications for power generation and ecological values, including fish, wildlife, and vegetation diversity and abundance downstream of the Peace Canyon Dam.

2.0 MONITORING PROGRAM PROPOSAL

2.1 Objective and Scope

The objective of the monitoring program is to:

- 1) Estimate the number of fish, size, and species of fish entrained through the spillway into Dinosaur Reservoir
- 2) Determine the relationship between spill discharge rate and number of fish entrained through the spillway during spill releases at WAC Bennett Dam
- 3) Determine the level of correlation between diel/spatial variables (e.g., time of day, fish depth in water column) and number of fish entrained through the spillway during spill releases at WAC Bennett Dam
- 4) Estimate the rate of acute mortality in fish entrained through the spillway

Monitoring of fish entrainment will occur at the spillway of the WAC Bennett Dam during the entire period of a spill or some statistically representative period of time should there be time constraints. Results of the monitoring program will be used to determine the relationship between numbers of fish entrained and spill discharge, as well as diel and spatial variation. The rate of fish mortality will be estimated using a pilot study in the first spill event. In the event of a second spill within the 10-year study period, the pilot study would be expanded/modified accordingly based on the initial results. The study would be broadened to examine factors influencing mortality rate such as variation in spill discharge and fish species.

Implementation of this study is conditional on the opportunistic occurrence of a spill event where spill discharge (Q_{sdi}) > 7240 cfs (205 cms) at WAC Bennett Dam occurs for two days or longer. The study will be implemented for each spill event that meets this criterion.

2.2 Approach

Entrainment of fish will be monitored using a fixed station hydroacoustic system that will detect fish presence in the water column and differentiate fish size as they approach the spillway gates. Concurrent to the hydroacoustic assessment, a pilot study will assess acute mortality rate of entrained fish. This study will initially be limited in scope until the technology is proven to be successful. Combined, these assessment studies will address the concerns of the Committee.

An entrainment program, the BC Hydro Entrainment Strategy, is currently underway to assess entrainment at all BC Hydro facilities; this program is separate from the Water Use Plan program. However, if the BC Hydro Entrainment Strategy provides an alternative approach to quantifying the impact of fish entrainment that is suitable, then that approach should be considered for this WAC Bennett Dam Entrainment WUP study.

2.3 Methods

2.3.1 Task 1: Project Coordination

Project coordination will involve the general administrative and technical oversight of the monitoring program. 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 associated with the Peace Spill Protocol and the Peace River Flood Pulse Plan.

In particular, coordination will be necessary between this monitoring program and Williston Reservoir Fish Index.

2.3.2 Task 2: Field Sampling Program

Hydroacoustic Assessment

Hydroacoustic equipment will be installed at a date that is as close as possible to the start of the spill and maintained throughout the spill. If possible, installation will occur just prior to the start of a spill if there is a high degree of certainty of a spill.

The general approach will be to deploy split-beam transducers or a combination of single- and split-beam to estimate fish passage rates and estimate vertical and horizontal distribution of fish in spillbays. Transducer sampling volumes will be positioned to minimize ambiguity in fish passage routes and the potential for multiple detections of the same fish. As most fish were detected in the upper 10 m of the water column of the 1996 study, the transducer beam may be more effective in detecting fish than in the previous hydroacoustic assessment by using an upward-looking mount where the transducer is aimed towards the surface and having a larger sample volume (Ebel 1996). Equipment and data collection will be monitored remotely to ensure proper functioning.

During the on-site installation and equipment removal components of monitoring program, a survey (e.g. 3-4 transects) will be conducted in the immediate forebay near the spillbays using fish finder/hydroacoustic equipment to estimate the number of fish in the area.

Reservoir Sampling

Dinosaur Reservoir will be sampled to assess which fish species suffered injury/mortality as a result of the spill. The main purpose is to simply identify species and size of fish (length and weight) observed floating on the surface and not to necessarily determine the cause of mortality (e.g., gas bubble trauma in a fish entrained over spillway vs. gas bubble trauma in a resident fish of Dinosaur Reservoir). However, any evidence detected that indicates a fish was entrained will be recorded. A boat survey to collect fish will occur over two days and two nights during the spill but not necessarily consecutively. Previous surveying found the constriction downstream from Johnson Creek to the 500 kV power line at the edge of the canyon to be far enough out of the turbulence of the spill to collect fish.

Mortality Assessment

An experimental study will be implemented to assess the mortality rate of fish entrained through the spillway. The study will be implemented initially as a pilot study

with a limited scope until the initial results establish that the technology can successfully estimate mortality rate of fish entrained through spillway.

The scope of the mortality assessment will be limited to a maximum of two fish species and a single discharge rate. Adult lake whitefish and kokanee smolts may be good candidate species based on previous investigations that indicate they are entrained during spills (BC Hydro 1997; 2002). Fish collected directly from Williston Reservoir or obtained through other means will be implanted with radio tags or a similarly effective tool for assessing fish mortality. Three groups of fish will be tagged. Group 1 will be live fish tagged and released in tailrace area of the spillway (or as close as possible). Group 2 will consist of fish carcasses that are tagged and released into the spillway. Group 3 will consist of live fish that are tagged and released into the spillway. Each group should contain a minimum of 25 individuals. Group 3 fish will be classified as dead or alive based on spatial and temporal movement of Group 1 and 2.

Collection of mortality rate data is not exclusive to this method if an appropriate alternative cost-effective method is determined.

2.3.3 Task 3: Data Entry and Analysis

The proponent will enter, check, and store all data collected into Microsoft Access database. Data processing and a reduction process will take place to separate echograms to detect entrained fish from noise. Depending on the volume of data collected, sub-sampling may be required.

The analysis will examine the correlation between fish entrainment and spill discharge. Other factors will also be considered in explaining observations. Fish distribution in the water column will be analyzed in terms of vertical (within spillbays) and horizontal (among spillbays) distribution in the water column, as well as diel and temporal variation in fish entrainment. Using the data from the split-beam transducer, analysis will differentiate fish sizes and estimate size distribution of fish entrained. Speculation on species of fish impacted by entrainment will be possible using data collected from the reservoir sampling. Direct estimates of mortality rate, and possibly total mortality, at a given discharge rate will be calculated for each fish species tested in the mortality assessment.

2.3.4 Task 4: Reporting

Following the conclusion of the spill a summary report will be prepared outlining the following:

- a) an executive summary of the annual report;
- b) field methods, including diagrams and photos of installation techniques and setup;
- c) environmental data collected, presented in tabular and graphical form;
- d) biological data from the study sites and control sites summarized in tabular and graphical form;
- e) description of results as well as the analytical methods, known biases, and assumptions used;
- f) an assessment of the findings as they relate to the management questions and hypotheses;
- g) summary of data gaps and recommendations for improving future studies.

A report will be provided in hard-copy and as Microsoft Word and Adobe Acrobat (*.pdf) format. The required maps and figures will be included as embedded objects in the report. All maps and figures will also be provided in their native format as separate files. Raw data will be submitted in a Microsoft Access database. All photos will be submitted electronically.

2.4 Interpretation of Monitoring Program Results

The information from the study will contribute to the overall assessment of environmental response to spills. If the hydroacoustic assessment and mortality assessment indicate that large numbers of fish are suffering acute mortality from entrainment then this will suggest a need to assess spill strategies and mitigate the negative impacts on reservoir fish. Additionally, if this study in combination with Williston Reservoir Fish index suggests that the relative impact to upstream populations is substantial then this will further support the need to assess spill strategies. Establishing a correlative relationship between spill discharge rate (or environmental variable such time of day) and number of fish entrained will assist in the development of spill strategies to mitigate the negative impacts.

2.5 Schedule

The WAC Bennett Dam Entrainment study is conditional on a spill event occurring at WAC Bennett Dam where $Q_{sdi} > 7240$ cfs (or 205 cms) for two days or longer. Hydroacoustic equipment will be installed at a date that is as close as possible to the start of the spill. The pilot study to assess mortality will occur over a 2-3 day period during the spill.

2.6 Budget

The estimated cost of the study for each spill is \$234,691 assuming that the spill occurs over a one-month period. However, the budget will be subject to adjustment based on the actual length of data collection during the spill. Table 4-1 summarizes the budget estimated in 2007 dollars.

Table 4-1 Estimated costs for the WAC Bennett Dam Entrainment study

Sub-total		\$198,475
Inflation	2%	\$25,040
Contingency	5%	\$11,176
Total		\$234,691

2.7 References

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