Spillimacheen Project Water Use Plan

Monitoring of Habitat Maintenance Flow within Spillimacheen Canyon

Reference: SPNMON#2

*Monitoring of Habitat Maintenance Flows within the Canyon Channel between the Dam and the Powerhouse*

Study Period: 2008

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June 30, 2008
Spillimacheen Dam Monitoring of Canyon Habitat Maintenance Flows

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TECHNICAL MEMORANDUM
June 30, 2008

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R.E. Spillimacheen Dam Monitoring Program No. SPN-2 – Monitoring of Habitat Maintenance Flows within the Canyon Channel between the Dam and the Powerhouse

Monitoring Program Objectives

The objective of this project is to confirm the effectiveness of the current minimum flow (0.85 m³/s) from the gated undersluice for prevention of unacceptable freeze-up of pool refuge habitat and maintain habitat connectivity for overwintering fish in the canyon between the dam and powerhouse.

The primary management hypotheses to be tested by the monitoring program are:

H₀: The current minimum flow from leakage and the gated undersluice of Spillimacheen Dam of 0.85 m³/s is adequate to maintain flow connectivity and prevent ice build up within the canyon.

H₁: A higher minimal flow release is required to maintain flow connectivity and prevent ice build up within the canyon.

Background

Originally, in 2006, this project was advertised for invitation to tender. At that time, Westslope Fisheries Ltd. advised BC Hydro technical specialists that we would not be participating in the proposal process due to concerns for; 1) occupational safety, 2) in situ sampling expectations that could not, in our opinion, be completed in an effective or scientifically defensible manner,
and 3) budget short-comings. These concerns for proposed Water Use Planning (WUP) monitoring in the canyon environment were previously articulated to BC Hydro by both Westslope Fisheries Ltd. and the Canadian Columbia River Inter-Tribal Fisheries Commission; through previous work we had conducted in this environment.

The study design and Terms of Reference (TOR) were initially conceived during the Water Use Planning (WUP) process. During that period Mr. Cope participated as a technical advisor to the Fisheries Technical Committee for East Kootenay Generating Facilities (Aberfeldie, Elko, Spillimacheen). Initially, sampling was conducted in the canyons of these facilities during the late summer and fall periods. Although there were significant safety challenges accessing the canyon reaches, the sampling was conducted with safety and the precautionary principle (i.e. in regards to occupational safety) as the primary tenants of the project. It was felt that the initial sampling could be replicated and would provide value to ensuring minimal flows were adequate to protect aquatic resources within the canyon environment between the dam and the powerhouse (Bisset and Cope 2003).

Subsequently, the WUP Fisheries Technical Committee felt that severe cold periods (e.g. 5 days with daily maximum air temperatures of below –10 °C) might limit leakage flows and compromise minimum flow volumes that could result in anchor ice formation and potentially isolate and kill resident fish. A winter sample session was subsequently completed in the Bull and Elk River canyons in 2003 (Cope 2003). While the sampling was completed successfully (Cope 2003), there were serious concerns for worker safety. This sampling was completed in late November and there was very little snow cover or ice build-up at that time.

Subsequent canyon sampling during the Aberfeldie Redevelopment Project in 2004 and 2005 re-enforced our reluctance to work under these conditions and in this winter environment (Cope 2005). On January 5, 2005, to achieve sampling during a daily maximum temperature of no more than –10 °C, we were working in the water in temperatures of –29 to –14 °C. This caused serious worker discomfort and safety concerns, as sampling requires an individual to establish transects and work within the stream channel. Climbing back out of the canyon under these conditions was extremely difficult and staff expressed “never again” sentiments. Falls and spills resulted in damaged equipment and bruises but no serious injuries. It was recognized that a two-person crew would be incapable of self-rescue if something went wrong.

The 2005 sampling was conducted later in the winter, under colder conditions than previously attempted. Serious technical issues were identified that limited the validity of the data collection procedures under these conditions. During this sampling, it was recognized that the weather
patterns of the East Kootenay result in an alternating pattern of freezing and thawing. This results in layer after layer of ice forming in shallow water habitats with air pockets and slush layers in between ice layers. In some places the ice can be over 2 m thick. In deeper water, the rising and falling water levels result in unstable ice formations and thin ice. These ice formations are unsafe to walk on and severely limit our ability to access the river and collect meaningful data. In addition, frazil ice jams meters and calibration is almost impossible. Reliable discharge estimates are difficult as there is no way of knowing how much water flows under and between ice layers. In addition, almost invariably, frazil ice clogs the penstock intake and often results in additional spill as the system backs up and flow is forced over the spillway. As a result, the minimum flow measurements are often not representative, and additional spill compromises worker safety within the canyon environment.

Notwithstanding this challenging history of winter sampling, Westslope Fisheries Ltd., and in particular, Mr. Scott Cope, was commissioned to work with BC Hydro to develop a winter canyon flow monitoring program that addressed the intent of the monitoring program while ensuring occupational safety.

The following summarizes the study design, results to date, sampling challenges, and provides recommendations for future monitoring and potential improvements to occupational safety.

**Study Design**

The study design was based on the BC Hydro Monitoring Program ToR and every effort was made to ensure methods were consistent with the intent of this document.

*Air Temperature and Discharge Monitoring (e.g. implementation trigger)*

The budget is not sufficient to deploy site-specific air temperature monitoring equipment. Such equipment requires remote download capabilities (e.g. satellite link-up). Alternatively, we monitored the Invermere Airport and Environment Canada forecast data via the Internet. It was felt this regional and district data would suffice to capture the intent of the 5 days with air temperatures less than –10 °C. The following were monitored for the weather trigger:

- 5-day forecast for Golden Airport; supplemented by daily forecasts for the Columbia Districts of B.C. (East Columbia); and
- Daily maximum air temperature reported for Invermere Airport by soartherockies.com.
Spillimacheen Dam Monitoring of Canyon Habitat Maintenance Flows

Discharge Monitoring, Water Temperature and Assessment of Anchor Ice Development

Index stations (n=3) and access routes were pre-selected in the canyon reach in the late fall to verify minimum flow discharges, water temperatures and dissolved oxygen levels. These sites correspond to the previous sampling sites (Bisset and Cope 2003) selected in consultation with a swiftwater rescue safety consultant. At each site the following was attempted;

- A permanent cross-sectional transect for discharge estimation was established. Discharge was estimated using a Price AA meter calibrated by Environment Canada and standard hydrometric techniques. Discharge was to be estimated during site selection and at three subsequent site visits during winter conditions (e.g. 5 days with air temperatures less than –10 °C).

- An Onset Hobo Temp thermistor was installed on-site. Temperature was recorded every 15 minutes and the hourly mean logged. Thermistors would be downloaded at each subsequent site visit during winter conditions.

- Sites for anchor ice monitoring were pre-selected and established such that ice monitoring could be completed in a safe and controlled manner. At each site in a riffle and a pool type habitat sample locations were chosen such that holes could be drilled and equipment lowered into the river where personnel could be safely secured via rope tethers and fall protection harnesses on solid rock outcrops, river margins, or over known shallow water habitat.

- Background dissolved oxygen levels were measured at anchor ice monitoring sites.

- An automated “spy” or “trail” camera was deployed to take a photograph of the river conditions at 13:00 each day. The camera was retrieved in spring and the photos downloaded.

- Index sites (e.g. riffle and pool margin) were measured for ice thickness.

- Spot measurements of dissolved oxygen were taken and profiling completed in a deep pool (margin site).

- At locations where holes are bored for measuring ice thickness and for dissolved oxygen and temperature profiling, a digital camera will be lowered at various depths. Still photos and video clips will be collected for documentation purposes.

Site Access and Safety Considerations
Pre-determined routes and sample site selection were to be completed immediately before the onset of winter conditions (November). Site access requires traversing upland areas and descending into the river canyon. Potential for slips, trips and dangerous falls were identified and, if possible, roped off. Potential for falling rock from above is also a concern in several locations. An access plan has been developed that seeks to minimize worker risk. Workers accessing these sites require fall protection harnesses with shock absorbing lanyards and 5/8” trailing rope grab and hardhats. A three-person crew was implemented to ensure self-rescue was a possibility. Work on ice was limited to shallow water habitat (e.g. less than 1.5 m deep).

Results

On November 29-30, 2007 the Spillimacheen Canyon sites were selected, temperature loggers and cameras were deployed, discharge verified, and anchor ice methods were tested and evaluated. For context, Photo 1 illustrates the working conditions collecting discharge measurements at –22 °C in the Spillimacheen River November 30, 2007.

On November 30 at 11:00 discharge was estimated to be 2.84 m³/s at the upper site. This was much higher than the expected 0.85 m³/s, but was consistent with visual estimates of between 1 – 3 m³/s made at the time. Access into the water at the lower and middle canyon sites were not attempted due to safety concerns (Photo 2 and 3).

Table 1 summarizes the water temperatures, dissolved oxygen, ice thickness and environmental conditions during the initial verification sample session. Unstable ice conditions, ice dams with overflow and steep canyon walls severely limited worker access to the river channel. The middle canyon location could not be reached and the site was abandoned (Photo 4). Anchor ice was observed at most boulder steps and slush or frazil ice was several feet thick under the ice in pool habitat. It was considered likely that anchor ice was restricting habitat connectivity in some areas. Underwater video clips of margin habitat anchor ice have been included on CD ROM. Due to unsafe ice conditions, anchor ice assessment in pool habitat was not possible except along the shallow margin habitat.

The digital time lapse cameras were set to record a digital photo daily at 13:00 MT. These digital photographs have been archived and provided on the attached CD ROM. Of the three cameras installed in the canyon, only the lower canyon functioned without incident. The middle logger recorded text but the photo was black. The lack of a weather trigger resulted in this error not being discovered until the termination of the monitoring project in April, 2008. The upper camera appeared to fall over due to the snow weight on March 12, 2008. Photo 5 illustrates the snow
and ice conditions in late January following 5 days of cold weather. This photograph clearly illustrates the challenges in estimating discharge using proposed wading methods.

Table 1. Data summary for Spillimacheen Canyon sites during site selection and equipment deployment November 29-30, 2007.

<table>
<thead>
<tr>
<th></th>
<th>Upper Canyon</th>
<th>Lower Canyon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Max. Air Temp. (ºC)(^1)</td>
<td>1.4 to – 4.5</td>
<td>1.4 to – 4.5</td>
</tr>
<tr>
<td>Daily Min. Air Temp. (ºC)(^1)</td>
<td>-6.8 to – 13.4</td>
<td>-6.8 to – 13.4</td>
</tr>
<tr>
<td>Water Temp. (ºC)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>DO (mg/l)</td>
<td>11.9</td>
<td>12.5</td>
</tr>
<tr>
<td>Pool Ice Cover (%)</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Riffle Ice Cover (%)</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Anchor Ice (%)</td>
<td>50(^a)</td>
<td>20(^a)</td>
</tr>
<tr>
<td>Surface Ice thickness (cm)</td>
<td>20.2</td>
<td>15.2</td>
</tr>
</tbody>
</table>

\(^1\) Note – range reported for 5 days previous.

\(^a\) Note – anchor ice and frazil ice forming layers and ice dams that result in flow on top of ice.

All three temperature loggers installed in the canyon, were retrieved and have been archived and data provided on attached CD ROM. Visual examination of the data noted the water temperature for both the middle and lower sites were less than 0 ºC (e.g. –0.004) suggesting anchor ice. This was consistent with observed site conditions during installation and attempted retrieval in April. The upper thermister was placed at the undersluice gate and there was no anchor ice. Water temperature varied between 0.0 and 1.0 ºC from November 30, 2007 to April 1, 2008.

There was no weather trigger observed for the Invermere Airport (e.g. 5 days with daily maximum temperatures less than –10 ºC) during the Nov 27, 2007 to April 01, 2008 sample period. Upon review of the camera log, there did appear to be a weather trigger during the 5 days January 20 to 25, 2008 (e.g. Air temperature at 13:00 was between –15 ºC and –20 ºC.)
This discrepancy in air temperature was considered plausible as the Spillimacheen canyon is located on the shady west facing side of the Columbia Valley, and the camera was perpetually in the shade; while the Invermere Airport is located on a bench on the sunny east side of the Columbia Valley with a south facing aspect. The mean temperature for the period December 01, 2007 to February 29, 2008 were −0.37 °C and −5.67 °C for the Invermere Airport and the upper Spillimacheen camera, respectively. As the camera thermometer accuracy and precision were not known, a calibration test was conducted in a meat freezer. The camera and an Onset Tidbit thermistor were both placed in a freezer for 72 hours and the temperatures were compared. The camera recorded air temperatures −2.8 °C colder than the thermistor of known accuracy and precision. The camera temperature data was corrected using this value. Figure 1 illustrates the temperature data for the camera at 13:00 in the upper Spillimacheen canyon site and the daily maximum reported for the Invermere Airport.

![Graph showing temperature data](image)

**Figure 1.** Daily maximum air temperature reported for Invermere airport and the air temperature reported at 13:00 by the upper Spillimacheen Canyon camera. Note that the camera data has been calibrated and a correction factor of +2.8 °C applied.

**Summary**
During the initial site selection and project start-up, the discharge due to leakage and the under sluice gate was 2.84 m$^3$/s. This is over 300% above the required minimum flow. Based on the time lapse photography and the April 2, 2008 site visit, it was felt that subsequent discharge estimation under late winter snow and ice conditions would not be possible; especially during the cold weather trigger.

Anchor ice and habitat isolation were identified as a potential concern, even at the high discharge value observed (2.84 m$^3$/s).

The middle canyon site could not be accessed due to ice conditions and safety concerns.

Digital time lapse photography could be utilized to safely document canyon minimum flows and anchor ice conditions in a qualitative manner. Overview photos illustrate ice conditions, and if verified by observations during a weather trigger could provide some confidence in forming a biological opinion. Placing cameras down in the canyon for close-up photographs is not recommended for safety reasons and due to the probability of equipment damage and loss.

Ice conditions within the canyon are unsafe due to variable flow regimes. Self-rescue will be extremely difficult and under the proposed cold weather conditions and the ability of workers to get back out of the canyon once they have gotten wet and cold could be very dangerous.

**Recommendations**

It appears that the location and aspect of the Spillimacheen Canyon are colder than the Invermere Airport weather station and a cold weather trigger on January 20-25, 2008 was missed.

Confirmation of minimum flow requirements during a cold weather trigger is unlikely using spot measurements and cross-channel transect methods. Ice cover, unstable footing and occupational safety concerns will severely limit the accuracy of the data and the ability to complete the task after the cold weather trigger. We recommend that standard WSC methods be employed to develop a rating curve for this site. Subsequently, river stage data can be collected remotely and utilized to compute discharge. Calibration of the rating curve can be completed during appropriate weather windows. This recommendation will require several years and significant budget increases. Alternatively, it may be possible to estimate discharge using a portable walkway and ice auger.

Recognizing that worker safety is of paramount importance to BC Hydro, we recommend the abandonment of sending personnel into the Spillimacheen canyon under winter conditions, or
the addition of personnel with a higher level of rescue expertise (e.g. a 3 person search and rescue rope extraction team). Any habitat and anchor ice assessments should be done from safe vantage points above the canyon. Accessing the canyon during the proposed weather trigger is inherently risky and once in the canyon the ice conditions are unsafe and under no circumstances should anybody be permitted to walk on the ice. The canyon ice is formed in layers of ice and slush and the rising and falling river levels result in unstable and unpredictable ice formations. The river current further compromises ice safety.

Occupational safety concerns prohibit the collection of dissolved oxygen profiles or the drilling of holes to assess anchor ice formation in pool habitat. Spot measurements in shallow margin habitat do not meet the intent of the TOR and should be abandoned.

There has been some discussion of bundling the Aberfeldie canyon monitoring into the current project. This will not be feasible due to logistical constraints and Westslope Fisheries Ltd. resources. This would require 5 days of the cold weather trigger plus 2 days of further cold weather for each canyon (e.g. 6 days) for a total of 11 days of weather below the temperature threshold.

Westslope Fisheries Ltd. is not prepared to send any crew member into this environment unless under the direct supervision of Scott Cope. Mr. Cope’s knowledge of the sites and the pre-selected access routes and safe working conditions are required to ensure worker safety. This means Mr. Cope is required to be on call for three years through the winter season. Mr. Cope will not be available for annual holidays. This is scheduled for November 27 to December 17, 2008.

Please call if you have any questions or if I can be of any further assistance.

Yours truly;

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Photo 1. Illustration of discharge data collection procedures and conditions (Spillimacheen River November 30, 2007; air temperature –22°C).

Photo 2. Lower Spillimacheen canyon outlet illustrating ice conditions and water volumes November 29, 2007.
Photo 3. Middle canyon illustrating ice conditions and water volumes November 29, 2007.

Photo 4. Middle canyon illustrating anchor ice, frazil ice and overflow conditions November 29, 2007.
Photo 5. Upper Canyon following 5 days of daily highs less than –10 °C on January 25, 2008 illustrating snow and ice conditions and the challenges in discharge estimation by proposed wading methods.