Cheakamus Project Water Use Plan

Monitoring Groundwater in Sidechannels of the Cheakamus River (Year 1)

Reference: CMSMON-6

*Monitoring Groundwater in Sidechannels of the Cheakamus River – Year One Summary Report*

Study Period: January 2008 – January 2009

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Executive Summary

This report provides a summary of the work completed on the Cheakamus Groundwater Monitoring project from January 2008 to January 2009, and the data collected to date. Since the bulk of the data analysis will be conducted at the end of Year Three, this summary contains minimal interpretation and discussion, focusing on data quality and sufficiency of the monitoring system itself. The Year Three report will contain a detailed analysis of the data collected and a discussion of the consequences of the results.

Pottinger Gaherty Environmental Consultants, in cooperation with SRK Consulting (Canada) Inc., has been conducting a groundwater monitoring program in side channels of the Cheakamus River near North Vancouver Outdoor School. This work is part of the monitoring related to the Water Use Plan for the Cheakamus River. This report summarizes the work completed during Year One of the three-year monitoring program.

Eighteen locations are currently being monitored for parameters such as water level, temperature, pH, dissolved oxygen and stream discharge. These include four surface water monitoring locations, six regional groundwater wells, and eight shallow/deep pairs of groundwater piezometers. Eleven locations have data loggers which record water level and temperature every 15 minutes. Dissolved oxygen (DO) and pH are measured during bi-monthly site visits, along with stream discharge and water levels at those sites which do not have loggers.

Analysis of data from Year One of the monitoring program indicates that data collection is functioning as required. Suggestions for Year Two include adjusting the program to collect more groundwater data from the BC Rail Channel, where Instream Consultants have indicated that the fisheries data is of higher quality relative to some of the currently instrumented side channels at the North Vancouver Outdoor School.
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### List of Acronyms

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>dissolved oxygen</td>
</tr>
<tr>
<td>NVOS</td>
<td>North Vancouver Outdoor School</td>
</tr>
<tr>
<td>PGL</td>
<td>Pottinger Gaherty Environmental Consultants Ltd.</td>
</tr>
<tr>
<td>WUP</td>
<td>Water Use Plan</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION

This report provides a summary of the work completed on the Cheakamus Groundwater Monitoring project from January 2008 to January 2009, and the data collected to date. Since the bulk of the data analysis will be conducted at the end of Year Three, this summary contains minimal interpretation and discussion, focusing on data quality and sufficiency of the monitoring system itself. The Year Three report will contain a detailed analysis of the data collected and a discussion of the consequences of the results.

As part of the Cheakamus River Water Use Plan (WUP), monitoring of groundwater in side channels has been conducted by Pottinger Gaherty Environmental Consultants Ltd. (PGL), in cooperation with SRK Consulting (Canada) Inc., since January 2008. The purpose of the monitoring program is to determine the relationship between flows in the Cheakamus River mainstem and groundwater-fed side channels in the vicinity of the North Vancouver Outdoor School (NVOS). This relationship is being explored as part of a larger program to determine the potential effects of the WUP flow regime on salmonid production in these side channels.

2.0 EXISTING DATA

Extensive work has already been completed on site prior to the start of this monitoring program, by Quinn Jordan-Knox of Simon Fraser University as part of his M.Sc. thesis. The subject of his thesis was interactions between groundwater and surface water at the NVOS. Pertinent data collected as part of Mr. Jordan-Knox’s thesis, in addition to valuable interpretation of the hydrogeologic conceptual model, includes:

- More than 12 months of monthly water level and temperature data from a network of 72 piezometers; and
- Water quality from surface water and groundwater monitoring points including dissolved metals and field parameters (e.g., pH, dissolved oxygen (DO), Alkalinity).

These data will be compared with project data as part of the Year Three detailed analysis.

BC Hydro has supplied data relating to flow releases from the Daisy Lake Dam, and flow data from the flow gauge on the Cheakamus River at Brackendale (8GA043) operated by the Water Survey of Canada. These data will be incorporated into all appropriate data graphics.

3.0 MONITORING LOCATIONS

Eighteen locations are monitored as listed in Table 1. A map of the locations is shown in Figure 1.
### Table 1: Monitoring Locations for Cheakamus Groundwater Project

<table>
<thead>
<tr>
<th>Code</th>
<th>Date Installed</th>
<th>Description</th>
<th>Data Collection</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGCH</td>
<td>January 2008</td>
<td>Cheakamus River Staff Gauge</td>
<td>Water level/temperature logger, surface water pH/DO every 2 months</td>
<td>North end of Paradise Valley Road bridge</td>
</tr>
<tr>
<td>SGBCR</td>
<td>January 2008</td>
<td>BC Rail Channel Staff Gauge</td>
<td>Water level/temperature logger, discharge and surface water pH/DO every 2 months</td>
<td>100mm diameter PVC stilling well</td>
</tr>
<tr>
<td>SGUP</td>
<td>January 2008</td>
<td>Upper Paradise Channel Staff Gauge</td>
<td>Water level/temperature logger, discharge and surface water pH/DO every 2 months</td>
<td>100mm diameter PVC stilling well</td>
</tr>
<tr>
<td>SGKIS</td>
<td>January 2008</td>
<td>Kisutch Channel Staff Gauge</td>
<td>Water level/temperature logger, discharge and surface water pH/DO every 2 months</td>
<td>100mm diameter PVC stilling well</td>
</tr>
<tr>
<td>D11/D12</td>
<td>Existing</td>
<td>Shallow/deep well pair in Paradise Channel</td>
<td>Water level/temperature loggers, groundwater pH/DO every 2 months</td>
<td>19mm diameter steel drive-point piezometers</td>
</tr>
<tr>
<td>D21/D22</td>
<td>Existing</td>
<td>Shallow/deep well pair in Upper Paradise Channel</td>
<td>Manual water levels every 2 months</td>
<td>19mm diameter steel drive-point piezometers</td>
</tr>
<tr>
<td>D23/D24</td>
<td>Existing</td>
<td>Shallow/deep well pair in Upper Paradise Channel</td>
<td>Water level/temperature loggers, groundwater pH/DO every 2 months</td>
<td>19mm diameter steel drive-point piezometers</td>
</tr>
<tr>
<td>D27/D28</td>
<td>Existing</td>
<td>Shallow/deep well pair in Upper Paradise Channel</td>
<td>Manual water levels every 2 months</td>
<td>19mm diameter steel drive-point piezometers</td>
</tr>
<tr>
<td>D39/D40</td>
<td>Existing</td>
<td>Shallow/deep well pair in Kisutch Channel</td>
<td>Manual water levels every 2 months</td>
<td>19mm diameter steel drive-point piezometers</td>
</tr>
<tr>
<td>D45/D46</td>
<td>Existing</td>
<td>Shallow/deep well pair in Kisutch Channel</td>
<td>Water level/temperature loggers, groundwater pH/DO every 2 months</td>
<td>19mm diameter steel drive-point piezometers</td>
</tr>
<tr>
<td>D50/D51</td>
<td>January 2008</td>
<td>Shallow/deep well pair in Kisutch Channel</td>
<td>Water level/temperature loggers, groundwater pH/DO every 2 months</td>
<td>19mm diameter stainless steel drive-point piezometers</td>
</tr>
<tr>
<td>Code</td>
<td>Date Installed</td>
<td>Description</td>
<td>Data Collection</td>
<td>Notes</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>-------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>D52/D53</td>
<td>January 2008</td>
<td>Shallow/deep well in BC Rail Channel</td>
<td>Water level/temperature loggers, groundwater pH/DO every 2 months</td>
<td>19mm diameter stainless steel drive-point piezometers</td>
</tr>
<tr>
<td>TEND</td>
<td>Existing</td>
<td>Regional well at Tenderfoot Creek Hatchery</td>
<td>Water level/temperature logger, groundwater pH/DO every 2 months</td>
<td>Large (approx 250mm diameter) steel well</td>
</tr>
<tr>
<td>R4</td>
<td>Existing</td>
<td>Regional well located near North Vancouver Outdoor School buildings</td>
<td>Manual water level every 2 months</td>
<td>19mm diameter steel drive-point piezometer</td>
</tr>
<tr>
<td>R8</td>
<td>Existing</td>
<td>Regional well north of Paradise Channel</td>
<td>Manual water level every 2 months</td>
<td>19mm diameter steel drive-point piezometer</td>
</tr>
<tr>
<td>R13</td>
<td>Existing</td>
<td>Regional well</td>
<td>Manual water level every 2 months</td>
<td>19mm diameter steel drive-point piezometer</td>
</tr>
<tr>
<td>R24</td>
<td>Existing</td>
<td>Regional well</td>
<td>Manual water level every 2 months</td>
<td>19mm diameter steel drive-point piezometer</td>
</tr>
<tr>
<td>RBCH</td>
<td>January 2008</td>
<td>Regional well near BC Hydro tower</td>
<td>Water level/temperature logger, groundwater pH/DO every 2 months</td>
<td>100mm diameter PVC well</td>
</tr>
<tr>
<td>BARO1/2</td>
<td>January 2008</td>
<td>Barometric loggers located at North Vancouver Outdoor School</td>
<td>Barometric pressure used to correct water level logger readings from wells</td>
<td>Loggers stored in Fire Shed near Main Building</td>
</tr>
</tbody>
</table>
4.0 SUMMARY OF FIELDWORK COMPLETED

Fieldwork was completed at the site at bi-monthly intervals to check proper operation of the installations and instrumentation, download data from the loggers, and take water quality and flow measurements at a variety of discharges and stage levels.

Fieldwork, including installation of monitoring stations, was completed on the following dates:

- January 8, 2008;
- January 17, 2008;
- January 21, 2008;
- March 13, 2008;
- May 27, 2008;
- July 22, 2008;
- September 30, 2008;
- December 2, 2008; and

5.0 FIELDWORK METHODS

Four new drive-point wells were installed in January 2008. The existing 16 piezometers onsite were filled with sediment during the flood event in 2003, and required purging to be usable for this study. These piezometers were purged to allow their use in this project, while the remaining wells remain unusable in their present condition. Solinst Levelogger data loggers were installed in the study wells. Table 1 above lists all the study wells.

On each subsequent visit, a manual water level reading was taken using a Solinst water level tape in each well prior to removal of the data logging transducer. Where applicable, data was downloaded from loggers, and wells were purged to stabilize water chemistry for measurement of pH, temperature and dissolved oxygen. A peristaltic pump was used in the smaller wells, and a submersible pump used in the larger wells (Tenderfoot Hatchery and RBCH). Barometric data was downloaded from the loggers at the North Vancouver Outdoor School.

At each of the staff gauges in the side channels, water levels were recorded, data loggers downloaded, flow transects taken using a Swofler flow meter, and water quality parameters measured and recorded using a WTW Oxi 330i meter (dissolved oxygen) and a WTW pH 320 meter. Flow transects were not taken at the SGCH stations as the primary purpose of this station is to provide stage data for the Cheakamus River, upstream of the NVOS side-channel system.

6.0 SUMMARY OF DATA COLLECTED

After each site visit, well water level data was backed up by PGL and transferred to SRK Consulting for processing. Dissolved oxygen and pH levels were recorded by PGL in a Microsoft Excel spreadsheet, and discharge measurements were calculated from the flow transect data using the velocity-area method.
6.1 Water Level, Temperature and Water Quality Measurements

Summary graphs showing water level and temperature as recorded by the data loggers, and water quality parameters (pH and dissolved oxygen) as measured during each site visit are presented in Appendix 1. The data are grouped into surface water sites, regional groundwater sites, and sites in the three named channels.

6.2 Discharge Measurements

Table 2 below is a summary of stage measurements and calculated discharges from the gauges in the BC Rail, Upper Paradise, and Kisutch channels. As further measurements are taken in Year Two of the project, rating curves will be developed for each of the sites. These will allow the water level measurements from the data loggers to be converted into discharge values.

7.0 DATA QUALITY AND SCREENING ANALYSIS

Full analysis and discussion of the collected data will be presented in the Year Three report, and the commentary below is primarily intended to demonstrate that overall, the data collection objectives are being met. Suggestions for refining the study during Year Two are also presented.

7.1 Water Level, Temperature and Water Quality Measurements

The sum of data collected so far suggests that changes in water levels are dampened when compared to river changes. Groundwater levels at all monitoring stations show relatively low magnitude changes in relation to changes in the level of the Cheakamus River, as measured at the staff gauge. Temperature data indicate variable time lags between peak river temperatures and channel temperatures, with shorter time lags for the surface water temperatures compared to the groundwater temperatures.

For water level data, quality control is provided by a systematic process of data checks incorporating manual water level measurements collected prior to removing the logger for download. Each time the data is processed, the previous record is matched to the new manual water levels as an assessment of drift. If necessary, the raw water level data are shifted to match up the records. So far only minor adjustments have been required, and these are tracked in a spreadsheet. The most likely explanations for the adjustments are subtle changes in the depth of the loggers, random error, or error in the manual water level measurements. For records that cannot be matched without shifting data by more than the manual measurements suggest is reasonable, the temperature data are checked. Two loggers (D24 and D50) are showing some temperature drift, which is resulting in an offset trend. Data from the adjacent loggers (D23 or D51) have been used to correct these variations. If necessary, these loggers will be further checked and replaced.

Specific “events” indicated by significant abnormal water level variations are compared with the surrounding data for verification, and if appropriate, levels are adjusted. If the event is of a short time interval and the subsequent data appear reasonable, no change is made.

Overall the water level record is considered reasonable when compared to the low amplitude of water level changes for the drive-points.
Table 2: Stage Measurements and Calculated Discharges at Cheakamus Groundwater Monitoring Sites

<table>
<thead>
<tr>
<th>Date</th>
<th>BC Rail Channel</th>
<th>Upper Paradise Channel</th>
<th>Kisutch Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stage (m)</td>
<td>Discharge (m³/s)</td>
<td>Average Velocity (m/s)</td>
</tr>
<tr>
<td>13 Mar 08</td>
<td>0.298</td>
<td>0.045</td>
<td>0.043</td>
</tr>
<tr>
<td>27 May 08</td>
<td>0.362</td>
<td>0.169</td>
<td>0.125</td>
</tr>
<tr>
<td>22 Jul 08</td>
<td>0.295</td>
<td>0.046</td>
<td>0.042</td>
</tr>
<tr>
<td>30 Sep 08</td>
<td>0.276</td>
<td>0.010</td>
<td>0.007</td>
</tr>
<tr>
<td>2 Dec 08</td>
<td>0.289</td>
<td>0.066</td>
<td>0.257</td>
</tr>
<tr>
<td>20 Jan 09</td>
<td>0.286</td>
<td>0.033</td>
<td>0.031</td>
</tr>
</tbody>
</table>
7.2 Discharge Measurements

Inherent difficulties exist in measuring low, shallow flows in relatively wide channels, where flow can be greatly affected by objects in the stream such as woody debris. Low channel gradients result in low flow velocities. As such, the margin of error when conducting discharge measurements can be high in such conditions. The measurement threshold of the Swoffer flow meter is approximately 0.01–0.02m/s, and measured velocities were often around this threshold. As a result, the discharge measurements are likely to be much less accurate than the stage measurements, particularly at low flow.

The variation in stage at each of the measuring sites, as recorded on discharge measurement visits, has been less than 10cm between high and low flow. Measured discharge generally corresponds with stage as shown in Graphs 7a (Upper Paradise Channel), 7b (Kisutch Channel) and 7c (BC Rail Channel) (Appendix 1). The small number of data points makes it difficult to generate reliable rating curves at this time, and the additional points collected during Year Two will help to define the stage-discharge relationship further.

One potential outlier can be seen in the data from Kisutch Channel, but this may be the result of a measurement being taken off the routine cross-section line. The Kisutch Channel staff gauge is located in an area with very low flow velocities, and measurements are typically taken a few metres downstream where the channel becomes more confined and there is more visible flow. The potential outlier may represent a measurement taken closer to the staff gauge, and thus may underestimate flow, due to velocities being closer to the measurement threshold.

7.3 Fisheries Data

As requested by BC Hydro, PGL has discussed the program and related aspects of their work with Instream, who are responsible for the parallel fish studies. As with work under this contract, Instream’s Year One report does not include detailed interpretation. Our discussions with them have focused on identifying opportunities to mutually support each other’s work.

8.0 YEAR TWO PLAN AND RECOMMENDATIONS

PGL’s work program calls for installation of continuous DO/pH data loggers in five locations for a three-month period in Year Two of the program. Based on discussions with Caroline Melville of Instream, we concluded that the November to January period was the most appropriate for collection of water quality parameters to correlate to spawning and incubation life stages for chum and coho in the side channels.

In addition to identifying a suitable time period for continuous DO/pH measurement, our discussion with Instream also revealed that the most robust biological data is being gathered (in order of data quality) in the BC Rail Channel, the Kisutch Channel, and at a distant third the Upper Paradise channel. As shown in Figure 1, the BC Rail Channel is the only one of the three monitored side channels that does not have a monitoring location at the downstream end of the channel. As a result, we recommend that BC Hydro consider adjusting the side channel monitoring program to include a station at the downstream end of the BC Rail Channel near the confluence with the Cheakamus. Due to budgetary constraints, to instrument a new monitoring station would require transferring one or two data logging transducers from the D11/12 or D23/24 well pairs in the Upper Paradise Channel to a new drive-point well or pair in the BC Rail Channel. Based on 2008 data, we expect that this can be done with a minimal loss of data resolution in the Upper Paradise Channel, which:
• has the lowest resolution biological data, per Instream;
• displays the lowest head difference between well pairs; and
• has two well pairs (D11/12 and D23/24) in close proximity.

While we do not believe that the installation of one or two new drive-point wells would incur significant costs, if you decide to go ahead with this adjustment we would review the cost in more detail within the context of the existing budget.

An additional dataset we discussed with Instream is daily manual DO measurements February to May. Instream is onsite daily during this period and offered to collect DO readings in side channels of interest daily if we coordinated rental and calibration of the appropriate instrument. Based on our discussion to date and the stated objectives of the monitoring program, this would be valuable data to collect during the emergence and outmigration stage. This work would take place at the end of Year Two and the start of Year Three.

The work program also calls for water chemistry analysis of 14 samples taken during one field visit in Year Two. Based on a review of the available water quality data, we propose that this include isolated stable isotope sampling.

We trust that this meets your needs. If you have any questions or require clarification, please contact Chris Doughty or Will Gaherty at 604-895-7640 and 604-895-7601, respectively.

Respectfully submitted,

POTTINGER GAHERTY ENVIRONMENTAL CONSULTANTS LTD.

Per:

Chris Doughty, B.Sc. Ｗilliam Gaherty, M.S., P.Eng.
Environmental Scientist President

Reviewed by Dan Mackie, Senior Hydrogeologist, SRK Consulting, Inc.
CMD/WDG/kmp
P:001-199/035/27-01v-035-27-01-Apr09-FINAL.doc
Appendix 1


1a. Surface Water Elevations

1b. Surface Water Temperature
1c. Surface Water Dissolved Oxygen

1d. Surface Water pH
2a. Regional Groundwater Elevations

2b. Regional Groundwater Temperature
2c. Regional Groundwater Dissolved Oxygen

2d. Regional Groundwater pH
3a. Upper Paradise Elevations

3b. Upper Paradise Temperatures
3c. Upper Paradise Dissolved Oxygen

3d. Upper Paradise pH
4a. Kisutch Elevations

4b. Kisutch Temperatures
5a. BCR Elevations

Cheakamus Flow at Brackendale and Daisy Lake Dam Release (m3/s)

Elevation (m a.s.l.)

5b. BCR Temperatures

Temperature (°C)

PGL
5c. BCR Dissolved Oxygen

- DO (mg/L)
- 14-Nov-07
- 3-Jan-08
- 22-Feb-08
- 12-Apr-08
- 1-Jun-08
- 21-Jul-08
- 9-Sep-08
- 29-Oct-08
- 18-Dec-08
- 6-Feb-09
- 28-Mar-09

5d. BCR pH

- pH
- 14-Nov-07
- 3-Jan-08
- 22-Feb-08
- 12-Apr-08
- 1-Jun-08
- 21-Jul-08
- 9-Sep-08
- 29-Oct-08
- 18-Dec-08
- 6-Feb-09
- 28-Mar-09

7a. Upper Paradise Channel Stage vs Discharge
7b. Kisutch Channel Stage vs Discharge

7c. BC Rail Channel Stage vs Discharge