Wahleach Project Water Use Plan

Boulder Creek Flow Bypass Facility Rehabilitation

Reference: WAHWORKS#1

Boulder Creek Diversion Rehabilitation
Construction Report

Works Period: August - September 2007
Report Date: October 2007

BC Hydro Engineering

October 2007
ACKNOWLEDGEMENTS

Generation Engineering
Hydrotechnical

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D. Sakamoto, P.Eng.
WAHLEACH GENERATING STATION

BOULDER CREEK

DIVERSSION REHABILITATION

CONSTRUCTION REPORT

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WAHLEACH GENERATING STATION

BOULDER CREEK

DIVERSION REHABILITATION

CONSTRUCTION REPORT

1.0 INTRODUCTION

This construction report details work undertaken to build a new rock weir and riffle in Boulder Creek about 0.6 km upstream from the Wahleach Reservoir near the town of Hope. Work included clearing the remnants of a previous lock-block weir from the channel that had been installed in 2005 but was breached in November 2006. The design intent of the rock weir (and also the previous lock-block weir) is to provide a temporary means of diverting water into a diversion structure on Boulder Creek to supplement flows on lower Jones Creek. This diversion is being tested under an agreement in the Wahleach Water Use Plan as a potential means of maintaining minimum required flows in lower Jones Creek. BC Hydro’s water licenses for the Wahleach Project are attached to an Order from the British Columbia Comptroller of Water Rights, arising out the Wahleach Water Use Plan, which specifies minimum flows to be achieved in Lower Jones Creek at specific times of the year.

Background information regarding the original intent of the Boulder Creek weir is available in BC Hydro Report E423 (2006). An analysis of the failed lock-block weir is available in BC Hydro Inter-Office Memo WR559 from Sakamoto to Sherbot entitled “Boulder Creek Temporary Diversion Weir Breach Assessment” (File No. GENMIS07-HYD06, 2006). Further details regarding the Wahleach Water Use Plan are available in BC Hydro’s “Wahleach Water Use Plan Consultative Committee Report” (2003), the “Wahleach Water Use Plan” (2004), and the Comptroller of Water Rights’ Order under Section 88 of the Water Act (file nos. 0265227 and 2002751, dated 1 December 2004).
Details on the design intent of the new rock weir are presented in Section 2.0 below, and an account of the construction sequence is presented in Section 3.0. Environmental considerations are presented in Section 4.0. The project's budget and actual expenditures are compared in Section 5.0. Section 6.0 contains future considerations for the rock weir, and project conclusions follow in Section 7.0. A description of the Project Team is given in Section 8.0. Appendices A through G contain additional project information.
2.0  **DESIGN INTENT**

The original lock-block weir was intended as a temporary structure to allow partial diversion of flows from Boulder Creek to Lower Jones Creek, and permit the collection of monitoring data to assess the effectiveness of enhancing Jones Creek flows with Boulder Creek flows from 2005 to 2010. At the conclusion of the monitoring study data collection period, a decision will be made whether to install a permanent structure in Boulder Creek for flow diversion, or to decommission the structure. The original lock-block structure constructed in 2005 failed in November 2006, providing limited data for the decision making process. The new weir was built in summer 2007 with an intended design life of the remaining three years of the monitoring program. It had to be robust enough to withstand three winters of peak flows while being built at a relatively low cost.

Design requirements and key considerations that affected the preliminary design and as-built structure are discussed immediately below. The preliminary design concept is presented in Section 2.1, and the as-built structure is discussed in Section 2.2.

Several challenging design requirements were a feature of this project. Key requirements included:

1. Low cost, effective design using readily available materials (whether natural or engineered products).
2. Must be able to divert substantial flows from Boulder Creek to Jones Creek; while;
   - Maintaining passage for resident kokanee through the site, and
   - Maintaining minimum flows in Boulder Creek (0.14 cubic metres per second) as first priority.
3. Must withstand a design discharge of 30 cubic metres per second (cms) for at least 3 years. (note the large variation in discharge requirements from minimum to maximum flows).
Other key considerations for design included:

4. High energy and “flashy” nature (quick response to precipitation events) of Boulder Creek and the demonstrated ability of the creek to move large particles (e.g. lock blocks from the previously failed structure were observed several hundred meters downstream of the intake site).

5. Minimized disturbance of existing habitats (fish and wildlife) during construction.

6. Ability to construct the structure within the two-week fisheries window.

7. Sourcing low-cost material and delivering it to a remote worksite along a steep, poorly maintained road.

8. Ensure flushing of natural sediment load in Boulder Creek past the weir structure to minimize infilling of weir with debris.

9. Boulder substrate of the natural stream bed provides a challenge for ensuring stream flow does not go subsurface.

2.1 Preliminary Design Concept

The preliminary design concept for the new weir was based largely on the client requirements and key considerations discussed above. Additionally, the design concept considered the conclusion of the original lock-block structure breach assessment (WR559, 2006) that the likely failure mode of the original weir was toppling of the lock-blocks under high flows and subsequent erosion of the weir toe. Therefore, the preliminary design concept for the new rock weir was to extend the weir further downstream to armour the toe under high flows. To minimize eroding of the weir toe, the weir was made of imported rock of a size greater than the observed bed load of Boulder Creek. The rock weir would actually be constructed more as an extended riffle with the upstream weir crest elevation set to backwater the diversion intake. The wedge shape of the riffle avoids sudden drops in the stream grade and their associated concentrated energy loss. By eliminating oversteep sections, the tapered downstream face of the riffle concept more readily adapts to allow fish passage.
An initial calculation of the required rock size based on the channel characteristics for Boulder Creek suggested that 600 mm nominal diameter rock would be required to safely pass the design flow without becoming mobile. However, it was eventually decided to use available 1200 mm nominal rip rap as the largest size (anchor rocks), 600 mm rip rap for the mid-size, and a graded spawning gravel to fill voids.

It was originally intended to source the rip rap from a quarry on the west shore of the Wahleach Reservoir, but site safety and permitting requirements precluded use of this source. Material was eventually sourced from Armstrong Sand & Gravel in Armstrong, near Chilliwack.

The preliminary design sketches, shown in Appendix A, detail the original design intention as having a flat crest and integral v-notch within the crest to accommodate fish passage and satisfy the remaining client criteria. Based on preliminary calculations the crest of the weir was set at an elevation to maximize diversion flows while ensuring continuity in Boulder Creek for relatively low flows.

2.2 **As-Built Condition**

The as-built condition (see Sheet 1 in Appendix B) shows minor changes to the design sketches presented in Appendix A. Firstly, the straight v-notch channel for low flows was installed as a sinuous channel to decrease channel velocities and aid fish passage. The shape of the outlet is not an exact “v” shape since it was built with natural rock; an approximate cross-section of the weir crest is shown on Sheet 1 in Appendix B. The roughness and relatively low gradient of the riffle face creates multiple routes and resting areas (small pools) for fish.

The second notable change is the absence of the second rise shown on the design sketches, which was originally intended to provide energy
dissipation and a resting area for upstream migrating fish. With the larger rip rap (about 1200 mm nominal) used in conjunction with the design-size rip rap (600 mm nominal) it was felt that the second rise would not be necessary for energy dissipation. Additionally, the difficulty in building a tight upstream face for the lower weir precluded its use as a resting pool for upstream migrating fish. Low water resting areas were provided on a smaller scale by the roughness of the riffle face as described above.

Further, it was suggested that after the passage of several large winter inflow events such a rise (whose original design was 0.25 m height) would be in-filled with large boulders and require maintenance to return to its original condition, if at all possible. The rise would also have required a steeper localized channel bed in Boulder Creek, which may have concentrated energy losses over a relatively short length of the riffle.

The third change is the increase in riffle length over the original design. The riffle was built to tie into an existing natural elevated area of the creek about 30 – 40 m downstream of the diversion headwall structure. A nearby pool will also provide energy dissipation. The increase in length over the preliminary design was necessary to prevent a drop from forming between the riffle and natural creek bed. Such a drop could promote erosion of the riffle toe, leading to regression and possible steepening of the riffle. This could ultimately lead to a lowering of the weir crest elevation and/or impair fish passage.

The as-built condition has resulted in a structure that better simulates natural stream conditions than the preliminary design. The slope of the riffle face closely matches the observed natural channel gradient upstream, resulting in a relatively stable channel feature. The riffle may still over time require general maintenance to ensure the weir crest elevation is maintained, the diversion structure remains clear of sediment, and low water fish passage is possible. Final material
quantities included 1075 tonnes of rip rap and 600 tonnes of spawning gravel.

Project rating curves are provided in Appendix C as a guide for diversion gate openings. These should be field-verified and updated as necessary. Several photographs comparing the pre-construction to as-built condition are presented in Appendix D. A summary report by Alan Bates, P.Eng, an engineer retained by BC Hydro to provide design consultation and construction supervision, is provided in Appendix E.
3.0 CONSTRUCTION SEQUENCE

A short two-week work window was provided for this project, requiring diligent use of site resources. Delivery of material to site had the potential to delay the project; therefore, a stockpile of material was created during the two days leading up to the start of in-stream work. Two mid-sized excavators (Komatsu 300 LC and John Deere 330C LC) were mobilized to the site by the contractor. The first was used for in-stream work only. The second was used as a utility machine for forwarding materials to the in-stream excavator, for creating stockpiles after material delivery, for placing pumps in the creek for water diversion operations, and for other general tasks.

The following were key project dates:

- August 22, 2007: Contractor Mobilization
- August 23, 2007: First Delivery of Rip-Rap
- August 27, 2007: Commencement of In-Stream Works
- September 6, 2007: Project Completion
- September 7, 2007: Contractor De-Mobilization
- September 17, 2007: Diversion Testing

Construction was undertaken in the following sequence: site preparation, base placement, weir construction, grade lifting, and low-flow channel construction.

3.1 Site Preparation

Prior to delivering the excavators or any rip-rap to site, large warning signs advising the public of heavy truck traffic were placed on the Jones Lake Forest Service at various locations. The campsite caretakers were also advised of the planned work several weeks in advance.

Once on-site and having delivered several loads of large and medium sized rip-rap, the excavators worked to establish three material stockpiles on-site: large rip-rap, medium rip-rap, and a future place to put spawning...
gravel. Brush towards the east end of the diversion berm road (upstream of the diversion headwall) was cleared to make space for the large rip-rap stockpile and a generator that was used to power the dewatering pumps. These pumps were used to bypass a majority of the Boulder Creek inflow around the worksite to minimize sediment loading in the stream. The medium rip-rap pile was built on the north side of the diversion berm roughly in-line with the diversion headwall. The spawning gravel pile was created adjacent to the medium rip-rap pile. The close proximity of each stockpile to the edge of the diversion berm meant that the secondary (utility) excavator did not have to track far (if at all) to access the three stockpiles and feed the primary excavator.

Following stockpile creation the primary excavator built an access ramp down the face of the diversion berm to perform in-stream works. This location had previously been used as an excavator access location. In-stream works were supervised by consultant site engineer Alan Bates of Streamworks Unlimited.

3.2 Base Placement

Construction of the riffle base layer proceeded immediately once access to the creek had been established. The primary excavator used several pieces of the large rip-rap to build an elevated work area to sit above moving water while working. From this platform the primary excavator proceeded to place large base blocks in the channel. Pieces were keyed and hammered into the existing creek bed using the excavator bucket. Following placement of an entire layer of large blocks, the medium-sized rip-rap was used to fill the voids left between the large rip-rap. Then, spawning gravel was distributed over the medium rip-rap and washed into the smaller voids using a portable pump. This completed construction of the base layer (first lift), raising the bed by approximately one metre.
The intent of the rock riffle was to raise the grade of the channel, thereby back-watering the diversion intake. Surface flow during late summer must be maintained over the riffle to achieve fish passage. This is difficult when constructing a riffle/weir out of large material as the voids between the big rocks can pass substantial flows. Therefore, these interstitial spaces must be filled by material of mixed grade (medium sized rip-rap, then spawning gravel) to “plug up” and force the water to the surface. Although these voids would naturally infill with time given bedload supplies in Boulder Creek, a key goal of this project was to ensure fish passage immediately upon completion, as kokanee migration and spawning was expected to occur in early September.

3.3 **Weir Crest Construction**

Once a base had been laid down for the riffle, construction on the weir crest was initiated. Similar to laying the base-layer, several large pieces of rip-rap and many of the salvaged lock-blocks from the failed weir were placed in the creek to act as the bottom row of weir blocks. Voids in the large pieces were filled with medium rip-rap and spawning gravel, and another layer of large rock placed on top. Construction continued in this manner until the approximate desired height of the weir crest was achieved. Heavy seepage through and around the weir was initially evident; however, as voids were plugged a pool formed behind the weir. Seepage may continue through the weir throughout its lifetime, but the weir should continue to seal itself over time. The high energy and degrading nature of Boulder Creek provides bed load from upstream areas during high flow events.

The diversion headwall had become choked with sand and sediment following the lock-block weir breach in November 2006. Prior to the final lift being placed on the weir the primary excavator cleaned out the diversion headwall so that water could freely enter the diversion pipe inlet area.
3.4 **Grade Lifting**

Raising the creek bed continued downstream of the weir crest in a similar manner to the construction of the base. Raising the channel grade downstream of the weir is intended to promote energy dissipation and back-up the weir crest. During high Boulder Creek flows, which usually occur as a result of fall and winter rainstorms, the crest of the weir is likely to be overtopped by very turbulent high flows. If the original creek bed was left intact (i.e. not raised) downstream of the weir crest, the turbulence caused by water cascading over the weir and onto the natural bed below would act to dislodge the base layer of the weir, eventually undermining and collapsing the structure. For this reason the base layer discussed in Section 3.2 was created up to, and integral with, the weir crest. Now that the weir crest was effectively tied into the base layer, raising of the base layer using the same method as described in Section 3.2 could continue. The creek was raised such that a gradual transition from the weir crest to the natural bed level downstream was established.

To accommodate a higher water surface profile created by the riffle, it was also necessary to armour the channel banks in the vicinity of the riffle. Concreted riprap on the right bank remained intact and little additional armouring was required. The left bank had previously eroded, leaving over-steepened, erodeable banks and overhanging tree roots. This area was armoured with riprap to a minimum height of one metre above the crest and face of the riffle. In addition, a large log that had recently fallen into the channel was relocated along the left bank to help reduce further erosion of the bank.
3.5 Low-Flow Channel Construction

Construction of a low-flow channel was the final in-stream item completed by the primary excavator. This channel was necessary to ensure passage for spawning kokanee up to and over the weir during spawning season. It is expected this channel may shift over time during high inflow events and may require occasional adjustment to ensure continued fish passage. Fish passage through the low-flow channel into the upper pool was confirmed in late September.

The low-flow channel is located adjacent to the diversion headwall (along the right bank looking downstream) to encourage higher flows adjacent to the diversion structure. This should help to prevent sediment deposition at the diversion inlet.
4.0 ENVIRONMENTAL CONSIDERATIONS

Preservation of the surrounding environment was a primary objective when planning this project. Key considerations included:

- Minimizing fish and wildlife habitat disturbance
- Minimizing local vegetation disturbance
- Minimizing sediment loading in the creek during construction activities
- Creating an isolated work-site not accessible by fish.

Greenbank Environmental Services were contracted to provide full-time environmental monitoring services and develop an Environmental Management Plan (EMP) for the project. The final EMP is provided in Appendix F. Environmental consultants Jeff Greenbank, Jason Macnair and Matt Townsend supervised the site on a rotating basis throughout the project. The final environmental summary report is provided in Appendix G.

Fish were excluded from the work area using nets across the creek upstream from the worksite. A screened box was used to prevent fish entering into the diversion pumps; this allowed multiple pumps to sit in a single box for use in diverting water around the worksite. See Figure 9 in Appendix D and Figure 3 in Appendix G.

Water diversion was implemented on the second day of in-stream construction once finer material was being placed in the creek. One 6 inch, one 4 inch, and one 3 inch pump were used to divert flows around the worksite and promote dilution of suspended sediment. Work was performed during the approved fisheries works window such that any sediment released downstream would have a minimal impact on fish or fish habitat.
5.0 **COMPARISON OF BUDGET AND ACTUAL EXPENDITURES**

A project cost estimate was completed by BC Hydro’s Estimating Group for this project. The estimate was based on the estimate for the original lock-block weir but with appropriate modifications. Unit prices were increased to account for higher market costs, and a 35% contingency was applied to the estimate to account for possible expenditures including filter fabric and spawning gravel. An allowance was also made in the cost estimate for a full-time environmental monitor and full-time site engineer.

Final project expenditures were not available at the time of writing this report, as time for post-construction project management was not yet available via PeopleSoft. However, all major transactions have occurred, and the actual project expenditures are expected to be within the budget prepared by the Estimating Group. Table 1 below shows a breakdown of the estimate compared to the actual expenditures, with the project variance shown at right. The costs shown below are direct (unloaded); however, since the project was performed as maintenance to an existing structure and not funded under a capital EAR, no overhead or IDC charges will be applied to the project. Therefore, the unloaded costs will represent the actual costs. The GST is excluded from direct costs.

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<td><strong>$4,688</strong></td>
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<td>Contingency</td>
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<td><strong>Total</strong></td>
<td><strong>$247,334</strong></td>
<td><strong>$187,898</strong></td>
<td><strong>$(59,435)</strong></td>
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Note: Actual indirect costs are an estimate as final values are not yet available via PeopleSoft.
About $65,000 more than what was originally estimated for total rock purchase was required to procure the additional rock for the un-planned additional riffle length and large amount of spawning gravel required to seal the riffle. However, many cost savings were achieved by the contractor including savings on labour costs, foreman costs, and most notably, pumping costs. With the contractor’s savings and additional required rock, a net increase of about $25,000 is reflected in the direct construction cost over BC Hydro’s original estimate.

An additional item not considered during the estimating process was the re-grading of Jones Lake Road following construction. This was suggested by the original construction officer (Keith Taylor) to promote good relations between the Water License Requirements Group and local Generation staff. The net cost of re-grading the road on two occasions (once during construction prior to a holiday weekend and once following construction) realized a net additional cost of about $4,500. Combining this item with the extras to the direct construction cost and savings on indirect construction costs, the project finished with a direct sub-total of approximately $188,000.
6.0 FUTURE CONSIDERATIONS

Annual maintenance may be required with this new structure to ensure fish passage, and has been provided for in the BC Hydro Wahleach WUP budget. The toe of the riffle should be monitored and repaired if it appears to regress or get steeper. To prevent sedimentation within the diversion headwall, consideration should be given to opening the flow gate during the receding limb of the fall flood hydrograph. This will help to flush out sediment accumulated in the eddy formed during peak flow.

Consideration should be given to upgrading the culvert crossing under the Jones Lake Road that conveys Boulder Creek flows to Lower Jones Creek. Presently the high overflow culvert is collapsed and not considered useful for service. The remaining culvert should be extended and / or replaced to provide energy dissipation at the culvert outlet. The current drop-structure is undermining Jones Lake Road. Sediment will continue to infill the culvert inlets until the Boulder Creek diversion channel stabilizes itself. Until this stabilization occurs, continued removal of this sediment at the road crossing will be required.
7.0 CONCLUSIONS

1. The original lock block weir which failed during a large flow event in November 2006 was replaced with a new rock riffle weir in August – September 2007. The new weir is provided as a temporary structure to assess Boulder Creek diversion efficiency until 2010.

2. The as-built condition of the new weir closely resembles the preliminary design with the following modifications:
   - Removal of downstream lip
   - Meandering low flow channel
   - Lengthened riffle bed
   - Increased boulder size

3. In-stream construction was completed from 27 August to 7 September 2007 during the approved fisheries works window. A full-time site engineer and a full-time environmental monitor were provided to ensure design criteria were met and compliance with the Environmental Management Plan. No environmental or safety incidents occurred during the project.

4. About 1100 metric tonnes of rip rap and 600 metric tonnes of spawning gravel were used to construct the riffle.

5. The cost estimate to complete this work was about $250,000 including contingencies. Final direct project expenditures are forecast at $188,000. Extra costs were incurred to the direct construction cost for additional rip-rap, spawning gravel, and road grading. Significant savings were achieved in pumping costs and indirect (non-construction) tasks.

6. Ongoing monitoring is required at the site. Attention should specifically be directed towards:
   - Management of sediment load at intake
   - Monitoring of riffle toe
   - Maintenance of low flow channel
   - Maintenance of Boulder Creek diversion channel culvert crossing under Jones Lake Road
8.0 PROJECT STAFF

The project team and their roles are discussed below:

**BC Hydro Staff**

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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<tbody>
<tr>
<td>Dave J Hunter</td>
<td>Generation, Water License Requirements</td>
</tr>
<tr>
<td>Kelly Galway</td>
<td>Generation Engineering, Hydrotechnical</td>
</tr>
<tr>
<td>Derek Sakamoto</td>
<td>Generation Engineering, Hydrotechnical</td>
</tr>
<tr>
<td>Keith Taylor</td>
<td>Generation Engineering, Implementation</td>
</tr>
<tr>
<td>Todd Ewing</td>
<td>Generation Engineering, Implementation</td>
</tr>
<tr>
<td>Carol Lamont</td>
<td>Generation, Environment &amp; Social Issues</td>
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**Consultants**

<table>
<thead>
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<tbody>
<tr>
<td>Alan Bates</td>
<td>Streamworks Unlimited, Site Engineer &amp; Design Review</td>
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<tr>
<td>Jeff Greenbank</td>
<td>Greenbank Environmental Services, Environmental</td>
</tr>
<tr>
<td>Jason Macnair</td>
<td>Greenbank Environmental Services, Environmental</td>
</tr>
<tr>
<td>Matt Townsend</td>
<td>Greenbank Environmental Services, Environmental</td>
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**Contractor**

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<tr>
<td>Scott Roberge</td>
<td>Mission Contractors, Foreman</td>
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9.0 REFERENCES


2. Boulder Creek Temporary Diversion Weir Breach Assessment. 2006. BC Hydro Inter-Office Memo WR599 (Sakamoto to Sherbot). File No. GENMIS07-HYD06


5. Order for Wahleach Project. 2004. Issued by the Comptroller of Water Rights (their file no. 0265227 / 200275)
APPENDIX A: DESIGN SKETCHES

- Boulder Creek Diversion Rehabilitation - General Notes
- Boulder Creek Diversion Rehabilitation - Plan View
- Boulder Creek Diversion Rehabilitation - Section Views - Section B-B
- Boulder Creek Diversion Rehabilitation - Sections View - Section D-D
1. USE CLASS 3 RIPRAP WITH LARGER (~2 m) ROCKS FOR ROCK WEIR FOUNDATION AND HIGH TURBULENCE ZONES
   CLASS 3 RIPRAP
   $d_{\text{max}}$ - 1.20 m - 2400 kg /48" - 5200*
   $d_{80}$ - 0.90 m - 1000 kg /36" - 2200*
   $d_{50}$ - 0.80 m - 700 kg /30"- 1500*
   $d_{20}$ - 0.50 m - 200 kg /20" - 400*

2. IMPORTED GRAVEL TO FOLLOWING GRADATION (OR DFO-APPROVED EQUIV.)

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<td>BIRD'S EYE</td>
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<td>TORPEDO</td>
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</tr>
<tr>
<td>3/4' ROUND</td>
<td>19.1 mm</td>
<td>55%</td>
</tr>
<tr>
<td>1 1/2' ROUND</td>
<td>38.1 mm</td>
<td>90%</td>
</tr>
<tr>
<td>2 1/2' ROUND</td>
<td>63.5 mm</td>
<td>100%</td>
</tr>
</tbody>
</table>

3. USE NILEX ENVIROFLEX 30 OR EQUIVALENT GEOMEMBRANE WHERE REQUIRED BY SITE ENGINEER.

4. PLACE FOUNDATION ROCK IN PREPARED TRENCH AND IMBED TO 1/2 NOMINAL DIAM.

5. ENSURE TIGHT SEAL BY TAMMING TOGETHER WITH HEAVY EQUIPMENT AND FILLING VOIDS WITH SpoIL.

6. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED.

7. SITE DATUM IS TOP OF STOPLOG AT DIVERSION HEADWALL EL -652.23 m

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

BOULDER CREEK DIVERSION REHABILITATION
GENERAL NOTES - SCALE: N.T.S.
PREP. KLG.
DATE: JULY 2007
SHEET 1 OF 4
APPENDIX B: AS-BUILT CONDITION

• Boulder Creek Diversion - Rock Riffle Construction - As-Built Sketch
TO YELLOW ACCESS GATE

SEE DETAIL 'X'

GRATED GRAVEL
600 mm NOM Ø
1200 mm NOM Ø

DETAIL 'Y'

TOP OF DIVERSION BERM

SECTION A-A

REFERENCE DATUM CONVERSION
ADD 650 m

E1.0.19
E1.0.66
E1.1.22
E1.1.44
E1.1.64
E1.2.06
E1.2.35
E1.2.82
E1.2.90
E1.2.93
E1.2.48
E1.3.06
E1.3.30

EX. 600 mm
CSP INV.
E1.1.31

RIFPLE SLOPE ~ 6%

REFERENCE DATUM, EX STOPLOG E1.2.23

GENERAL PROFILE

BOULDER CREEK DIVERSION
ROCK RIFFLE CONSTRUCTION
AS-BUILT SKETCH

BY: KLG
DATE: 2 OCT 2007
SCALE: NTS

PAGE: 1 OF 1
APPENDIX C: PROJECT RATING CURVES

- Pipe Discharge vs Boulder Creek Inflow
- Pipe Discharge vs Water Surface Elevation
- Rock Riffle Overflow Weir
Boulder Creek Diversion Rehabilitation Rating Curve
Pipe Discharge vs Boulder Creek Inflow

Boulder Creek Inflow is Sum of Boulder Creek Weir Overflow and Discharge Through Pipe for Specific Opening

Discharge Through Pipe (m³/s)

Boulder Creek Inflow (m³/s)

% Gate Opening

- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%

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Boulder Creek Diversion Rehabilitation Rating Curve
Pipe Discharge vs Water Surface Elevation

Discharge Through Pipe (m³/s)

Water Surface Elevation in Headwall (El-m)

% Gate Opening

- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%
- 90%
- 100%

- Stoplog El
- Weir Crest

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APPENDIX D: SELECTED SITE PHOTOGRAPHS

Figure 1: View from left bank looking d/s pre-construction (22 Aug 2007).
Figure 2: View from right bank looking d/s pre-construction (22 Aug 2007).
Figure 3: View of finished riffle from right bank. Flow is from left to right (6 Sept 2007).
Figure 4: View across breached weir from left bank, pre-construction (22 Aug 2007).
Figure 5: View of breached weir from right bank, pre-construction (22 Aug 2007).
Figure 6: View from right bank looking d/s at finished riffle (6 Sept 2007).
Figure 7: View of clogged diversion headwall, pre-construction (23 Jul 2007).
Figure 8: Clearing out clogged headwall (5 Sept 2007).
Figure 9: Pumping apparatus (29 Aug 2007).
Figure 1: View from left bank looking d/s pre-construction (22 Aug 2007).

Figure 2: View from right bank looking d/s pre-construction (22 Aug 2007).

Figure 3: View of finished riffle from right bank. Flow is from left to right (6 Sept 2007).
Figure 4: View across breached weir from left bank, pre-construction (22 Aug 2007).

Figure 5: View of breached weir from right bank, pre-construction (22 Aug 2007).
Figure 6: View from right bank looking d/s at finished riffle (6 Sept 2007).

Figure 7: View of clogged diversion headwall, pre-construction (23 Jul 2007).
Figure 8: Clearing out clogged headwall (5 Sept 2007).

Figure 9: Pumping apparatus (29 Aug 2007).
APPENDIX E: ENGINEERING CONSULTANT
SUMMARY REPORT

- Streamworks Unlimited - Memo to Kelly Galway from Alan Bates, Re: Boulder Creek Intake Rewatering, October 10, 2007
October 23, 2007

BC Hydro
6911 Southpoint Drive,
Burnaby, B.C.,
V3N 4X8

Attention: Kelly Galway
Project Engineer

Memo Re: Boulder Creek Intake Rewatering

Kelly;

As per your request, here is a point form summary of the construction sequence and other comments concerning the rewaterning of the Boulder Creek/Jones Creek diversion intake.

General Construction Sequence

Week of Aug 20-24

- Cleared access road of brush
- Began grading FSR
- Hauled large rock (33 loads 1m+ diam) [typically 6 trucks, 2 trips each per day for the duration of the project].
- Used excavator to stockpile large rock on road/berm beyond intake

August 27

- Began construction in creek, established access ramp, placed some large rock to form working pad.
- Broke up old concrete infill section
- Removed and/or lowered undermined lock blocks
- 2nd excavator arrived
- Hauled large and small (60cm diam) rock.

August 28

- Completed first layer of large rock
- Added smaller rock to occupy large voids
- Set-up 6” submersible pump with fish screen and began pumping 75% water around site
- Established fish exclusion net upstream.
- Sample of ‘spawning’ gravel delivered, too much sand (~50%). Site Eng travelled to gravel pit to review materials. Requested round gravel with less than 10% sand.
- Hauled small and large rock.

August 29

- Hauled spawning gravel
- Placed gravel in voids while pumping around site.
- Cleaned out intake structure by machine and hand.
- Completed first lift and re-established surface flow.
- Began construction of riffle crest adjacent to intake.

August 30
- Placed gravel in voids while pumping around site.
- Used trash pump to pack gravel and recycle dirty water.
- Finished riffle crest and continued with second lift of big and small rock.

August 31
- Continue rock placement (2nd lift) with gravel to ensure surface flow through weekend.
- Fish stopper net removed.
- Shut down at 14:00 due to lack of material.

September 4
- Armoured left bank to 1m above channel base.
- Moved fallen tree to location along left bank.
- Completed the toe/transition of riffle and worked upstream.

September 5
- Few trucks available, only four loads delivered.
- Finished riffle surface with big rocks and gravel (only one excavator operator)
- Ran out of material to finish, left small area incomplete to access portions still needing gravel.
- Site Engineer left for work engagement in the Kootenays

September 6, 7
- Job completed with construction of low-flow channel

Discussion on the range of rock sizes used:
- A range of rock sizes was needed to fill voids between large ‘anchor’ rocks in the riffle. A broad range of sizes (including boulders, cobbles, gravels and fines) is necessary to form a tight matrix of material and force water to the surface of the riffle. Without the intermediate sizes, sands and gravels will simply wash through, leaving little surface flow. Sediment loading in the creek will likely fill the voids with time, however the riffle may act as a fish barrier in the interim. As natural sediment loads the creek are minimal until the flood season, packing the riffle with progressively smaller material during construction was necessary to ensure fish passage this fall.

Discussion on changes from original design concept:
- Boulder Creek in the vicinity of the intake is flowing in a man-made (diversion) channel. Although it has naturalized somewhat since its construction (~60 years ago) it lacks the structure normally found in natural channels. Natural channels typically lose energy around bends, through woody debris jams and by passing through pool/drop sequences. The diversion channel has few of these natural energy dissipaters and this may have contributed to downcutting and scour in the vicinity of the intake. Building a rock riffle mimics a relatively stable natural channel feature and creates a more complex channel profile to help dissipate energy. Large boulders, supported by a series of boulders downstream, gives a scour resistant base to the riffle. The re-established weir crest is backed up by a wedge of oversized, stable material and controls bed elevation at the intake site. Blending/feathering the downstream end into natural substrates avoids sudden drops in the profile and a concentration of stream energy that could lead to local scour. In this case, the slope of the riffle was consistent with the natural slope of the stream. The lower end of the riffle tied into an existing riffle/cobble bar formation. The
pool formed upstream of the riffle will help to dissipate energy and create a complex profile.

- Putting the double crest as shown on the design may have exposed some rocks to higher tractive forces with less downstream support (i.e. steeper local gradient). This may have worked with big enough rock, but in my experience it is better to keep a low profile and keep the energy well dissipated (not drawing attention to any one point). Stream energy would have been focussed on the second crest. I think the double crest would have been reshaped/dismantled/infilled by the creek to form a single riffle after the first major discharge/bedload event.

- The fish passage notch shown on the design was not constructed as this would create a preferred flow route resulting in focussed energy under high discharge. In addition, the straight notch was not necessary to enable fish passage. Developing a shallow V cross-section gives a less defined but still functional low flow channel. Fish likely prefer the more natural situation that allows them to hop and rest through a broken series of jumps and pools, as opposed to a long, straight high-velocity ‘ditch-like’ channel. The final configuration of the low flow channel traversing the riffle mimicked fish passage conditions observed both upstream and downstream of the site.

- The weir was constructed to additional length to tie into the existing cobble bar at the same slope downstream from the finished toe shown on the design sketches. It also tied into an existing pool near the left bank (pools typically form at riffle toes). There may be some scour of the cobble bar as it is comprised of smaller material than used to build the riffle. This area should be monitored to see how it rearranges itself and to ensure the toe of the riffle doesn’t start to regress (much).

Lessons Learned

- Make sure the contractor is aware of the need for sands and gravels in riffle construction. It’s not all big rock.
- Book enough trucks in advance.
- More pumping capacity may have reduced the release of sediment during construction; however, the environmental monitors were not concerned with the amount of sediment that was released.
- Better communication with the environmental monitor regarding importance of intermittent testing during construction would have allowed a better view of overall project effectiveness and would have provided room for construction changes. Since testing was prevented until project completion, all that the testing performed after project completion could ascertain was whether the finished product satisfied the requirements. By this period resources were not available to effect any changes, had they been required.

Sincerely,

Alan Bates, P.Eng.
Water Resources Engineer
Streamworks Unlimited
APPENDIX F: ENVIRONMENTAL MANAGEMENT PLAN

Boulder Creek Diversion Upgrade

*Draft ENVIRONMENTAL MANAGEMENT PLAN*

*Version 1*

Prepared for:

Carol Lamont  
BC Hydro Engineering, Environment  
6911 Southpoint Drive  
Burnaby, BC  
V3N 4X8

By:

Jeff Greenbank, RPBio.  
913 Baker Drive  
Coquitlam, BC  
V3J 6X3

August 2, 2007
# Boulder Creek Diversion Upgrade

*Draft ENVIRONMENTAL MANAGEMENT PLAN*

*Version 1*

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Appendix 2  Environmental Orientation Record
1. INTRODUCTION

1.1. PROJECT BACKGROUND

Boulder Creek was originally a tributary of Jones Creek that was diverted by construction of an embankment dam into Jones Lake reservoir (Figure 1). An intake structure and pipe was constructed as part of the diversion dam to divert water through the embankment dam into the original Boulder Creek channel. Through erosion and sedimentation, the performance of the diversion had been impacted and it no longer functioned as intended. The diversion was not used for several years prior to being upgraded in the summer of 2005.

Under the Wahleach Water License, BC Hydro is required to maintain flows in Lower Jones Creek at or above 1.3 m³/s in the fall and at least 0.6 m³/s during the rest of the year. To meet this criteria, BC Hydro upgraded the Boulder Creek diversion in 2005 in order to use water from Boulder Creek to augment flows in Lower Jones Creek. The upgrade involved construction of a new lock-block weir to redirect flows from the left bank of the river to the intake structure on the right bank, creating a pool to create hydraulic head at the intake structure.

Work done on the weir in 2005 was deemed inadequate to maintain the required flow regime for Lower Jones Creek. In 2006 work was done to buttress and seal the lock-block weir, raising water levels in the pool behind the weir closer to the level of the intake structure. Fish-passage via the flume section and the channel below the weir was also enhanced. High flows in November 2006 completely removed the lock-block weir and filled the intake structure with sand, rendering the diversion unusable. The work proposed below will repair the diversion dam and intake structure.

1.2. PROJECT DESCRIPTION

The proposed concept includes building a rock weir structure at the site of the previous lock-block weir. Boulders and lock-blocks that have been displaced from last year will also be moved as required. A chute section will be constructed to provide a path for water and sediment to flow during lower flow periods and to ensure it is passable to fish.

The environmental requirements for this project to ensure the protection of aquatic and terrestrial life and their habitats will be the focus of this environmental management plan (EMP).
1.3. PURPOSE OF THE ENVIRONMENTAL MANAGEMENT PLAN

The purpose of this EMP is to; (1) identify any elements of the work that could present a risk to the receiving environment, and (2) describe how those risks can be mitigated through proper work management including incident response procedures and protocols that will limit impacts to the environment.

The EMP is a guide and resource for BC Hydro construction staff, contractors, the environmental monitor and government agencies. Environmental risks associated with this project can be managed during project planning and construction as discussed in this EMP. The EMP is included as an appendix to the tender documents issued by BC Hydro and will form part of the binding contract with the Contractors. It is the Contractors’ responsibility to become familiar with the contents of the EMP and to comply with the practices and procedures identified.
1.4. ENVIRONMENTAL OBJECTIVES AND GENERAL SITE CONSIDERATIONS

This project will be guided by BC Hydro’s mission statement, “To provide integrated energy solutions to our customers in an environmentally and socially responsible manner”. BC Hydro will plan work to avoid impacts on the environment. Where impacts are created, work will be done to reduce them and implement recommended mitigation techniques.

B.C. Hydro and its contractors will keep environmental disturbances to the minimum necessary for accomplishing the planned work. BC Hydro and its contractors will take precautions necessary to avoid detrimental impacts on fish resources and habitat and avoid or minimize impacts to vegetation and wildlife. Potential contaminants of water bodies and ground water will be contained. All excavations will be filled in or properly protected for public safety and disturbed soils will be graded and protected from erosion. All disturbed areas will be re-vegetated and completely restored following an approved remediation plan. In general, BC Hydro and its contractors will leave the completed work areas in a safe, clean and environmentally stable and restored condition.

1.5. PERMITS AND APPROVALS

Approval under the Water Act (Section 9) is not required for this work, as it is considered to be an improvement to existing works and is completed under the existing Water License. A Ministry of Environment Notification has bee submitted by BC Hydro. Fish salvage permits have been received from the Ministry of Environment and the Department of Fisheries and Oceans.

1.6. ENVIRONMENTAL REGULATIONS

Federal, provincial and regional environmental regulations are also applicable to the construction phase of the Project. All work carried out by BC Hydro and its Contractors will be in compliance with the applicable regulations. Some details of the significant environmental regulations applicable to this project are provided below.

Federal Environmental Legislation

The Fisheries Act is one of the federal water pollution control statutes. The Fisheries Act deals with the release of toxic substances to the environment and is applicable to the release of disinfectants or other potential contaminants, such as pH adjustments, chemicals and construction runoff carrying high contents of silts or oils and greases. Section 36(3) of the Act prohibits any person, unless otherwise authorized in the Fisheries Act, from depositing or permitting the deposit of a deleterious substance of any type in water frequented by fish.

The Migratory Birds Convention Act prohibits the unauthorized taking or killing of migratory birds, their nests and eggs, and the deposition of harmful substances in areas frequented by migratory birds.

British Columbia Environmental Legislation

The Contractor will be required to adhere to all British Columbia laws and regulations for the management of water, air, land, wildlife, archaeological and other resources. This provincial legislation includes the Environmental Management Act, Waste Management Act, Water Act, Wildlife Act, Fisheries Act and Heritage Conservation Act.
Land Development Guidelines for the Protection of Aquatic Habitat

The land development guidelines were prepared jointly by the Department of Fisheries and Oceans and the Ministry of Environment. The Contractor is required to become familiar with and adhere to the guidelines established in this document.

Regional

BC Hydro and its Contractors will be required to adhere to regional air quality, sewerage and drainage and solid waste disposal as regulated by the GVRD in the Lower Mainland.

Municipal

Local municipal bylaws shall provide the regulatory basis for noise control and hearing protection. Noise bylaws or formal exemptions from the bylaws shall be used in setting hours of work limitations.

2. ENVIRONMENTAL RESOURCE ASSESSMENT AND MANAGEMENT

2.1. AQUATIC RESOURCES

Boulder Creek is a relatively steep (~ 5 %), high-energy creek with substrate dominated by boulders and large cobble with some smaller gravel-sized substrate. The creek provides habitat for resident rainbow trout as well as non sport-fish species. The creek also provides spawning habitat for a population of kokanee which migrate from Jones Lake reservoir to spawn in September. Rainbow trout also migrate from the reservoir to spawn in Boulder Creek in the spring. The work is planned to be completed in early September prior to the kokanee migration.

2.2. VEGETATION

Only minor clearing of understory and immature deciduous trees (alder, cottonwood) is expected. Riparian trees that are require removal will be replaced to standard Fisheries and Oceans specifications. Disturbed vegetation along access roads, excavation and spoil areas will be revegetated upon completion of the project.

2.3. WILDLIFE HABITAT

Birds, mammals, reptiles and amphibians common to the area are likely to be present in the working area and surrounding areas. The ground and vegetation disturbance associated with this project is minor and the duration of the project is short. As a result, impacts on wildlife are not anticipated.

The environmental monitor will inspect the area for nesting birds and raptor nests prior to the start of the project. If nests are found, precautions will be taken to avoid disturbing active nests.

2.4. RECREATION/VISUAL

Jones Lake reservoir is a well used recreational area. This work will be outside of the area utilized by the public and public impacts are not anticipated.
2.5. HERITAGE OR ARCHAEOLOGICAL SITES

Although no archeological sites have been recorded in the work area, the site may include heritage artifacts. Historical artifacts are legally protected by the provincial Heritage Conservation Act. If any remains or item of historic interest or value are discovered during the project, the contractors will inform BC Hydro’s representative and stop the work activity until an appropriate archaeological assessment can be done.

3. CONSTRUCTION IMPACTS AND ENVIRONMENTAL MANAGEMENT

3.1. GENERAL

Negative impacts to the natural resources in the area are not expected to occur as a result of the proposed construction work. The work will occur on an existing structure and the work will be closely monitored to ensure there is no contamination of the adjacent aquatic and terrestrial habitats.

To minimize disturbances and impacts to the surrounding environment during construction, all the work will be conducted as per the guidelines provided in the DFO/MELP publication “Land Development Guidelines for the Protection of Aquatic Habitat”. The Contractor will be required to adhere to the guidelines established in this document as listed in the sections of the EMP below.

Generally, the potential environmental issues associated with the Project include the following:

- Sedimentation or contamination of the reservoirs due to activities associated with the drilling;
- Fuel or oil spills;
- Waste management;
- Sewage and refuse disposal; and
- Contamination of fish habitat.

Protection of the aquatic habitats in both the Boulder Creek and Jones Lake is the most critical environmental issue during this work. All hazardous materials and waste will be contained and removed from site.

3.2. ACCESS DEVELOPMENT

Access to the work site will be gained from the existing access road to Jones Lake. From there, access will be along the right bank of Boulder Creek where a pre-existing road will be cleared and re-established. The roads will be maintained in a clean condition during the work to ensure accumulated sediment, debris or hazardous material are not washed off the road and into the receiving waters during rain events.

3.3. SEDIMENTATION AND WATER HANDLING

Silts and fine materials introduced into creeks and lakes can have adverse effects to the aquatic environment. Work will be completed in the isolation of flowing water. Water will be diverted to one side of the channel while work is completed in the other.
3.4. EROSION CONTROL

No significant land clearing is expected to be necessary during the project. However, if land clearing is required, silt fencing will be installed along the edge of all disturbed areas in accordance with the manufacturer’s instructions. The Environmental Monitor may request additional silt fencing in areas that have a high risk of erosion or instability.

In general, the following criteria will be followed when installing silt fencing:

- The base of the silt fence fabric shall be installed in a 150mm deep trench and covered with native material to prevent sediment flow underneath the fence.
- Supporting posts shall be installed on the side of the fence opposite to the potential silt generating activity. These posts shall be 50 mm x 50 mm dimensional lumber embedded 450mm below grade and spaced every 1.4 meters.
- Silt fencing that is moved or damaged for any reason shall be restored immediately.

3.5. OIL AND FUEL

Activities related to construction work will require use of machinery, including dump trucks and excavators that use fuels, lubricating oils and hydraulic fluids. These fluids can negatively impact terrestrial and aquatic environments and must be managed properly. To reduce the risk of these fluids reaching terrestrial and aquatic environments the following procedures will be followed:

- machinery servicing shall take place only within designated areas.
- plastic containers used to carry petroleum products must be designed for that purpose and cannot be more than 5 years old
- containers must not leak and must be sealed with a proper fitting cap or lid
- containers of 23 litres (5 gallons) or less will be stored in an equipment box of a vehicle; able to contain any fuel leaks from the equipment in the event of a spill during transit
- equipment refuelling and refilling small field containers is to be carried out well away from water bodies or wetlands.
- small trucks, equipment, or chain saws must not be serviced or refuelled in riparian areas.
- large equipment, including their hydraulic fittings, must inspected daily and be free of leaks.
- in the event of a spill, the emergency spill response contingency plan (Appendix A) will be implemented.
- any minor spills shall be clearly marked with flagging tape and reported to the Environmental Monitor or Construction Officer for later clean-up and removal immediately – implement spill response plan if required.
- an on-site supply of spill kits and absorbent pads will be maintained.
- all spills greater than 500 ml (0.5 litre) must be reported to the Construction Officer and immediately cleaned up, and,
- The contractor will report all spills to authorities as set out in the appropriate legislation and regulations.

3.6. WASTE MANAGEMENT

B.C. Hydro will manage all work and ensure a final cleanup of the work area is completed.

Special wastes and hazardous materials are not anticipated for this project. However, it should be noted that absorbent materials or soils saturated with oil or gasoline are classified as special
waste. Soils and/or other materials contaminated by petroleum products, chemicals, or other undesirable materials will be cleaned up according manufacturer’s instructions and to regulatory standards. Contaminated soils will be excavated, treated on-site, or hauled off-site to an accepted treatment/disposal area. B.C. Hydro employees and its contractors will adhere to provincial Special Waste Regulations, with respect to storage, land filling, and disposal of materials.

Other solid wastes generated during this project and requiring disposal off site will need approval from the local landfill operator prior to disposal. Local landfills may have specific restrictions on what waste items will be accepted. B.C. Hydro employees and their contractors are required to comply with these procedures.

Sanitary facilities in the form of portable toilets will be provided for the use of workers for the duration of the work.

4.0 ENVIRONMENTAL MONITORING

Onsite environmental monitoring will be undertaken by a qualified professional. An environmental representative will attend any pre-job meetings to ensure the contractor understands the requirements of the EMP and the sensitivities of the work site.

The Environmental Monitor will liaise with field staff as well as visit the site regularly to perform the following tasks:

1. Ensure compliance with the Environmental Management Plan;
2. Assist with the Emergency Response Contingency Plan, if necessary;
3. Address any environmental problems;
4. Identify and report any emerging environmental issues;
5. Keep complete records of inspections and make regular reports to the project manager; and
6. If necessary, meet with environmental agency personnel and other stakeholders.

The Environmental Monitor will remain on call during working periods to respond to any environmental emergencies that may arise. They will note any deviations from the specified environmental plan in a written report to the Construction Officer and project team.

The Environmental Monitor will liaise with the BCH Construction Officer and report details of site visits or any environmental concerns. The Monitor will not notify contractors in advance of site visits. The Environmental Monitor will report to the Project Manager any potential environmental consequences that could result from any anticipated or actual delay in the construction schedule.

The Environmental Monitor will monitor site restoration and clean-up to ensure that site(s) are left in an acceptable manner. In the event of an emergency that could impact water quality in the aquatic environment, the Monitor shall take water samples for analysis by a reputable laboratory.

THE ENVIRONMENTAL MONITOR AND CONSTRUCTION OFFICER MAINTAIN THE RESPONSIBILITY AND AUTHORITY TO SHUT DOWN JOB ACTIVITIES IF ENVIRONMENTAL DAMAGE APPEARS TO BE OCCURRING OR IS IMMINENT.
Any environmental emergencies shall be reported immediately, according to the following guidelines.

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<thead>
<tr>
<th>Type of Emergency</th>
<th>Reporting Order</th>
<th>Required Action</th>
<th></th>
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| Hazardous Material Spill           | 1. Provincial Emergency Program (1-800-663-3456).  
                                 | 2. Emergency Contacts (see Appendix A). | *See Spill Response  
                                 |                                               | *Shut down job activities if necessary  
                                 |                                               | * if affecting water quality, sample water for analysis |
| Emergency Affecting Water Quality | 1. Construction Officer or Environmental Monitor.  
                                 | 2. Emergency Contacts | *Shut down job activities if necessary  
                                 |                                               | *sample water for analysis  
                                 |                                               | *notify water licence holder if applicable |
| Other Environmental Emergency     | 1. Construction Officer or Environmental Monitor.  
                                 | 2. Emergency Contacts (see Appendix A). | *Shut down job activities if necessary |

5.0 SCHEDULE

The construction of the project is scheduled to start near the end of August and must be completed by September 15, 2006.

6.0 SITE RESTORATION AND POST CONSTRUCTION MONITORING

6.1 SITE RESTORATION

Excavated and disturbed areas will be restored to pre-construction condition. Site restoration will include replacement of riparian trees and vegetation.

6.2 POST CONSTRUCTION MONITORING

Post construction monitoring will be undertaken to ensure the diversion weir remains stable and functions as intended. Assessments will also be undertaken during the Kokanee migration to ensure the weir remains passable to fish.
APPENDIX 1

BOULDER CREEK DIVERSION

SPILL RESPONSE PLAN

INCIDENT

If a spill of fuel, oils, lubricants or other harmful substances occurs at the site, the following procedures will be implemented.

<table>
<thead>
<tr>
<th>Spill Response Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ENSURE SAFETY</td>
</tr>
<tr>
<td>2. STOP THE FLOW (when possible)</td>
</tr>
<tr>
<td>3. SECURE THE AREA</td>
</tr>
<tr>
<td>4. CONTAIN THE SPILL</td>
</tr>
<tr>
<td>5. NOTIFY/REPORT (PEP 1-800-663-3456)</td>
</tr>
<tr>
<td>6. CLEAN-UP</td>
</tr>
</tbody>
</table>

(Circumstances may dictate another sequence of events)

1. ENSURE SAFETY
   - Ensure Personal, Public and Environmental Safety
   - Wear appropriate Personal Protective Equipment (PPE)
   - Never rush in, always determine the product spilled before taking action
   - Warn people in immediate vicinity
   - Ensure **no ignition sources** if spill is of a flammable material

2. STOP THE FLOW (when possible)
   - Act quickly to reduce the risk of environmental impacts
   - Close valves, shut off pumps or plug holes/leaks, set containers upright
   - Stop the flow of the spill at its source

3. SECURE THE AREA
   - Limit access to spill area
   - Prevent unauthorized entry onto site

4. CONTAIN THE SPILL
   - Block off and protect drains and culverts
   - Prevent spilled material from entering drainage structures (ditches, culverts, drains)
   - Use spill sorbent material to contain spill
   - If necessary, use a dike, berm or any other method to prevent any discharge off site
   - Make every effort to minimize contamination
   - Contain as close to the source as possible

5. NOTIFY/REPORT
   - Notify appropriate Site Supervisor or alternate of incident (provide spill details)
   - When necessary the first external call should be made to (see spill reporting requirements):
     **Provincial Emergency Program (PEP) 1-800-663-3456 (24 hours)**
   - Provide necessary spill details to other external agencies (see spill reporting requirements)
SPILL REPORTING REQUIREMENTS
PEP 1-800-663-3456

<table>
<thead>
<tr>
<th>SUBSTANCE:</th>
<th>AMOUNT:</th>
<th>REPORTABLE TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oils</td>
<td>&gt; 100 litres</td>
<td>PEP</td>
</tr>
<tr>
<td></td>
<td>Any amount into water</td>
<td>PEP, DFO &amp; MELP</td>
</tr>
<tr>
<td>Special Wastes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Oil with &gt; 50 ppm (PCB)</td>
<td>&gt; 1 litres</td>
<td>PEP</td>
</tr>
<tr>
<td>- Corrosive</td>
<td>&gt; 5 kilograms</td>
<td>PEP</td>
</tr>
<tr>
<td>- Hazardous</td>
<td>&gt; 5 litres</td>
<td>PEP</td>
</tr>
</tbody>
</table>

Note: If in doubt regarding spill size, affected environment, material involved and whether reportable, err on the side of caution and report the spill.

EMERGENCY CONTACTS

<table>
<thead>
<tr>
<th>Contact</th>
<th>Organization</th>
<th>Position</th>
<th>Phone</th>
<th>Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carol Lamont</td>
<td>BC Hydro</td>
<td>Env. Coordinator</td>
<td>604-528-1877</td>
<td>604-230-7470</td>
</tr>
<tr>
<td>Keith Heppner</td>
<td>BC Hydro</td>
<td>Construction Officer</td>
<td>604-329-1558</td>
<td></td>
</tr>
<tr>
<td>Charlotte Bemister</td>
<td>BC Hydro</td>
<td>Community Relations</td>
<td>604-528-2354</td>
<td>604-290-5121</td>
</tr>
<tr>
<td>Jeff Greenbank</td>
<td>GES</td>
<td>Environmental Monitor</td>
<td>604-469-4494</td>
<td>604-802-4299</td>
</tr>
<tr>
<td>Matt Townsend</td>
<td>GES</td>
<td>Environmental Monitor</td>
<td>604-253-4704</td>
<td></td>
</tr>
</tbody>
</table>

6. CLEAN-UP

- Technical assistance is available from the Environmental Monitor on clean-up procedures and residue sampling.
- All equipment and material used in clean-up (e.g. used sorbents, oil containment materials etc.) must be disposed of in accordance with MELP regulations. The Environmental Monitor will assist in compliance with MELP regulations.
- Accidental spills may produce special wastes (e.g. material with > 3% oil) and contaminated soil. All waste disposals must comply with the B.C. Special Waste Regulations and the Waste Management Act. The Environmental Monitor will assist in compliance with MELP regulations.
- Waste sorbent material may not be disposed of in a landfill without prior approval from MELP.
- Contaminated soil must be treated and dealt with as required on a site-specific basis, and must comply with the requirements of the B.C. Contaminated Sites Regulations.

7. SPILL REPORT

The spill report should include the following information:
- Name and phone number of person reporting the spill
- Name and phone number of person involved with the spill
- Location and time of the spill
- Type and quantity of material spilled
- Cause and effect of spill
- Details of action taken or proposed to contain the spill and minimize its effect
- Names of other persons or agencies advised
SORBENT SUPPLIERS

Spill containment booms, sorbent sweeps and pads are also available from the below listed companies. Custom made kits and supplies are also available upon request.

A. **Acklands**\(^1,3,4\) (days) 521-8861
   742 Chester Road (after hours) 533-0696
   Annacis Island, New Westminster V3M 6J1

B. **Aquaguard**\(^1,2\) (days) 980-4899
   Unit #203, 1305 Welch Street
   North Vancouver, B.C. V7P 1B3

C. **B.C. Bearing Engineers Ltd.**\(^1,2,5\)
   722 Chester Road (after hours) 671-2265
   Annacis Island, New Westminster V3M 6J1

D. **Canada West Ecological Systems Inc.**\(^2,8\) (days) 328-0911
   P.O. Box 911, Stn. 'A'
   Vancouver, B.C. V5C 2N7

E. **CG Industrial Specialties Ltd.**\(^2,7\) (days) 263-1671
   979 West Kent Avenue (after hours) 942-5739
   Vancouver, B.C. V6P 6K8

F. **Environ-Guard Products Ltd.**\(^1\) (days) 276-9112
   Unit #6, 4751 Shell Road
   Richmond, B.C. V6X 3H4

G. **Hazmasters Environmental Controls Inc.**\(^2\) (days) 420-0025
   3131 Underhill Avenue (after hours) 443-9908
   Burnaby, B.C. V5A 3C8

H. **Infratech Polymers Inc.**\(^2\) (days) 888-8808
   Unit #4, 1947 Telegraph Trail 1-800-567-4888
   R.R. #6, Langley, B.C. V3A 4P8

I. **Pigmalion Environmental Products**\(^1,3\) (days) 521-9522
   Unit 5-A, 1595 Cleveden Avenue
   Annacis Island, Delta, B.C. V3M 6M2

J. **Spill-Check Environmental Products**\(^1\) (days) 549-1044
   P.O. Box 1952 1 800 565-6544
   Vernon, B.C. V1T 8Z7

K. **StanChem Inc.**\(^8\) (days) 685-1411
   800 Terminal Avenue (after hours) 685-5036
   Vancouver, B.C. V6A 2M8

L. **Tech/Power Industrial Supplies Ltd.**\(^1\) (days) 868-0190
   389 Queensway Avenue
   Kelowna, B.C. V1Y 8E6

M. **Total Distributing/Enviro Guard Products Ltd.**\(^1,4\) (days) 987-7158
   Unit #6 4751 Shell Road (days) 276-9112
   Richmond, B.C. V6X 3H8

N. **Versatech Products Inc.**\(^2\) (days) 922-5357
   2437 Bellevue Avenue (after hours) 434-5600
   West Vancouver, B.C. V7V 1E1464-7857

**Note:** Each type of sorbent has a **specific** use and purpose.
Note: The following suppliers provide:

Supplier 1: Cellulose treated sorbent **booms, pads and socs**
Supplier 2: Polypropylene **booms and pads**
Supplier 3: Cellulose treated **pads**
Supplier 4: Clay sorbents (kitty litter)
Supplier 5: Inorganic sorbent (Magic-Sorb™)
Supplier 6: **Natural fibre sorbents and booms**
Supplier 7: Sawdust and diatomaceous earth sorbents
Supplier 8: Corn cob particulates
APPENDIX G: ENVIRONMENTAL SUMMARY REPORT

Boulder Creek Diversion Upgrade

Environmental Summary Report

To: Carol Lamont
cc: Kelly Gallway
Environmental Monitors: Jeff Greenbank, Jason Macnair
Date: September 30, 2007

Introduction

Boulder Creek, located upstream of Jones Lake, near Hope, BC (Figure 1) was diverted into Jones Lake with an embankment dam to increase flows into the reservoir during the original hydroelectric development. The embankment dam is equipped with a pipe and valve to divert water through the dam and into the original Boulder Creek channel to supplement flows in lower Jones Creek. Over time erosion in the Boulder Creek channel resulted in the inability to divert flows and all of the water was delivered to the reservoir. A weir was constructed in the summer of 2005 which made the diversion operable; prior to this the diversion was not used since the early 1990’s.

Under the current water use plan (WUP), BC Hydro is required to maintain flows in Lower Jones Creek at or above 1.1 cms from September 15 to November 30 and 0.6 cms during the rest of the year. BC Hydro occasionally requires flow from the Boulder Creek diversion to augment flows in lower Jones Creek to meet the minimum flow criteria. In the summer of 2005 the diversion was upgraded by construction of a new lock-block weir that created a head-pool adjacent to the existing intake structure which allowed flow to be diverted from Boulder Creek through the diversion Dam to lower Jones Creek. In August 2006, maintenance was carried out on the lock block weir to re-establish fish passage over the weir and to re-armour the area downstream of the structure which had degraded over the 2005-06 winter season. The lock block weir was completely destroyed during high-flow events over the 2006-07 winter season.

In September 2007, BC Hydro constructed a boulder riffle type weir to re-grade the channel and provide the required pool elevation adjacent to the intake to allow diversion flows to the existing intake. This work is the focus of this report.

Scope of Work

The work consisted of the construction of a large boulder riffle designed to increase the water elevation adjacent to the existing intake structure. The boulder riffle was constructed placing large rip rap over a length of about 40 m within Boulder Creek. The rip rap was imported to the site from a quarry.
located in the Fraser valley. Once the riffle was constructed and the proper elevation was achieved it was sealed up with placement of a 4” minus round rock mix (spawning gravel) to fill the interstitial voids and minimize flow beneath the new boulders.

The work was undertaken with an excavator (John Deere 330) operated by Mission Contractors. The weir was designed and overseen by Streamworks Unlimited (Al Baites). Environmental monitoring was undertaken by Greenbank Environmental (Jeff Greenbank, Jason Macnair).

Work Summary

Equipment was mobilized to site on 24 August 2007. Rock was hauled to the site starting 24 August 2007 and continued through the duration of the project. Excavator access to the creek and rock placement commenced on 27 August. Although it was previously discussed with BC Hydro that dewatering pumps would be on site for the start of construction they were not on site on 27 August. Work commenced on 27 August by placing large boulder in the stream to divert flow away from the working area. This was determined to be insufficient and pumps were established the following day. One six inch and two 3” submersible electric pumps were installed on 28 August. A combination of pumping and flow diversion was used to minimize sediment generation during construction. Dewatered areas were searched for stranded fish throughout the work. No fish were observed within the work area.

Work was completed on 5 September 2007. The boulder riffle appeared passable to fish upon completion and this was verified on 17 September when Kokanee were observed upstream of the weir (Figure 7). The overall gradient of the boulder riffle is approximately 3.5 % and it appears similar in gradient and structure with the naturally occurring riffles in the creek.

Conclusions

This work was completed without spills or other environmental incidents. Impacts were kept to the minimum required to complete the work. The site has been left in a clean and stable condition. It is anticipated that the structure will hold up well in high flows, however, it is recommended that the weir is inspected periodically throughout the winter months to monitor its durability.

Sincerely,

Jeff Greenbank, RPBio.

Greenbank Environmental Services
Figure 1. General location of Boulder Creek and construction area.
Figure 2. Boulder Creek diversion dam on August 27, prior to upgrade work. Note the remnants of the lock block weir (In red).

Figure 3. View of pumping established during diversion weir construction.
Figure 4. Boulder Creek diversion dam on August 28, during construction.

Figure 5. Boulder Creek diversion on August 29, during construction.
Figure 6. Boulder Creek diversion on August 30, during construction.

Figure 7. Downstream view of completed weir on September 17. Note Kokanee present upstream of weir.