BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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Beak Consultants Limited

Montreal
Toronto
Calgary
Vancouver

Suite 602/1550 Alberni Street
Vancouver/British Columbia
Canada/V6G 1A5
Telephone (604) 684-8361
Telex 04 508736

beak
Environmental Specialists

HAT CREEK PROJECT DETAILED ENVIRONMENTAL STUDIES WATER RESOURCES SUBGROUP HYDROLOGY, DRAINAGE, WATER QUALITY AND USE

VOLUME 1
SUMMARY

A Report For:

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
Vancouver, B.C.

Prepared by

BEAK CONSULTANTS LIMITED
Vancouver, B.C.

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A MEMBER OF THE SANDWELL GROUP

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1.0 SUMMARY

1.1 INVENTORY

(a) Hydrology

(i) Ground Water

The potentially significant ground water aquifers in the Hat Creek Valley are small and of limited areal extent. Most of the bedrock and surficial sediment materials have relatively low hydraulic conductivities and coupled with the low annual precipitation in the area, the recharge to the ground water table is also low.

Generally the ground water recharge zones are located at the higher elevations and the ground waters flow mostly through the surficial sediments. Less than 2 percent total ground water flow is estimated to flow in the bedrock. Total ground water flows towards Hat Creek along the length of the valley have been estimated to be between 284 and 568 $m^3 \cdot d^{-1}$ per kilometer.

Based on borehole information and an evaluation of the regional hydrogeology, the limestone and granodiorite bedrock, glacio-fluvial sediments and alluvium form the only significant aquifers. The bedrock aquifers are concentrated mainly in the north and east of the Hat Creek Valley. With the exception of the Houth Meadows area these bedrock aquifers are generally located away from the proposed development areas.

The thicker sequences of glacio-fluvial sediments are generally located near the valley bottoms and two distinct potential aquifers have been identified in the Marble Canyon and north end of the Upper Hat Creek Valley. Potential ground water flows of 2,000 and 5,000 $m^3 \cdot d^{-1}$ respectively have been estimated for these aquifers.

A shallow alluvial aquifer is present in the Hat Creek Valley bottom. This aquifer is hydraulically connected to Hat Creek and the water flows, both from aquifer to creek and creek to aquifer, have been observed in various reaches along the valley.

Existing data indicate that without the proposed Hat Creek Project there will be no noticeable hydrogeologic changes in the foreseeable future.

(ii) Surface Water

Considerable streamflow records and climatic data exist for Hat Creek and the surrounding area. An active streamgauging site on Hat Creek and an active climatological station fall within the proposed pit perimeter. Both stations have almost continuous records since 1960.

A multivariate regional analysis of streamflow records for the interior plateau of B.C. indicates that drainage area, elevation, mean annual precipitation and forest cover can explain the magnitude and variability of floods to a large degree. The Hat Creek region is shown to produce lower floods than most other areas within the interior plateau but the year-to-year variability of floods in the Hat Creek area is about average.

Precipitation, snow accumulation and evaporation vary considerably with elevation. Curves giving mean annual precipitation and mean maximum snow water equivalent as functions of elevation are developed in the report.

The streamflow records of Hat Creek are analyzed in terms of flood frequency, flow duration and flow probability curves. Flood frequency curves for ungauged tributary basins are derived on the basis of results from the regional analysis.

Thornthwaite water balance tabulations computed by the Atmospheric Environment Service for several climatic stations in the Hat Creek area show the elevation dependence of the main components. An elevation-adjusted water balance for Hat Creek is estimated from these records and is shown to be consistent with observed runoff.

The channel and floodplain morphology and channel geometry of Hat Creek downstream of the mine are described qualitatively from air photos and ground inspection and quantitatively on the basis of surveyed sections and profiles for a few typical reaches.

The surface water regime of Hat Creek is presently stable and would likely remain so into the foreseeable future without the project. The irrigated area could be expanded somewhat and an abandoned irrigation diversion out of the Hat Creek drainage could be re-activated.

(b) Water Quality

This section briefly summarizes the conclusions made from the inventory data obtained in this study.

(i) Ground Water

In examining the data collected, it was found that all of the ground waters sampled could be placed in one of four categories: (1) shallow, characterized by a high calcium to sodium ratio and a comparatively low filtrable residue and conductivity; (2) intermediate or surficial, characterized by an intermediate calcium to sodium ratio and intermediate filtrable residue and conductivity levels; (3) deep permeable bedrock, characterized by a low calcium to sodium ratio and high levels of filtrable residue and specific conductance; and (4) unique samples due to special conditions. In spite of the great variability in water quality between different sample sites, it was found that the water from all sites met the Canadian Drinking Water Standards for toxic chemicals and, with the exception of the calcium level at one specific sample site, met these same standards for recommended limits for other chemicals.

No significant change in the quality of the ground water is anticipated without the project.

(ii) Surface Water

The data for Hat Creek showed that the water in this creek has a significant ground water component, probably from a shallow aquifer. This was shown by the comparatively high levels for calcium, magnesium, and total hardness. There was also indication of the presence of soluble strontium and soluble fluoride bearing minerals in the area. The nitrogen to phosphorous ratio was found to be low indicating the presence of agricultural runoff into the creek.

Temperatures at the mouth of Hat Creek were found to be high for rainbow trout during the summer months which would classify Lower Hat Creek as being only marginal in water quality for cold water game fish with respect to temperature. A comparison of the data obtained in this program from Hat Creek with existing data from other sources showed good agreement except in the case of phosphorous, where a seasonal bias in the existing data was indicated.

The data for the Bonaparte River showed that the water quality in this river is significantly different to Hat Creek, suggesting that Hat Creek has a marginal effect on the water quality of the Bonaparte River. In terms of its water quality the Bonaparte River is moderately hard and exhibits a low nitrogen to phosphorous ratio indicative of fertilizer input. A comparison of the data obtained in this program for the Bonaparte River with existing data from other sources showed good agreement with the few minor differences probably being attributable to differences in sample site location.

The data for the Thompson River showed that the water quality in this river is very different to Hat Creek, suggesting that Hat Creek has, at most, only a minimal effect on the water quality of the Thompson River. In terms of its water quality, the Thompson River is a soft water river and the ratios of its important ions shows near average values, reflecting the relatively large size and diversity of the Thompson River drainage area. A comparison of the data obtained in this program for the Thompson River with existing data from other sources showed good agreement except for chemical oxygen demand, turbidity, and aluminum. In the case of chemical oxygen demand, this was attributed to a single high value obtained in this program which has been considered an unexplainable outlier. In the case of turbidity, a comparison of the value obtained with the nonfiltrable residue obtained in the same study showed marked disagreement indicating that the referenced program turbidity data may be faulty. In the case of aluminum, from the same program, no explanation could be found for the difference observed.

In examining the lakes of the Hat Creek Valley, two lakes were chosen to represent the two extremes of the spectrum of lakes in the valley. The data for Finney Lake shows it to be an oligotrophic lake with an ionic distribution characteristic of the other surface waters found in the Hat Creek Valley. At the other end of the spectrum is Goose/Fish Hook Lake which with its high sodium, sulphate, filtrable residue, and specific conductance is characteristic of the alkali sloughs found in the southern interior of British Columbia. The other lakes examined in the valley then fall between these two extremes.

A decrease in Hat Creek Valley surface water quality can be expected in the future due to projected increased agricultural activity and consequent land disturbance and fertilization, even without the proposed project.

(c) Water Use

(i) Ground Water

Present ground water use has been estimated to be about 160 $m^3.d^{-1}$, which represents about 1.7 percent of the total ground water potential in the area.

Future use without the project is anticipated to remain essentially the same as at present.

(ii) Surface Water

A. Irrigation

Present water use data for the study area was based on water licence information and reported on the basis of four drainage areas: Hat Creek Drainage Basin, Lower Bonaparte Drainage Basin, Cornwall and Cheetsum Drainage Basins, and Oregon Jack and Minaberriat Drainage Basins. The results are summarized in the following table:

TABLE 1-1

WATER LICENCE ANALYSIS SUMMARY

	Seasonal Water Quantity (ha-m)	Irrigated Land (ha)
Hat Creek Drainage	631	1016
Cornwall & Cheetsum Drainages	125	307
Lower Bonaparte Drainage	1290	1246
Oregon Jack & Minaberriat Drainages	148	166
Total	2194	2735

Present use in Hat Creek Valley was also analyzed by a mathematical water use model using actual soil, climate and crop variables. The results are very similar to the water licence analysis results.

Projected water use in the study area without the project considers two cases, maximum potential use and probable use. Potential use is limited only by the availability of irrigable land while probable use considers all significant constraints to irrigation development, the most prominent limitation in this case being the availability of irrigation water. Projected water use results are summarized in the following table:

TABLE 1-2

PROJECTED IRRIGATION WATER USE SUMMARY

	Seasonal Water Quantity (ha-m)		Irrigated Land (ha)	
	Potential Use	Probable Use	Potential Use	Probable Use
Hat Creek Drainage	4164	1005	6033	1934
Cornwall Bonaparte Oregon Jack Drainages	4095	2417	4500	2656
Total	8259	3422	10533	4590

The projection of probable irrigation use in Hat Creek Valley is roughly one and one-half times that of present use.

B. Livestock

The quantity of water presently used by livestock was estimated for the Hat Creek Valley from reported cattle populations and water use rates. The total annual use is 2.4×10^4 m^3 (6.4 million U.S. gallons) and represents approximately 0.4 percent of water presently used for irrigation in Hat Creek Valley.

Projected water use by livestock was estimated from reported cattle number projections and water consumption rates. The projection of annual use without the project was 4.1×10^4 m^3 (10.7 million U.S. gallons).

C. Domestic and Municipal

The present surface water licenced for domestic use in Hat Creek Valley is 84 $m^3 \cdot d^{-1}$ with 22 percent of this being licenced for diversion out of the Hat Creek watershed. Seventy-eight percent of the water licenced for domestic use is from Hat Creek and the remainder is from it's tributaries. The present quantity of water licenced for use from the Bonaparte River between the Hat Creek junction and the Thompson River is 9,222 $m^3 \cdot d^{-1}$ of which 88 percent is licenced for the

Village of Cache Creek. The quantity of water licenced for or in application status for domestic, municipal and industrial use from the Thompson River between Wallachin and Lytton is 89,177 $m^3 \cdot d^{-1}$. Two percent is licenced for use by the community of Ashcroft and the majority of the remainder is licenced for mining in the Highland Valley.

As the increase in Hat Creek Valley population without the project is expected to be negligible, surface water use should remain unchanged. However, the projected increase in population of Cache Creek and Ashcroft is expected to increase surface water use for municipal purposes in these communities by about 50 percent between 1976 and 1990.

1.2 IMPACT ASSESSMENT

(a) Hydrology

(i) Ground Water

The proposed Hat Creek Project would not seriously affect the total ground water resource of the area. Once the Thompson River water supply is available, most of the ground water abstractions will cease.

Pit excavation and dewatering would cut the valley alluvial aquifer and significantly reduce the flow in its northern end. Except for a small percentage lost in evaporation, most of the water from dewatering will be returned to Hat Creek.

The upper parts of the proposed dumps will absorb precipitation during wet periods and will gradually release this water along with soil moisture expelled due to consolidation, during the remainder of the year. Provided the waste rock compacts under its own weight and that a suitably graded filter material is placed on the upstream side of the embankments and against the limestone rock, the seepage quantities leaving the dump will be very small. This seepage will be directed into the valley walls and to surface water channels.

Seepage from the proposed ash dump in the Medicine Creek Valley will be minimal, due to the presence of the low permeability waste rock to be placed downstream of the ash dump. Small recharges to ground water aquifers will occur as a result of losses from the diversion canal and diversion ditches.

All impacts on the ground water resources would be restricted to an area within 1.5 km from the limits of the proposed waste dumps and coal pit. Minor negative impacts are mitigated by an equal number of beneficial impacts and thus the net impact is considered ambivalent.

(ii) Surface Water

The most significant effects of the proposed project on surface water hydrology are either due to modifications of the local water balance by changing the nature of the ground surface (e.g. clearing, replacing forest lands with impervious waste dumps, paving, etc.) or due to re-arrangements of the drainage system (e.g. diversions, drainage of lakes, creation of storage in reservoirs and sedimentation lagoons, etc.).

Impacts of the construction phase are difficult to assess because they depend to a large degree on the details of construction planning and on the degree of care exercised in executing the work. Major, clearly defined impacts result from the loss and displacement of 9 km of natural Hat Creek channel and significant reaches of some of its tributaries.

Operation of the mine will normally not have a significant impact on the flow regime of Hat Creek. Mine drainage and the flow from dewatering wells consists mainly of water which would have found its way into Hat Creek under natural conditions.

Operation of the power plant will have only minor impacts, except for the loss of 5 km of natural Medicine Creek Valley with the ash disposal scheme, water supply reservoir and waste dump. The consumptive use of Medicine Creek water appears to be the most significant impact with respect to operation of the power plant.

The adopted Hat Creek diversion scheme will have only minor impacts on flow regime and channel morphology. By maintaining the Hat Creek diversion around the pit after completion of mining, as has been adopted several major impacts on Hat Creek have been eliminated.

The surface water hydrology impacts are almost all concentrated in the Hat Creek drainage basin where they constitute a significant impact. Impacts on the Bonaparte and Thompson Rivers are not significant.

Opportunities for further mitigation are rather limited. Procedures and techniques for minimizing impacts are well known and the proponent is committed to their implementation. Construction should be scheduled in such a way that the drainage and erosion control works will be in place before extensive areas are disturbed. Use is being made of the fact that the water balance of the Hat Creek area is highly negative (potential evaporation exceeds precipitation).

(b) Water Quality

(i) Ground Water

Significant impacts on ground water quality have not occurred during the preliminary site development activities, nor is it projected that any long-term affects would evolve from activities carried out thus far.

Construction phase activities should not produce any significant interactions with ground water quality provided proper procedures and methods are included in the design and operation of camp sewage systems and refuse disposal. Impermeable base and lining will be used to control seepage from the coal stockpile, low grade waste pile and all lagoons or impoundments containing contaminated waters.

Operation of the mine itself does not affect ground water since most of the significant interactions are water extractions (i.e. dewatering). Drainage from the proposed waste dumps in Houth Meadows and Medicine Creek area will result in some seepage into the ground water systems in these areas. This seepage is projected to contain elevated levels of dissolved solids and some metal ions. Utilization of impermeable base conditions in the coal stockpile area will prevent significant ground water contamination.

With interception of the valley alluvial aquifer by the open pit, the aquifer downstream of the development is predicted to begin conveying a larger component of ground water from the Marble Canyon area. The projected potential impact of this together with the inclusion of some seepage from the Houth Meadows waste dump will be to cause a minor increase in the dissolved solids level of the ground water downstream of the development.

Interactions with ground water quality from operation of the power plant will occur at the ash disposal sites. Since the quantity of seepage will be minimal, the impact will be restricted to the area between the disposal site and the open pit. Major impacts on ground water quality are not envisioned during construction or operation of the offsite activities.

Decommissioning activities will, in general, have a beneficial effect of reducing contaminated inputs to the ground water regime through surface reclamation and the cessation of the generation of solid and liquid wastes. The proposal to leave the mine pit as a void will cause no adverse impact on the ground water quality of valley bottom aquifers provided the level of accumulated seepage in the pit void remains low.

Ground water quality monitoring during all phases of the development as early warning systems to safeguard this component of the area water resources is recommended.

(ii) Surface Water

Preliminary site development activities to date have not caused any noticeable changes to surface water quality. Surface disturbance could be mitigated by reclamation to avoid long-term affects should the project not proceed.

The main impacts on water quality during construction will be related to wind and water born residual sediments originating from construction activities and erosion entering the surface water creeks and streams. The timing of certain construction phase activities and utilization of sediment control measures will be required to minimize detrimental impacts on water quality. The impact should be minor if sediment control reduces the suspended solids level to the regulatory guideline for point source discharges. Total containment of all low quality drainages (coal stockpile and low grade waste stockpile dump seepages and bedrock dewatering system discharges) to a zero discharge system has now been adopted. This procedure substantially reduces the potential impact on Hat Creek water quality. Sewage disposal systems proposed do not resort to positive discharge thus they will not affect the quality of any surface streams or rivers.

During operation, major interactions with surface water quality have been mitigated. Seepage surfacing from the main waste disposal dumps along with low quality mine waters are sources that will be contained in a zero discharge system in order to avoid serious impact. Leachates and runoff from coal piles, low grade waste dump will also be contained. Based on the adopted mine drainage plans, projections indicate that the dissolved and suspended sediment yields in Hat Creek are unlikely to change significantly as a result of the development. Nitrogen and phosphorus losses from reclamation fertilization could eventually begin to raise the nutrient levels in the Hat Creek Valley runoff to the point where increased plant life (algae) becomes a detriment to stream values. Temperature projections on the water in the Hat Creek diversion canal during low summer flows indicates there are inherent problems if the existing fishery resource of Hat Creek is to be maintained. Water temperatures considerably above those suitable for rainbow trout are predicted which will make portions of the lower part of Hat Creek, in addition to the canal, unsuitable for fish life.

Potential effects on surface water quality during and after decommissioning include both beneficial and negative impacts. Reclamation of the remaining disturbed areas would reduce residual dissolved solids and sediment in the runoff. Nutrient losses would be contingent on fertilization activities.

Mitigation measures which should be considered in the design and development phases include adoption of additional sediment control procedures to development of a creek diversion scheme less suseptible to causing temperature impacts.

Further research is desirable to confirm the nature of runoff and leachates from overburden and ash wastes. It may be possible to gather some of this information from the test reclamation plots being studied in the Hat Creek Valley.

Monitoring recommendations include a continuation of the baseline sampling network established in the inventory work of this study plus the establishment of a few new surface water stations to allow detection of project related effects. Point source monitoring will also be required at all discharges to receiving streams under terms of permit from the Ministry of the Environment.

(c) Water Use

(i) Ground Water

The proposed development would not affect the quantities of ground water being used upstream or downstream of the study area. Construction camps would use about 328 $m^3 \cdot d^{-1}$ of ground water. Ground water use for industrial purposes could increase to about 1,400 $m^3 \cdot d^{-1}$. The total ground water use at maximum could approach 36 percent of the available ground water towards the end of the construction stage. Some irrigation water for reclamation revegetation activities could be supplied from ground water sources.

(ii) Surface Water

A. Irrigation

Construction of project facilities would alienate use of 165 $ha\text{-}m\text{-}yr^{-1}$ (1337 $ac\text{-}ft\text{-}yr^{-1}$) of irrigation water on lands projected as likely being irrigated in the future. Part, or perhaps all, of this water may be available for the irrigation of other lands and thus the net impact on water use would be reduced accordingly. The Hat Creek and Finney Creek diversions would block the use of present irrigation conveyance ditches associated with the supply of 35 ha-m (284 ac-ft) of water.

Project operation could affect the availability of up to 295 $ha\text{-}m\text{-}yr^{-1}$ (2406 $ac\text{-}ft\text{-}yr^{-1}$) of water for irrigation use. Partially composed of non-consumptive uses that would only change the location of water availability, the net impact on irrigation water use would be less than the above quantity.

Major potential benefits to irrigation would be associated with decommissioning of the project through the use of project reservoirs for water storage. Around 300 $ha\text{-}m\text{-}yr^{-1}$ (2431 $ac\text{-}ft\text{-}yr^{-1}$) of water of the Hat Creek drainage basin could be made available for irrigation in this way. This is nearly one-half the current use of water for irrigation in the Hat Creek Valley. In addition, around 2600 $ha\text{-}m\text{-}yr^{-1}$ (21070 $ac\text{-}ft\text{-}yr^{-1}$) of Thompson River water might also be available although the feasibility of this has not been assessed.

Compensation for the loss of irrigation water use due to land alienation could be possible in part, or perhaps in full, by the development of suitable alternate agricultural lands.

The possible relocation of a few project activities was identified as helping to mitigate impacts on irrigable lands and thus impacts on the associated water use.

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Design modification of the water supply reservoir outlet works was suggested as a compensation measure. In general the supply of water for project use by providing additional storage in project reservoirs would alleviate some of the potential conflict of project use with that of irrigation.

B. Livestock

The losses or benefits from the project on livestock water use would appear to be minor in nature, especially in view of the fact that the magnitude of this use is small in comparison to other water uses.

C. Domestic and Municipal

Surface water uses throughout the various phases of the project are all small relative to the specific resources and therefore the impact in all cases is insignificant.