

# **Jumbo Glacier Resort Master Plan**

## **Appendix 5-G**

Supplementary Groundwater Supply Assessment  
prepared by Golder Associates

**Golder Associates Ltd.**

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E/03/2160  
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December 23, 2003

Pheidias Project Management Corporation  
1660 – 1188 West Georgia Street  
Vancouver, B.C. V6E 4A2

Attention: Mr. Oberto Oberti, MAIBC

**RE: SUPPLEMENTARY GROUNDWATER SUPPLY ASSESSMENT  
JUMBO GLACIER RESORT,  
INVERMERE AREA, BRITISH COLUMBIA**

Dear Sir:

Golder Associates Ltd. (Golder) has previously carried out a series of geotechnical, glaciology, hydrogeology, and natural hazard studies over a period of several years from about 1993 onwards as input to development of the Master Plan Concept for the proposed Jumbo Glacier Resort. The Golder letter dated December 11, 2003 provides a summary of the available information and presents the results of our recent review, assessment and professional opinion related to the following items contained in the “Jumbo Glacier Resort, Environmental Assessment Application Checklist – Combined Agency Response (Dec. 3/03)”:

- Water supply and impact on Jumbo Creek;
- In-ground wastewater disposal; and
- Debris flow hazard potential.

The available information was listed in the December 11, 2003 letter and is not repeated herein. This letter presents a supplementary assessment and Golder’s professional opinion related to the availability and long term sustainability of groundwater supply for the Jumbo Glacier Resort development described in the Master Plan Concept. As set out in Project Specification D.2 (A) #4, this letter also presents Golder’s assessment and professional opinion of the relationship (degree of connectivity) between groundwater and instream flows in Jumbo Creek, and the impacts of groundwater withdrawals on this exchange.



## **1.0 HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENT**

As described in Section 5.35 of the Master Concept Plan Volume 5: Infrastructure, groundwater from drilled wells is to supply all of the water needed for the resort, with the wells envisaged as being located at one or more locations approximately 1 km upstream from the resort site. Civil engineering studies have determined that the water supply requirements for all resort uses will be less than about 185,000 cubic metres/year, which can be achieved with a well water supply of 20 litres/second or less. There is no need or plan for use of surface water from Jumbo Creek or elsewhere in the Jumbo Valley to provide water supply.

### **1.1 Subsurface Conditions and Hydrogeological Characteristics**

Jumbo Creek is located within a “U” shaped valley. Previous air photograph interpretation, site reconnaissance, and on site investigations confirm that the lower portions of this valley where groundwater wells will be located are underlain by variable but typically coarse and permeable granular deposits. These deposits have been derived from the fans of localized tributary drainage channels, avalanches or rockfalls, as well as the alluvial deposits from sediment transport and reworking of the side valley deposits by Jumbo Creek. The granular deposits are expected to be of substantial thickness within the lower, more gently sloping terrain near the bottom of the valley.

Preliminary geotechnical and hydrogeological investigations have confirmed the variable but generally high permeability and the presence of groundwater levels at shallow to moderate depth. In addition, observations of disappearance of tributary streams into the fan deposits provide confirmation of the high permeability and continuing groundwater recharge conditions along the Jumbo Creek valley.

- Based on the available information and our extensive experience with comparable deposits and conditions, it is Golder’s opinion that the water supply needs for the Glacier Resort development can be readily provided by groundwater well installations. The current indications of a suitable groundwater source location a relatively short distance upgradient (upstream) of the main resort site is also considered beneficial since the risk of an adverse change in the groundwater characteristics resulting from the resort development or other factors is considered very low.

The specific locations and type of the well installation(s), and the desirability or need for one or multiple wells to accommodate the inherent variations in subsurface conditions, control groundwater drawdown, and provide redundancy of supply should be determined as part of more detailed study once the master plan concept has been finalized and accepted.

## 1.2 Hydrology and Water Balance

The previous studies of surface water within the Jumbo Creek conducted by KPA Engineering Ltd. determined that the catchment area above the proposed Jumbo Glacier Resort site is some 18.3 square kilometers at a location about 1.3 km upstream (about elevation 1,710 m) of the proposed site, and 27 square kilometers at the resort area, at about elevation 1,690 m. At these locations, KPA have estimated that the 10 year low surface flows in Jumbo Creek are 50 and 80 l/sec, respectively, or some 1.5 to 2.5 million cubic metres/year.

The total annual precipitation within this catchment area is estimated to be 900 to 1000 mm/year, using the data available from the publication "Canada's Rural Water Resources". In addition, information from other weather stations in the general area of the Jumbo Glacier Resort site was reviewed and the relevant annual precipitation values and elevations of these stations are summarized below:

<b>Station Name</b>	<b>Elevation (metres)</b>	<b>Annual Precipitation (mm)</b>
Kootenay NP West Gate	899	424
Kootenay NP King Crossing	1170	511
Yoho NP	1219	616
Bugaboo Creek	1494	914

All of these weather stations are at appreciably lower elevations than the Resort site (about elevation 1700 m) and catchment area. Further, comparison of this data indicates that higher, potentially significantly higher, precipitation levels are likely to occur within the higher elevation catchment area of the Jumbo Glacier Resort site. Consequently, the estimate of total annual precipitation given above is considered to be conservative. Assuming 900 mm/year precipitation, it is estimated that the total annual precipitation within the 27 sq. km catchment area at and above the Jumbo Glacier resort will be approximately 25,000,000 cubic metres/year.

Using the water balance method of evaluation, the total annual precipitation within the catchment area upstream of the proposed Jumbo Glacier Resort must be equal to (balanced by) the sum of the losses due to evapotranspiration, sublimation from the snowpack and glaciers, surface runoff, and groundwater flow. No allowance has been included for possible additional discharge from long term recession or thinning of the glaciers, which would increase the overall discharge from the catchment area if taken into consideration. With allowance for potential evapotranspiration / sublimation losses of 500 to 600 mm/year (13.5 to 16 million cubic metres/year), the remaining 9 to 11.5 million cubic metres/year of annual precipitation must be discharged from the catchment area through a combination of surface runoff and groundwater seepage flows.

- Using the KPA values for 1,500,000 to 2,500,00 cubic metres/year (50 to 80 litres/sec) flows in Jumbo Creek at about the Resort site, it is estimated that annual groundwater flows of 6,500,000 to 10,000,000 cubic metres/year occur within the soil deposits and near surface bedrock along the Jumbo Creek valley.
- In comparison, the water supply requirements for all resort uses will be less than about 185,000 cubic metres/year, which is only 1.8 to 2.8 percent of the annual groundwater flow value determined by this preliminary water balance. Even if the actual annual surface water flow in Jumbo Creek is considerably larger than the values derived from the KPA data, it is Golder's opinion that there is more than adequate groundwater flow within the Jumbo Creek valley to provide a long term, sustainable water supply for the proposed Jumbo Glacier Resort described in the Master Concept Plan.

The water balance assessment should be reviewed as part of subsequent, more detailed design once the master plan concept has been finalized, accepted and site specific precipitation and metrological data is available.

### **1.3 Impact of Groundwater Withdrawals**

The use of in-ground disposal of the wastewater effluent from the resort after tertiary treatment will result in return to the groundwater regime of an equivalent volume to that obtained from the water supply wells, which are to be located a short distance upstream of the resort site.

- Consequently, no net withdrawal of groundwater will occur within the Jumbo Valley.

The upper portion (apex) of the fan deposits located along but above the valley bottom are typically composed of very coarse granular soils varying in composition from boulders to sands and gravels. These materials have very high permeability and infiltration capacity and are exposed at or near surface. Further, the results of previous investigations, including site specific test pits, confirm that these soils are unsaturated to depths of at least 2 to 4 m. At least locally, the fan deposit apex soils have infiltration capacities of some 225 cubic metres per day. These areas are considered to represent unconfined, high capacity aquifers.

- While it is considered unlikely that wells would be installed near the apex of fan deposits due to the potential risk of damage from avalanche or localized debris flow activity, it is Golder's opinion that the very high permeability of these soils would prevent any significant drawdown of the groundwater level resulting from well water withdrawal.

Near and below the base of the fan deposits and underlying the flat lying floodplain of Jumbo Creek, the alluvial or mixed alluvial and fan deposits are generally granular but are irregularly stratified, with variable and locally significant (up to 35 percent) fines content identified in previous investigations. Groundwater level was found to be close to ground surface and ponding of water occurs within the floodplain area. Due to the stratification, vertical permeability and infiltration capacity is likely to be significantly lower than horizontal.

- As such, it is Golder's opinion that the floodplain and valley bottom soils represent a "leaky" aquifer condition. Consequently, it is also Golder's opinion that localized groundwater drawdown and withdrawal at well installations will have nominal or no significant impact on surface water conditions which would remain "perched" above the well extraction zone.

In summary, it is Golder's opinion that there will be no significant or detrimental impact on the groundwater conditions within the Jumbo Valley. Equally, there will be no impact on the surface water conditions.

We trust that this information is sufficient for your immediate requirements. If you have any questions concerning this letter or require further assistance, please do not hesitate to contact the undersigned.

Yours very truly,

**GOLDER ASSOCIATES LTD.**



Richard C. Butler, P.Eng.  
Principal

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