SCRD STAFF REPORT

DATE: 1 September 2006

TO: Infrastructure Services Committee – 7 September 2006

FROM: Steve Lee, GM Infrastructure Services

RE: **Draft HOTEL LAKE HYDROLOGIC STUDY**

RECOMMENDATION(S)

That the technical memorandum by Kerr Wood Leidal entitled "Hotel Lake Hydrologic Analysis" dated September 1, 2006 be received as information, and
Staff be directed to circulate the report to all stakeholders and convene a public meeting to discuss the report and receive input.

BACKGROUND

The SCRD Board at its regular meeting on 8 April 2004 directed:

(303/04) THAT staff proceed immediately with a definitive study of Hotel Lake.

As a result of the Public Hearing on the appeal on the transfer of water licenses from Garden Bay Waterworks District, the Environmental Appeal Board (EAB), in August 2005, directed:

That the Regional Manager shall ensure that hydrologic impact on Hotel Lake are taken into consideration in setting the minimum lake levels under clause (e) and in setting the license volumes…also require the Regional District to make available to the public the …the water balance study…"

DISCUSSION

The draft water balance report including a recommended "minimum water level" for Hotel Lake is now complete and has been submitted to the Ministry of Environment for review. The next step in the approval process is to release the draft report to the public for comments to the Ministry of Environment.

In discussion with Mr. Herath of the Ministry of Environment, he advised that it is now appropriate to release the report to stakeholders for comments and a public meeting be convened to receive input.

Intergovernmental Implications

The recommendation complies with EAB ruling.

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Technical Memorandum - DRAFT

DATE: September 1, 2006

TO: Steve Lee, MBA, P.Eng., Sunshine Coast Regional District

FROM: David Roche, M.A.Sc., P.Eng.
Mike Currie, M.Eng., P.Eng.

RE: **HOTEL LAKE HYDROLOGIC ANALYSIS**
Recommendations for Interim Minimum Lake Level
Our File 724.004

1. BACKGROUND

This study was initiated in December 2004 by the Sunshine Coast Regional District in response to concerns raised by local residents and the BC Ministry of Environment regarding water availability at Hotel Lake.

The scope of the study was expanded in August 2005 to address directions 1(b), 1(c), 2, and 5 of BC Environmental Appeal Board Decision Nos. 2004-WAT-003(b) and 2004-WAT-004(b) (EAB, 2005). The scope of this report is limited to hydrologic issues; as such, it does not address the environmental implications of direction 5 of the EAB decisions.

2. INTRODUCTION

The Sunshine Coast Regional District (SCRD) is an established water purveyor in the Pender Harbour area of BC's Sunshine Coast (see Figure 1), providing water for a limited service area from Hotel Lake.

The SCRD currently holds three water licences on Hotel Lake authorizing a total maximum withdrawal of approximately 89,376 m^3 per year. The SCRD is amalgamating with the Garden Bay Waterworks District, which holds a water licence authorizing the diversion of an additional 11,843 m^3 per year. These water licences are summarized in Table 1 below.

Table 1: SCRD Water Licences

Licence No.	Maximum Quantity	
	(gal/year)	(m^3/year)
C119333	10,950,000	49,780
C119338	7,300,000	33,186
C121563	1,410,000	6,410
C121564 (GBWD)	2,605,000	11,843
Total	22,265,000	101,219

In addition to the water licences summarized in Table 1, the SCRD has a pending application (Application No. Z118466) for an additional 63,645 m^3/year (14M gal/year). The SCRD intends to withdraw this application once the directions of the EAB decisions have been implemented and the amalgamation with GBWD finalized (including interconnection of the water distribution systems for Hotel Lake and Garden Bay Lake).

Although the four existing water licences authorize water diversions throughout the year, Conditional Water Licence Nos. 119338, 121563, and 121564 all contain the following condition in Clause (e):

> "This licence does not authorize the diversion and use of water at any time when the level of Hotel Lake falls below the minimum level established by an engineer under the Water Act."

This clause was included in Conditional Water Licence No. 49985 (ultimately superceded by CWL Nos. 121563 and 121564) in response to objections from local water users concerned about water availability. An Order under Section 18 of the Water Act added clause (e) to CWL No. 119338 in December, 2004.

Direction 1(c) of the EAB decisions (EAB, 2005) requires that the Regional Water Manager obtain the technical studies necessary to define the minimum lake level specified in Clause (e).

A number of previous studies have examined the hydrology of Hotel Lake. A complete review of these studies was prepared by KWL for Land and Water BC (LWBC) in 2005. While the previous studies provide much useful information, they do not provide enough certainty to make precise water management decisions.

This technical memorandum provides the results of KWL's water balance study for Hotel Lake. Sections 3 through 10 describe the methodology used for each component of the water balance. Section 11 presents the results of calibration against 2005 data. Results of the water balance for normal and 10-year drought years are presented in Section 12.

Section 13 recommends a minimum lake level and presents a possible plan for implementation.

3. WATERSHED DESCRIPTION

3.1 PHYSICAL CHARACTERISTICS

A topographic map of the Hotel Lake watershed is shown in Figure 2. The area of the watershed is approximately 99 ha (0.99 km²). Of this, the lake surface area accounts for approximately 27 ha (0.27 km²).

The Hotel Lake watershed consists of local slopes that discharge directly to the lake, which has no significant tributaries. Elevations in the watershed range from about 230 m in the west (Pender Hill) and 186 m in the east (Harbour Peak) down to a nominal lake elevation of about 51 m.

Westland Resource Group (1992) reports that Hotel Lake has a maximum depth of about 11 m and a volume of about 1.7×10^6 m³. These numbers are generally supported by bathymetric survey data collected in 2001 (Jacques Whitford, 2003b).

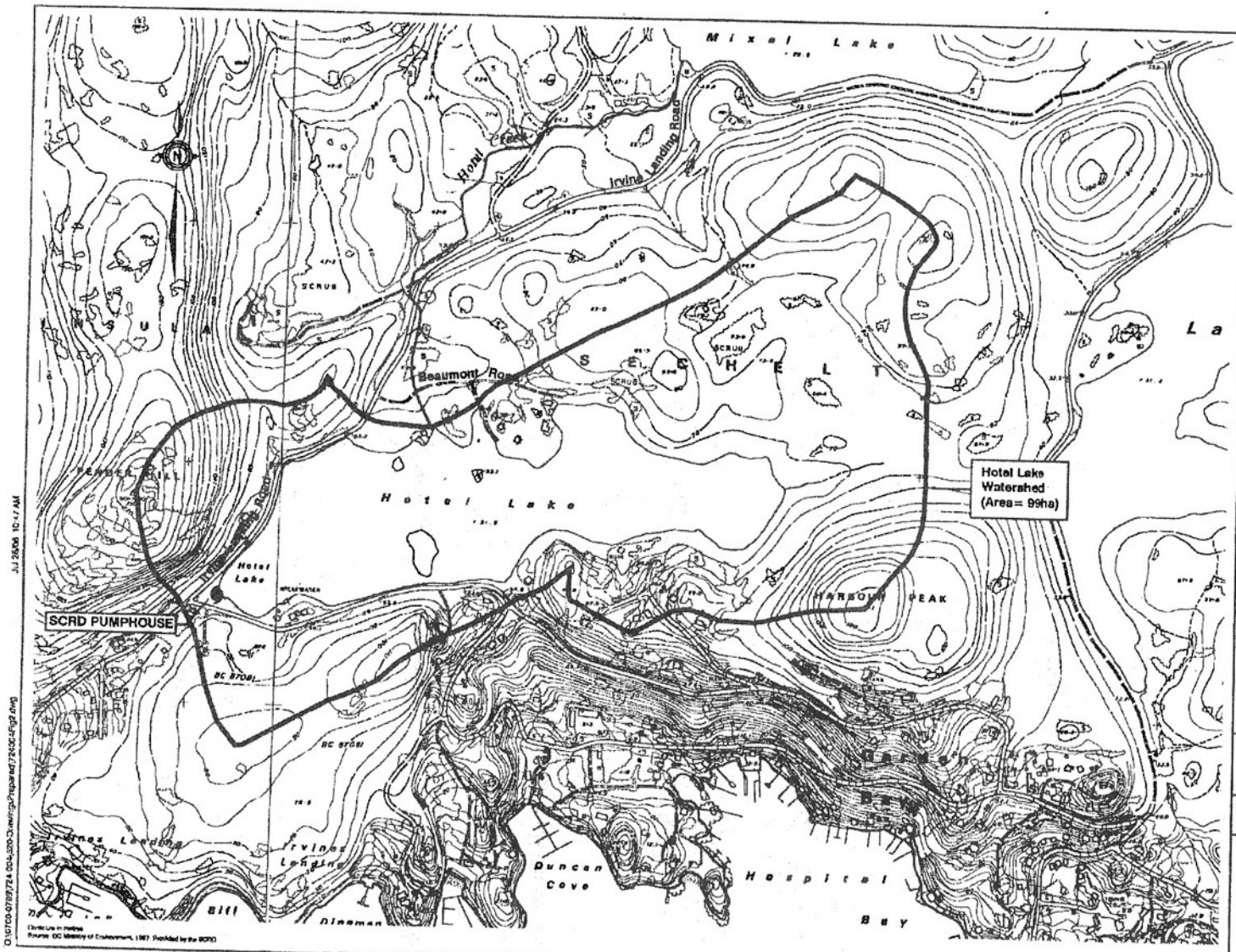
The lake discharges seasonally to Hotel Creek, which typically flows throughout the wet season when lake levels are high. DFO has constructed a concrete weir at the lake outlet to aid in flow measurement.

A cascade on Hotel Creek downstream of Beaumont Road is considered impassable to fish (Jacques Whitford, 2003a). Hotel Creek flows into Mixal Lake, Sakinaw Lake, and ultimately into Agamemnon Channel.

3.2 CLIMATE

Hotel Lake is located toward the northern end of the Sechelt Peninsula. The general area is referred to as the Sunshine Coast for its climate, which is clearer and drier than areas to both east and west (Demarchi, 1996). The climate is a result of location: the Sunshine Coast is located in the Georgia Depression between the St Elias mountains of Vancouver Island and the Coastal mountains of the mainland (McBain, 2004).

Temperature throughout the region is moderated by the presence of the Pacific Ocean, resulting in wet, mild winters and warm, dry summers (Coulson and Obedkoff, 1998). Rainfall is classified as moderate to high, with upland areas frequently receiving snow during the winter (McBain, 2004). However, the development of a substantial snowpack within the Hotel Lake watershed is not common.



Sunshine Coast Regional District
Hotel Lake Hydrologic Analysis

KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

150 0 150
Scale in Metres

Project No.	Date
724-004	July 2006

Map of Hotel Lake Watershed

Figure 2

Page 36(a)
found between page 344

3.3 WATER USE

In addition to the SCRD and GBWD water licences described in Section 1, riprarian property owners hold a number of smaller water licences on Hotel Lake. These include two seasonal irrigation licences and 10 licences for year-round domestic water supply. The total quantity of water authorized to be diverted annually from Hotel Lake (including the municipal purveyors) is approximately 126,446 m^3. A summary of water licences on Hotel Lake is included in Appendix A.

3.4 WATER RESERVES AND RESTRICTIONS

A listing of Ministry of Environment water reserves for the Vancouver – Jervis District shows no water restrictions or reserves on Hotel Lake. A copy of this listing is included in Appendix B.

4. PRECIPITATION

4.1 LOCAL PRECIPITATION DATA

The nearest official climate station to Hotel Lake is the Pender Harbour station, operated by Environment Canada's Meteorological Service of Canada (MSC) as Station #1046115. The station is located just outside the Hotel Lake watershed at an elevation of 64 m. The Pender Harbour station collects only precipitation data, and has a short period of record. Intermittent data are available from May 1961 through February 1964, while more complete data are available from March 2001 to the present.

Precipitation data are also collected near the Hotel Lake outlet at an unofficial station operated by DFO since late 2004. This data is not formally quality controlled and was not used for this study.

Local precipitation records are not long enough to allow estimates of the "normal" and "drought-year" climate conditions typically used as the basis for water management decisions. In this case, precipitation climate normals for Hotel Lake must be estimated using alternate approaches.

4.2 TRANSPOSING REGIONAL PRECIPITATION DATA TO HOTEL LAKE

Several other MSC climate stations on the Sunshine Coast have records long enough to allow the calculation of regional climate normals. Table 2 summarizes these stations.

Table 2: Long-Term Climate Stations on the Sunshine Coast

Station Name	MSC Station #	Distance to Hotel Lake (km)	Elevation (m asl)	1971-2000 Average Annual Precipitation (mm)	Period of Data Available
Pender Harbour	1046115	<1	64	N/A	1961 – 1964[1] 2001 – present
Gibsons Gower Point[2]	1043152	47	34	1,369	1961 – present
Lois River Dam	1044710	27	157	1,547	1931 – 2004
Merry Island Lightstation[2]	1045100	21	6.1	1,035	1942 – present
Powell River[2]	1046390	44	52	1,104	1924 – 2004
Powell River Airport	1046391	38	130	1,244	1953 – present
Stillwater Powerhouse	1047770	24	7.0	1,392	1931 – 2004

1. Data collected intermittently during this period.
2. Station meets WMO Standards for calculating temperature and precipitation climate normals.

The data in Table 2 show that climate normals for precipitation on the Sunshine Coast vary with location and elevation. Therefore, transposition of climate normals to the study area must be conducted with care.

While the period of record for the Pender Harbour climate station is not long enough to allow the direct calculation of local climate normals, it does allow calibration of a weighted average of nearby longer-term stations. Calibration based on monthly precipitation totals (2001-2005) for the various stations in Table 2 produced an acceptable fit between weighted-average estimates and observed monthly precipitation totals at Pender Harbour. Optimized weights for the stations are shown in Table 3.

Table 3: Weights for Calculating Precipitation at Garden Bay Lake

Station Name	MSC Station #	Optimized Weight
Gibsons Gower Point	1043152	0.085
Lois River Dam	1044710	0.000
Merry Island Lightstation	1045100	0.672
Powell River	1046390	0.243
Powell River Airport	1046391	0.000
Stillwater Powerhouse	1047770	0.000
Total		**1.00**

Notably, the three stations assigned non-zero weights during the optimization process represent the only three stations on the Sunshine Coast that meet the standards of the World Meteorological Organization (WMO) for calculating 30-year climate normals.

Table 4 compares estimates of monthly precipitation at Hotel Lake for 2005 (calculated using the regional stations and weights outlined in Table 3) to recorded values at the Pender Harbour climate station. The data demonstrate the acceptable correlation between estimated and observed precipitation at a monthly timescale.

Table 4: 2005 Precipitation for the Pender Harbour Area

Month	Hotel Lake (estimated, mm)	Pender Harbour (recorded, mm)
January	195.5	195.7
February	33.3	33.7
March	93.1	92
April	49.6	52.5
May	65.6	64.5
June	70.0	62.2
July	40.2	N/A
August	41.1	26.1
September	49.6	65.1
October	198.5	188.8
November	102.1	100.1
December	158.3	122.2

4.3 Normal Precipitation for the Garden Bay Lake Area

Applying the weights in Table 3 to published precipitation normals for the Sunshine Coast, average annual precipitation at Hotel Lake is estimated as approximately 1,080 mm. This value compares well with the 1,099 mm of annual rainfall reported by Westland Resource Group (1992) for the community of Sechelt. Estimated 30-year climate normal precipitation at Hotel Lake for the period 1971-2000 is presented in Table 5.

The estimated monthly precipitation normals for Hotel Lake are subject to some uncertainty, and may be refined as more precipitation data is collected at local stations. In the meantime, any use of these estimates should respect their inherent limitations.

Table 5: Estimated Monthly Precipitation Normals (1971-2000) for Hotel Lake

Month	Precipitation (mm)
January	134
February	108
March	92
April	69
May	65
June	59
July	41
August	39
September	55
October	107
November	163
December	148
Annual	1,080

4.4 DROUGHT-YEAR PRECIPITATION FOR THE GARDEN BAY LAKE AREA

For medium-sized waterworks systems, the Ministry of Environment recommends the 10-year return period drought as the basis for assessing water availability (BC MELP, 1993). Medium-sized waterworks systems are defined as those serving between 101 and 1,000 lots.[1]

Long-term records of annual precipitation are available for all stations used in the weighted average estimate; therefore, an independent frequency analysis was performed for each of the records.

Annual precipitation at Hotel Lake for a 10-year drought can be estimated using the weighted average of corresponding drought year precipitation at Merry Island Lightstation, Powell River, and Gibsons Gower Point. Table 6 shows the results of the frequency analysis. Annual precipitation at Hotel Lake during a 10-year drought is estimated as 824 mm.

[1] Current growth forecasts show that, at build-out, the Hotel Lake system will serve 240 lots while the interconnected Garden Bay Lake – Hotel Lake system will serve a total of about 750 lots (KWL, 2005).

Table 6: Estimated Annual Precipitation for a 10-Year Drought on the Sunshine Coast

Drought Return Period (years)	Annual Exceedance Probability[1]	Merry Island Lightstation (mm)	Powell River (mm)	Gibsons Gower Point (mm)	Hotel Lake[2] (mm)
Years of Data[3]		43	78	40	N/A
1.25	80%	1151	1170	1525	1187
2	50%	1016	1028	1379	1050
5	20%	873.4	875	1208	902
10	10%	798.3	793.6	1110	824
Normal		1035.1	1103.7	1369.1	1080
1:5 as % of Normal[4]		84.4%	79.3%	88.2%	83.5%
1:10 as % of Normal[5]		77.1%	71.9%	81.1%	76.3%

1. AEP is the likelihood that drought condition will be equalled or surpassed in each year.
2. Calculated using weighted average of regional data, with weights given in Table 3.
3. Years of annual precipitation data used in the frequency analysis for each station.
4. Ratio of total annual precipitation for a 5-year drought to normal annual precipitation.
5. Ratio of total annual precipitation for a 10-year drought to normal annual precipitation.

5. RUNOFF

5.1 TYPICAL RUNOFF CHARACTERISTICS

Runoff hydrographs for low-elevation Sunshine Coast watersheds tend to follow precipitation patterns, as the development of a significant snowpack is not common. Work by Coulson and Obedkoff (1998) and Obedkoff (2003) indicates that most runoff occurs in the winter months (December through March). Regional runoff decreases throughout the late winter and spring. Typically, less than 10% of the total annual runoff occurs during the months of July, August, and September.

5.2 AVERAGE-YEAR RUNOFF

In the absence of runoff observations for Hotel Lake or other nearby small watersheds, a regional approach is required. Obedkoff (2003) estimates regional runoff for a variety of hydrologic zones in southwestern B.C. For Obedkoff's Hydrologic Zone 27 (which includes the Sunshine Coast), a watershed with a median elevation of approximately 50 m should have an annual runoff on the order of 620 mm (0.62 m^3/m^2). This estimate is believed to be fairly representative of actual runoff conditions for small, lower elevation watersheds such as Hotel Lake.

It is important to note that Obedkoff's estimates of annual runoff include surface response during storm events, subsurface stormflow or "interflow", and groundwater base flow contributions.

A monthly runoff distribution is required to distribute total annual runoff throughout the year. Larger and higher nearby gauged systems (e.g., Roberts Creek) may not reflect the very low

summer flows experienced by small watersheds. Multi-year runoff statistics are available for only a few small, low-elevation lotic (i.e., no lake) watersheds in southwestern B.C. These include:

- Sandhill Creek at Pat Bay Highway (WSC 08HA060) on Vancouver Island (catchment area = 3.07 km², record length = 11 years);
- Yorkson Creek near Walnut Grove (WSC 08MH097) in the Lower Mainland (catchment area = 5.96 km², record length = 18 years); and
- Spring Creek near Newton (WSC 08MH019) in the Lower Mainland (catchment area = 1.04 km², record length = 3 years).

The average monthly runoff distribution for these three systems is applied to distribute the 620 mm of annual runoff at Hotel Lake throughout the year. The resulting conservative fraction of summer runoff (5.2% of annual runoff occurs between June 1 and September 30) as compared to larger but nearby systems (e.g., 9.1% of annual runoff for Roberts Creek) outweighs the uncertainty of transposing the average monthly flow distribution to the Sunshine Coast. The expected monthly distribution of runoff for the Hotel Lake watershed is reported in Table 7.

Table 7: Estimated Average-Year Watershed Runoff for Hotel Lake Watershed

Month	Monthly Runoff Distribution[1] (% of annual total)	Runoff for Hotel Lake (mm)
January	21.1	131.1
February	14.0	87.0
March	11.8	73.3
April	5.1	31.6
May	2.7	16.6
June	1.4	8.5
July	1.2	7.2
August	1.1	6.9
September	1.5	9.4
October	5.8	35.9
November	15.1	93.5
December	19.2	119.2
Annual	100.0	620

1. Average of WSC hydrometric gauges 08HA060, 08MH097, 08MH019, normalized % of annual runoff based on data reported by Obedkoff (2003).

5.3 DROUGHT-YEAR RUNOFF

For medium-sized waterworks systems, the Ministry of Environment recommends the 10-year return period drought as the basis for assessing water availability (BC MELP, 1993).

Obedkoff (2003) provides ratios of 10-year drought annual runoff to average-year annual runoff for a number of hydrometric stations across B.C. Averaging the ratios for stations in Hydrologic Zone 27 indicates that annual runoff for the 10-year drought will be about 76% of average-year annual runoff. This compares well with estimated annual precipitation for a 10-year drought precipitation (shown in Table 6 as 76.3%).

Average-year runoff in the vicinity of Hotel Lake is estimated above as 620 mm. For a 10-year drought, annual runoff is expected to total about 76% of average annual runoff, or approximately 470 mm. Applying the monthly flow distribution from Table 7 provides monthly estimates of runoff as shown in Table 8.

Table 8: Estimated 10-Year Return Period Drought Runoff for Hotel Lake

Month	Monthly Runoff Distribution[1] (% of annual total)	Drought Runoff for Hotel Lake (mm)
January	21.1	99.1
February	14.0	65.8
March	11.8	55.4
April	5.1	23.9
May	2.7	12.5
June	1.4	6.4
July	1.2	5.4
August	1.1	5.2
September	1.5	7.1
October	5.8	27.1
November	15.1	70.7
December	19.2	90.1
Annual	100.0	469

1. Normalized % of annual runoff based on data reported by Obedkoff (2003).

6. LAKE EVAPORATION

Lake evaporation was recorded by Environment Canada at the Vancouver UBC climate station (# 1108487) between 1962 and 1990. Average annual lake evaporation for that period is estimated to be approximately 680 mm.

Although this estimate is most applicable in the Vancouver area, it is not unreasonable to apply the value on the Sunshine Coast due to the relatively similar climate and elevation of the Vancouver UBC station and Hotel Lake.

Numerical methods were employed to validate the Environment Canada data. Maidment (1993) provides several approaches for estimating of evaporation and evapotranspiration. Three methods were selected for this study: the Priestley-Taylor formula, the Hargreaves formula, and the Turc formula. The following assumptions were made in the analysis:

- hours of sunshine were taken as the average of 1971-2000 normals for Powell River Airport (# 1046391) and Vancouver International Airport (# 1108447);
- mean, average maximum, and average minimum daily temperatures are taken as the average of 1971-2000 normals Powell River (# 11046390) and Gibsons Gower Point (# 1043152);
- soil heat flux and advected energy are negligible for Hotel Lake;
- water surface temperature is equal to the mean monthly air temperature;
- the density of water is constant at 1,000 kg/m^3; and
- albedo for open water is 0.08.

Implementing these assumptions with the above equations results in the monthly evaporation results listed in Table 9. For this project, the average of the four data sets shown in Table 9 has been adopted to represent evaporation from Hotel Lake.

Table 9: Estimated Lake Evaporation for Hotel Lake

Month	Vancouver UBC (mm)	Priestley - Taylor (mm)	Hargreaves (mm)	Turc (mm)	Average (mm)
January	11.3	0.0	12.0	9.7	8.3
February	18.8	10.5	19.4	15.6	16.1
March	39.0	35.5	40.1	32.4	36.8
April	64.5	70.3	64.8	55.6	63.8
May	94.4	110.0	94.2	85.2	96.0
June	108.2	124.1	106.2	96.3	108.7
July	117.2	148.3	119.3	115.7	125.1
August	102.1	123.3	101.3	102.2	107.3
September	65.1	69.8	64.9	67.7	66.9
October	31.9	24.7	33.3	34.9	31.2
November	17.0	2.5	15.3	15.3	12.5
December	11.2	0.0	10.1	9.3	7.6
Annual	680.8	719.1	681.0	639.9	680.2

Since the evaporation calculations depend only on temperature data and hours of sunlight, they are not adjusted to represent the case of a 10-year drought scenario. Although temperature and sunlight can be correlated with drought conditions (e.g. through higher temperatures and clear skies), the second-order nature of the correlation is beyond the scope of this analysis.

7. WATER WITHDRAWALS

The SCRD monitors its water withdrawals at the Hotel Lake pump station. Actual pumping records from 2000 to 2004 were used to develop an average monthly demand distribution. This distribution is used to estimate monthly SCRD withdrawals assuming that all SCRD water licences are fully utilized.

No data exist regarding water use by holders of other domestic water licences. For the purposes of the water balance, annual water use is therefore assumed equal to the maximum licenced amount (e.g., 500 gal/day for 365 days). Given the lack of monitoring and compliance information, this is believed to be a conservative assumption.

Of the two irrigation licences on Hotel Lake, the smaller is for 1 AF/year (1,233 m³/year), while the larger is for 6 AF/year (7,401 m³/year). These seasonal licences may be used between April 1 and September 30; as such, they are assumed to be utilized at 5%, 15%, 20%, 25%, 30%, and 5% each month between April and September, respectively.

8. RETURN FLOW

Water diverted for use outside the watershed (e.g., by the SCRD) is considered a consumptive use in the present analysis. However, a large fraction of water withdrawn by riparian licencees typically returns to the lake through groundwater discharge. This is known as "return flow".

For houses with septic fields, about 80% of in-home water use is typically discharged through the septic system. Lawn sprinkling, which is usually very low efficiency, typically accounts for the largest percentage of outdoor water use. Excess irrigation water (e.g., from overwatering of lawns) and septic field discharges are two major components of return flow.

Return flow is calculated using an assumed split between indoor and outdoor water use, with water use efficiencies adjusted to calibrate the 2005 water balance as described in Section 10. The resulting proportions of water use that become return flow were found to be reasonably conservative, varying from 50% for indoor water use to 30% for irrigation applications.

Without more information on local water use patterns, the local and regional groundwater system, and the distribution of water use, it is not possible to develop less subjective estimates of return flow on Hotel Lake.

9. SURFACE DISCHARGE AND LAKE DRAWDOWN

9.1 SURFACE DISCHARGE

During late autumn, winter, and spring, the water level of Hotel Lake is high and the lake discharges into Hotel Creek. As summer approaches, surface discharge decreases as the lake level declines. No surface discharge occurs in summer months when the lake is drawn down below the lake outlet. In the autumn, runoff increases while water use and evaporation decrease, allowing the lake to recharge. Surface outflow resumes once the lake surface rises to the invert of the lake outlet. Although the timing and quantity of surface discharge have changed over time, this general pattern likely pre-dates water withdrawals from Hotel Lake.

For this analysis, surface discharge is assumed to account for all excess inflow in months where the elevation of the lake exceeds the invert of Hotel Creek. While some of the additional inflow would be temporarily stored as the lake attenuates inflow events, this assumption should have minimal impacts on a monthly water balance.

9.2 FISHERIES RELEASES

Discussions with DFO identified a preliminary fisheries release target of 100 L/min (1.67 L/s) from Hotel Lake between mid-November and mid-January. For the purposes of this study, it is assumed that fisheries releases can be provided as required via a low-level intake and are therefore independent of water levels on Hotel Lake.

9.3 LAKE DRAWDOWN

In months where outflow exceeds inflow, the lake level drops below the lake outlet and surface discharge ceases. Lake drawdown is calculated by tracking the total month-over-month storage deficit and dividing the monthly change in storage by the lake surface area. Recharge occurs in the autumn as inflow increases and withdrawals decline, and no surface discharge occurs until the storage deficit is fully replenished.

Lake surface area decreases with declining lake level. This is accounted for by interpolating based on a stage-storage relationship developed by Jacques Whitford (2003b).

10. LAKE SEEPAGE

Under "normal" topographic and stratigraphic conditions, the water table will generally follow local surface topography. As the lowest part of its tributary watershed, the boundary of a natural lake typically defines the intersection of the water table with the surrounding land.

Differences in elevation between the lake surface and the phreatic surface beneath the upstream catchments typically result in continuous groundwater discharge into the lake. The same recessional process is responsible for base flow in a river during dry weather.

In some situations, however, it is possible to have net seepage out of, rather than into, a lake or pond. It has been suggested that this may be the case for Hotel Lake, given the lake's position as a headwater system and its higher elevation relative to the rest of the Sakinaw Lake basin.

Exploring the significance of lake seepage to the water balance is most easily accomplished by defining the direction of net groundwater movement during a dry period in the drawdown season. During such a period, surface inflow and interflow can be assumed to be zero, any groundwater inflow can be assumed to be at a minimum, and there is no surface discharge from the lake.

The week of August 13-19, 2004 was selected as the best window among the available data for conducting a seepage analysis for Hotel Lake. During this period, the lake was drawn down below the outlet channel. Environment Canada records for Pender Harbour show that no precipitation occurred between August 6 and August 20, and the daily maximum temperature exceeded 25°C from August 8 onward.

Natural surface inflow and interflow were assumed to be zero for the August 13-19, 2004 window. Water level measurements provided by DFO show that the lake elevation declined approximately 31 mm between readings taken August 12 and August 19.

SCRD withdrawals were taken as the actual total for the reporting period of August 12 through August 18. Withdrawals by other licenced users were pro-rated based on SCRD pumping records using a ratio of the respective water licence allocations. An additional allowance was made for unlicenced users identified by local residents during the EAB proceedings. Irrigation water withdrawals were estimated by assuming that 30% of the total licence quantity was used during the month of August. Approximately 40% of licenced and unlicenced riparian withdrawals were assumed to return to the lake as return flow (i.e., infiltration from lawn watering, septic system discharges, etc.).

Using data provided by DFO, lake evaporation was estimated as approximately 30 mm over a nominal lake surface area of 27.3 ha. This value correlates well with expected values and PET estimates reported on farmwest.com.

These assumptions resulted in the one-week water balance shown below in Table 10.

Table 10: Hotel Lake Water Balance for August 13-19, 2004

Group	Source / Sink	Quantity (m^3)
Inflow (I)	Surface	0
	Interflow	0
	Return Flow	460
Outflow (O)	Surface	0
	SCRD	1,748
	Other Licenced	1,022
	Other Unlicenced	127
	Lake Evaporation	8,408
Change in Storage (ΔS)		(8,463)
Partial Closure (I – O – ΔS)		(2,383)
Assumed Net Groundwater Movement (GW)		2,383
Closure (I – O – ΔS + GW)		0

Because a water balance must always sum to zero, "closing the water balance" must account for all processes not explicitly addressed elsewhere. In this case, the only significant factor not explicitly addressed in the water balance is groundwater (i.e., lake seepage). Closing the water balance suggests net groundwater movement of nearly 2,400 m^3 into the lake.

While Table 10 does not conclusively prove or disprove the existence of seepage losses from Hotel Lake, it does suggest that seepage losses are not likely a major component of the water balance. Therefore, seepage out of Hotel Lake is neglected in further analyses of the Hotel Lake water balance.

11. CALIBRATION

Data from DFO, the SCRD, farmwest.com, and Environment Canada were combined to create a calibration data set for the 2005 calendar year. The normal runoff of 620 mm (Obedkoff, 2003) was pro-rated to 599 mm based on the ratio of observed precipitation at Pender Harbour to estimated climate normal precipitation. The percentage of riprarian use that contributed to return flow was adjusted as described in Section 7.

The results of the water balance calibration are shown in Table 11. Maximum estimated drawdown reached approximately 0.28 m in August 2005. The comparison of estimated versus observed drawdown shown in Figure 3 shows a good fit between estimated and observed data for the majority of the drawdown season.

Table 11: Water Balance Calibration for Hotel Lake Using 2005 Data

Watershed Area[1] = 0.99 km²
Lake Area[2] = 0.27 km²

Month	Precipitation			Runoff[4]		Lake Evaporation[5]		Pumping			Minimum Fish Release[10]		Closure			
	Estimated[3]	Above Lake	On Lake					SCRD (2005)[6]	Other (WL[7] + Unlicenced[8])	Return Flows[9]			Outflow + ΔS[11]	Outflow[12]	Relative Lake Storage[13]	Relative Depth[14]
	(mm)	(x 1000 m³)	(x 1000 m³)	(mm)	(x 1000m³)	(mm)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(L/s)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(m)
Jan	196	140.1	53.4	127	90.6	12	3.3	2.3	2.0	1.0	0	0.0	137.5	137.5	0.0	0.00
Feb	34	24.1	9.2	84	60.1	24	6.6	1.7	1.8	0.9			60.2	60.2	0.0	0.00
Mar	92	65.9	25.1	71	50.7	46	12.6	2.2	2.0	1.0			60.1	60.1	0.0	0.00
Apr	53	37.6	14.3	30	21.8	72	19.7	2.9	2.7	1.2			12.0	12.0	0.0	0.00
May	65	46.2	17.6	16	11.5	104	28.4	4.1	3.3	1.3			-5.4	0.0	-5.4	-0.02
Jun	62	44.5	17.0	8	5.9	102	27.8	4.7	3.6	1.4			-11.9	0.0	-17.4	-0.07
Jul	40	28.8	11.0	7	5.0	116	31.7	6.8	4.1	1.5			-25.2	0.0	-42.5	-0.16
Aug	26	18.7	7.1	7	4.8	118	32.2	7.7	4.6	1.7			-30.9	0.0	-73.4	-0.28
Sep	65	46.6	17.8	9	6.5	70	19.1	5.0	2.3	1.0			-1.2	0.0	-74.6	-0.28
Oct	189	135.2	51.5	35	24.8	30	8.2	4.0	2.0	1.0			63.2	0.0	-11.4	-0.04
Nov	100	71.7	27.3	90	64.6	14	3.8	2.9	1.9	0.9	0	0.0	84.2	72.8	0.0	0.00
Dec	122	87.5	33.4	115	82.4	11	3.0	4.0	2.0	1.0	0	0.0	107.8	107.8	0.0	0.00
Annual	**1043**	**746.9**	**284.8**	**599**	**428.6**	**719**	**196.3**	**48.2**	**32.3**	**13.8**		**0.0**	**450.5**	**450.5**		

Notes:

1. From KWL watershed delineation using TRIM topographic mapping.
2. From Westland Resource Group, 1992
3. Monthly data reported for Environment Canada climate station 1046115 at Pender Harbour.
4. Estimated for tributary area above Hotel Lake for Hydrologic Zone 27 at 50 m elevation (Obedkoff, 2003) and factored by ratio of 2005 observed precip to normal precip.
5. Based on monthly data reported for Powell River Airport on farmwest.com.
6. Based on reported monthly SCRD withdrawals for 2005.
7. Based on LWBC records, including ten licences for domestic use and two licences for irrigation applied with an assumed summer distribution.
8. Based on AAQWA estimate of eight unlicenced water users at 500 gal/day per user.
9. Fraction of riparian (non-SCRD) withdrawals that return to Hotel Lake. Assumed percentages: 60% of indoor domestic, 32% of outdoor domestic, 8% of nursery irrigation, 24% of agricultural irrigation.
10. Based on estimate of 100 L/min required provided by Grant McBain.
11. Net monthly surplus (+) or deficit (-) calculated by closing the water balance. Represents net monthly combined surface outflows plus change in storage.
12. Assumes all of (11) is outflow when lake level is above the outlet.
13. Cumulative change in storage relative to full pool datum.
14. Relative lake storage expressed as depth based on relationship given in Jaques Whitford's Environmental Technical Response of September 11, 2003.

Assumptions:

Lake surface area is constant in calculating lake precipitation and evaporation.
Evaporation is calculated using generic parameters recommended by Maidment (1993).
Annual water usage is 100% of licenced quantity for users other than the SCRD.
Evaporation remains constant at "normal" scenario.
No attenuation of outflows occurs in months with spill (i.e. no storage above the outlet channel invert).
Drawdown begins May 1.
Runoff is distributed according to monthly average runoff distribution for small, low-elevation lotic systems in southwestern BC.

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Comparison of Estimated and Observed 2005 Drawdown
Hotel Lake

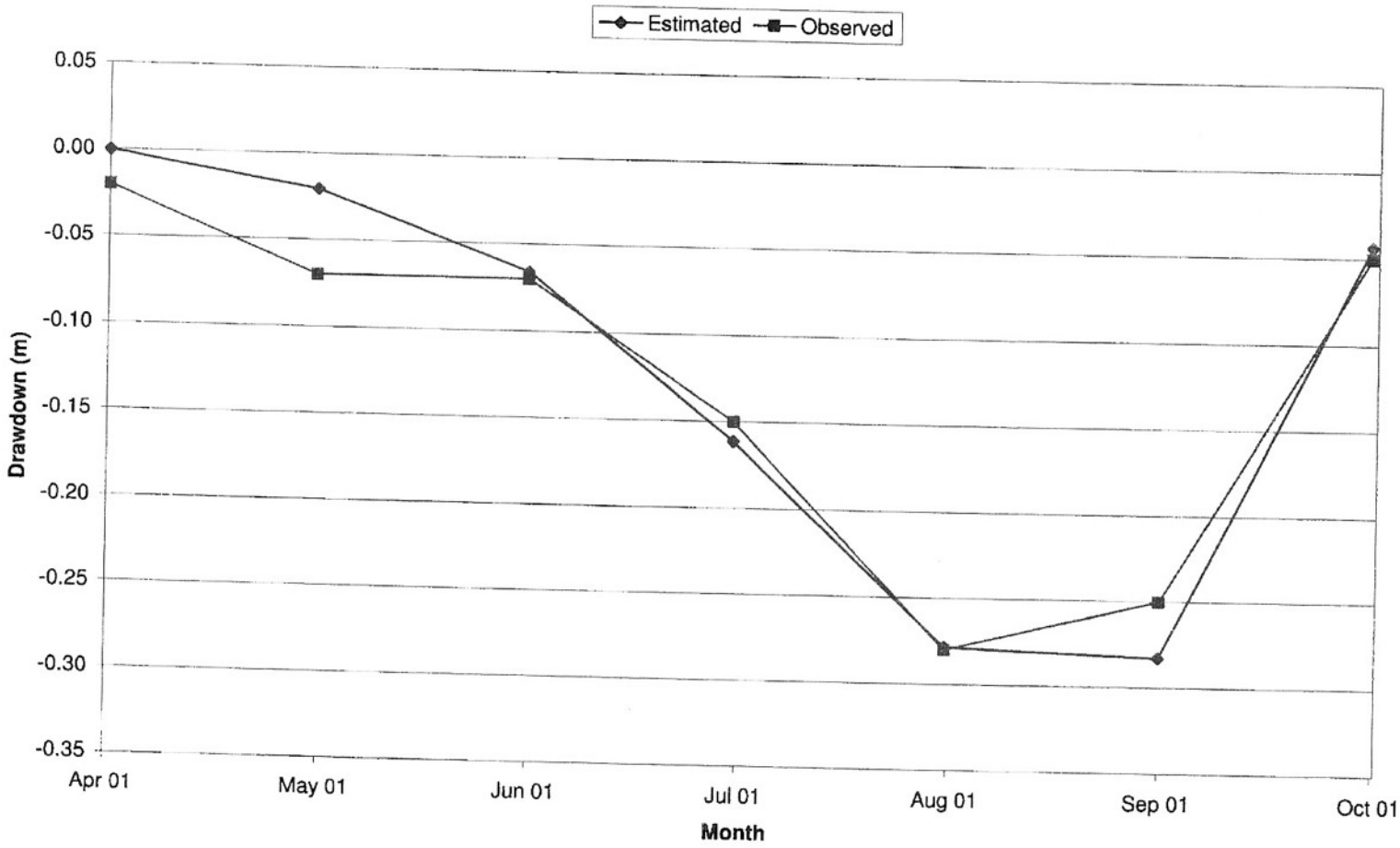

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Figure 3

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12. WATER BALANCE RESULTS

The results of a water balance for a "normal" year are presented in Table 12. This scenario assumes that all licences held by the SCRD and GBWD are fully utilized. The maximum drawdown for this scenario is estimated as 0.39 m below the lake outlet.

The results of a water balance for a 10-year drought scenario are presented in Table 13. As above, this scenario also assumes that all licences held by the SCRD and GBWD are fully utilized. The maximum drawdown for this scenario is estimated as 0.49 m below the lake outlet.

13. RECOMMENDATIONS

13.1 MINIMUM LAKE LEVEL

The Vancouver Island Region of the BC Ministry of Environment's Water Stewardship Division applies the following guideline in evaluating allowable drawdown on natural water bodies (BC MELP, 1994):

> "Withdrawals from natural water bodies (lakes, ponds, swamps and marshes) supporting natural fisheries resources shall not reduce the shoal area more than 10%."

The Water Stewardship Division defines the shoal area as the area from the lake shore at average summer lake level to a 6 metre depth.

For the case of Hotel Lake, average summer lake level is not well defined due to significant water use and seasonal water level fluctuations. However, one can conservatively assume that the "average summer lake level" is equal to the elevation of the lake outlet and that the slope of the lake bottom is constant through a 6 m depth. In this case, applying the Water Stewardship Division's guideline suggests that the lake depth should not be reduced more than 0.6 m below the lake outlet.

Table 13 estimates the maximum drawdown for a 10-year drought condition at Hotel Lake to be 0.49 m below the lake outlet. Further analysis suggests that drawdown during more significant droughts could approach 0.55 m. Anecdotal evidence reported by Hugh G. Harris and Associates (2001) suggests a historic maximum drawdown of 61 cm (0.61 m) below the lake outlet.

Based on the water balances, adopting an interim minimum lake level of 0.6 m below the invert of the lake outlet appears reasonable for Hotel Lake. This should be refined in the future as additional site-specific hydrologic data becomes available.

Table 12: Normal-Year Water Balance for Hotel Lake - SCRD withdrawals based on all water licences

Watershed Area[1] = 0.99 km²
Lake Area[2] = 0.27 km²

Month	Precipitation[3]			Runoff[4]		Lake Evaporation[5]		Pumping			Minimum Fish Release[10]		Closure			
	Estimated	Above Lake	On Lake					SCRD (All WL)[6]	Other (WL[7] + Unlicenced[8])	Return Flows[9]			Outflow + ΔS[11]	Outflow[12]	Relative Lake Storage[13]	Relative Depth[14]
	(mm)	(x 1000 m³)	(x 1000 m³)	(mm)	(x 1000m³)	(mm)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(L/s)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(m)
Jan	133.6	95.7	36.5	131.1	93.9	8.3	2.3	6.8	2.0	1.0	1.67	2.2	118.1	118.1	0.0	0.00
Feb	108.4	77.6	29.6	87.0	62.3	16.1	4.4	5.8	1.8	0.9			80.8	80.8	0.0	0.00
Mar	92.3	66.1	25.2	73.3	52.5	36.8	10.0	6.5	2.0	1.0			60.2	60.2	0.0	0.00
Apr	68.9	49.3	18.8	31.6	22.6	63.8	17.4	6.6	2.7	1.2			15.9	15.9	0.0	0.00
May	64.7	46.3	17.7	16.6	11.9	96.0	26.2	8.3	3.3	1.3			-6.9	3.1	-10.1	-0.04
Jun	58.9	42.1	16.1	8.5	6.1	108.7	29.7	10.0	3.6	1.4			-19.7	0.0	-29.8	-0.11
Jul	40.7	29.1	11.1	7.2	5.2	125.1	34.2	14.7	4.1	1.5			-35.2	0.0	-65.0	-0.25
Aug	39.2	28.1	10.7	6.9	4.9	107.3	29.3	13.6	4.6	1.7			-30.1	0.0	-95.1	-0.36
Sep	54.9	39.3	15.0	9.4	6.7	66.9	18.3	10.2	2.3	1.0			-8.1	0.0	-103.2	-0.39
Oct	107.5	77.0	29.3	35.9	25.7	31.2	8.5	7.7	2.0	1.0			37.8	0.0	-65.4	-0.25
Nov	163.2	116.9	44.6	93.5	66.9	12.5	3.4	5.5	1.9	0.9	1.67	2.3	99.3	33.9	0.0	0.00
Dec	147.9	105.9	40.4	119.2	85.3	7.6	2.1	5.6	2.0	1.0	1.67	4.5	112.5	112.5	0.0	0.00
Annual	1080	773.5	294.9	620	443.9	680	185.7	101.2	32.3	13.8		8.9	424.5	424.5		

Notes:

1. From manual watershed delineation using TRIM topographic mapping.
2. From Westland Resource Group, 1992
3. Based on weighted average of 1971-2000 climate normals for Gibsons Gower Point, Powell River and Merry Island Lightstation.
4. Estimated for tributary area above Hotel Lake for Hydrologic Zone 27 at 50 m elevation (Obedkoff, 2003).
5. Estimated for nominal surface area of Hotel Lake based on average of measured values at Vancouver UBC and Priestley-Taylor, Turc, and Hargreaves approaches.
6. Based on full utilization of all existing SCRD and GBWWD water licences and average monthly demand distribution for SCRD withdrawals 2000-2004.
7. Based on LWBC records, including ten licences for domestic use and two licences for irrigation applied with an assumed summer distribution. All licences assumed to be used at WL limit.
8. Based on AAQWA estimate of eight unlicenced water users at 500 gal/day per user.
9. Fraction of riparian (non-SCRD) withdrawals that return to Hotel Lake. Assumed percentages: 60% indoor domestic, 32% outdoor domestic, 8% nursery irrigation, 24% agricultural irrigation.
10. Based on estimate of 100 L/min required provided by Grant McBain. Implemented as a bypass (e.g. pipe) out of the lake.
11. Net surplus (+) or drawdown (-) calculated by closing the water balance. Represents net monthly combined surface outflows plus change in storage.
12. Assumes all of (11) is outflow when lake level is above the outlet. Assumes May outflow equals (11) - (13).
13. Cumulative change in storage relative to full pool datum. May assumes 60/40 weighting on precip and 40/60 for demand for first and second halves of the month.
14. Relative lake storage expressed as depth based on relationship given in Jaques Whitford's Environmental Technical Response of September 11, 2003.

Assumptions:

Lake surface area is constant in calculating lake precipitation and evaporation.
Evaporation is calculated using generic parameters recommended by Maidment (1993).
Annual water usage is 100% of licenced quantity for users other than the SCRD.
Evaporation remains constant at "normal" scenario.
No attenuation of outflows occurs in months with spill (i.e. no storage above the outlet channel invert).
Runoff is distributed according to monthly average runoff distribution for small, low-elevation lotic systems in southwestern BC.

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Table 13: 10-Year Drought Water Balance for Hotel Lake - SCRD Withdrawals based on all water licences

Watershed Area[1] = 0.99 km²
Lake Area[2] = 0.27 km²

Month	Precipitation[3]			Runoff[4]		Lake Evaporation[5]		Pumping			Minimum Fish Release[10]		Closure			
	Estimated	Above Lake	On Lake					SCRD (All WL)[6]	Other (WL[7] + Unlicenced[8])	Return Flows[9]			Outflow + ΔS[11]	Outflow[12]	Relative Lake Storage[13]	Relative Depth[14]
	(mm)	(x 1000 m³)	(x 1000 m³)	(mm)	(x 1000m³)	(mm)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(L/s)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(x 1000 m³)	(m)
Jan	101.9	72.9	27.8	99.1	70.9	8.3	2.3	6.8	2.0	1.0	1.67	2.2	86.6	86.6	0.0	0.00
Feb	82.7	59.2	22.6	65.8	47.1	16.1	4.4	5.8	1.8	0.9			58.6	58.6	0.0	0.00
Mar	70.4	50.4	19.2	55.4	39.7	36.8	10.0	6.5	2.0	1.0			41.4	41.4	0.0	0.00
Apr	52.6	37.6	14.3	23.9	17.1	63.8	17.4	6.6	2.7	1.2			5.9	8.6	-2.8	-0.01
May	49.3	35.3	13.5	12.5	9.0	96.0	26.2	8.3	3.3	1.3			-14.0	0.0	-16.8	-0.06
Jun	44.9	32.1	12.3	6.4	4.6	108.7	29.7	10.0	3.6	1.4			-25.0	0.0	-41.8	-0.16
Jul	31.0	22.2	8.5	5.4	3.9	125.1	34.2	14.7	4.1	1.5			-39.1	0.0	-80.9	-0.31
Aug	29.9	21.4	8.2	5.2	3.7	107.3	29.3	13.6	4.6	1.7			-33.9	0.0	-114.8	-0.44
Sep	41.9	30.0	11.4	7.1	5.1	66.9	18.3	10.2	2.3	1.0			-13.3	0.0	-128.1	-0.49
Oct	82.0	58.7	22.4	27.1	19.4	31.2	8.5	7.7	2.0	1.0			24.6	0.0	-103.5	-0.39
Nov	124.5	89.1	34.0	70.7	50.6	12.5	3.4	5.5	1.9	0.9	1.67	2.3	72.4	0.0	-31.1	-0.12
Dec	112.8	80.8	30.8	90.1	64.5	7.6	2.1	5.6	2.0	1.0	1.67	4.5	82.1	51.0	0.0	0.00
Annual	824	589.8	224.9	469	335.6	680	185.7	101.2	32.3	13.8		8.9	246.1	246.1		

Notes:

1. From manual watershed delineation using TRIM topographic mapping.
2. From Westland Resource Group, 1992
3. Based on 76.3% of weighted average of 1971-2000 climate normals for Gibsons Gower Point, Powell River and Merry Island Lightstation as per frequency analysis results.
4. Estimated for tributary area above Hotel Lake for Hydrologic Zone 27 at 50 m elevation (Obedkoff, 2003) and modified by 76.3% as per frequency analysis results.
5. Estimated for nominal surface area of Hotel Lake based on average of measured values at Vancouver UBC and Priestley-Taylor, Turc, and Hargreaves approaches.
6. Based on full utilization of all existing SCRD and GBWWD water licences and average monthly demand distribution for SCRD withdrawals 2000-2004.
7. Based on LWBC records, including ten licences for domestic use and two licences for irrigation applied with an assumed summer distribution. All licences assumed to be used at WL limit.
8. Based on AAQWA estimate of eight unlicenced water users at 500 gal/day per user.
9. Fraction of riparian (non-SCRD) withdrawals that return to Hotel Lake. Assumed percentages: 60% indoor domestic, 32% outdoor domestic, 8% nursery irrigation, 24% agricultural irrigation.
10. Based on estimate of 100 L/min required provided by Grant McBain. Implemented as a bypass (e.g. pipe) out of the lake.
11. Net surplus (+) or drawdown (-) calculated by closing the water balance. Represents net monthly combined surface outflows plus change in storage.
12. Assumes all of (11) is outflow when lake level is above the outlet. Assumes April outflow equals (11) - (13).
13. Cumulative change in storage relative to full pool datum. April assumes 60/40 weighting on precip and 40/60 for demand for first and second halves of the month.
14. Relative lake storage expressed as depth based on relationship given in Jaques Whitford's Environmental Technical Response of September 11, 2003.

Assumptions:

Lake surface area is constant in calculating lake precipitation and evaporation.
Evaporation is calculated using generic parameters recommended by Maidment (1993).
Annual water usage is 100% of licenced quantity for users other than the SCRD.
Evaporation remains constant at "normal" scenario.
No attenuation of outflows occurs in months with spill (i.e. no storage above the outlet channel invert).
Runoff is distributed according to monthly average runoff distribution for small, low-elevation lotic creek systems in southwestern BC.

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13.2 Possibile Future Use of Stoplogs for Improved Water Management

The present hydrologic analysis indicates that 0.6 m below the lake outlet is an appropriate interim minimum lake level for Hotel Lake. However, it would be virtually impossible for local water users to cease withdrawals if lake levels were to reach this minimum. From a water management perspective, it would be prudent for the SCRD and other users to establish an additional margin of safety for the Hotel Lake water supply. One method of improving water management would involve using stoplogs to marginally increase the seasonal water storage available at Hotel Lake.

Stoplogs are removable structures used to temporarily increase the water level heading into the drawdown season. Creating additional seasonal water storage reduces the likelihood of reaching the minimum lake level as well as providing a greater ability to meet fish flow requirements. DFO currently uses stoplogs to help regulate water levels on nearby Garden Bay Lake.

Stoplogs could be used at Hotel Lake to increase the lake level above the natural lake outlet prior to the start of the drawdown season. The water balances shown in Tables 12 and 13 were modified to explore the effects of introducing two 75 mm stoplogs at the Hotel Lake outlet. For simplicity, the first stoplog is assumed to be installed on February 1 and the second on March 1. They are typically removed once the lake is drawn down below the bottom of each stoplog.

Revised water balances for normal and 10-year drought years show that the increase of 0.15 m in water level created by the stoplogs reduces maximum summer drawdown by the same amount (i.e., from 0.39 m to 0.24 m below the natural lake outlet in a normal year, and from 0.49 m to 0.34 m below the natural lake outlet for a 10-year drought).

It would be appropriate for the SCRD to explore the feasibility of installing a stoplog system at Hotel Lake. This is likely to include stakeholder consultations and a survey to confirm that flooding would not occur.

Stoplogs would be best used at Hotel Lake to create a margin of safety for water supply management. Ideally, water withdrawals would be limited to existing allocations and the interim minimum lake level would be maintained at 0.6 m below the natural lake outlet.

13.3 Implementation Strategy

While easily regulated, the adoption of a minimum lake level creates operational challenges. To minimize the likelihood of encroaching on the minimum lake level, it is best to adopt a proactive strategy incorporating both supply and demand management throughout the drawdown season.

Key aspects of a suggested implementation strategy for the SCRD's Hotel Lake water supply are listed below:

1. Obtain an independent opinion from a professional biologist on the environmental impacts of adopting an interim minimum lake level of 0.6 m below the invert of the natural lake outlet for Hotel Lake.

2. Subject to the above, adopt an interim minimum lake level of 0.6 m below the invert of the natural lake outlet for Hotel Lake.

3. Request that the Ministry of Environment implement a water reserve for municipal water supply in recognition of the significant utilization and key importance of Hotel Lake as an SCRD water source. Exceptions could be made for current unlicenced users who wish to protect their rights by acquiring a water licence.

4. Transfer responsibility for the existing data collection infrastructure and outlet works at Hotel Lake from DFO to the SCRD, and begin to compile a hydrologic database.

5. Investigate the feasibility of constructing a stoplog structure at the outlet of Hotel Lake.

6. Expand the existing SCRD water conservation program and seasonal sprinkling restrictions into a staged Water Shortage Response Plan (e.g., GVRD, 2004). Implementation dates and stages could be harmonized with GVRD to create continuity for part-time residents.

7. Develop a source utilization strategy for Hotel Lake to minimize the likelihood of encroaching on the minimum lake level. The source utilization strategy could include monthly drawdown thresholds linked to the WSRP.

8. Complete the proposed Hydrologic Master Plan for the Mixal Creek Watershed, including recommendations for an optimal system-wide source utilization strategy that incorporates DFO requirements for seasonal fisheries releases.

9. Complete the integration of the Garden Bay Lake and Hotel Lake water supply systems to allow for optimal and balanced source utilization.

Adopting an implementation strategy that includes the suggestions listed above would considerably improve the ability of the SCRD to manage the water supply at Hotel Lake.

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STATEMENT OF LIMITATIONS

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Appendix A: Current Water Licences held on Hotel Lake

Based on data from Ministry of Environment - Water Stewardship Division website as of July 6, 2006

Licence No.	WR Map / Point Code	Purpose	Quantity	Unit	Licensee	Priority Date
C016733	92.F.070.2.3 A (PD44536)	Domestic	500	GD	SUNSHINE COAST SCHOOL DISTRICT NO 46 BOX 220 GIBSONS B C V0N1V0	7/28/1945
C024211	92.F.070.2.4 D (PD44538)	Domestic	4000	GD	NELSON PETER J 11670-218 ST MAPLE RIDGE V2X5M1	2/6/1958
C030375	92.F.070.2.4 B (PD44542)	Domestic	2000	GD	387987 BC LTD 6-2735 MATHESEN BLVD E MISSISSAUGA ON L4W4M8	10/24/1932
C037713	92.F.070.2.4 J (PD44543)	Domestic	500	GD	UHRLE KARL 481 VENTURA CRESCENT NORTH VANCOUVER BC V7N3G8	11/18/1970
C037714	92.F.070.2.4 K (PD44537)	Domestic	500	GD	HAWRYCHUK FRANK & CARON BOX 7 GARDEN BAY BC V0N1S0	12/17/1970
C039324	92.F.070.2.4 L (PD44545)	Domestic	500	GD	CROFT SHARON L & BRIAN J 21237 43 AVE LANGLEY BC V3A7R9	10/14/1971
C045086	92.F.070.2.3 C (PD44534)	Domestic	500	GD	JAMES RALPH B 12011 MITCHELL RD RICHMOND BC V6V1M7	2/25/1975
C072130	92.F.070.2.4 T (PD61050)	Irrigation	6	AF	TRI LAKES DEVELOPMENT LTD PO BOX 37 GARDEN BAY BC V0N1S0	3/23/1965
C113624	92.F.070.2.4 (PD74083)	Nurseries	1	AF	KNIGHT RONALD LEONARD & CARLA 2710 WALPOLE CRESCENT N. VANCOUVER BC V7H1K8	9/15/1998
C113624	92.F.070.2.4 (PD74088)	Domestic	500	GD	KNIGHT RONALD LEONARD & CARLA 2710 WALPOLE CRESCENT N. VANCOUVER BC V7H1K8	9/15/1998
C119333	92.F.070.2.3 B (PD44535)	Waterworks Local Auth	10950000	GY	SUNSHINE COAST REGIONAL DISTRICT PO BOX 800 SECHELT BC V0N3A0	4/23/1969
C119338	92.F.070.2.3 B (PD44535)	Waterworks Local Auth	7300000	GY	SUNSHINE COAST REGIONAL DISTRICT PO BOX 800 SECHELT BC V0N3A0	3/15/1946
C121345	92.F.070.2.4 (PD79486)	Domestic	500	GD	STEERNBERG FREDERIK BERNARD 302-10 CONFEDERATION PL SASKATOON SK S7L5R8	11/1/2005
C121346	92.F.070.2.4 (PD79487)	Domestic	500	GD	BEZEREDI DIANA 1977 WEST 41ST AVE VANCOUVER BC V6J2K1	11/1/2005
C121563	92.F.070.2.3 B (PD44535)	Waterworks Local Auth	1410000	GY	SUNSHINE COAST REGIONAL DISTRICT PO BOX 800 SECHELT BC V0N3A0	3/24/1972
C121564	92.F.070.2.3 B (PD44535)	Waterworks Local Auth	2605000	GY	GARDEN BAY WATERWORKS DISTRICT ATTN: SANDY LOXTERKAMP BOX 21 GARDEN BAY BC V0N1S0	3/24/1972
Z118466	*92.F.070.2.3 B (PD44535)*	*Waterworks Local Auth*	*14000000*	*GY*	*PENDING APPLICATION - SUNSHINE COAST REGIONAL DISTRICT PO BOX 800 SECHELT BC V0N3A0*	*5/15/2003*

Appendix B: Water Reserves and Restrictions for LWBC's Vancouver District (Jervis Precinct)

Based on data from Ministry of Environment - Water Stewardship Division website as of July 6, 2006.

Water Reserves

Reserve Description/Date	Water Rights Map No.	Comments	NTS Map (1:50 K)
GRAY CREEK & TRIBUTARIES - OIC 1701/85 1985/08/29	92.G.052.1.3	ORDER IN COUNCIL; RESERVED FOR WATERWORKS. CONSENT IS REQUIRED FOR ALL PURPOSES AND MUST BE "SUBJECT TO".	092G/12
HOMATHKO RIVER & TRIBUTARIES - OIC 1325/26 1926/12/15	92K/15(f)	ORDER IN COUNCIL, RESERVED FOR CROWN (POWER) SOURCE WITHIN VANCOUVER & CARIBOO WATER DISTRICTS	092K/15
LANG CREEK & TRIBS - PROPOSED RESERVE 1989/07/04	92.F.079.3.3	PROPOSED RESERVE 1989/07/04 - LANG CREEK & TRIBS RESERVED FOR USE BY POWELL RIVER REGIONAL DISTRICT FOR WATERWORKS PURPOSE STUDIES.	092F/16
SOUTHGATE RIVER & TRIBUTARIES - OIC1325/26 1926/12/15	92K/15(f)	ORDER IN COUNCIL, RESERVED FOR CROWN (POWER) RESERVE INCLUDES TASEKO LAKE, RIVER & TRIBS (CARIBOO WATER DIST), CHILKO LAKE, RIVER & TRIBS (CARIBOO WATER DIST) HOMATHKO R & TRIBS (VANC & CARIBOO WATER DIST)	092K/15

Water Restrictions

Restriction Description/Date	Water Rights Map No.	Comments	NTS Map (1:50 K)
BLUFF SPRING - RNW /	92.F.060.4.4	REFUSED, NO WATER; 0251566.	092F/9
BOISSEVAIN SPRING - FR 1957/04/24	92.K.035	FULLY RECORDED; 0215817.	092K/6
BUCCANEER SPRING - FR 1963/04/22	92.G.051.1.1	FULLY RECORDED; 0249277.	092G/12
CASSEL LAKE - RNW 1980/01/08	92.K.026	REFUSED NO WATER - 0341105	092K/2
CLOWHOM LAKES - OR 1932/11/16	92.G.073.1.2	REFER ALL APPLICATIONS TO L.I. (LETTER INWARD) 922872; 0057780. OFFICE RESERVE WAS PLACED ON BEHALF OF J A MCKERCHER WHO HELD TIMBER LICENCE TO FLOAT LOGS DOWN CLOWHOM LK 7 RIVER. REQUESTED REFERRAL OF ALL APPLICATIONS	092G/12
CLOWHOM RIVER - OR 1932/11/16	92.G.073.1.2	REFER ALL APPLICATIONS TO L.I. 922872; 0057780. OFFICE RESERVE WAS PLACED ON BEHALF OF J A MCKERCHER WHO HELD TIMBER LICENCE TO FLOAT LOGS DOWN CLOWHOM LK & RIVER. REQUESTED REFERRAL OF ALL APPLICATIONS	092G/12
COMMUNITY CREEK - FR 1991/03/08	92.F.080.3.3	FULLY RECORDED - 2001421. REFUSED NO WATER - 2001421	092F/16
EAGLE CREEK - FR 1992/02/05	92.K.035	FULLY RECORDED 2001433. REFUSED NO WATER 2001433	092K/6
HALL CREEK - RNW 1980/05/05	92.K.017	REFUSED, NO WATER; 0355467.	092G/12
HAMMIL CREEK - OR 1979/09/04	92.F.088.2.1	OFFICE RESERVE; NOTIFY POWELL RIVER REGIONAL DISTRICT OF ANY APPLICATIONS FOR WATER LICENSES; 0281479.	092F/16
HASLAM LAKE - OR	92.F.088.4.1	NOTIFY DISTRICT OF POWELL RIVER OF APPLICATIONS;	092F/16
HOMESITE CREEK - RNW	92.G.051.1.2	REFUSED, NO WATER; 0340247.	092G/12
JEFFS CREEK - FR 1981/12/17	92.F.060.4.4	FULLY RECORDED; 0368398.	092F/9
JOINT SPRING - FR 1963/05/21	92.G.041.4.2	FULLY RECORDD; 0247200.	092G/5
LANG CREEK - FR-EXC 1980/04/24	92.F.079.3.3	FULLY RECORDED EXCEPT SMALL DOMESTIC; REFUSED, NO WATER; 0355696.	092F/16
MINTER BROOK - RNW 1978/12/09	92.G.071.3.2	REFUSED, NO WATER; 0341974.	092G/13
MULLINS BROOK - OR 1958/09/24	92.F.079.3.4	SOURCE CONTAMINATED; 0217427.	092F/16
NIELSEN SPRING - FR 1980/08/14	92.F.096.2.4	FULLY RECORDED; 0365452.	092F/15
POLLOCK BROOK - FR 1991/05/14	92.G.071.1.1	REFUSED, NO WATER; 2000262, 2001219 . FULLY RECORDED 2001219	092G/12
RAVINE CREEK - FR 1984/01/04	92.K.045	FULLY RECORDED; 0370047. REFUSED, NO WATER; 0370047.	092K/6
ROLLISON CREEK - FR 1977/09/22	92.G.051.1.3	FULLY RECORDED; 0329651.	092G/12
UZZELL CREEK - RNW 1969/10/22	92.F.097.2.2	REFUSED, NO WATER; 0285939.	092F/15