Upflow sludge blanket filtration used at BC ski resort

The upflow sludge blanket filtration (USBF) wastewater treatment system is a single sludge denitrification biological treatment process that incorporates all processes required for biological treatment in a single circulation loop. It utilizes fluidized bed filtration as a method of mixed liquor clarification. The process delivers high treatment efficiency, including biological nitrogen and phosphorus reduction, and avoids a commonly encountered problem of the conventional biological plant – gravity separation.

Over one hundred plants have been installed in Canada, the United States and the Caribbean. The plant at Sun Peaks Resort, Kamloops, British Columbia, was one of the first in 1999.

Sun Peaks Resort is situated at the base of Tod Mountain, approximately 40 kilometres northeast of Kamloops, BC. Tod Mountain, with a summit elevation of 2,152 metres, was originally developed as a ski operation in the early 1960s. In 1972, the former operator decided to develop a few residential lots and formed a private utility to operate a simple community water supply and wastewater leaching field that was replaced in 1987 with a simple lagoon system. While the permit granted a maximum disposal of 230 m^3/day, discharge was intermittent, if at all.

Sun Peaks wastewater treatment plant – Phase 1

In 1992, the property was purchased by Nippon Cable Company Limited and the resort's name was changed to Sun Peaks. Nippon's strategy for Tod Mountain was to upgrade the ski lift and trail system and transform the area into a major four-season, mountain resort with all the amenities.

In 1993, the resort operator, Sun Peaks Resort Corporation completed the Tod Mountain Master Plan and entered into an agreement with the Provincial Government to take the resort from a winter-only ski hill to a year round community that will eventually support as many as 24,000 residents and visitors during any period.

Sun Peaks' base development has been rapidly expanding since 1993. As a consequence, wastewater flows at the Sun Peaks Utilities' treatment facility have been steadily increasing. Sun Peaks Utilities Co. Ltd. (SPUCL) has made a number of improvements to the lagoon system to keep pace with the increasing hydraulic and organic loading. These improvements range from surface aeration mixers to subsurface fine bubble diffusion piping.

Plant expansion - 2003.

After the 1998 Christmas period when the holding time in the 6,000 cubic metre lagoon dropped to under six days, Sun Peaks Utilities decided to replace the lagoon with a system that could deal with the growing flows.

After evaluating a few alternatives, SPUCL decided to go with the upflow sludge blanket filtration (USBF) system supplied by Ecofluid Systems Inc. The design/build contract was awarded to Knappett Construction Ltd. in the latter part of July 1999, the construction began on August 24, 1999 and the plant started receiving wastewater on November 19, 1999. By December 15, the effluent was below 10 mg/l BOD_5 and 10 mg/l Total Suspended Solids.

Phase 1

The design had to be flexible and allow for flows that change ten-fold within a month and double on weekends from weekdays. Additionally, the design had to be modular and expandable to allow for the resort and the population growth.

The first phase installed in 1999 included two bioreactors with three sludge blanket filters and a waste sludge storage tank.

Plant upgrades and expansions

The resort's growth required a number of upgrades and expansions. In 2001, a fourth sludge blanket filter was added, and in 2002 a sludge dewatering centrifuge was installed.

However, the flows kept increasing. (See Table 1) Consequently two additional modules were installed in 2003 and in the summer of 2008 another module was added.

Flows vary dramatically from winter to summer. Each beginning of the winter season is like starting up a new plant when the plant flow triples from mid to the end of December.

Ski resorts (and this may apply to resorts in general) are not 'typical wastewater' generators. Flows change dramatically from day to day and holiday period to holiday period.

At Sun Peaks, a plumbing code was implemented for water conservation and the average daily flow per person is currently 220 litres and dropping (the Canadian average is 375 litres). Day visitors add about 40 litres per person per day (very high ammonia content). The Utility has learned to track lift tickets sales and occupancy rates, holidays and weather trends. It is surprising how powder ski or rainy days affect flows.

Influent characteristics

To get a better reading of the incoming influent, 24-hour composite samples collected every hour throughout the day were taken and analyzed. The results illustrate a very uneven pattern of influent characteristics throughout the day as demonstrated by one such sample in Table 2.

The highly variable biological loading throughout the day is only one of the challenges. The water in the resort is from wells and it has poor buffering capacity to begin with. Up to 3,000 day skiers add a lot of ammonia to the wastewater stream, resulting in reduced alkalinity during the treatment process. Possibly due to the type of cooking oils and cleaning detergents used in the resort's restaurants and hotels, uncommonly high COD is encountered at times. Very high peak hourly flows, and the fact that the influent temperature may change 5-7 degrees C within a matter of days, complete the picture.

Plant operation

To cope with the variable biological loading, the air blowers are controlled by a continuous DO monitor/VFD (variable frequency drive) system.

To 'control' alkalinity as much as 100 kg/day of slaked lime ($Ca(OH)_2$) has been added into the anoxic and aeration compartments. (In the 2006-07 season close to one hundred 25 kg bags of lime at $11 per bag were used).

Effluent parameters

The permitted effluent parameters are at 30 mg/l each for BOD_5 and TSS, which is not very demanding and the plant delivers much better. BOD_5 is typically less than 10 mg/l, TSS from 5 to 20 mg/l, ammonia less than 1 mg/l and total nitrogen in the 10 to 20 mg/l range. When the supernatant from the sludge dewatering process is not returned back into the influent, the total phosphorus is biologically reduced to 2 to 3 mg/l.

Table 3 records an analysis of grab samples taken at about 11 am on March

continued overleaf...

Table 1 – Annual Flow Increases

Season	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008
Winter High	930	997	1,244	1,206	1,303	1,362	1,431
Summer Low	35	42	127	157	186	198	

Table 2 - Influent Characteristics Variation

2007	24-hour Low mg/L	Hour	24-hour High mg/L	Hour	Average mg/L
BOD_5	120	6:30 am	590	9:30 am	385
COD	310	5:30 am	1300	9:30 am	813
N-NH4	30	1:30 pm	107	8:30 am	61

7, 2007, immediately after the highest flow of the day period and after US President's week (2nd highest annual occupancy).

BOD was not analyzed; however, based on the rest of the numbers, it is safe to assume that it was less than 10 mg/l. Together with averages of 5.7 mg/l for TSS, 0.074 mg/l for ammonia, and 7.9 mg/l for total nitrogen the results would satisfy most very stringent requirements. The average total phosphorus of 7.1 mg/l is much elevated from what has been experienced before the centrifuge installation. Almost all 'biologically up-taken' phosphorus returns to the system with the centrifuge supernatant recycle to the equalization tank.

Capital costs

The total capital cost from 1999 to 2007, including the initial construction of the plant, the expansions and the sludge dewatering system, all work out cumulatively to approximately $2,500 per m^3/d, or $7,500 per kg BOD/d.

Operating costs

Total operating costs include many contributing costs of which the main 'direct costs' are electricity, wages and benefits, chemicals, waste sludge disposal, and lab analysis.

The operating costs are year-round average costs and they are, of course, negatively affected by the high seasonality of the operation.

General operating experience

One of the challenges in the past was coping with the resort's fast growth. To allow for better planning of the plant expansions, Sun Peaks Resort has developed 'per bed factors' to gauge both water demand and the biological loading.

There are many restaurants in the resort and fat, oil and grease (FOG) has entered the plant in the past. Upstream management of FOG has become very important and SPUCL is working with the restaurants to become more proactive in dealing with their grease traps and oil trapping systems.

Another challenge is the effluent disposal. The current use of rapid infiltration (RI) trenches allows for a maximum daily discharge of 850 cubic metres only, and since the resort is built on the mountainside, land for additional RI trenches is limited. Options currently under study include stream augmentation, snow making and golf course irrigation. The challenge with the last two options is weather.

One of the key challenges at Sun Peaks is that, in addition to the wastewater treatment plant, the utility operates three water treatment plants and a gas distribution system. Like many small utilities, getting, training and keeping operators is an increasing challenge, no matter what type of system one operates.

The ownership of the resort is very happy with the modular expansion options of the USBF system and its ability to expand the system as needed. After all, expansion costs are paid by new users being added to the system rather than by the existing customers.

This article is based on a presentation by Pat Miller, Sun Peaks Utility Corp., at the BCWWA 2007 Annual Conference. For more information E-mail: jhebner@ecofluid.com

Table 3 - Grab Sample Analysis

		Bioreactor 1	Bioreactor 2	Bioreactor 3	Bioreactor 4
TSS	mg/l	5.7	9.7	3.7	3.7
Ammonia (as N)	mg/l	0.067	0.077	0.073	0.079
Nitrate (as N)	mg/l	6.75	4.17	7.42	6.58
Nitrite (as N)	mg/l	0.0504	0.0969	0.0545	0.0468
Total Nitrogen	mg/l	8.1	7.6	8.9	6.96
Total Phosphorus	mg/l	6.86	9.87	5.78	6.04
Chloride	mg/l	110	111	112	109
pH	mg/l	7.99	7.70	7.78	7.80
Conductivity		853	900	900	880