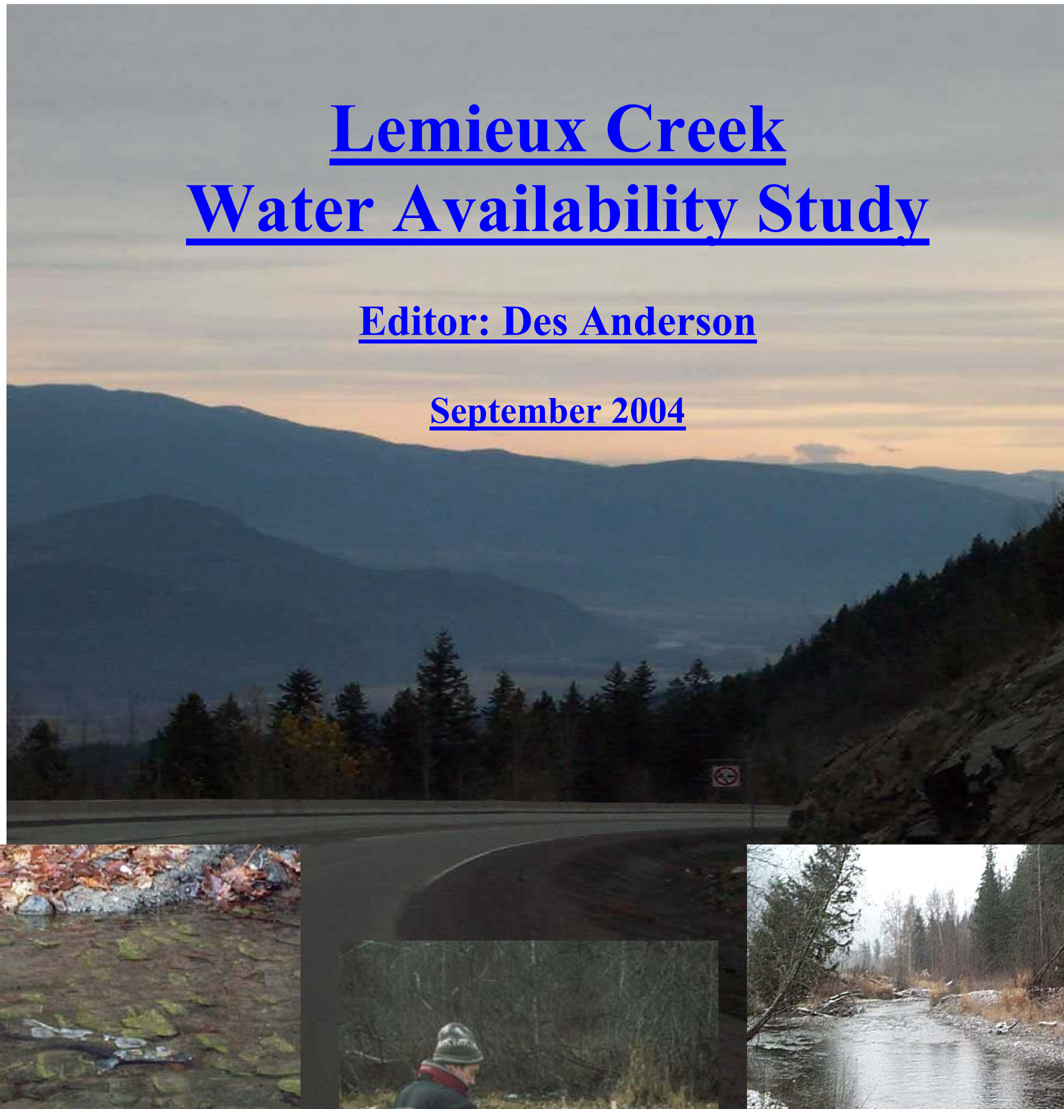
BRITISH
COLUMBIA

Lemieux Creek Water Availability Study

Editor: Des Anderson

September 2004



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Executive Summary

Des Anderson

The Key Issues

The Southern Interior of British Columbia has a number of streams that are at or near fully allocated status and have aquatic ecosystems that are stressed due to chronic stream low flows during the late summer and fall. It has become increasingly difficult to adjudicate new water license application on such streams due to competing interests and the lack of a systematic process that balances these conflicting interests in a transparent manner.

The current practice for quantifying available streamflow for licensing is to determine the difference between the 1:5 year 7-day low flow and a deterministic in-stream flow specified for aquatic needs. This means that the last water licensee to be granted a water license risks being denied water one year in every five, on average. Thus, by default, this chance of streamflow depletion (1:5 return period) also applies to in-stream aquatic habitat for a fully allocated stream. While this may be acceptable risk for agricultural purposes, it may not be appropriate for specific aquatic species, particularly species at risk, or any species dependent on the stream for rearing.

Groundwater discharge to streams is very important as it sustains baseflow and can also moderate stream temperatures. Both can be essential for the survival of fish populations during the late summer period. This can be a common problem in British Columbia, especially in the semi-arid region of the Southern Interior. Groundwater is not licensed at this time in BC. In general, LWBC is unable to consider the cumulative effects of existing groundwater extractions when adjudicating surface water licenses due primarily to a lack of groundwater information.

Solutions

Whenever the desired stream low flow return period for aquatic needs exceeds 1:5, water licensing adjudication should be based on the more stringent aquatic low flow return period standard.

Options for the integration of surface and groundwater management in areas with chronic water shortage are proposed.

Approach Used

An inter-agency steering committee was formed. In-stream flow criteria were developed and field verified during the fall of 2001.

An existing Water Allocation Tool (WAT) was upgraded. This enabled hydrographs of in-stream flows over a range of return periods to be evaluated against different aquatic low flow return period standards. The graphical output from this tool yielded the estimated cut-off date for new water licenses. Mean daily discharge data were then analysed on a 7-day low flow basis using the existing ministry frequency analysis utility. This was done in 7-day increments about the estimated cut-off date. This approach should permit the cut-off date (declaration of fully allocated status) to be identified, along with streamflow surpluses for the week(s) prior to cut-off.

While there was insufficient groundwater information in the study area to enable specific actions to be taken, it was possible to deal with the issues from a regional perspective. This focus was in two water management areas. The first being ways to ensure that existing and new water wells are adequately considered in surface water licensing decisions. This review would include an assessment of potential impacts of the proposed well on other water users. The second is the area-based planning that integrates groundwater and surface water within the proposed legislation for Water Management Areas. This would be used a priority areas with chronic water shortage.

Study Area

Lemieux Creek became a pilot study area where the above method evolved. The Lemieux Creek watershed was selected for this study because:

- it has high fishery values,
- has documented low flow and channel de-watering issues that impact the fishery,
- there are a number of outstanding water licence applications, and
- there has been a moratorium on further water licensing pending more work to understand the flow regime and in-stream flow requirements.

Results

The results from this study confirm that Lemieux Creek has chronic low flow problems at the mouth and 7km upstream. It is apparent that full-term (until September 30th) water licenses can not be issued, as streamflows fall below the aquatic flow standard during early August and this deficit continues beyond September 30th. A slight in-stream deficit is estimated on August 8th at the mouth of Lemieux Creek. This is based on an aquatic flow requirement of 0.612 m^3/s (20% of the Mean Annual Discharge) for summer rearing, and an 80% chance that this discharge will occur in any year. When the aquatic flow requirement is reduced by 50%, an in-stream surplus of 0.194 m^3/s is estimated on Lemieux Creek at the mouth on August 15th, based on the same chance of stream flow recurrence.

Streamflow surpluses and deficits were also estimated for other reaches on the Lemieux Creek mainstem. The results indicate that the cut-off for new irrigation water license applications is likely to be between August 1st and 15th, depending on the aquatic flow criteria used.

Key Recommendations

The pending irrigation water license applications for Lemieux Creek should have a cut-off date between August 1^{st} and August 15^{th}, depending on the in-stream flow criteria used.

Diversions to water storage structures within Lemieux Creek should be limited to the April 1^{st} to June 15^{th} so as to conserve natural streamflow during the rest of the year.

A streamlined form of the steps in this report should be used in future water availability studies. WAT should be used only as a screening tool. However, WAT may have limited application due to insufficient hydrometric record, and/or uncertainty about the timing and volumes of water withdrawn that prevents the naturalization of the hydrometric record in a statistically defensible manner. The Ministry's flood frequency analysis utility (FFAME) should be used to quantify streamflow surpluses for a water licensing decision.

In order to reduce the potential for baseflow depletion in areas with chronic water shortage and water-use conflicts, a two tiered approach is proposed. Tier I deals with groundwater licensing, whereas Tier II covers options for area-based long-term planning.
Tier I - Decision-makers are provided with a framework for considering the cumulative effect of existing groundwater production on streamflow. With respect to the incremental effect of new water wells on baseflow, new groundwater legislation should require proposed wells with a design production rate in excess of an appropriate threshold for the area to be subject to review. This review would include an assessment of sustained yield and potential impacts on other water users.
Tier II - Proposed legislation for Water Management Plans (Part 4 of the Water Act) should be used to implement effective water resource management in priority areas with chronic water shortages. This includes provisions for the establishment of Area Authority to manage the water resources across multiple jurisdictions with conflicting uses. The approach favours the integration of surface and groundwater management into a comprehensive framework.

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INTRODUCTION

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The Lemieux Creek watershed was selected as the first candidate in the Southern Interior for a water availability study because it has high fishery values, has documented low flow and channel de-watering issues that impact the fishery. In addition, there are a number of licence applications that have been in the backlog for several years because of a moratorium on the issuance of new water irrigation licences. A comprehensive study was required to support the statutory decision-maker in the adjudication of these applications and provide direction on future water use. This report addresses these issues within a systematic and transparent framework.

PROJECT STEERING & OBJECTIVES

Des Anderson

This project was initiated during the fall of 2001. It required a multi-disciplinary approach involving professionals from both provincial and federal agencies within a project team. All provincial representation was within the former Ministry of Environment, Lands and Parks at initiation of the project. The project team was disbanded as a result of re-structuring of provincial ministries during January 2002, thus impeding completion of this project. A project steering committee was formed to facilitate coordination and completion of the project. Steering committee members were:

Kevin Dickenson	Land and Water BC
Dave Jones	Ministry of Water, Land and Air Protection
Dave Whiting	Ministry of Sustainable Resource Management

The following objectives were set:

- To enable defensible adjudication of the outstanding water licence applications.
- To identify in-stream flow requirements: quantity and timing.
- To identify opportunities for and limitations to future off-stream uses.
- To encourage only applications that could be readily adjudicated by providing information to potential applicants on in-stream requirements.
- To gain insight into the surface/ground water relationship.
- To seek input from appropriate agencies in developing the plan and to have general acceptance of the plan by the watershed residents.
- To make policy recommendations to foster the stewardship of the water resource.

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GENERAL WATERSHED INFORMATION

Wayne Weber and Ramona Holota

Geography

The Lemieux Creek Water Allocation Plan area, consisting of the watershed of Lemieux Creek, is located about 85 km north of Kamloops, on the west side of the North Thompson River, shown in Figure 1. The study area includes Little Fort at the mouth of Lemieux Creek, north to Taweel Lake and west to Lac Des Roche**.** The watershed covers an area of 529.3 km^2 (204.4 $miles^2$), according to information in the Watersheds B.C. database, maintained by the B.C. Fisheries program. The watershed was sub-divided into Upper Lemieux, Mid-Lemieux and Lower Lemieux for hydrologic analysis. Map A shows the watershed boundary and other features on the watershed.

Topography, Landforms and Vegetation

The Lemieux Creek watershed is mostly located within the northern part of the Thompson Plateau of the Interior Plateau. About two-thirds of this watershed is a rolling plateau, part of the Fraser and Thompson Plateaus. Lac De Hache is, however, just outside the north-western boundary of the Thompson Plateau. Holland (1964) describes the Thompson Plateau as a gently rolling upland of low relief, generally between 1200m (4000 ft) and 1500m (5000 ft) covering an area of approximately 28,500 km^2 (11,000 $miles^2$). The Thompson Plateau was occupied by glacial ice from the Pleistocene epoch and a thick mantle of glacial drift covers the bedrock. Large meltwater channels bounded by cutbacks and terraces were formed by the melting of glacial ice and depositing stratified drift from the meltwater. The bedrock consists of both sedimentary and volcaniclastic rock from the Nicola Group and ranges in age from the Lower Jurassic to the Upper Triassic Periods.

The highest point in the watershed is Mount Heger, west of Taweel Lake, at 1893 metres (6210 ft); the lowest point is the creek mouth on the North Thompson River, at 382 metres. Lemieux Creek flows southeast and then south from Taweel Lake (altitude about 1220 metres – 1220 ft) through a deep and rather broad valley. This valley is separated from the North Thompson Valley by a sharp ridge, with Skwilatin Mountain (1490 metres – 4088 ft) and Mount Olie (1230 metres – 4035 ft) as its highest points. The two largest tributaries, Eakin and Nehalliston Creeks, enter Lemieux Creek from the west, descending through deep, steep-sided valleys. The plateau area features many large lakes, including Taweel, Long Island, and Birch Lakes, and Lac des Roches.

The original vegetation of the watershed consisted almost entirely of conifer forest ecosystems, except for the lakes and a few extensive wetlands. Areas of natural grassland are restricted to a few pockets on steep south-facing slopes, and no point in the watershed extends above timberline.

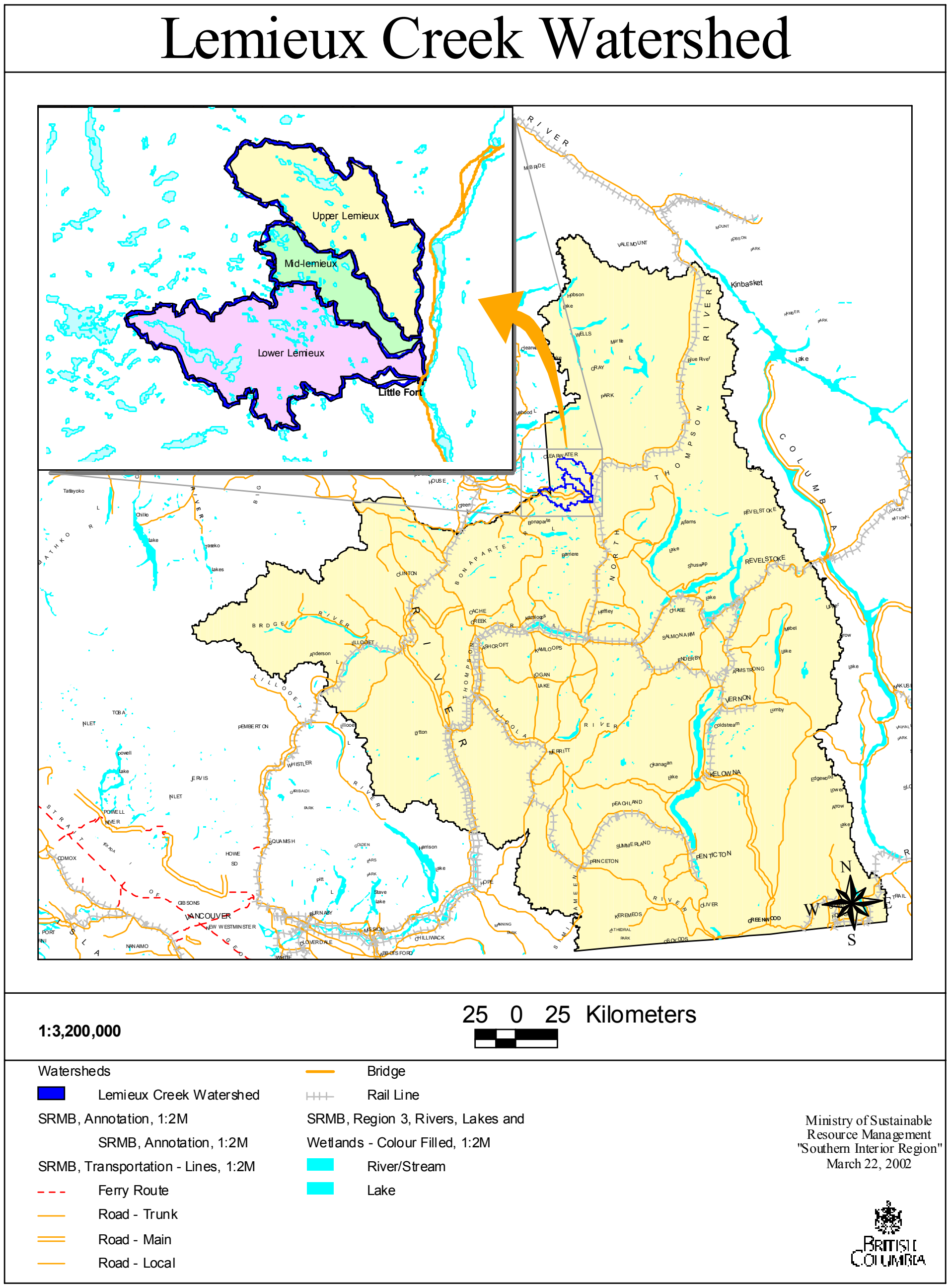


Figure 1 - Location Map

When classified according to the system of biogeoclimatic zones developed by Krajina (1965) and revised later by Pojar et al. (1987) and Lloyd et al. (1990), 61% of the watershed is occupied by the SBS (Sub-boreal Spruce) Zone; 16% by the IDF (Interior

Douglas-fir) Zone; 13% by the ESSF (Engelmann Spruce-Subalpine Fir) Zone; and 10% by the ICH (Interior Cedar-Hemlock) Zone.

Climate

The climate is continental, with major differences in temperature and precipitation between the cool, moist plateau and the warmer, drier valley bottoms. No climatic stations are located in the watershed. Darfield, located 14 km south of Little Fort on the North Thompson River, probably has a very similar climate to Little Fort. Mean monthly temperatures at Darfield range from -6.5 degrees C in January to 18.8 degrees C in July. Annual snowfall totals 128 cm, and total annual precipitation averages 456 mm.

There are no climatic stations on the plateau close to Lemieux Creek. However, by extrapolating data from other stations at 1200 to 1300 metres altitude in the southern Interior (McCulloch, Highland Valley, Barkerville), it would appear that temperatures on the plateau would average about -6 to -8 degrees in January and 13 to 14 degrees in July, with an annual snowfall of 250 to 400 cm, and total precipitation of about 600 to 900 mm.

Land Use History

Prior to European settlement, the area in and around Lemieux Creek was home to the Secwepemc or Shuswap people. There are no Indian reserves within the watershed boundary. However, the North Thompson Indian Band has two main reserves, North Thompson Reserve #1, which occupies 1236 ha along the North Thompson River south of Little Fort, and Boulder Creek Reserve #5, which occupies 280 ha in the Joseph Creek watershed northeast of Little Fort, plus several smaller reserves. One smaller reserve is located directly across the North Thompson River from the mouth of Lemieux Creek. It was set aside as the local Secwepemc used that area as a fishing station. The watershed falls within the traditional use area of the North Thompson Band. There are several traditional trails used by the Secwepemc people running throughout the watershed up to Taweel Lake, Tuloon Lake up into Heger and Buck mountains and then over to Canim Lake and Alberta. Some of these trails were incorporated into the Hudson Bay trail network and today's Yellowhead Pass. (pers. Com. Chief Nathan Mathew – North Thompson Band).

Agricultural development in the watershed apparently began very early in the 1900s. The first irrigation licence was issued on Eakin Creek in 1909 to Oliver Eakin, and is currently held by Bob Cartwright.

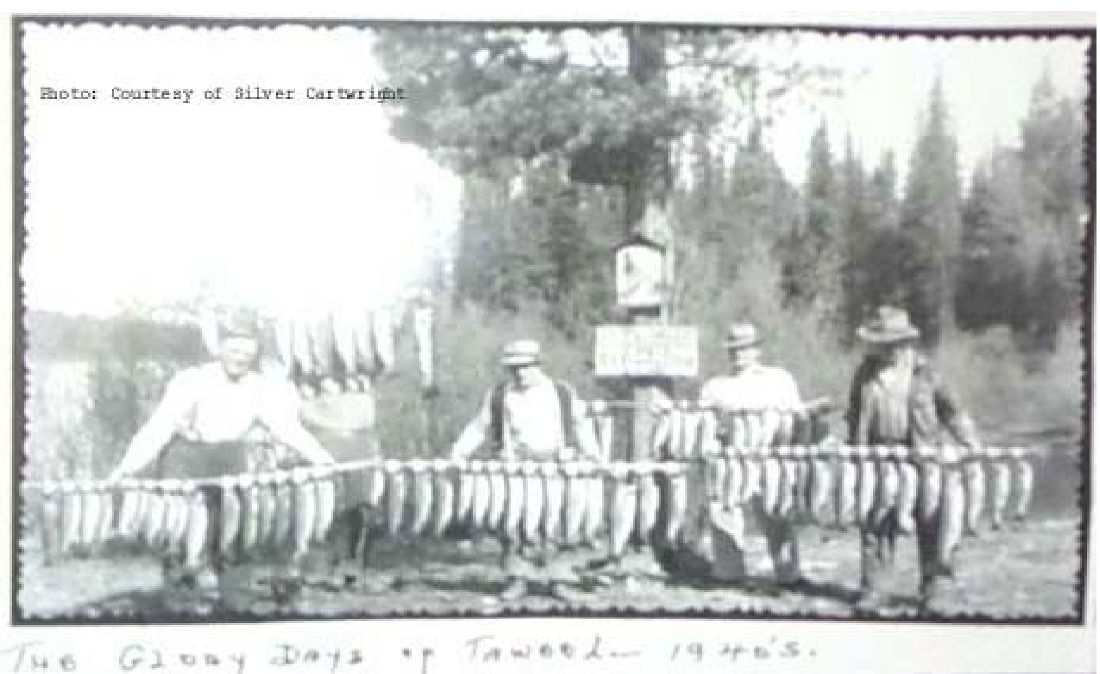
The settlement of Little Fort, known until the 1930s as Mount Olie, grew up early in the 20th century. In 1912, Joseph Latremouille surveyed the town of Mt. Ollie and developed a hydroelectric power station for the town on Three-Mile Creek (now known as Eakin Creek). Gung Loi Jim the late brother of Bob Cartwright's wife, Silver opened the first General Store and Post Office in Mount Olie in 1919. An earlier Post Office was operated across the river out of Eledor Latremouille's barn in the late 1890's. In 1939, Gung Loi

Jim and Louie Latremouille opened up the first fishing camps on Taweel Lake. (Ta-weel is said to be a Shuswap word for "big beaver dam"). The fishery was an important activity in this watershed during the 1940's, as illustrated in Photographs 1.

Also in the early 1900s, forestry activities began in the watershed. A company called Northern Construction harvested Douglas-fir and cedar for railroad ties and telephone poles, respectively, and floated them down Lemieux Creek during the spring freshet. Roy Livingstone, the father of valley resident Mack Livingstone, worked for the company as caretaker of a rough dam (built over top of a beaver dam) at the outlet of Taweel Lake, and supervised the log drive for a number of years. Booms were tied across side channels of Lemieux Creek during the drives to prevent logs from becoming trapped. However, to this day, one can find the occasional railroad tie or cedar pole stranded in the channel. Louie Latremouille still has his father's log stamp that scaler's used to mark the logs.

The main forest companies currently operating in the watershed are Tolko Industries Ltd. (Louis Creek Division) and Gilbert Smith Forest Products Ltd., both of which have mills in and near Barriere.

Land-use data, tabulated from recent aerial photographs, indicate that about 81% of the entire watershed is occupied by young and medium-aged forest; 5% by old-growth forest (older than 140 years); and 8% has been recently logged. Lakes and ponds make up 4.3% of the total area, and wetlands an additional 1.1%. Agricultural land comprises only 0.5% of the total, open rangeland 0.2%, and urban areas 0.1%.



Photograph 1 Fishing at Taweel Lake 1940's

Water licensing has a long history in Lemieux Creek dating back to the early 1900's. Photograph 2 illustrates the building of a flume to transport water from the watershed for landowners use.

Photograph 2 Historical Water Flume

As a result of the Kamloops Land and Resource Management Plan (LRMP), which was completed in 1995, four new Class A Provincial Parks were established within the Lemieux Creek watershed. These parks were established by Order-in-Council in 1997. The four parks are as follows:

- Taweel Park (4393 hectares) includes most of Taweel Lake and a large surrounding area.
- Emar Lakes Park (1618 hectares) includes Long Island Lake, Emar Lake, and 15 other lakes south of Highway 24 and north of Eakin Creek.
- Eakin Creek Floodplain Park (123 hectares) a linear park along Eakin Creek, extending downstream from a short distance below the confluence of Emar Creek.
- Eakin Creek Canyon Park (10 hectares) a small park on both sides of Eakin Creek, a short distance upstream from its confluence with Lemieux Creek.

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HYDROLOGY & SCALING FACTORS

Des Anderson

An initial review of available hydrometric data was done to characterize the hydrologic response of the watershed.

Hydrometric Data

Three Water Survey of Canada (WSC) gauging stations have operated at various times in the Lemieux Creek watershed. Stations locations are shown in Map A. These stations are as follows:

- Station 08LB078 (Lemieux Creek near the mouth), located at 51°25'31" N, 120°12'1" W-- operated year-round for 19 years (Jan. 1977 to November 2001)
- Station 08LB042 (Lemieux Creek near Mount Olie), located at 51°28'0" N, 120°12'58" W-- operated for 4 years (1926 to 1928, 1979) from April through September only, and for May 1980 through June 1987, year-round.
- Station 08LB043 (Nehalliston Creek near Mount Olie), located at 51°29'0" N, 120°14'35" W-- operated in the irrigation season (April through September) for 3 years only (1926 to 1928).

Data from Stations 08LB078 and 08LB043 were used in this report, and are referred to as <u>Lemieux @ Mouth</u> and <u>Upper Lemieux</u>, respectively. The period of record used in the analyses was 1926-28 and 1979-87, and 1977-98 for Stations 08LB043 and 08LB078, respectively.

Hydrologic Response

Mean daily discharge hydrographs for the period of common hydrometric record are provided in Figure 2. This shows that runoff from Upper Lemieux Creek is approximately 50% of runoff for Lemieux Creek at the mouth. Since Upper Lemieux occupies about 33% of the total watershed, its higher relative discharge is attributed a greater proportion of its area in the snowpack zone.

The hydrologic response of Lemieux Creek is typical for a watershed in the BC Interior with its headwaters on the Thompson Plateau. The hydrographs shows the on-set of freshet during April, with peak runoff occurring, on average, between the second and third week of May. Thereafter, runoff declines to near base flow levels during the last week of August. The base flow period extends from late August through early April, on average.

The information in Figure 2 suggests that a runoff excess may typically exist between mid-April and mid-August, as stream flows are likely to exceed in-stream flow requirements for aquatic needs. However, this can not be determined without detailed analyses. Uncertainty about off-stream water availability will be dealt with in more detail in Section 9.

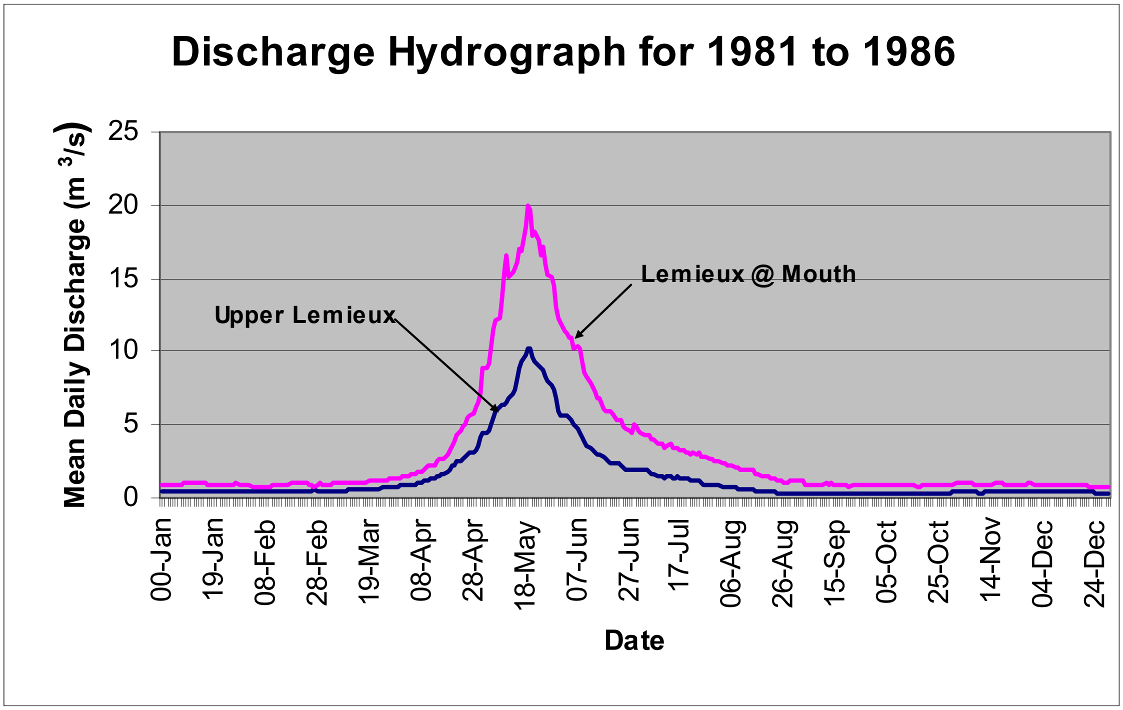

Figure 2

Mean unit runoff hydrographs for Upper Lemieux and Lemieux @ Mouth, for the period of common record, are provided in Figure 3(a). Note the reversal in the relative

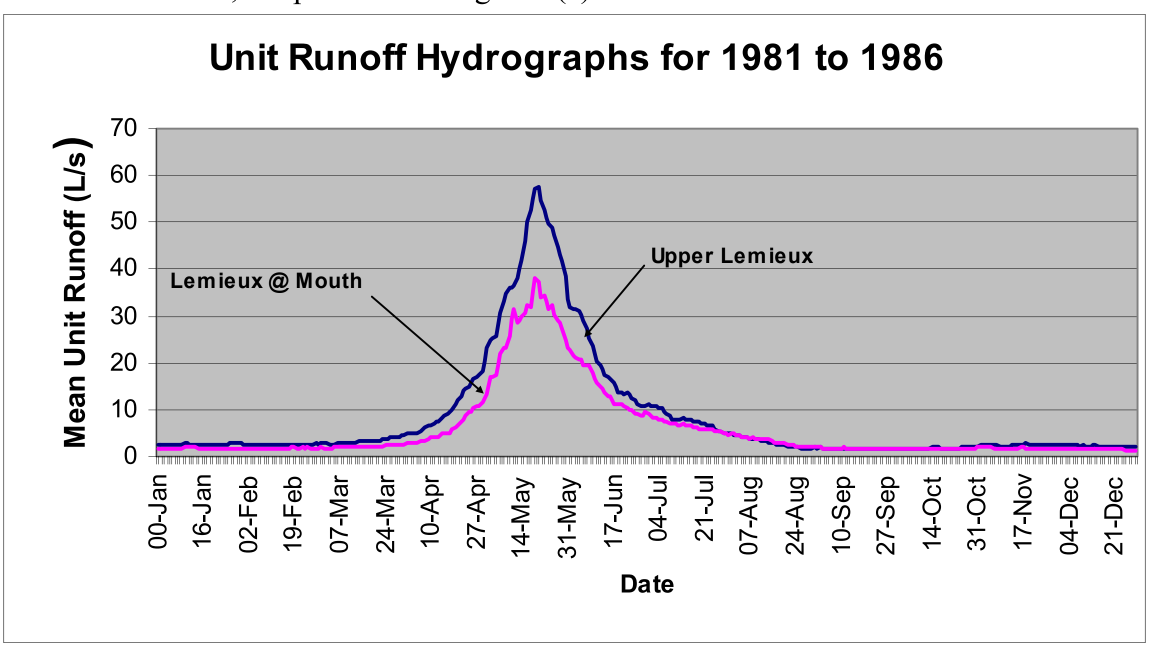

Figure 3 (a)

position of these hydrographs, with higher mean unit runoff from Upper Lemieux during freshet. Again, this is expected, since Upper Lemieux has a higher percentage of its area within the snowpack zone, compared to the entire watershed. Upper Lemieux generally has slightly higher mean unit runoff, as shown in Figure 3(b). The exception to this is early August through late October, when the unit runoff ratio (scaling factor) is approximately 1.0. This information is subsequently used in Section 9.0 to distribute stream flow to the stream network nodes between Upper Lemieux and Lemieux at the Mouth. It would appear that there is an anomaly in the February 27th data. This has not been investigated, as it does not occur during the period of interest for this report.

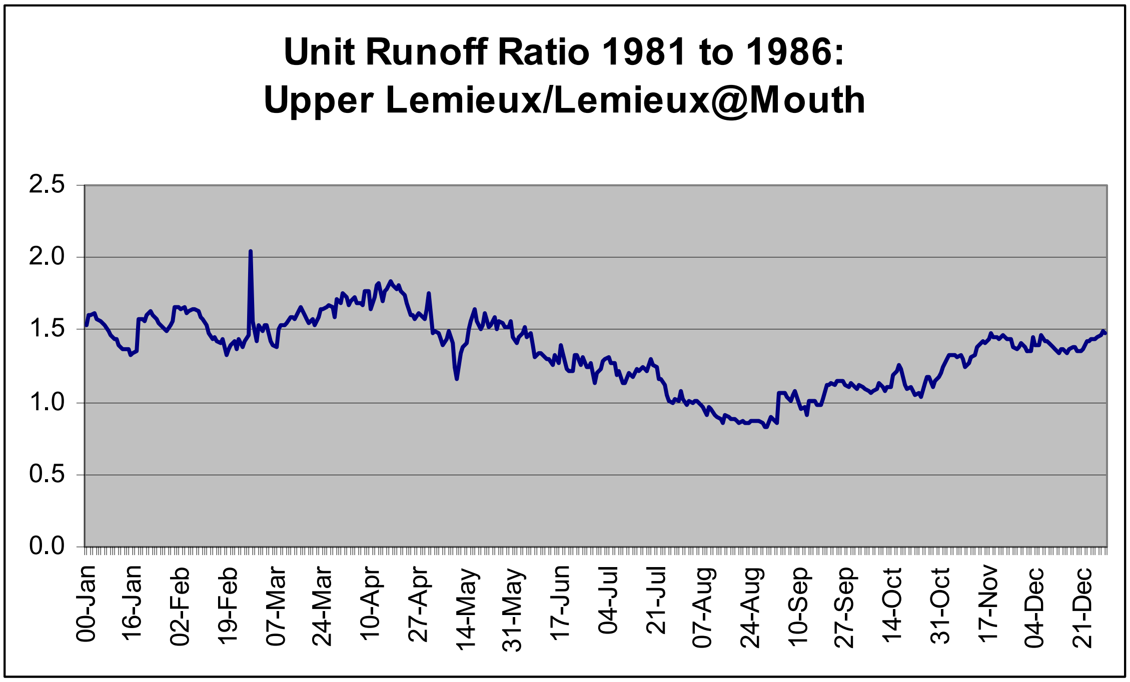

Figure 3 (b)

Since base flows are primarily from groundwater discharge to the creek, Figures 3(a) and 3(b) provide some insight into the influence and importance of groundwater for the maintenance of stream flows for aquatic needs during the fall, winter and early spring. A review of the groundwater resource is provided in the next section.

5

GROUNDWATER

Bill Hodge and Mike Wei

A review of groundwater conditions within the Lemieux Creek watershed has been carried out to provide groundwater information to the Lemieux Creek Water Availability Study. This summary is compiled from a review of water well records and surficial and bedrock geology mapping within the watershed area, relevant groundwater reports, including the memorandum entitled *Small Water Systems – Little Fort* by Ronneseth (1997).

Groundwater Conditions

As of 2000 there are twenty-one wells completed in the unconsolidated (sand and gravel) aquifer(s) and six wells completed in fractured bedrock aquifer(s) reported in the Ministry's WELL database within the Lemieux Creek watershed (Table 1). One borehole completed in the unconsolidated deposits is reported as dry. Most of the wells completed into sand and gravel are located at the lower reaches of Lemieux Creek. Of the 21 wells completed in sand and gravel, depths range between 2.1m and 63.7m (7 ft and 209 ft) and reported well yields range between 0.23 L/s and 4.2 L/s (3 gpm and 55 gpm). Well yields are based on short-term bail and air lift tests by the water well contractors and are not considered as reliable as long-term pumping tests. The median well depth and median estimated well yield is 16.6m (54.5 ft) and 1.5 L/s (20 gpm) respectively. Depth to groundwater ranges from 4.3m to 11.6m (14 ft and 38 ft) while the median depth to groundwater is 7.6m (25 ft).

Table 1 – Water Well Data

BCGS Map	No.	Well Tag No.	Lot	Plan	D.L.	Aquifer Type	Well Depth (ft)	Water Depth (ft)	Bed. Depth (ft)	Estimated Yield	Unit	Const Date	Well Use
92P.049.2.2.2.	1	000000000447	A		1819	Confined	54	37	unk	20	gpm		Domestic
92P.049.2.2.2.	2	000000051529	A	14141	1818	Bedrock	93	30	19	5	gpm	Jan-82	Domestic
92P.049.2.2.4.	1	000000053794	65	1154	1658	Unconfined	54	27.9	unk	8	gpm	Jul-84	Domestic
92P.049.2.2.4.	2	000000037150	101	1154	1658	Confined	51	29	unk	20	gpm	May-77	unk
92P.049.2.2.4.	3	000000034637	2	21975	1658	Confined	65	21	unk	20	gpm	Apr-76	unk
92P.049.2.2.4.	4	000000056483			1811	Bedrock	144	83	93	1	gpm	Sep-86	unk
92P.049.2.2.4.	5	000000057740		B-6296	1658	Unconfined	90	23	unk	20	gpm	Nov-87	Commercial
92P.049.2.2.4.	6	000000058727	4A		1658	Unconfined	57	26	unk	40	gpm	Apr-89	Domestic
92P.049.2.2.4.	7	000000059342		1154	1658	Unconfined	38	19	unk	50	gpm	Jun-90	Domestic
92P.049.2.2.4.	8	000000059373		13095	1658	Confined	58	14	unk	40	gpm	Jun-90	Domestic
92P.049.2.2.4.	9	000000059374	4A	1154	1658	Confined	58	17	unk	25	gpm	Jun-90	Commercial
92P.049.2.2.4.	10	000000060050	91	1154	1658	Confined	58	23	unk	30	gpm	Jun-92	unk
92P.049.2.2.4.	11	000000060064	98	1154	1658	Unconfined	54	25	unk	30	gpm	Jul-92	unk
92P.049.2.4.2.	1	000000000101			1812	Confined	97	25	unk	7	gpm		Domestic
92P.049.2.4.2.	2	000000059527	1	1499	1658	Confined	55	35	unk	18	gpm	Oct-90	Domestic
92P.049.2.4.4.	1	000000054412	1		1816	Unconfined	17		unk	3	gpm		unk
92P.049.2.4.4.	2	000000060220	A	33378	2034	Confined	200	dry	unk	nil		Nov-92	unk
92P.049.4.4.1.	1	000000050496	A	28266	3402	Unconfined	7		unk	6	gpm	Jun-82	unk
92P.049.4.4.1.	2	000000054383	A	28266	3402	Unconfined	10		unk	10	gpm		unk
92P.049.4.4.1.	3	000000050235	1	28266	3402	Unconfined	11		unk	11	gpm	May-82	unk
92P.049.4.4.1.	4	000000051476	1	33611	3402	Bedrock	200		36	Dry		Oct-83	unk
92P.049.4.4.1.	5	000000059340			1828	Confined	209	37	unk	15	gpm	Jun-90	Domestic
92P.057.2.2.2.	1	000000057726	9	32601	1461	Bedrock	240		23	1.25	gpm	Nov-87	unk
92P.057.2.2.2.	2	000000061969	16	34641	1461	Bedrock	162		51	6	gpm	Nov-94	Domestic
92P.057.2.2.2.	3	000000062003	8	34641	1461	Confined	30	15	unk	10	gpm	Apr-93	Domestic
92P.057.2.2.2.	4	000000075330	A	56582	1461	Unconfined	58.6	38	unk	40	gpm	Nov-98	unk
92P.057.2.2.2.	5	000000075331	C	56582	1461	Unconfined	38	13	unk	55	gpm	Nov-98	unk
92P.057.2.2.2.	6	000000060147	30	15392	1460	Bedrock	362		75	0.03	gpm	Sep-92	unk
92P.059.2.4.2.	1	000000059661			1827	Bedrock	125		18	5	gpm	May-91	Domestic

There are 6 wells completed in the fractured bedrock with depths ranging from 28.3 m and 110m (93 ft to 362 ft) and reported well yields ranging between 0.002 L/s and 0.38 L/s (0.03

gpm and 5 gpm). The median well depth is 49.4m (162 ft) and the median well yield is 0.23 L/s (3.1 gpm). One borehole completed 61 m (200 feet) into bedrock is reported as dry.

Other wells completed in the surficial and bedrock aquifer(s) may exist, however, if there is additional well record information, it is not currently in the WELL database. A field survey would be required to locate any wells not reported in the WELL database. Actual groundwater use is also not confirmed. The reported well yields in the well record indicate the capacity of the well or intended use of the well, not its actual withdrawal (see Estimated Yields in Table 1).

Surficial Aquifer(s)

One surficial aquifer has been identified and classified within the Lemieux Creek watershed. The Little Fort aquifer (Aquifer No. 296) was mapped and classified as an IIB (9) aquifer. An explanation of the British Columbia Aquifer Classification System is available at:

http://wlapwww.gov.bc.ca/wat/aquifers/Aq_Classification/Aq_Class.html#03.

The aquifer extends north up the Lemieux Creek valley for a distance of approximately 2.2 km and covers an area of approximately $4km^2$ (Figure 4). Additional well record information, obtained since that area was mapped by Ronneseth in 1997, has not warranted changing or extending the aquifer boundaries north along Lemieux Creek valley since that time.

The IIB aquifer mapped by Ronneseth in 1997 is considered moderately developed and moderately vulnerable to surface contamination. Domestic and commercial wells are completed in sand and gravel of fluvial and possibly glacio-fluvial origin. The aquifer is confined with "windows" with approximately 50 percent of the wells confined by clay while the confining layer appears to be absent in the remaining wells. Well records suggest that the confining material is generally clay and silty clay ranging in thickness from 0.3 m to 13.7m (1 ft to 45 ft). In the Little Fort area, local topography suggests that the direction of groundwater flow is predominantly to the south-east towards the North Thompson River (Ronneseth, 1997). Actual flow directions in the aquifer are not known but can be inferred by measuring non-pumping water level elevations in the wells. North of Little Fort, the steep bedrock valley walls on both sides of Lemieux Creek likely control groundwater flow towards Lemieux Creek. A groundwater level survey would be necessary to more accurately determine the direction of groundwater flow in the aquifer.

The principal source of recharge to the Little Fort aquifer is likely precipitation and snowmelt. Based on knowledge of groundwater level fluctuations in Provincial Observation Wells in the southern interior, the main period of recharge to the Little Fort Aquifer is expected to occur in late spring-early summer corresponding to snow melt - this is the period when groundwater levels are expected to be seasonally highest. The height of groundwater level rise and the amount of recharge the aquifer receives annually is expected to be dependent on the amount of snowpack accumulated over the previous winter. Groundwater levels are expected to be at their seasonal lowest in winter when the ground is frozen and little or no recharge occurs. An observation well would need to be established to help better understand groundwater level fluctuation in the aquifer.

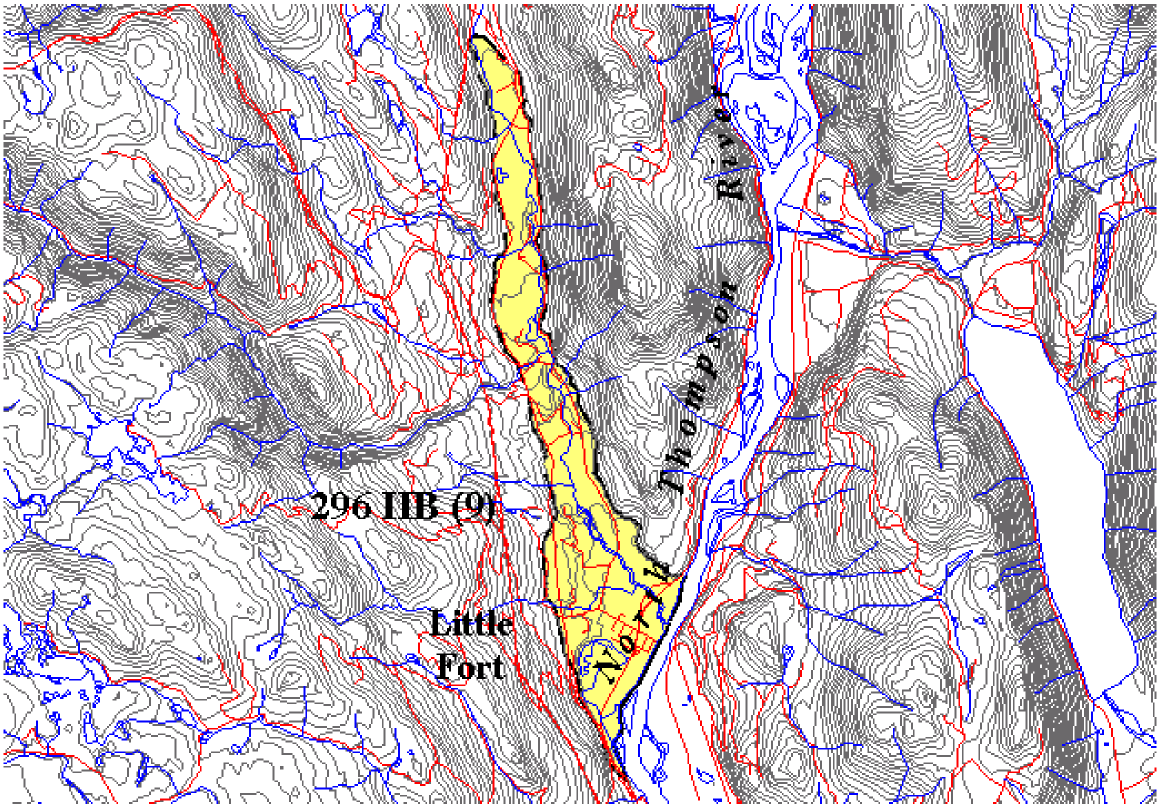

Figure 4 - Little Fort Aquifer

A hydraulic relationship may exist between Lemieux Creek and groundwater in the Little Fort aquifer. Lemieux Creek may contribute to recharge of the Little Fort aquifer for at least part of the year. Water level elevations of the groundwater and creek are necessary to infer the surface water-groundwater interaction.

Bedrock Aquifer(s)

The bedrock aquifer(s) have not been mapped and classified. The few well records on groundwater files suggest that groundwater occurrence is from fractures within the bedrock. It is not currently known if fracturing is widespread however, reported well yields to date suggest that the bedrock may be massive and not highly fractured. A few well records indicate that the bedrock type is fractured basalt. As indicated for the Little Fort surficial aquifer (Aquifer No. 296) the principal source of recharge to the fractured bedrock is likely precipitation and snowmelt and the main period of recharge is also expected to occur in late spring-early summer corresponding to snowmelt. Groundwater levels are also expected to be at their seasonal lowest in winter when the ground is frozen and little or no recharge occurs. The direction of groundwater flow in the bedrock is not known; however, the water table (from which ambient groundwater flow directions can often be inferred) is expected to form a subdued replica of the topography.

Groundwater Quality

Ground water quality information is currently available from only four shallow wells completed in the surficial aquifer(s). Three of these wells are located northwest of the Little Fort Aquifer in an unmapped surficial aquifer. The water chemistry data show that the groundwater is slightly alkaline (pH = 6.79 to 7.8), hard (hardness = 159 to 245 mg/L) and moderately mineralized (total dissolved solids = 178 to 326 mg/L). Water quality information is not available from the bedrock aquifer(s). Water quality information for any community wells (wells serving more than one household or serving a public or commercial premise) in the Lemieux Creek watershed may also be available from the local health unit offices.

Groundwater Quantity and Groundwater / Surface Water Interaction

An estimate of groundwater extraction is provided in Section 10. Groundwater / surface water interaction is also briefly discussed in this section.

6

LICENCED WATER DEMAND

Bob Petrie and John Bochard

The Lemieux Creek watershed has a total "full term" licenced irrigation demand of 710.95 acre-feet [1123.66 $dams^3$] of which 25.0 ac-ft is backed by storage. An additional 200 acre-feet of storage is diverted into Spokane Creek and this is not available to the main-stem of Lemieux Creek. See the discussion on Spokane Creek below. Total licence demand includes 12,500 gallons per day (gpd) [56,825 litres per day] for domestic purposes and 7,000 gpd [31,822 l/d] for enterprise purpose. Additional licencing which removes water from streams for minimal distances, are not considered to be off-stream demand of water in the Licence Demand Report Summary are: 2.20 cubic feet per second (cfs) [0.062 cubic metres per second] for Industrial (fish culture) Ponds and 1.086 cfs [0.031cms] for residential power generation.

The last irrigation licence issued within the Lemieux Creek watershed was in 1963 and the last domestic licence was issued in 1967. There has been a moratorium on further licensing pending more work to understand the flow regime and in-stream flow requirements.

Current Licenced Demand (Surface Water):

The irrigation licencing is the dominant off-stream use within the Lemieux Creek watershed. The licenced demand can be subdivided by purpose as follows:

Irrigation *:		910.95 ac-ft (97.20 %)
Domestic:	12,500 gpd	16.82 ac-ft (1.79 %)
Enterprise:	7,000 gpd	9.42 ac-ft (1.01 %)
		937.19 ac-ft

* includes 200 ac-ft of storage diverted to back Spokane Creek rights.

There are a total of 54 water licences in the Lemieux Creek watershed excluding those on Spokane Creek. Of those, 21 include domestic rights, 21 include irrigation, 4 enterprise, 4 ponds, 2 residential power and 2 are issued for storage.

There are 25.0 acre-feet of storage to back an irrigation licence on Demers Creek. Less than 3% of the irrigation licences within the Lemieux Creek drainage are backed by storage. 200.0 ac-ft of storage on Dum Lake is exported from the Dum Creek / Eakin Creek watershed to back an irrigation licence on Spokane Creek.

Spokane Creek is a small stream located at the lower end of the Lemieux Creek basin and is noted as "Fully Recorded for Irrigation". Spokane Creek is not identified as tributary to Lemieux Creek system under the Water Licensing Information System (WLIS), as the stream sinks in the lower reaches and does not have a surface connection to Lemieux

Creek. The above noted demand figure does not include 321.63 acre-feet (121.63 ac-ft unsupported by storage) licenced on Spokane Creek.

Note that the above quantities are for licenced surface water only. Refer to Section 10 for an estimate of groundwater extractions within the Lemieux Creek watershed.

Licensed demand is at a maximum during the irrigation season. The total licensed demand for Lemieux Creek at the mouth is 0.2024 m^3/s between April 1st and September 30th. This figure reduces to 0.1753 m^3/s when storage is taken into account.

Restrictions on Water Licensing:

There are currently no restrictions on existing water licences on the main-stem of Lemieux Creek. Four of the tributaries have restrictions noted on the Stream Register:

- Spokane Creek - Fully recorded for irrigation purposes (status in effect since 1981),
- Walmsley Creek - Fully recorded for irrigation purposes (status in effect since 1978),
- Demers Creek - Fully recorded for irrigation purposes (status in effect since 1981); and
- Miracle Creek - Possible water shortage (status in effect since 1974).

Outstanding Applications for a Water Licence:

There are currently 5 outstanding water licence applications (1 Conservation: store and use, 1 Power (Residential) and 3 irrigation) in the Lemieux Creek watershed which are currently being adjudicated:

File No.	Source	Purpose	Quantity	Date of Application
3001273	Taweel L.	Conservation	3300.0 ac-ft	1988
3002138	Lemieux Cr.	Irrigation	60.0 ac-ft	1992
3003294	Lemieux Cr.	Irrigation	84.0 ac-ft	1997
3003920	Lemieux Cr.	Irrigation	120.0 ac-ft	2002

The most significant of these is the application for 3300 acre-feet of conservation storage on Taweel Lake, which was filed by the Fisheries Program (then the Ministry of Environment, Lands & Parks) in 1988, following a severe drought in 1987. The DFO, in a letter dated June 2, 1992, requested further consultation on File No. 3002138, should further consideration be given to this application, due to concerns with low flows in Lemieux Creek which impede fish passage. A copy of this letter is provided in Appendix I.

LWBC requires a defensible basis for the adjudication of these outstanding water license applications. The following sections of this report provide a basis for such decision-making. This begins with a review of fishery resources, followed by the setting of in-stream flow requirements, then the analysis of water availability for off-stream use.

7

FISHERY RESOURCES

Wayne Weber

The Lemieux Creek watershed has important fishery resources. It is considered to be one of the most important salmon spawning streams in the larger North Thompson watershed, especially for endangered (SARA listing) coho salmon (Harding et al. 1994). Because of the important fish populations, as well as the apparent negative effects of water shortages, the Lemieux watershed was among those proposed in 2000 for designation as a Sensitive Stream under the provincial Fish Protection Act.

Extensive fish inventories have been carried out in the watershed, and at least 16 species and major forms of fish are known to occur there. This includes 4 species of Pacific Salmon, plus kokanee, a landlocked form of sockeye; rainbow trout and eastern brook trout; burbot; and 8 species of non-game fish. An e-mail from Brian Chan to Bob Petrie dated 14 January 2002 summarizes trout values in the watershed (copy in Appendix I)

Anadromous Salmon Stocks and Low Flow Concerns

Three species of salmon-- coho, chinook, and sockeye-- spawn regularly in Lemieux Creek. Pink salmon and kokanee have been recorded occasionally in the creek, but are not known to spawn there. Rainbow trout are present and may include resident and migratory, fluvial populations.

The coho population is by far the most significant of the three salmon species, and Lemieux Creek is one of the most important coho spawning streams in the North Thompson watershed. A fish enumeration fence operates yearly to count coho in the Lemieux Creek. Estimates of coho escapement are available for almost every year from 1951 to 2000. The average numbers of coho returning to Lemieux Creek were 1245 fish from 1951-1960; 1270 from 1961 to 1970; 571 from 1971 to 1980; 683 from 1981 to 1990; and 661 from 1991 to 2000. The trend in population is shown in Figure 5. The apparent decline between the 1950s and 1960s and more recent years parallel similar trends for coho in many other North Thompson tributaries.

The chinook population is much smaller. Although chinook escapement averaged more than 100 fish in the 1950s, with a peak run of 400 in 1953, it has averaged 25 fish or fewer since 1970. Sockeye is also a minor species, with an average escapement of only 14 fish, and they occur only every fourth year (1992, 1996, etc.). The trend in population for chinook is also provided in Figure 5. Anadromous salmon species will be considered here as these are the stocks most obviously impacted by low flows in Lemieux Creek. Rainbow trout are equally susceptible.

The upper limit of spawning for all 3 salmon species is about km 8 of Lemieux Creek. For coho, the main spawning areas are between km 4 and km 8, and between the mouth and km 1 (below the Highway 24 bridge.) A low waterfall at km 13.4 prevents the passage of salmon beyond that point. There are no reports of salmon using tributaries such as Eakin and Nehalliston Creeks; all use seems to be concentrated in the Lemieux Creek main-stem.

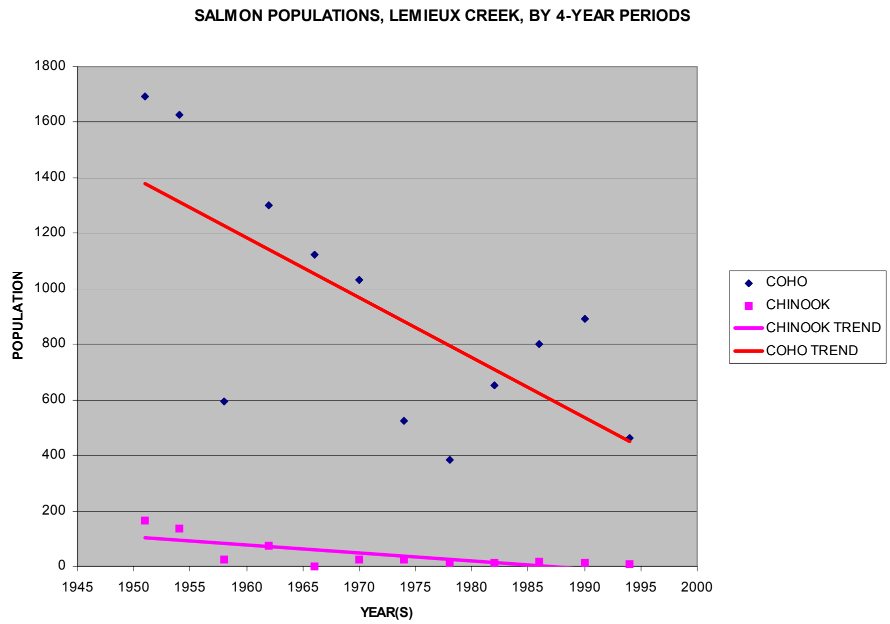

Figure 5

A spawning and rearing channel, constructed at km 7.6 in 1988, is heavily used by coho. The population has also been enhanced by releases from the nearby Dunn Creek fish hatchery each year since 1983 (pers. com., Rick Gray, Fisheries & Oceans Canada).

Fishery agencies and local residents have reported periodic dewatering of Lemieux Creek near km 7 and near the mouth during August through October (Hutton et al. 1983; Gene Tisdale, pers.com. 2001). In a letter dated June 2, 1992 (copy in Appendix I) the DFO state, "….low flows … often exist in this system which impede fish passage." These concerns have lead to a moratorium on the issuance of new water licenses.

In the fall of 2000, Lemieux Creek was proposed for designation as a Sensitive Stream under the Fish Protection Act. However, many provisions of this act were not brought into effect through regulations; hence Lemieux Creek was not so designated.

8

IN-STREAM FLOW REQUIREMENTS

Wayne Weber (in consultation with Dean Watts, DFO) and Des Anderson

Periodicity Chart

Biologists with the DFO and the MWLAP reviewed available data and agreed on the species and life-cycle schedule provided in Table 3. It was also agreed that chinook and coho would be the species governing in-stream flow requirements because of apparent low flow concerns that may impact these species.

Table 3 – Fish Periodicity (submitted by DFO)

Fish Life Stage & Habitat Usage	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
CO – migration and spawning	-------	--]							[---	-------	-------	-------
- summer/winter rearing (1+~80%)	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- incubation	-------	-------	-------	-------	--]						[------	-------
CH – migration and spawning								[------	-------	--]		
- summer/winter rearing (1+~90%)	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- incubation	-------	-------	-------	-------	--]				[---	-------	-------	-------
SO – migration and spawning								[--	-------	--]		
- incubation	-------	-------	-------	-------	--]				[------	-------	-------	-------
RBT - spawning				[---	-------	--]						
- migration	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- summer/winter rearing	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- incubation					[---	-------	----]					
BT - spawning									[------	-------	------]	
?? - migration	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- summer/winter rearing	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- incubation	-------	-------	-------	-------	--]					[------	-------	-------
WT - spawning	------]									[---	-------	-------
- migration	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- summer/winter rearing	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
- incubation	-------	-------	-------	------]						[--	-------	-------

In-Stream Flow Methodology

An attempt was made to apply the "B.C. Rules" for the determination of in-stream flow requirements for fish in Lemieux Creek. This in-stream flow setting method was developed for BC streams by Ron Ptolemy (Ptolemy 1999) and is a modification of the Tennant Method (Tennant 1976). Unfortunately, the column depths observed in Lemieux Creek were essentially off the scale on the Habitat Suitability Index (HSI) curves. This is thought to be due to the fact that the HSI curves were developed for larger rivers that are primarily in wetter regions of the province. Other, much more sophisticated approaches to determining in-stream flow requirements have been developed, especially the In-stream Flow Incremental Methodology or IFIM, which is widely used in the U.S. (Rushton 2000). However, application of IFIM requires intense field data collection and complex computer modelling. This approach is frequently not necessarily better than the Tennant Method for determining flow requirements for particular streams. Consequently, it was agreed to use the Tennant Method. Thus, in-stream flow requirements were based on percentages of the Mean Annual Discharge (MAD).

In situations where streamflows are regulated, as is the case at Lemieux Creek, MAD is usually derived from a reconstructed (naturalized) hydrograph where the licensed demand is added to the streamflow record. A reconstructed hydrograph is required by the Modified Tennant method. It was decided not to reconstruct the hydrograph in this study for the following reasons:

- uncertainty about the timing and quantities of actual water withdrawal rates due to a lack of metering of licenced water usage, the potential for unlicenced surface water usage, and lack of data on groundwater extraction rates;
- licenced demand is likely to have increased over the period of hydrometric data record as the new water licences were approved;
- the stepped water demand profile for irrigation that assumes the total licensed demand is extracted at 5, 10, 20, 25, 25, and 15 percent for the months April through September, respectively, which creates unnatural steps in the reconstructed hydrograph,
- unknown volume of irrigation water that infiltrates and returns (via groundwater discharge) to the stream, and
- uncertainty about the timing and quantities of surface water diversions to storage within the watershed.

This approach to the MAD calculation is considered acceptable where the percentage of licensed withdrawals is low, compared to total discharge, as is the case for Lemieux Creek. However, if licensed extractions are significant and if most of the water licences were granted near the end of a long hydrometric record, then substantial bias may be introduced in the MAD calculation due to “backend demand loading” of the hydrometric data. The MAD, based on hydrometric data from a regulated stream, will be lower than the true natural MAD. Thus, in summer, recorded flows will be lower than natural flows for such a stream.

Interim In-Stream Flow Criteria

In-stream flow criteria are more accurate when supplemented by field validation for the period of interest. Late summer rearing and migration spawning are considered the most critical in-stream flow periods for coho and chinook fish in Lemieux Creek. Since this project was initiated during the late fall of 2001, interim flow criteria were used because it was not possible to undertake field validation until summer/fall 2002.

The following interim in-stream flow criteria were agreed:

a) 10% MAD for <u>summer rearing</u>, provided that streamflow is monitored at strategic locations in Lemieux Creek during this period.
b) 25% MAD from September 15 to February 15 to meet <u>coho migration and spawning</u> requirements.

c) 30% MAD or the mean daily discharge for the period, whichever is the lesser, but not less that 25% MAD for chinook migration and spawning, with the period extending from **August 15** through October 15.

Although a criterion (a) is lower than “BC Rules” (typically 20% MAD), it was based on the preliminary analysis that showed in-stream low flows approach the 10% MAD threshold during late summer in an average year. Criterion (a) may only be effective in confined channel reaches. The DFO agreed to these interim criteria, subject to suitable field assessment and verification. Criteria (b) and (c) were validated November 2001 through flow surveys and habitat assessment of a critical spawning reach 7.0 Km from the mouth of Lemieux Creek. Refer to Appendix IV for details.

Final In-Stream Flow Criteria

During August 2002, the DFO completed in-stream flow assessments on critical reaches of Lemieux Creek to refine in-stream flow criterion (a). The results from this work are summarized in a letter from DFO to LWCB, dated September 12, 2002 (copy in Appendix I). As a result, a criterion (a) was revised as shown in (d) and (e) below:

d) 15% MAD - Upper Lemieux for summer rearing, and

e) 20% MAD - Lemieux @ Mouth for summer rearing.

To summarize, two set of analyses were done. The first analysis used interim criterion (a) along with criteria (b) and (c). The second analysis used final criteria (d) and (e) in conjunction with (b) and (c).

In reality, the percentage MAD approach to in-stream flows is simply a basis referencing against a benchmark flow standard. Note that these in-stream flows are deterministic values. Clearly, it is desirable to quantify in-stream flows in terms of probability of recurrence. A coupling procedure is described in the next section that enables deterministic in-stream flow requirements to be associated with low flow recurrence intervals.

The percentage MAD approach is a straightforward desktop exercise. Values can be refined with field observation of fish use, wetted habitat area and hydraulic function (like (d) and (e)). The approach is a standard setting method versus incremental methods such as IFIM.

9

WATER AVAILABILITY FOR OFF-STREAM USE

Des Anderson

An excerpt from the Proceedings of the Professional Water Resources Engineers 1984 In-stream Flow Workshop, Victoria, BC, provides some insight into issues that we seek to resolve in this plan, "We talked about what are the best habitat criteria for fish and we agreed that velocity appears to be one, pool-riffle ratio appears to be another, and finally, the third one was the availability of water. We had difficulties describing what the availability of water is but we said that if there was no water that was a pretty serious thing to have happen." The procedure developed within this section provides a basis for "describing what the availability of water is".

Low Flow Return Period Standard

It was agreed that a 1 in 5 year low flow standard would be used for the analysis of in-stream surplus. This flow standard is widely accepted for allocation decision-making for irrigation licences. This flow standard means that the agricultural industry accepts the chance of not having water available for off-stream use one year in five. Since the analysis is based on mean daily discharges, the discharges estimated are one-day, 1:5 low flows (i.e., ${}_1Q_5$). Note that a ${}_1Q_5$ off-stream low flow standard is synonymous with 4:5 year in-stream discharge. Note also that a 4:5 year in-stream discharge is represented in this report by $Q_{0.8}$. This is the low flow discharge that has an 80% chance of occurrence in any year.

Existing Procedure for Irrigation Water License Adjudication

In general, low flow frequency analysis is based on a 7-day low flow - 1 in 5 year (${}_7Q_5$) streamflow standard). The Ministry's frequency analysis utility (FFAME) selects the lowest 7-day flows for the period of interest in each year of the hydrometric record. A frequency analysis of the average of the 7-day values is then performed and the results are provided for the Three Parameter Log-Normal, Gumbel, Pearson Type III and Log Pearson Type III distributions. Kolmogorov-Smirnov statistics are used to identify the distribution(s) with the best fit.

The output is a plot of the cumulative probability plot for each distribution listed above, with an accompanying table of estimated discharge by return period and associated 95% upper and lower confidence limits. Low flow frequency analysis is done for the proposed irrigation period for the application (generally April 1 through September 30).

For situations where a stream is approaching "Fully Allocated" status, ${}_7Q_5$ will be near the in-stream flow requirement late (and possibly early) in the irrigation season. Further frequency analyses may be required to ascertain if a cut-off date before September 30 is warranted. This is an uncoupled process involving trial and error. The Water Allocation

Tool (WAT) was developed to couple low flow frequency analysis with in-stream flow requirements in an Excel Workbook. Details of WAT are provided below.

Stochastic Coupling of Off-Stream Water Availability with In-Stream Flow Requirements

Version 1.0 of WAT was developed by Water Planning Staff (Roger Wysocki and Darren Boner) in the former Ministry of Environment, Lands and Parks, as a screening tool for the identification of Fishery Sensitive Stream under the Fish Protection Act. The primary output from WAT Version 1.0 is a hydrograph of mean daily discharge (MDD) with an overlay of in-stream flow requirements (Figure 6). The discharge for each day of the hydrograph represented the 1-day mean discharge. Although these data are not normally distributed, the MDD approximates the ${}_1Q_2$ or $Q_{0.5}$.

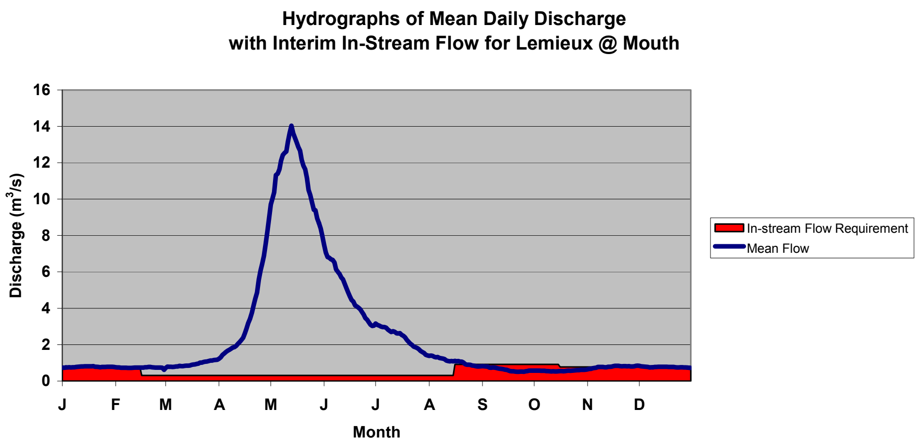

Figure 6

While such information is a useful coarse filter for identifying potential in-stream and off-stream conflicts, the approximated $Q_{0.5}$ is not a suitable return period standard. Other low flow return period hydrographs were needed to refine this screening tool.

In order to address this need, a method for estimating stream discharge at other probabilities was needed. This was resolved using a stochastic procedure based on log-normal distributions, as described in Appendix II. This then enabled stream discharge to be estimated for $Q_{0.75}$, $Q_{0.8}$, $Q_{0.85}$, $Q_{0.9}$, $Q_{0.93}$, and $Q_{0.95}$. Other enhancements to Version 2.0 of WAT included improved graphics that show low flow return period hydrographs versus in-stream flows requirements on an annual and monthly basis. Figure 7 is an update of Figure 6 (a) and is provided for clarity as it shows only the annual mean and $Q_{0.8}$ hydrograph. The $Q_{0.8}$ hydrograph shows a potential in-stream deficit during August, suggesting that a full-term licence (until September 30) may not be possible.

WAT Version 2.0 also provides hydrograph plots in monthly increments for July, August and September. Since Figure 7 indicates potential water shortage during August, the analysis focuses on this period. The August mean and $Q_{0.8}$ hydrographs with interim and final in-stream flow requirements at Upper Lemieux and Lemieux at the mouth are provided in Figures 8, 9, 10 and 11, respectively.

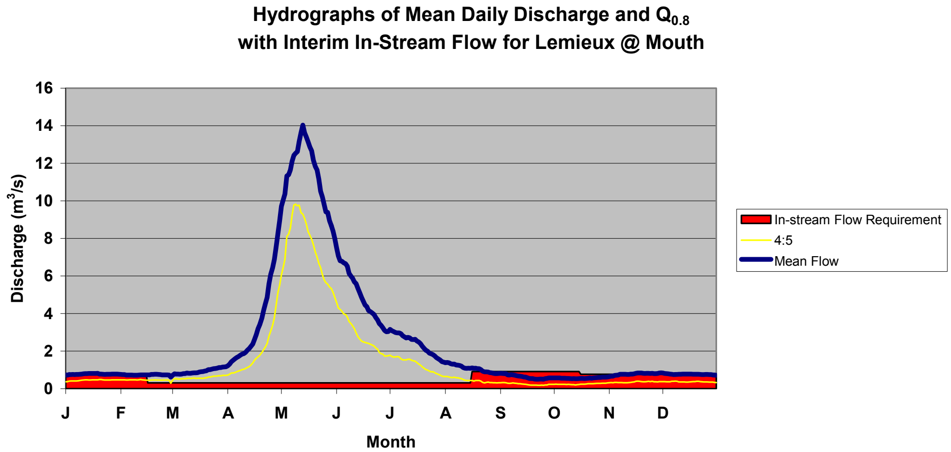

Figure 7

This screening exercise shows that an in-stream deficit is apparent between August 9 and 15 at Upper Lemieux, and August 3 and 15 for Lemieux at the mouth, depending on the criteria used. Since the outstanding water licence applications are for points of diversion between Upper Lemieux and Lemieux at the mouth, the analysis will focus on this stretch of Lemieux Creek. This is described in the next section.

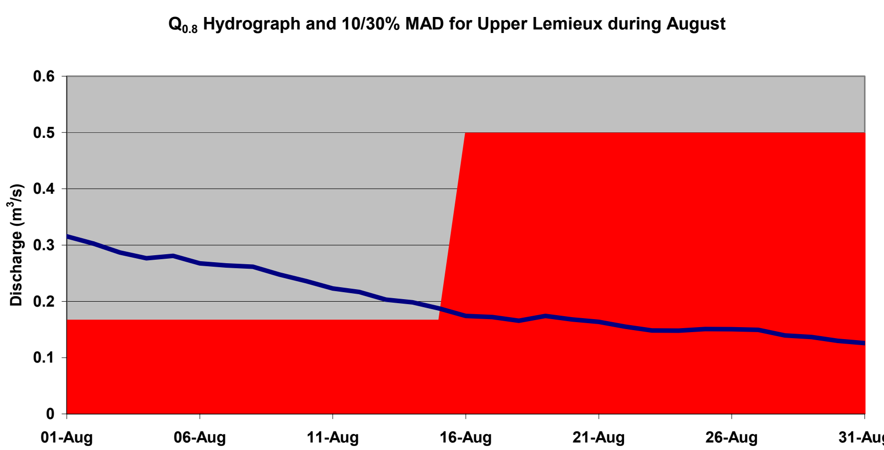

Figure 8

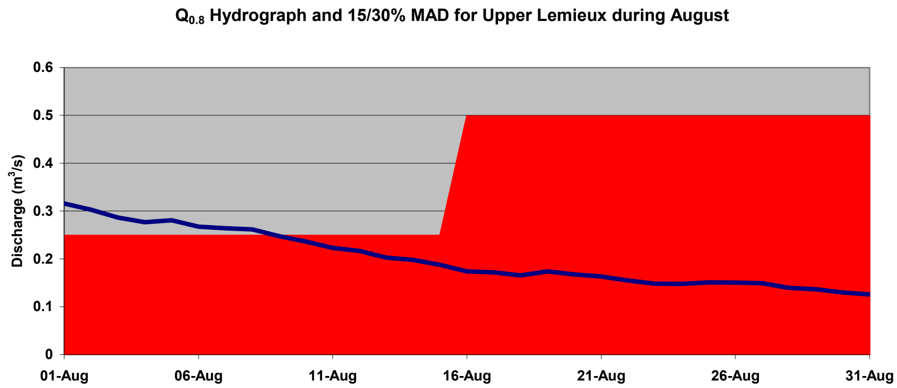

Figure 9

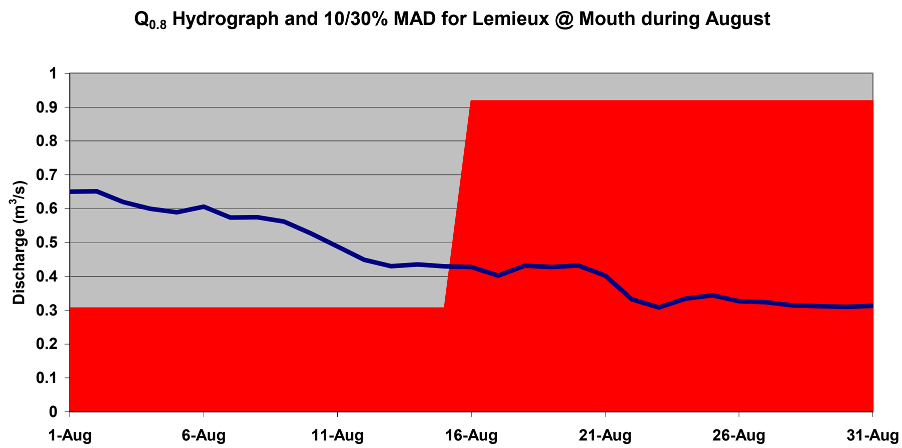

Figure 10

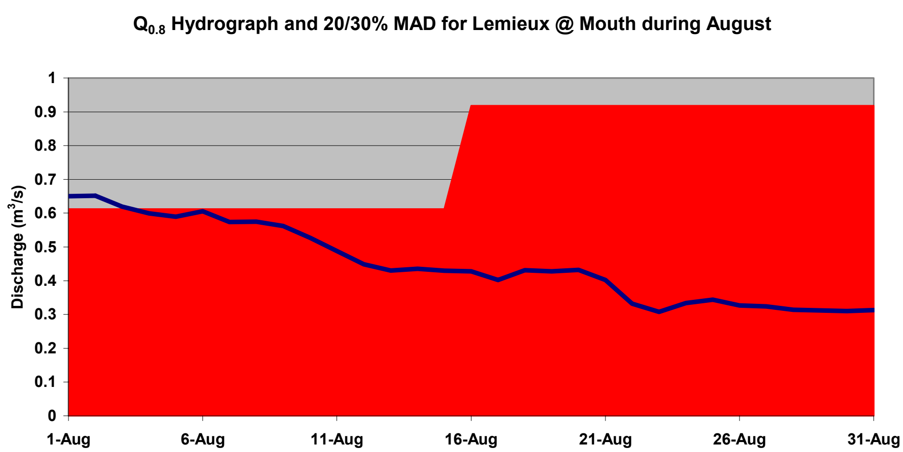

Figure 11

Streamflow Surplus/Deficit – Lemieux @ Mouth

The foregoing screening exercise for Lemieux at the mouth indicates that water shortages may occur during August 1 through 15, so this period was used here. Several distributions were used to estimated $Q_{0.8}$ along with associated 95% upper and lower confidence limits for both one and 7-day analysis periods. Results are summarized below for both the interim and final in-stream flow criteria.

Beginning with 1-day analyses, Figures 12 and 13 are summaries of results using the log-normal probability procedure incorporated into WAT Version 2.0. Note that

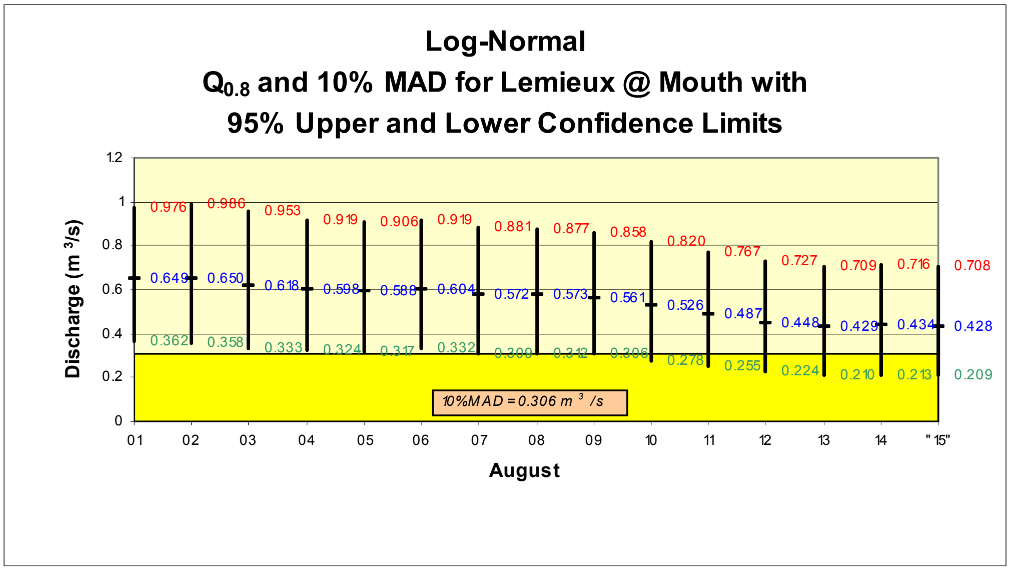

Figure 12

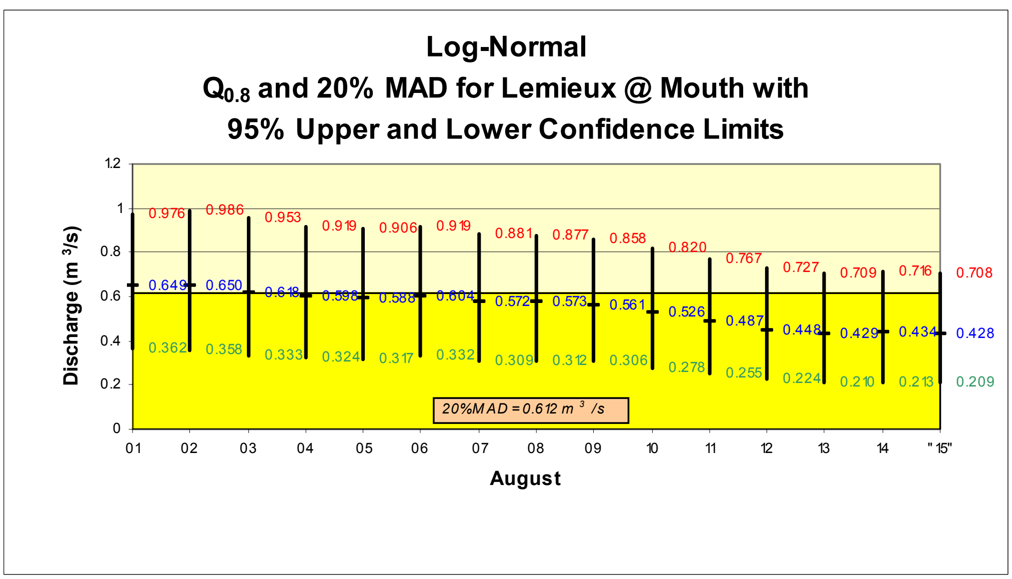

Figure 13

Goodness of fit testing for the distribution on each date confirmed that the log-normal transform of the data are normally distributed. Refer to Appendix II for details on goodness of fit testing. Confidence limits for the log-normal distribution were obtained from U.S. Forest Service FPL Statistics Unit website:

http://www1.fpl.fs.fed.us/webpr.html

The same data were analysed using the four distributions available through the Ministry's FFAME utility. Ninety five percent upper and lower confidence limits are provided with FFAME output. Based on inspection of the cumulative probability plots and the Kolmogorov-Smirnov Statistic, only the 3-Parameter Log-normal and the Log Pearson Type III distributions were acceptable. The results for these two distributions are summarized in Figures 14 and 15.

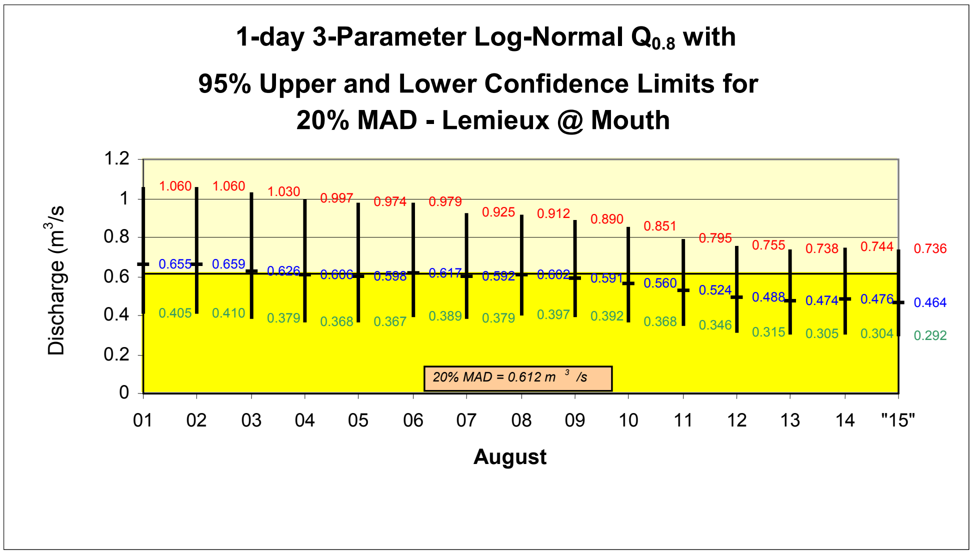

Figure 14

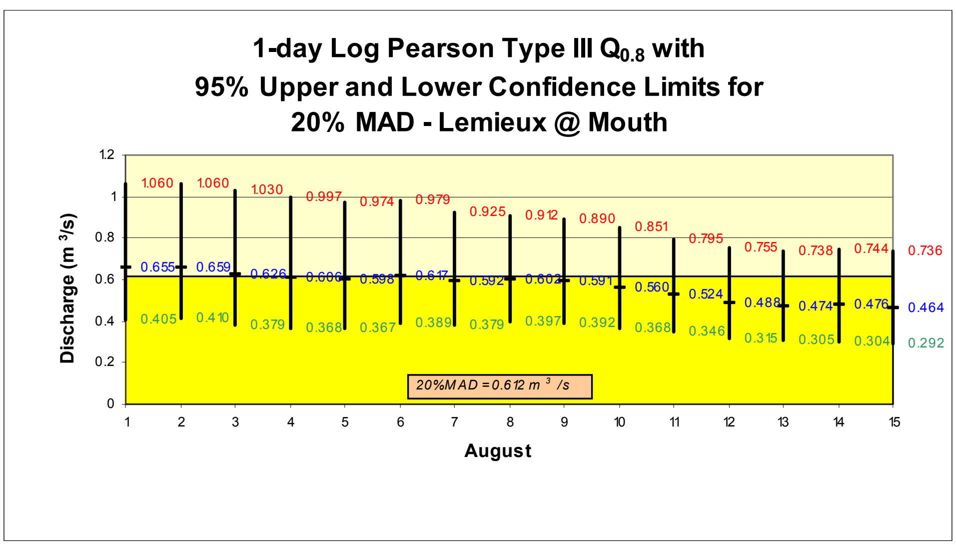

Figure 15

The $Q_{0.8}$ and the 95% upper and lower confidence limits for the Log-Normal, 3-Parameter Log-normal and the Log Pearson Type III distributions are in good agreement. It is recommended that the more rigorous and widely used 3-Parameter Log-normal and the

Log Pearson Type III distributions be used in the licensing decision. However, the Log-Normal distribution is useful for screening purposes within WAT Version 2.0, provided goodness of fit testing confirms the distributions are normally distributed.

Recognizing that the cut-off date for an irrigation licence is likely to be considered in 1-week increments, it is more practical to present the results on a 7-day basis. Therefore, FFAME analyses were also done using the conventional 7-day average for the periods July 29 to August 4, August 5 to August 11 and August 12 to 18. FFAME selects the median date for each period, which is August 1, 8 and 15. The results for the 3-Parameter Log-normal and the Log Pearson Type III distributions are included in Figures 16 and 17.

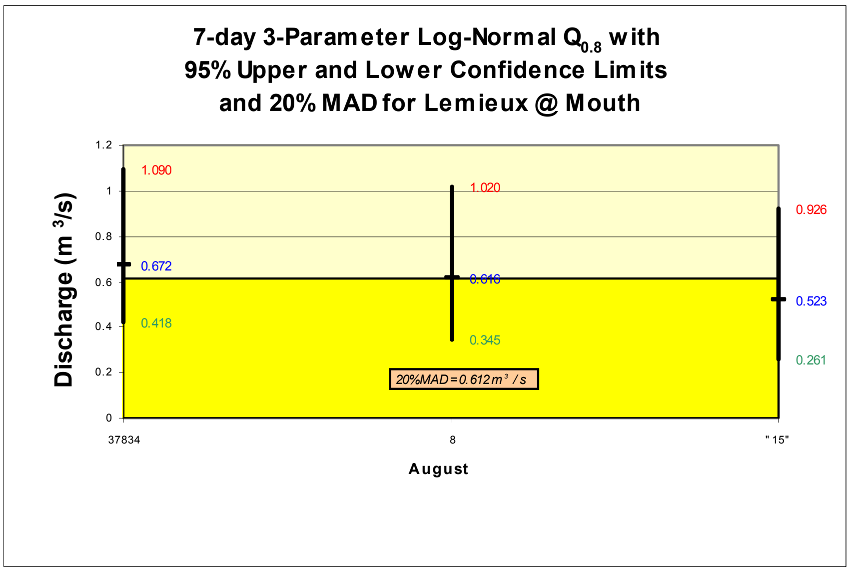

Figure 16

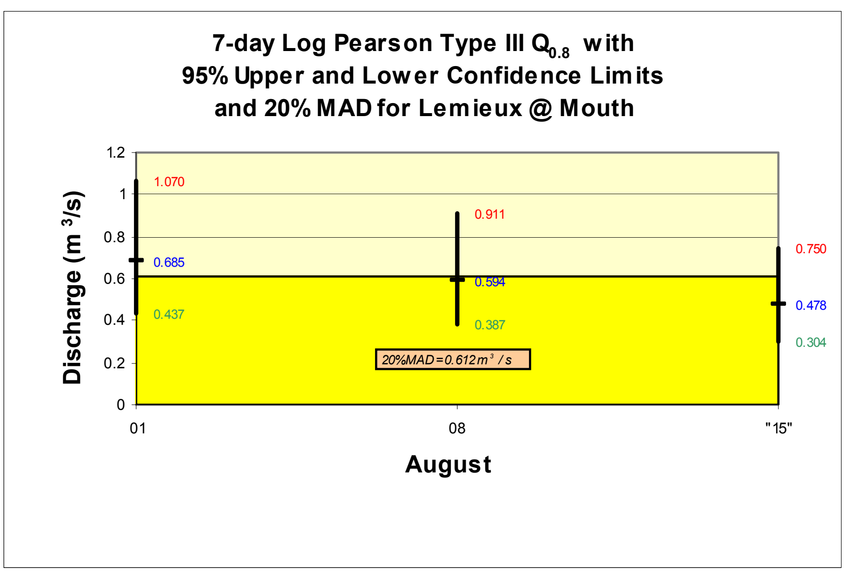

Figure 17

The magnitude of the range in the confidence limits is rather large because there are only 11 data points (years of data) for the Upper Lemieux WSC Station and 18 to 20 for Lemieux at the mouth. Additional years of hydrometric data would reduce the range in the confidence limits. The range in the confidence limits is less for the Log Pearson Type III distribution. Because the Kolmogorov-Smirnov statistic for the Parameter Log-normal and the Log Pearson Type III distributions (and the cumulative probability plots) are similar, it was decided to average the results from these two distributions. This is done in the next section. The $Q_{0.8}$ average discharge is therefore 0.605 m^3/s on August 8^{th}.

This information may be used in conjunction with the total licensed demand in Section 6 to gauge the relative magnitude of the $Q_{0.8}$ discharge versus total licensed demand. Using the figure 0.2024 m^3/s for total demand at the mouth and the above $Q_{0.8}$ value of 0.605 m^3/s, the total licensed demand represents about 25% of these combined streamflows components. On this basis, the existing licensed demand is a relatively high percentage of combined streamflow components. However, this information should not be used without a full understanding of the assumptions used and basis from which each figure is derived. In other words, they are not an "apples versus apples" comparison.

Distribution of Surpluses/Deficits by Zone

The watershed was delineated into four zones. Details of this delineation are provided in Appendix III.

Estimated in-stream surpluses/deficits for both interim and final in-stream flow criteria were incorporated into an Excel Workbook. FFAME 7-day low flow averages with median dates of August 1, 8 and 15 were run for Upper Lemieux and Lemieux at the mouth. The $Q_{0.8}$ results for the 3-Parameter Log-normal and the Log Pearson Type III distributions are averaged for these two locations and distributed by area ratio to Upper Lemieux, Mid-Lemieux, Lower Lemieux and Lemieux @ Mouth zones. This area ratio approach was validated in Section 4.0 (refer to Figure 3 (b)), where it is shown that the unit runoff ratio (scaling factor) for Upper Lemieux and Lemieux at the Mouth is approximately 1.0 during August.

The results are summarized in Figures 18 and 19. Using Criteria (a), it can be seen that 0.372 m^3/s of in-stream surplus for Lemieux @ Mouth is estimated on August 1^{st} and decreases to 0.194 m^3/s by August 15^{th}. When criteria (d) and (e) are used, a small in-stream surplus of 0.066 m^3/s on August 1^{st} becomes an in-stream deficit of 0.112 m^3/s by August 15^{th}.

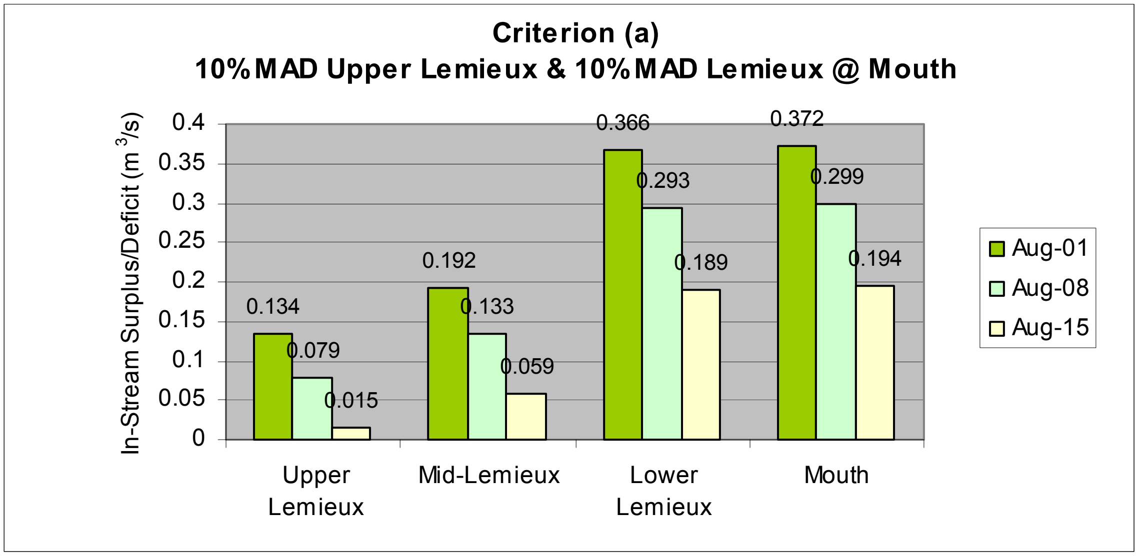

Figure 18

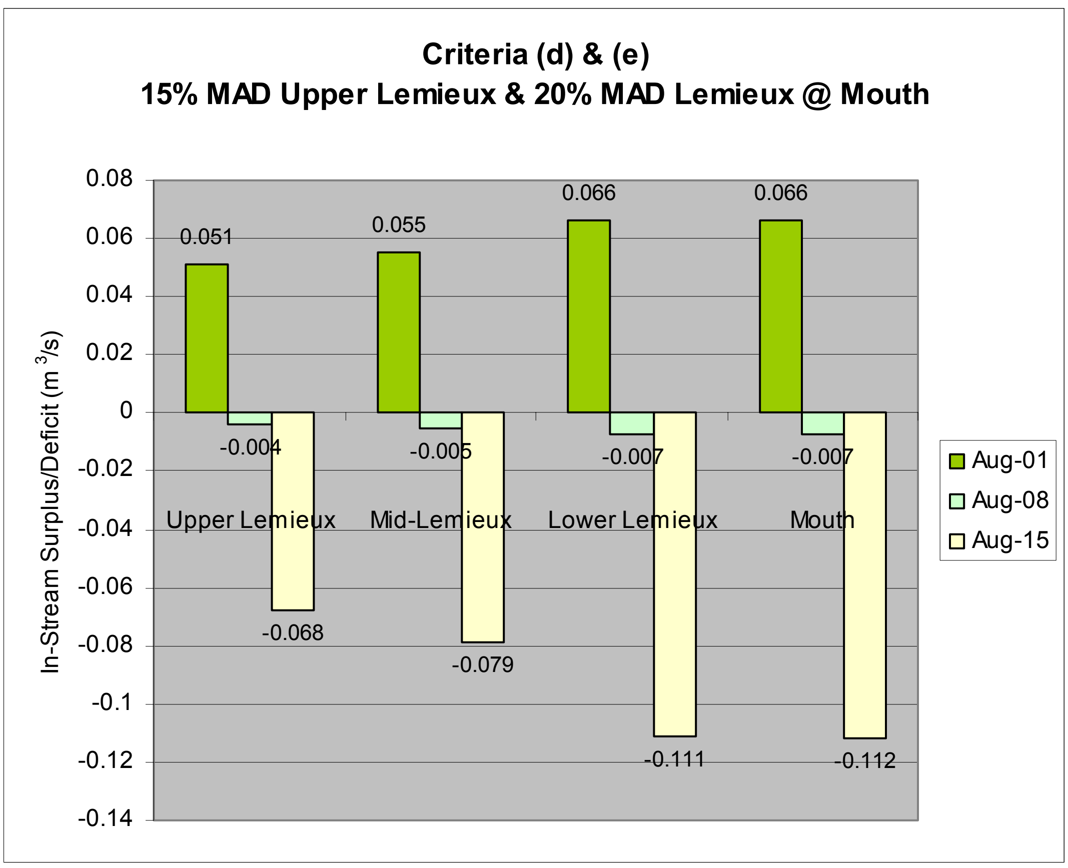

Figure 19

10

SUSTAINABLE GROUNDWATER MANAGEMENT IN AREAS WITH CHRONIC WATER SHORTAGE

Des Anderson and Mike Wei

Introduction

A comprehensive study of the water resource in an area, such as the Lemieux Creek watershed, should include the groundwater component. Groundwater discharge to streams is very important as it sustains baseflow and can also moderate stream temperatures. Both can be essential for the survival of fish populations during late summer period in the Southern Interior of BC.

It was not possible to properly integrate groundwater into this study due a lack of data on the groundwater resource and its interaction with surface water. Since this can be a common problem in British Columbia, especially in the semi-arid region of the southern interior, it was decided to deal with groundwater management issues within this report. This begins with an estimate of groundwater usage in the Lemieux Creek watershed, so as to demonstrate the relative importance of groundwater in this watershed. This is followed by a review of regulations and assessments for proving sustainable groundwater yield prior to approval of groundwater projects. This is done to show the limited application of such processes. Finally, solutions are proposed for improved surface water and groundwater management in BC's water-short areas, including Lemieux Creek.

Groundwater Extraction Estimate for Lemieux Creek

A survey to ascertain water well withdrawals in the watershed was beyond the scope for this study. Consequently, groundwater withdrawals were estimated from the yield data in Section 5, Table 1. Total groundwater extraction was estimated at 44,900 gpd. This is equivalent to approximately 66.3 ac-ft per year, or about 1.5 percent of total licensed water use in the Lemieux Creek watershed.

This estimate assumes that all the wells listed in Section 5, Table 1 of the report under "Unknown Use" are domestic use. A total of 25 domestic wells are assumed (the dry well is excluded). The average production rate for the domestic wells was assumed to be 500 gpd (quantity used for domestic water licensing of surface water), while the two commercial wells are assumed to have an average rate of production equal to 50 percent of their estimated yield. On this basis, annual groundwater extraction for domestic and commercial use (66.3 ac-ft per year) exceeds licensed annual surface water use for domestic and enterprise purposes (26.2 ac-ft per year) as listed in Section 6 of this report.

The foregoing suggests that groundwater extraction within the Lemieux Creek watershed may not represent a significant percentage of the total consumptive demand. This analysis may be conservative, as it only includes wells registered in the Ministry of

Water, Land and Air Protection's WELL database. Since submission of water well records for new well is not mandatory, there may be other water wells in the watershed with significant rates of withdrawal.

Irrigation from Groundwater Sources when Water Licenses are Denied

This study confirms that Lemieux Creek streamflow does not meet in-stream flow requirements for coho migration and spawning, thus confirming that this is a water-short stream during late summer. This is expected to result in a declaration of "Fully Allocated" status for Lemieux Creek in the foreseeable future. The co-authors of this report have asked the question, "What can be done to discourage farmers who have been denied a surface water license from further exacerbating stream low flows by drilling an irrigation well near a creek?"

The drilling of wells, including irrigation wells in proximity to fully allocated streams, are not currently licensed in British Columbia; the taking of groundwater from wells is generally not regulated at this time. This can be an issue because groundwater supplies baseflow to streams during low flows periods. The amount of withdrawal of some types of wells is subject to existing regulation but these represent a small number of wells in the Province. The following is a summary of existing requirements for proponents of a proposed groundwater extraction project.

<u>Public Water Utilities</u>
Water purveyors are regulated under the Public Utilities Act and Section 45 of the Utilities Commission Act. Section 45 of the Utilities Commission Act requires a Certificate of Public Convenience and Necessity (CPCN). Whenever a utility proposes to use groundwater extraction as a water source, they must show that the proposed rate of groundwater extraction is sustainable, as a pre-requisite for a CNCP. The document, "Evaluating Long-Term Well Capacity for a Certificate of Public Convenience and Necessity" provides guidelines on well pumping test requirements for proving the sustainable capacity of new wells. This includes guidelines on the monitoring neighbouring wells and streamflows during the well pumping tests to assess the potential impacts on other users.

Note that there is no extraction rate threshold that triggers an evaluation of long-term well capacity for CNCP. The CPCN requirements would not apply to irrigation and industrial wells.

<u>Federal Environmental Assessment</u>

The Canadian Environmental Assessment Act may apply to certain groundwater extraction proposals where the rate of groundwater extraction is greater than 200,000 cubic metres per year or to modifications that increase production capacity by more than 35%.

The Federal EA triggering threshold is equivalent to 6.3 litres per second or 120,500 Imperial Gallons per day or 0.444 ac-ft per day. Since federal funding is a pre-requisite for a Federal EA, this would exclude the vast majority of industrial and irrigation wells in BC.

Provincial Environmental Assessment

The British Columbia Environmental Assessment Act requires that certain types of groundwater project proposals undergo an environmental assessment and the proponent must obtain an environmental assessment certificate before proceeding with the project.

The environmental assessment process identifies and assesses the potential effects that may result from a proposed project, and considers measures to minimize or avoid adverse effects. The scope, procedures and methods for each assessment are tailored to the circumstances of the proposed project. Projects are reviewable at two levels of development. These are:

> New Facilities
>
> The development of a new facility is reviewable if it consists of one or more wells, operated either periodically or continuously for one year or more, designed to be operated to extract groundwater at the rate of 75 litres or more per second.
>
> Modification to an Existing Facility
>
> Where an existing facility is designed to extract groundwater at a rate of 75 litres or more per second, modifications to the facility are reviewable if the modifications will increase the rate of extraction by 35% or by 75 litres per second or more.
>
> Where an existing facility is designed to extract groundwater at a rate of less than 75 litres per second, modifications to the facility are reviewable if the modifications will increase the rate of extraction by 35% and result in an extraction rate for the facility of 75 litres per second or more.

The Provincial EA triggering threshold of 75 litres per second is equivalent to 1,425,000 Imperial Gallons per day or 5.25 ac-ft per day. This high threshold exempts the vast majority of proposed high production rate water wells from Provincial EA review. For example, if 100 ac-ft is required at a duty of 2.5 feet with 24 hour irrigation for 120 days out of a 180 day period, a water well producing at about 12 litres per second would be required. This example would apply to a 40 acre crop. The cumulative effect of several irrigation and/or industrial water wells with production rates of this magnitude and screened in the same aquifer could have a significant effect on stream baseflow. This could be particularly true if the aquifer has good hydraulic connection to a stream with chronic low flow problems.

Much of the EA information above may be found at the website listed below.

> http://wlapwww.gov.bc.ca/wat/gws/gws_eao.html

Potential Solutions

The foregoing EA processes are problematic for adequate water conservation management in water-short areas in BC because:

(a) the triggering threshold may be is too high in many situations, and
(b) in most situations they do not apply to irrigation, factory farm or industrial wells.

Solutions to address these issues could include:

- Characterizing aquifer and the inter-relationship between surface water and groundwater may allow coupled numerical models to be developed to assess how groundwater withdrawal might affect stream flow in specific watersheds. Part of the characterization may involve monitoring water levels. The other aspect may be to conduct a well survey to capture all wells in the watershed. A good example of this approach may be found at this website:

http://www.waterloohydrogeologic.com/consulting/project pdfs/CVC Water Budget 2003.pdf

- Under the new Water Act, WLAP can work with LWBC on these issues to identify potential regulatory tools for regulating groundwater extraction in a critical watershed (e.g., designate watershed to develop a Water Management Plan, establish minimum standards for well testing, licensing and drilling authorizations in designated area).

- Raising awareness with residents as well as LWBC that groundwater and surface water are connected. Encourage more efficient use of irrigation amongst the residents.

- LWBC could consider groundwater in adjudicating surface water license applications. This would be a more rigorous form of water budgeting and would have two components. The first being an estimate of the cumulative effect of groundwater withdrawals from all existing water wells upstream from the proposed point of diversion on stream baseflow. This amount would be factored into existing demand side of the licensing decision. Secondly, if LWBC begin licensing new water wells, each production rate increment would be added to the cumulative demand.

Something to consider.

(i) Establish a registry of designated areas with known water shortage and groundwater/surface water conflicts in BC.
(ii) Establish requirement for all proposed wells (including irrigation wells) above an appropriate threshold for the designated area to be subject to review for

sustainable yield and for any new wells to require a permit to drill – this could be based on proximity zones with a reducing threshold with reduced distance from existing high production wells or surface water body.

(iii) In the designated area, apply standard procedures for proving sustainable groundwater extraction, such as the guidelines for Evaluating Long-Term Well Capacity for a Certificate of Public Convenience and Necessity, to adjudicate reviewable well proposals. This should include an assessment of groundwater/surface water interaction where appropriate to protect in-stream values (see below for more details).

(iv) Set a maximum production rate for wells.

(v) Require metering and reporting of groundwater production as a condition of the drilling permit or license.

(vi) Require monitoring of well draw-down and/or streamflow as appropriate where appropriate to mitigate impacts.

(vii) Integrate surface and groundwater management under a single provincial agency.

In parallel with the above measures, an effective public education program is needed to ensure that water users are aware of the measures needed and benefits of water conservation for sustaining all the declared values of a designated area.

Groundwater / Surface Water Interaction

The degree to which groundwater extraction from the Little Fort aquifer impacts stream low flows in Lemieux Creek has not been quantified. Surface water and groundwater interaction can be difficult to quantify. This creates uncertainty about the magnitude of the interaction and hinders the development of suitable management strategies. A comprehensive set of guidelines and assessment methodologies on groundwater extraction effects on streamflow have been done in New Zealand. Details of this work may be found at:

http://www.ecan.govt.nz/plans-reports/groundwater/contents.html

Conclusions

Groundwater from wells is not licensed at this time in BC. This lack of a groundwater allocation regime means that most water wells can be developed without an assessment of potential impacts to other water users. This has been identified as a potentially significant issue in the study. It will be important to address this problem for water-short areas in BC through watershed specific studies on the interaction between surface water and groundwater, enactment of appropriate regulation and action, and public education as suggested in this section. It is recommended that water well drilling permits be required in designated water-short areas and the triggering threshold for proposal review be set at an appropriate level for each designated area. The issuance of a groundwater license would be contingent upon the results of pumping test results showing that the proposed rate of production is sustainable and will not adversely affect existing water users or stream baseflows.

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DISCUSSION

Des Anderson and Al Caverly

This analyses show that a surplus exists on August 15th at all nodes based on the interim criteria (a), whereas there is a slight in-stream deficit at each node by August 8th using the criteria (d) and (e). When criteria (d) and (e) are applied to August 15th data, an in-stream deficit occurs at all nodes, with 0.112 m^3/s estimated for Lemieux at the mouth. It is also apparent that streamflows fail to satisfy aquatic requirements during the late summer, fall and winter, based on the criteria used. This finding supports to need for additional storage, as proposed under the water conservation license applications on Taweel Lake.

The foregoing $Q_{0.8}$ in-stream surpluses/deficits are estimates based on statistical techniques and limited hydrometric data. This lack of data has resulted in relatively wide confidence intervals (refer to Figures 12 through 17). The following is a summary of the salient points regarding confidence limits:

- Confidence limits are the end-points of the confidence interval,
- The confidence interval is the likely range of the true value,
- There is only one true value, and
- The 95% upper and lower confidence limits define the range over which the true value is most likely to be, 19 times out of twenty.

Clearly, the Statutory Decision-maker should be aware of the likely range of the true value of $Q_{0.8}$ when adjudicating water licenses. Consequently, decision-makers should be aware that the surpluses/deficits identified in this study are simply estimates, based on statistical analyses of limited hydrometric data. The foregoing discussion on confidence limits demonstrates the importance of long-term hydrometric records from strategic locations in priority watersheds, so as to decrease the range of confidence limits. It will be important to maintain and, where possible, expand the hydrometric network in British Columbia such that adequate data exists in high priority areas for defensible water resources management and decision-making. Ideally, these stations should be nested so as to permit the partitioning of streamflow by stream reach.

The proposed in-stream flow requirement does not accommodate all the important species in the Lemieux Creek watershed. Fluvial and/or adfluvial rainbow trout are present in Lemieux (ref. FISS database) in the spring and juveniles of different ages are present in the fall. Eggs are incubating anytime from mid-April to mid-July as shown in the Fish Periodicity table (Table 3, Section 8). The proposed in-stream requirement does not capture a natural flow regime that allows rainbow migration and spawning (although it makes some provision for rearing). An examination of the mid-July to mid-August period may be necessary to protect alevins and young fry. Managers should replicate the natural hydrograph shape and timing, if not magnitude for rainbow trout and to retain natural stream processes. Any plan to construct storage in the watershed has the potential to alter run-off timing and magnitude. A flushing flow in the spring of a magnitude several times MAD is required to remove fine sediments and improve survival of both salmon and trout eggs.

It should be noted that raw WSC data was used in WAT Version 2.0, as described in this section and Appendix II. Since the raw data excludes the volumes of water extracted for off-stream use during the period of record, these streamflow data are not truly natural. The degree to which this approach violates the principles of randomness and independence in statistical analyses has not been established. However, the log-normal distribution of these data did satisfy tests for normality, as described in Appendix II. This may be due, in part, to the fact that off-stream withdrawals are believed to be a small percentage of total streamflow. If this screening technique is used for other water availability studies, professionals will need to decide whether to "naturalize" streamflow in order to satisfy these statistical principals. In any case, confirmation of normality of the distributions should always be confirmed. It is likely that this screening tool will have limited application in watersheds with significant stream regulation (dams, and/or high percentage of off-stream withdrawals).

Consideration should be given to updating this study whenever sufficient additional hydrometric data are available. An additional 10-years of hydrometric data from WSC Station 08LB078 is suggested as a suitable trigger for a review. It should be noted that this study is based on data up to and including 1998 for WSC Station 08LB078.

The techniques used in this study could be streamlined for subsequent water availability studies. It is suggested that WAT 2.0 be used to identify the date when there is a zero in-stream surplus. 7-day FFAME analyses can then be used to estimate stream flow at the desired return period for this date, plus and minus 3 days.

Other potential uses for WAT include the sizing and release schedules for new storage facilities to meet in-stream flow requirements and consumptive requirements. For example, WAT could be use to design storage and release schedules for the pending water conservation license application for Taweel Lake.

WAT Version 2.0 is a powerful visual screening tool that can be used to present water management options to agency staff and stakeholders. However, it is somewhat cumbersome in its present form. Further upgrading of WAT is warranted, but this should not occur until agency staff test it further and develop a list of priority enhancements.

On the basis of information in Appendix IV, it would appear that the spawning channel adjacent to Lemieux Creek near Km 7 contributes to dewatering of this creek reach. This is hardly a surprise, since presumably, this channel was excavated lower than the adjacent creek so as to access groundwater and maintain stream flow for longer periods during drought years. If there are doubts about the merits of the spawning channel, additional investigation and assessment of this channel (and perhaps the irrigation dugout in the vicinity) may be required to confirm any fish habitat benefits versus impacts on low flows within this stream reach.

If parts of the Lemieux Creek are designated “Fully Recorded”, it will be important to ensure that additional water extraction from these parts of the watershed do not come from groundwater that is connected hydraulically to those fully recorded reaches of the creek. If the changes proposed in Section 10 are not adopted, possible strategies to reduce the potential for baseflow depletion could include:

- Formation of a local watershed stewardship group for the management of both groundwater and surface water resources.
- Development of an awareness program on linkages between groundwater, stream flow and fish habitat.
- Discourage the development of high rate pumping wells unless evaluation proves that these will not exacerbate low flows in Lemieux Creek.

If funding and resources permit, a study of the Little Fort Aquifer could be done. This could involve a field survey to locate (GPS) and identify every well in the watershed, estimate their withdrawals, and where possible, measuring the well static water level elevation. The establishment of an observation well in the Little Fort aquifer would provide groundwater level trends over the long-term.

An overview of preliminary results from this study was presented to the Lemieux Creek Watershed stakeholders at a public meeting held on January 10, 2002 at the Little Fort Community Hall.

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RECOMMENDATIONS

Compiled after Consultation with LWBC, WLAP, MSRM, MAFF and DFO Staff.

Lemieux Creek Recommendations by Agency/Group:

Land and Water BC

1. The pending irrigation water license applications should have a cut-off date between August 1st and August 15th, depending on the in-stream flow criteria used (criteria selection is at the discretion of the Statutory Decision-maker at LWBC).

2. No further off-stream licences should be issued for the period August 1 to March 31 without full backup storage (the exception being domestic purposes for 500 gpd issued to an additional 35 households).

3. All storage licences (existing and new) should limit diversion to storage to the period April 1 to June 15.

4. The amount of storage licenced or special clauses on storage licences should take account of flows. Managers should replicate the natural hydrograph shape and timing, if not the historical magnitude for rainbow trout life history stages and to retain natural stream processes. A flushing flow in the spring of a magnitude several times MAD is required to remove fine sediments and improve survival of both salmon and trout eggs.

5. If feasible, any storage licence to be issued should partially back by existing irrigation licences for the period August 1 to September 30.

6. No inter-watershed diversions or new inter-sub-basin diversions are to be authorized.

7. Update this report whenever sufficient additional hydrometric data are available. An additional 10-years of hydrometric data from the existing WSC Station (08LB078) should trigger a review of this report.

8. The South East Kelowna Irrigation District implemented a water metering for program for its agricultural users in 1994 and 1995. This is reported to have been a very effective means of conserving and sharing a scarce resource. LWBC should consider establishing a volunteer program for the Lemieux Creek watershed where farmers meter and report actual monthly irrigation use (surface water and/or groundwater).

Ministry of Water, Land and Air Protection – Environmental Stewardship Division (subject to funding and resources)

9. Consider proceeding with the conservation water license applications for storage on Taweel Lake – developing a preferred hydrograph for spring and early summer.

10. Develop a mitigation plan to address fish access problems at the mouth of Lemieux during periods of low flow, and evaluate rainbow trout spawning and migration streamflow requirements.

11. Initiate a streamflow monitor program for critical reaches on Lemieux Creek during drought periods, and liaise with LWBC for shut-down of irrigation operations whenever flow depth reach critical values.

Ministry of Water, Land and Air Protection – Environmental Protection Division (subject to funding and resources)

12. Conduct a field reconnaissance to determine the extent of active water well usage and identify additional wells within the Lemieux Creek watershed that are not currently in the WELL database. Incorporate additional water well data into the WELL database. If appropriate, use new well information enhancement of the existing Little Fort aquifer boundary and possibly classification of other aquifers not presently mapped or classified in the watershed (e.g., the underlying bedrock aquifer).

13. Consider establishing an observation well in the Little Fort aquifer to monitor the long-term groundwater level trend.

Ministry of Agriculture, Food and Fishery Division (subject to funding and resources)

14. Encourage MAFF to consider:

    a. developing and implementing water-use plans for farms to maximize water efficiency, and
    b. implementing a program for farmers to adopt water conservation practices where ever possible.

Lemieux Creek Stewardship Group

15. Form a watershed stewardship group for voluntary management of both groundwater and surface water resources. Activities could include:

a. Development of an awareness program on linkages between groundwater, streamflow and fish habitat and distributed to the community.
b. Discourage the development of high rate pumping wells unless evaluation proves that these will not exacerbate low flows in Lemieux Creek.

Recommendations for Future Water Availability Studies:

16. Future Water Availability studies may be completed using a streamlined version of the steps in this report. There are a couple of important prerequisites that must be dealt with prior to proceeding with study. First, ensure that adequate hydrometric data exists for the area of interest. Second, ascertain if the hydrometric data is sufficiently "natural" or can be "naturalized" in a defensible manner so as to allow its use in WAT (see comments at the end of recommendation 16). The essential steps are:

a. Form a steering committee of agency staff.
b. Identify and document the key water-use and aquatic requirement issues, and the initial position of the respective agencies on applications for water licenses. The timing of critical streamflows and locations of stream reaches where impacts are known or suspected should be well documented.
c. Clearly define objectives, roles, responsibilities and timeframes.
d. Hydrologist/fish biologist conducts joint field reconnaissance to define reaches and control stream cross-sections for the study.
e. Complete hydraulic and fish habitat assessments, as described in Appendix IV. This must be conducted during a period of stream low flows when the target fish species are present. Propose in-stream flow requirements, based on these assessments and provincially recognized flow guidelines.
f. Refine fish periodicity chart.
g. Propose return periods necessary to sustain aquatic habit and fish populations.
h. Conduct preliminary screening runs using WAT Version 2.0 for the initial in-stream flow criteria. Compile outputs (similar to Figures 7 to 11 in this report) for a steering committee meeting showing periods of estimated streamflow surplus and/or deficit.
i. Hold steering committee meeting to agree on and document the in-stream flow criteria to be used and the period over which FFAME analyse is to be conducted.
j. Conduct FFAME analyses and prepare draft results (similar to Figures 16 to 19 in this report) for review by the steering committee
k. Hold steering committee meeting to review the FFAME results agree the recommended water availability option.
l. Draft the report and submit to the steering committee for review/comment.
m. Finalize the report and submit to LWBC statutory decision-maker.

Realistically, the entire process may take up to one year to complete. It is suggested that planning should commence during the spring or early summer, followed by field reconnaissance and field verification during the late summer (coinciding with the stream low flow period and critical aquatic life-cycle). Analysis, report writing and agency approval review meetings would follow during the fall or winter.

WAT should be used only as a screening tool, whereas the Ministry's flood frequency analysis utility (FFAME) should be used to quantify potential streamflow surpluses for water licensing decision. Note that WAT may have limited application where there is insufficient hydrometric record, and/or uncertainty about the timing and volumes of water withdrawn that prevents the naturalization of the hydrometric record in a statistically defensible manner.

17. If MAD is used as the initial basis for assigning in-stream flows requirements for aquatic habitat, the method for calculating MAD should be standardized.

18. In-stream flow assignments should be field verified using a suitable method (such as described in Section 8 and Appendix IV).

19. The decision to "naturalize" or not to "naturalize" raw streamflow data should be supported by adequate rationale and scaled to the time period when water is extracted. This may apply to MAD determinations and/or streamflow data input to WAT.

20. Since hydrometric data are generally inadequate in watersheds requiring water resource management, improved techniques for watershed scaling and data transposition would increase the utility of the existing hydrometric database.

Recommendations for WAT:

21. WAT Version 2.0 should be made available to staff in all agency staff involved with the setting of in-stream flows for aquatic needs and water licensing decisions. In addition:

    a. Agency staff should receive WAT Version 2.0 training, as it is somewhat cumbersome to use in its present form. Further upgrading is recommended to improve its ease of use and eliminate redundancies. However, this should not occur until agency staff has completed a trial period to document major short-comings and user problems.
    b. A technical expert at a lead agency should be central contact person responsible for version upgrades, WAT distribution and administration. This would ensure that agency staff receives upgrades.

Recommendations for Improved Long-term Water Resource Management in Chronic Water-short Areas:

22. Use the proposed legislation for Water Management Plans (Part 4 of the Water Act) to implement effective water resource management in priority areas. This would include areas with chronic water shortages (drought), water-use conflicts between in-stream needs and multiple off-stream surface water and/or groundwater users. Ideally, this should include coupled groundwater/surface water modeling, as described in Section 10. The focus should be areas where significant socio-economic and/or environmental benefits will be derived from improved water resource management. Suggested steps are:

    a. Develop a scoring matrix and rationale supporting Water Management Area designation, and screen candidate areas for inclusion on a proposed list of Water Management Areas.
    b. Develop a prioritized list of proposed candidate Water Management Areas.
    c. Initiate discussions with all potential stakeholders and agencies within proposed Water Management Areas.
    d. Form a steering committee for the each Area.
    e. Submit highest ranked candidates to the Minister, requesting designation as Water Management Plan Areas. The minister would specify who is responsible for completing the Plan and the timeframe for its completion. The completed Plan would be submitted to the Minster for approval. Minister approval would include conditions for implementation, monitoring and periodic reporting.
    f. Consideration should be given to the establishment of Water Management Area Authorities with powers to:
        - require the metering and monthly reporting of water use for all surface and groundwater use in excess of the domestic limit (500 gpd) (real-time reporting via telemetry may be warranted in some situations),
        - impose fee rates on water usage sufficient to fund the management of the Area,
        - fund monitoring networks (including climate, snowpack, streamflow, and groundwater levels)
        - retain a consultant to complete an Area water balance, 12-month water budget, and monthly water supply forecast based on actual precipitation and storage. This may include the completion of hydrological and hydrogeological assessments, and the modelling of supply and demand.
        - retain a consultant to report annually on water use, compliance with the Water Management Plan, and recommended amendments to the Plan.

23. Groundwater from wells is not licensed at this time in BC. This lack of a groundwater allocation regime means that most water wells can be developed without an assessment of potential impacts to other water users. This has been

identified as a potentially significant issue in the study. It will be important to address this problem for water-short areas in BC through watershed specific studies on the interaction between surface water and groundwater, enactment of appropriate regulation and action, and public education. It is recommended that water well drilling permits be required in designated water-short areas and the triggering threshold for proposal review be set at an appropriate level for each designated area. The issuance of a groundwater license would be contingent upon the results of pumping test results showing that the proposed rate of production is sustainable and will not adversely affect existing water users or stream baseflow.

ACKNOWLEDGEMENTS

Work on this project began prior to restructuring of the Ministry of Sustainable Resource Management and the Ministry of Water, Land and Air Protection, February 2002. The project team that initiated the project was lead by the Water Planning Section – MSRM, lead by Ron Smith (Section Head) and assisted by Ramona Holota (Fish Protection Biologist), Bob Petrie (Water Allocation Planner) and Wayne Weber (Fish Protection Biologist). Des Anderson (Hydrologist – MWLAP) was seconded to assist with hydrologic analysis.

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5. Robert Ianson for allowing access to Lemieux Creek at the study reach,,
6. Des Anderson (MWLAP), Craig Beeson (MWLAP), John Bochard (LWBC), Ramona Holota (MSRM), Bob Petrie (MSRM), Gene Tisdale (DFO contractor), Dean Watts (DFO), and Stacey Yaseniuk (MSRM) for field assessment work,
7. John Bochard (LWBC) for surveying and mapping the study area.
8. Des Anderson (MWLAP), Paul Doyle (MWLAP) and Ron Smith (MWLAP) for conceptual development of the statistical application,
9. Roger Wysocki (MSRM) and Darren Boner (Co-op Student) who developed the Water Allocation Tool (WAT Version 1.0), and to Darren Boner who programmed enhancements into WAT Version 2.0,
10. Public comment received from stakeholders at a public meeting help on January 10, 2002 at the Little Fort Community Hall, and
11. Jeptha Ball (MWLAP), Ron Smith (MSRM) and Chris Steeves (MSRM) for watershed delineation and GIS map preparation.
12. Ramona Holota (MSRM) for making the report cover.

The hydrological, hydrogeological and statistical principles used by the editor in this report were acquired at Montana Tech of the University of Montana. Dr. Richard Appleman, Professor, Environmental Engineering, and Dr. Willis Weight, Professor, Geological Engineering are gratefully acknowledged for their contribution to the advancement of the editor’s knowledge in these fields.

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Bill Hodge	MWLAP – Retired		
Ramona Holota	Former employee MSRM		
Bob Petrie	MSRM – Retired		
Dean Watts	DFO	250-851-4861	WattsD@dfo-mpo.gc.ca
Wayne Weber	Former employee MSRM		
Mike Wei	MWLAP	250-356-5062	Mike.Wei@gems5.gov.bc.ca

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ACRONYMS

ac-ft	Acre-feet
cfs	Cubic Feet per Second
DFO	Department of Fisheries and Oceans
FFAME	Ministry of Water, Land and Air proprietary flood frequency analysis utility
FISS	Fish Inventory Summary System
gpd	Gallons per days
GPS	Global Positioning System
HYDAT	Ministry of Water, Land and Air proprietary hydrometric data server
IFIM	In-stream Flow Incremental Methodology
L/s	Litres per second
LWBC	Land and Water British Columbia
MAD	Mean Annual Discharge
MAFF	Minority of Agriculture, Food and Fisheries
MDD	Mean Daily Discharge
MSRM	Ministry of Sustainable Resource Management
MWLAP	Ministry of Water, Land and Air Protection
m^3/s	Cubic metres per second
SARA	Species at Risk Act (Federal)
WAT	Water Allocation Tool
WSC	Water Survey Canada

Appendix I

Correspondence & Reviewer Comments

Appendix I

CORRESPONDENCE & REVIEWER COMMENTS

From: Chan, Brian WLAP:EX
Sent: January 14, 2002 10:27 AM
To: Petrie, Bob SRM:EX
Cc: Anderson, Des WLAP:EX
Subject: Fisheries Values within the Lemieux Creek Watershed

Importance: High

The Lemieux Creek watershed supports regionally significant wild rainbow trout and bull trout resources. In particular, there are literally hundreds of small lakes within the Nehalliston, Eakin and Lemieux creek systems. The small interconnecting streams provide excellent spawning and rearing habitat that supports the wild rainbow trout populations of the majority of these lakes. There are 8 fishing resorts located within the overall Lemieux Creek watershed. Seven of these resorts have been in business for more than 50 years. They all base their business on providing wilderness and semi-wilderness fishing for wild rainbow trout.

These lakes are also very popular with resident anglers who utilize numerous B.C.F.S. recreation sites for access and primitive camping facilities. Winter ice fishing is also growing in popularity.

Fisheries Branch estimate annual recreational fishing effort within these watersheds to be approx. 25,000 angler days. An angler day is currently valued at $75.00. This effort generates at least 1.8 million dollars/year to the provincial economy.

Please contact me if further information is required.

Government of Canada | Gouvernement du Canada
Fisheries and Oceans | Pêches et Océans
Box 610,
C'earwater, B.C.,
V.E 1N0

1992 June 2

Your File: 3002138

Our File: W2122

Your file Votre référence

Our file Notre référence

MINISTRY OF THE ENVIRONMENT

JUN 05 1992

KAMLOOPS, B.C.

Ministry of Environment
Water Management Branch
1259 Dalhousie Drive
Kamloops, B.C.
V2C 5Z5

Attention: Processing Clerk

Dear Sir/Madam:

Re: Water Licence Application by Joe Pastor, in the vicinity of Lemieux Creek.

The Department of Fisheries and Oceans has reviewed the above noted application. Our Department has concerns with this proposal for the following reasons:
Lemieux Creek is an important spawning and rearing stream for Chinook and Coho salmon. A salmon enhancement project operated jointly by the Dept. of Fisheries and Oceans and the North Thompson Indian Band is presently rebuilding salmon populations in the creek. Due to the high water utilization on Lemieux Creek at this time and considering the low flows that often exist in this system which impede fish passage, the Dept. of Fisheries and Oceans are not in favour of a new licence being issued unless some water storage can be incorporated in the proposal.

Should further consultation be required prior to a final decision on rejecting or amending this proposal, please contact our office in Clearwater at - (Phone - 674-2633).

Thank you for your concern for the fisheries resource.

Yours truly,

Tim Panko

Tim Panko
Fishery Officer

cc: B. Rosenberger, DFO, Kamloops

Canada

Fisheries and Oceans Canada
Pêches et Océans Canada

Pacific Region
Habitat and Enhancement
B.C. Interior – South
985 McGill Place
Kamloops, B.C. V2C 6X6

September 12, 2002

File: 8400-L and 8490-04

Mr. Kevin Dickenson, P.Eng.
A/Regional Manager
Land & Water – B.C. Inc.
3rd Floor, 145 3rd Ave.
Kamloops, B.C. V2C 3M1

Dear Kevin:

Subject: Lemieux Creek – Water Allocation/Management Plan

As you are aware Fisheries & Oceans Canada (DFO) has the legal responsibility, pursuant to the *Fisheries Act*, to protect and conserve fish habitat, a critical element of which is the maintenance of adequate stream flows. At least historically, issuance of water licenses rarely took into account in-stream flow requirements for fish and the maintenance of aquatic ecosystems. As such, many streams in the southern B.C. Interior experience frequent, critical low flow events due to excessive water abstraction, compounded by natural hydrological conditions. Lemiux Creek, specifically, experiences extreme low flows at times.

Over the past year, a member of my technical staff has been working in collaboration with your staff and other provincial agency staff in the development of a provincial water allocation/management plan for Lemieux Creek. It is my understanding that one of the objectives of this plan is incorporate in-stream flow requirements through an agreed upon process and methodology. It is also my understanding that the end product would be science-based, and the primary purpose of the document would be to support a technically defensible decision-making framework for the adjudication of water licence applications.

DFO agreed to assess a number of fisheries flow scenarios as to their applicability to Lemieux Creek. Based upon recent field assessment work conducted during the low flow period, we are now in a position to identify base flows for the summer rearing period (to August 15).

For the upper reach of Lemieux Creek (based on a reference site referred to as X-section #9 in the draft report), the estimated fisheries flow requirement is not less than 0.222 cms (approx. 15% of the mean annual discharge). For the downstream reach, from approximately 3 km upstream of the Hwy #5 bridge downstream to the mouth, 20% of the mean annual discharge (MAD) should be used as the base flow requirement (approx. 0.588 cms as measured at WSC Stn. 08LB078). The flow requirements in terms of

%MAD vary from the upper reach to the lower reach primarily due to differences in channel morphology and associated fish habitats.

The analysis of water availability in the upper reach must take into account the fisheries requirement for that reach, as well as water needed to support the flow requirement of 20% MAD in the downstream reaches (based on a 1 in 5 year drought as agreed). It should be noted that 20% of MAD is consistent with the scientific literature and provincial fisheries "rules" for B.C. streams. It should also be noted that 20% MAD is achieved on average near the mouth at WSC Stn. 08LB078.

The aforementioned flows also apply to the late winter/early spring rearing period. During the salmon migration and spawning period, higher flows are required, as indicated in the draft report.

As a final comment I wish to stress the importance of the fisheries resources of Lemiuex Creek. In addition to chinook salmon and resident species, the system supports an important run of Thompson coho. As you may be aware, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has recently listed Upper Fraser coho, of which Thompson coho are a component, as an endangered species. This underlines the importance of adopting a precautionary approach with respect to all management decisions, including water allocation, that may affect their habitat.

I trust the foregoing comments will be incorporated into your analysis. Given the importance of the proposed plan from a fisheries perspective, I would appreciate the opportunity to review a revised draft before the document is finalized. In any case, we request the opportunity for input to any future licensing decisions.

If you have any questions or concerns with regards to the above, please contact me at (250) 851-4959. Your cooperation in this matter is appreciated.

Sincerely yours,

Gord Kosoakoski
Area Chief, Habitat & Enhancement
B.C. Interior – South

Cc: DFO - Barry Rosenberger, A/Area Director, M. Crowe, D. Watts
B.C. Land & Water Inc. – Jim Yardley, Regional Director
MSRM – Dave Whiting, Ron Smith
WLAP – Monty Downs, Dave Jones, Ian McGregor Des Anderson
MAF – Graham Strachan

From: Caverly, Alan WLAP:EX Sent: Thursday 2004-02-26 13:31

To: Dickenson, Kevin LWBC:EX

Cc: Anderson, Des WLAP:EX; Jones, Dave WLAP:EX; McGregor, Ian WLAP:EX; McFarlane, Bruce WLAP:EX

Subject : Lemieux Creek Report

This short note is a formal request to extend the evaluation period for the report titled “Lemieux Creek Water Availability Study”. Bruce McFarlane and I were asked to complete a limited review of this document only a week or two ago. While a quick overview of specific sections of the report allowed Des to incorporate some of our comments, there are some key issues noted that need further discussion and/or clarification prior to consideration of sign-off or endorsement of the report from WLAP. Yesterday, I learned from John Bouchard of LWBC that the outstanding Water License applications for Lemieux Creek will be held over until the next fiscal year. The major rationale is the pending review of water supply at Lemieux under the "Agriculture Water Supply Expansion Program".

The report is a pilot for a methodology to evaluate and guide resolution of water allocation issues in watersheds with high fisheries values. However, the assumptions in the report are not suited to all streams and all fish species and we do not recommend identical analysis for other watersheds at this time. Specific outstanding concerns are:

- Intended use of the report in water allocation decisions
- The selected return period of one in five years.
- Flow requirements for fish species under provincial management
- Uncertainties around the calculated surplus

In summary, the report is an excellent start and a good test of a new methodology, however, we request an extension to March 26, 2004 to either resolve these concerns or ensure that the report adequately cautions and informs the decision makers about the limitations of the analysis and flow recommendations.

Alan Caverly, R.P. Bio

Bruce McFarlane, P. Eng.

To: Kevin Dickenson, P. Eng.,
A/Service Centre Director
Land & Water BC Inc.

March 17, 2004

From: Ron Smith, P. Eng., Resource Sustainability Officer, Water
Ministry of Sustainable Resource Management

Re: Lemieux Creek Water Availability Study - February 2004

Background

This project endorsed by Kevin Dickenson, Regional Water Manager was initiated by Ron Smith who was involved throughout its development. The Lemieux Creek Water Allocation Plan was to be a practical document with the hope that all parties would accept the recommendations. We approached the challenge in an open and transparent fashion resulting in a collaborative and cooperative attitude among the agency representatives. Agreement on the recommendations had not been reached when numerous staff/organizational changes and other events occurred. Work was further delayed as a process was developed to facilitate completion. The production of this draft done outside of the developed process and without consultation has denied parties the opportunity to continue to work together.

Comments on Lemieux Creek Water Availability Study – February 2004

Significant issues:

The long established downward trend for salmon populations in Lemieux Creek has occurred in spite of the fact that no water licences have been issued since 1967.

There is no data in the September 12, 2002 DFO letter that supports the 20%/30% MAD requirement. It is noted that the 20% in early August is for rearing consideration. Is the author suggesting that anything less would be fatal?

The standard for instream flow was increased from 10 to 20% MAD for Aug 1 to 15 period and from 25 to 30 % for the August 15 to ? period. No data is presented in the report that would support these changes. These standards are suspect if not unrealistic.

The validity of superimposing a % MAD on a 80% probability hydrograph is questionable, for example, Figure 11 shows a required instream flow of 0.918 m^3/sec. This compares to 80% probability of the flow being 0.3. Stopping all diversions will not achieve the standard. This point is easily seen when one compares the standard of 25% MAD with the 80% probability hydrograph for October 31, Figure 10 of the July draft. At this time there is virtually no extraction and yet natural flow is only about 40% of the standard. Figure 10 is not in the latest draft.

There is no information presented comparing proposed instream flow standards to the mean hydrograph. This was shown in Figure 3 of the July draft and should be included as the study should cover the entire year.

There is no recognition of the ability of the SDM to minimize risk to instream values by inclusion of a fish clause on any licence the SDM issues.

The study only touches in Recommendation 10 on the loss of surface flow at the mouth. The *Backgrounder for the Sensitive Stream* designation identified the stream bed losses in this reach and at a point upstream as major issues needing attention. This is an outstanding issue especially if funds are going to be allocated to construct a storage structure in the upper watershed. Will the released water appear in the channel where it is needed?

The recommendations do not reasonably reflect actions required to manage the water resource in the Lemieux Creek watershed.

Other considerations

The report is silent on temperature concerns. The lower reaches for all intent and purposes are devoid of vegetative cover.

The report is silent on economic benefits derived from diverted water; hence it implies no economic disbenefit to shortening the period of irrigation.

The report has little value in helping valley residents limit potential negative consequences of groundwater extraction.

Conclusions

The revised instream standards are not supported by data and are unrealistic.

The revised standards call into question the validity of using a % MAD superimposed on a 80% probability hydrograph.

The report in failing to make a hard recommendation on a cut-off date does not balance the risk posed to economic off stream use against the risk posed to the sustainability of the instream resource.

The recommendations require more work to better reflect financial and human resources of all parties.

From:	McFarlane, Bruce WLAP:EX	Sent:	Friday 2004-03-12 16:43
To:	Bochard, John LWBC:EX		
Cc:	Strachan, Graham AGF:EX; Jones, Dave WLAP:EX; Grant, Nelson T SRM:EX; 'WattsD@dfo-mpo.gc.ca'; McGregor, Ian WLAP:EX; Caverly, Alan WLAP:EX; Dickenson, Kevin LWBC:EX; Anderson, Des WLAP:EX		
Subject :	Lemieux Creek Water Availability Study (Feb 2004 draft)		

March 12, 2004 File No. 76940-01 Lemieux Creek

Dear John Bochard:

Dave Jones asked that I send this to you directly.

I have reviewed the hydrologic part of the subject report, and discussed several aspects with Des Anderson to improve my understanding of his methods, the results, and uncertainty associated with those results. Nevertheless, I am new to this project, and some of my comments are likely made without privilege of prior discussions. The report is rigorous and thorough, demonstrating a high propensity to the science side of decision-making. I understand from Des that the surplus/ deficit approach distinguishes this hydrologic analysis from many other comparative analyses.

The purpose of my review is to quantify risk to aquatic resources in assistance to the statutory decision maker. An extension to the deadline for comments was granted by Land and Water BC, but fundamentals of the methodology could not be reviewed in detail due to the urgency expressed by LWBC and my prior commitments. In this respect, my review is not intended to verify, endorse, or discount the report methodology, which responsibility must rest with the authors. Instead, I have tried to underscore uncertainty, which is intrinsic to the analysis, as it relates to water availability and risk to aquatic resource values.

One of the objectives of the report is to make policy recommendations. The Executive Summary recommends that a streamlined form of the steps in the report should be followed for future water availability studies. Since the report does not compare and contrast existing methodologies for water availability, it does not support a conclusion leading to this recommendation. Underlying the above, my concern that the decision maker understand uncertainties in the context of water availability would be greater if the report methodology were to be extrapolated to other watersheds than if the results are restricted in application to the decision making on Lemieux water allocation.

The surplus/ deficit approach used in the report clearly provides for explicit recognition of uncertainties both in the probability analysis and in expression of confidence limits. While the Q(0.8) addresses risk to crop failure 20% of the time, this same measure does little to address risk to aquatic resources, specifically fish, in that same 20% occurrence. Factors contributing to increased environmental risk then, relate to uncertainty about water that remains in the stream - year to year - after water has been removed for off-stream use. A reasonable approach for explaining how uncertainty relates to environmental risk is to examine water availability in years where flows fall below the requested conservation thresholds. I have chosen to look at the Aug. 8 cutoff scenario as well as deficit situations that occur in July (prior to the 1st cutoff date under consideration). I have not undertaken examination of flow measurements at the upper stations on Lemieux Cr., as these data are limited and relationships of withdrawal to discharge are more difficult to establish.

Examination of actual flows from WSC station 08LB078 lead to three main conclusions:

1. although the return period selected for analysis (4 of 5 year exceedence) may be appropriate for risk associated with irrigation supply, it does not adequately address risk associated with conservation flow thresholds. Unless the stream is completely dry, there is a 20% chance in any given year that water unavailable for irrigation withdrawal will be attained by drawing from conservation flows;

2. the percent withdrawal for off-stream use increases and the percent remainder of in-stream flow decreases as stream discharge decreases. As the severity of drought increases, this effect becomes more pronounced;

3. water deficits in July that are already affected by existing licensing, suggest that new licensing will further stress juvenile fish rearing in Lemieux Cr. in some years, since the earliest cutoff date under the report's consideration for new licensing is Aug. 1.

Flows that fall below conservation thresholds pose a greater risk to fish the lower the flow, the greater the duration, and the more frequent the occurrence (Pers. Com. Al Caverly, MWLAP). Focusing on the Aug 8 scenario, 6 of the 25 years of hydrometric record evidence deficit flows, but some are more dire than others. Using the reported licensed demand of 0.1753 cms at the mouth (p. 20) to naturalize Aug discharge, a careful review of flow records for 08LB078 (Table 1) helps to explain the in-stream/ off-stream relationship. As stream discharge drops below the Q(0.8), off-stream demand can only be sustained by donation of water from in-stream flows that are also needed for fisheries values.

- By default, licensed demand takes precedence over conservation flows (Figure 1). As total discharge decreases, the proportion of total discharge withdrawn increases because the absolute amount withdrawn remains theoretically constant year to year. In comparison, the proportion of total discharge remaining in the stream decreases with decreasing discharge, but the absolute amount of remaining in-stream flow also decreases (Table 1). In 4 of the 25 years, in-stream flows dropped to values below 10% MAD for the Aug 8 scenario, and two drought years (1979, 2003) had flows of 2% MAD, increasing risk to fish.

Table 1. Aug 8, 7-day low flow comparisons for Lemieux Cr. 08LB078.

Year		1978	2002 ‡	1988	1987	1979	2003 ‡
Discharge @ Mouth	(cms)	0.560	0.508	0.254	0.177	0.081	0.079
Naturalized Discharge based on Section 6	(cms)	0.735	0.683	0.429	0.352	0.256	0.254
Existing Licensed Withdrawal	(% of naturalized discharge)	24%	26%	41%	50%	68%	69%
Remainder in Stream after new licensing	(cms)	0.529	0.477	0.223	0.146	0.050	0.048
Remainder in Stream after new licensing	(% of naturalized discharge)	72%	67%	48%	38%	17%	17%
Remainder as % MAD to 2000		17%	15%	7%	5%	2%	2%

‡ Preliminary unapproved WSC data

Although the frequency of deficit flows is less for the July irrigation period, they have occurred in 4 of the 25 years of record and will likely be further impacted by new licensing. Not only will in-stream flows decrease but also will the duration of deficit flows increase. An analysis of water availability for the July period indicates that the onset of deficit flows commences as early as mid-July and the in-stream discharge is well below the 20% MAD rearing flow threshold (Table 2). In

2 of the years, discharge fell below 10% MAD. Increased withdrawal may also increase the frequency of deficit flows during the July period, but this effect has not been explored herein.

Table 2. Pre-Cutoff 7-day low flow comparison

Year		1988	1979	1987	2003 ‡
Date		25-Jul	25-Jul	14-Jul	26-Jul
Jul 31, 7-day ave. low flow	(cms)	0.410	0.342	0.272	0.187
July 31 Deficit with new licensing	(cms)	0.198	0.266	0.336	0.421
% MAD to 2000		13%	11%	9%	6%
Deficit duration with new licensing	(Days)	8	10	19	15
Deficit duration below 10% MAD	(Days)	0	2	10	7

‡ Preliminary unapproved WSC data

There are other factors contributing to uncertainty, but these are more appropriately categorized into measurement precision. At the heart of this issue is error associated with the identified surplus amount (Figure 1). If the Aug 1 scenario is used, the surplus amounts to 0.051 cms, but the relative amount of surplus to Q(0.8) is small by comparison (< 1/10 or 60/600). How much confidence is associated with surplus and deficits is not provided by the report, but the lower 95% confidence interval are much more distant than 20% MAD from Q(0.8).

Several other points relating to accuracy of the identified surplus are as follows:

The meaning of the results of probability analysis is related to the degree that data have been affected by upstream storage and withdrawal. As stated by the report (p. 36), total flow demand at the mouth of Lemieux Cr. comprises about 25% of total flow at Q(0.8). The effect of this much departure from natural flow on estimation of the return period is undetermined, but when the surplus of modified flows is just 10 % (60/600), 25 % seems large by comparison. In addition, this percentage increases as discharge measurements decrease. For example, the relative withdrawal for a 7-day low flow of 0.31 cms (10% MAD) becomes 56% (0.175/ 0.31). Since return periods for low flow are determined by discharge measurements as much or more so below than above the exceedence level, and the effect of stream withdrawals above the gauging station increases with decreasing flow below Q(0.8), the relevance of Q(0.8) becomes less meaningful. Furthermore, application of probability analysis to sample data requires that samples be independent, random, and normally distributed. It could be argued that the latter 2 requirements have been met, but the independence requirement is frustrated by affects from upstream storage and withdrawal that affects summer low flow in a consistent but unquantified way.

There are other influences that affect data precision and, consequently, uncertainty in the available surplus.

Stream-flow measurements

Although the standard for WSC accuracy is +/- 5% for 95% of the time, there are operational limitations to low-flow measurement relating to instrument accuracy, water depth, and stream connectivity to level recorders (Pers. Com. Bob Ellis, Environment Canada). Typically, placement of artificial control structures improves measurement precision, but such a structure does not currently exist for the WSC station, 08LB078.

- The uncertainty associated with actual off-stream use may eclipse all rationale above. Knowledge of actual use would help contextualize uncertainty associated with stochastic drivers of natural stream flow. Typical variations in demand due to summer temperatures and drought severity are certainly contained in the measured stream flow, but are unknown, so only predicted averages can be used to estimate demand. Ignorance of the effect of demand on stream flow over a monthly, weekly, or daily basis emphasizes the need to manage flows conservatively.

- Groundwater influence seems to be a major agent in total water availability in this watershed. How hydrogeology and well withdrawals affect surface hydrology is unquantified, but there is potential for one to affect the other.

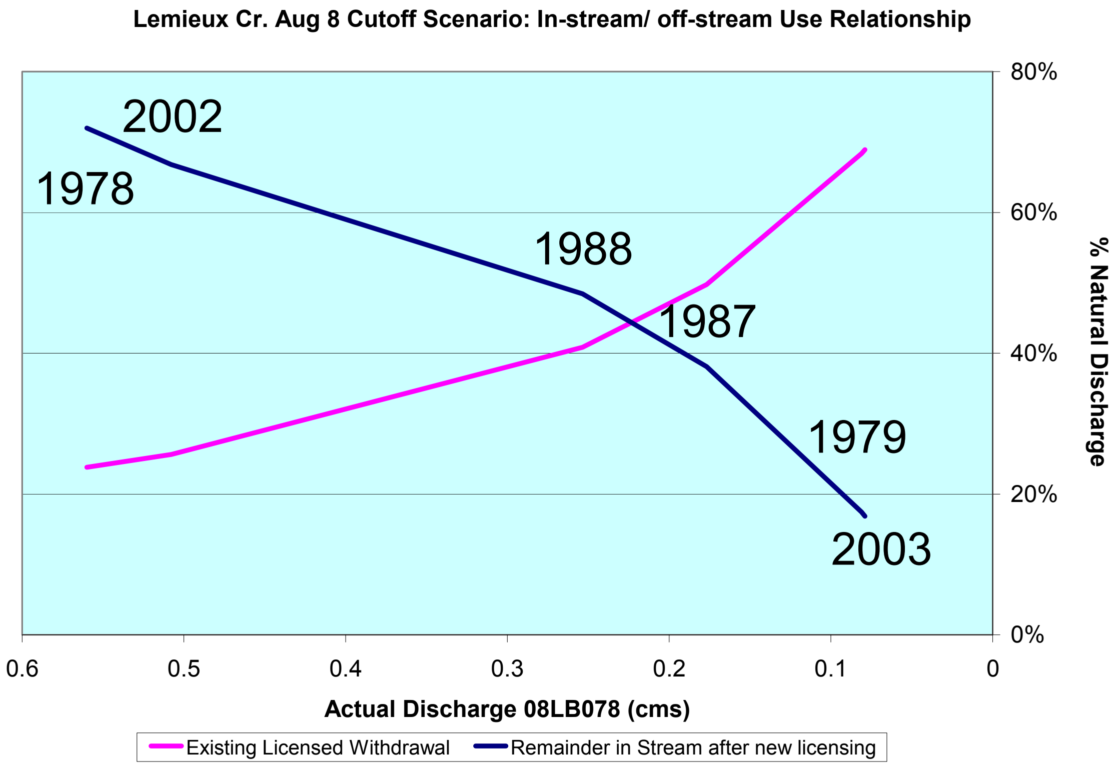
- Climate change predicts that crop demand will increase both because of extended growing season and increased ETP relating to temperature change. What allowance has been made for this change in available surplus? What is the uncertainty associated with future anticipated changes to existing demand, yet alone new demand?

In summary, the low relative amount of surplus (Aug 1 Fig. 19 scenario) offers only a narrow margin of flexibility for error, considering the evidence presented above. If a decision is made in favor of new licensing, there are at least two management actions that could address some of the environmental risk, and should be measured by their provisions for timely response to deficit scenarios. The first has already been mentioned in report recommendations - ie. Install water meters on intakes licensed for off-stream use. The second is to convert the WSC station at the mouth of Lemieux Cr. to a real-time station. There are pros and cons to both options, but the second is more transparent, more socially acceptable, and more results-based (ie. How much water is left in the stream) than the first. A third option is development of more storage, but I have not seen this measure being very effective at reducing conflict over water use in the long term except through water use planning.

This review has been an interesting experience, but I am sure no more so than for all others involved. I would be pleased to follow up this note under letter format if required. Please contact me at 371 -6314 for clarification or further discussion on the above.

Bruce McFarlane, P.Eng., MRM.

Regional Hydrologist, Ecosystems
MWLAP, Thompson Region, Kamloops, BC
Ph. (250) 371 - 6314
e-mail: Bruce.McFarlane@gems3.gov.bc.ca


Lemieux Cr. Aug 8 Cutoff Scenario: In-stream/ off-stream Use Relationship
80%
60%
40%
20%
0%
% Natural Discharge
2002
1978
1988
1987
1979
2003
0.6
0.5
0.4
0.3
0.2
0.1
0
Actual Discharge 08LB078 (cms)
Existing Licensed Withdrawal
Remainder in Stream after new licensing

From: Caverly, Alan WLAP:EX Sent: Wednesday 2004-03-17 17:24

To: Dickenson, Kevin LWBC:EX; Jones, Dave WLAP:EX; Anderson, Des WLAP:EX; McFarlane, Bruce WLAP:EX; Belliveau, Phil WLAP:EX; Bochard, John LWBC:EX; McGregor, Ian WLAP:EX

Cc: Grant, Nelson T SRM:EX; Dean Watts (WattsD@pac.dfo-mpo.gc.ca); Strachan, Graham AGF:EX; McGregor, Ian WLAP:EX

Subject : Lemieux Creek Water Availability

This attachment is a follow-up to Bruce McFarlane's comments on the Lemieux plan. Comment deadline was today. I'm still catching up on all the background for Lemieux so please forgive any minor errors.

Alan Caverly

File: 76940-01
Lemieux Creek

RE: Lemieux Creek Water Availability – A. Caverly Comments

This note is a follow-up response to assist completion of the report "Lemieux Creek Water Availability Study" and provide information to resolve outstanding water licenses on Lemieux Creek. I was not involved in the Lemieux plan development until very recently but I am involved in numerous water use and instream flow issues in southern B.C. Numerous commitments for March, 2004 limit my response. I have only a few points/questions for the Steering Committee:

- In general, the multi-disciplinary approach to evaluation of water supply/deficit and integrated approach to water allocation is progressive and consideration should be given to expanding the methods to other priority watersheds.
- The Lemieux pilot is a potential template to consider for regional application to help resolve difficult water use decisions, however, a provincial scale process is in development for determining instream flow needs and the methodology may differ. The provincial process is subject to extensive, multi-agency peer review so any regional approach to resolve specific stream situations would have to be compatible.
- The March 12,2004 review by B. McFarlane makes it clear that any risk presented by the uncertainties in the analysis and in low flow years falls on the aquatic resource, not off-stream uses. Licensed demand is an estimate of actual use in a given year. In low flow years, demand and unmeasured use exacerbates natural environmental stresses.
- In the introduction, the 1:5 year 7 day low flow practice for analysis states that the last licensee risks being denied water one in five years. Similar to proposed cut-off dates, once a provisional license is granted, will compliance monitoring prevent that water from being extracted? What are the environmental parameters that would trigger this provision in the license, who would collect this data and who would enforce the cut-off provision?
- The instream flow requirement and proposed cut-off dates for licenses are tailored to suit only two species based on “DFO concerns”, based on surveys in Lemieux Creek, however,the fish periodicity chart includes 6 species. The editor has included more on this topic in the Discussion section. It’s probable that Lemieux Creek is water short earlier in the summer, some years and the analysis may not have considered this for outstanding license decisions.
- A final editing note, the first part of the discussion on flow methods on page 25 confuses Tennant, Modified Tennant and IFIM. HSI curves are discussed in the review of the modified Tennant approach. I’m not sure what “off-the-scale” means. HSI curves are a combination of depth, substrate and velocity preferences for different fish species and life history stages and

are a requisite part of an IFIM analysis, but are not part of a desktop Tennant exercise. Tennant does not account for historic natural flows, so initial flow needs for aquatic life should be measured against what flows a system is naturally capable of sustaining. The balance of the discussion on flow setting is appropriate and accurate to my knowledge.

The report makes no assumptions of water use compliance with 1) actual quantity used vs. licensed demand, 2)cut-off dates and 3)effectiveness of any "fish clauses" that might be included in water licenses (no mention of fish clauses in the recommendations). The recommendation for agency liaison during drought is encouraging but totally dependent on adequate monitoring and staffing. The metering recommendation combined with user stewardship is appropriate and given the Kelowna example, quite realistic. A key point is fisheries agencies believe low flows are currently having a significant negative impact on fish habitat and associated fish populations in Lemieux Creek, therefore, further allocation of water may limit the long term sustainability of the fish stocks.

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Appendix II

Coupled Log-Normal Procedure for Estimating Low Flow Probabilities

Appendix II

COUPLED LOG-NORMAL PROCEDURE FOR ESTIMATING IN-STREAM SURPLUSES/DEFICITS

Des Anderson

A means of estimating low flow probabilities was needed to assess the availability of water for off-stream use. This was required as an enhancement to an existing screening tool (WAT Version 1.0) developed by staff of the former Planning Section in Water Management, Minister of Environment, Lands and Parks. Since there are established probability procedures using the Normal Probability Density Function, histograms of hydrometric data were reviewed to ascertain if these exhibited normal distribution characteristics. If this were the case, then low flow probability determinations would be possible.

Figure II-1 is a histogram of the Mean Daily Discharge (MDD) data for August 16th from Water Survey Canada (WSC) station 08LB078. The sample size is 20. If is apparent that these data are not normally distributed, as the distribution is right skewed, with higher frequency of small discharges and a lower frequency of relatively high discharges. However, it can be seen from Figure II-2 that the histogram for the natural log of same MDD data seems to have the characteristic shape of a normal distribution. Using the Shapiro Wilk Goodness of Fit test it was concluded that this distribution satisfies the requirements of normality, because the W test statistic was greater than the 0.05 quantile value. Details of the Shapiro Wilk Goodness of Fit test ("W" test) may be found in Gilbert (1987).

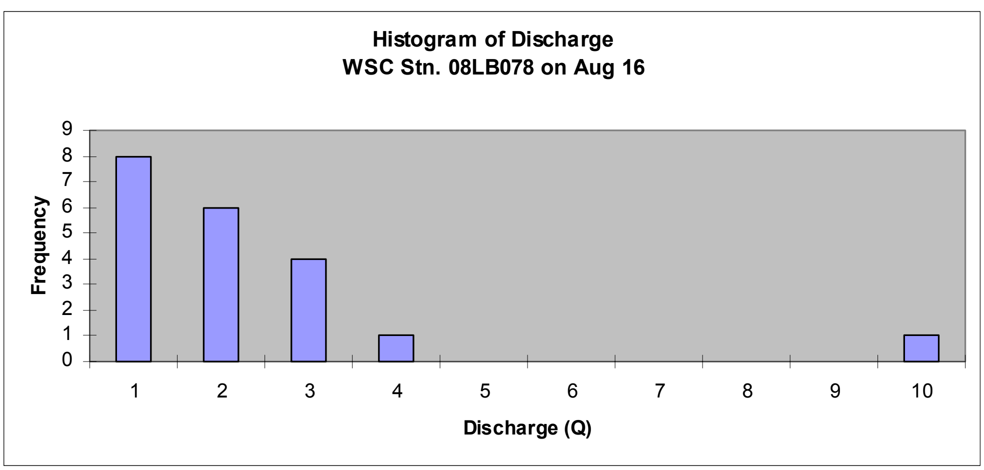


Figure II-1

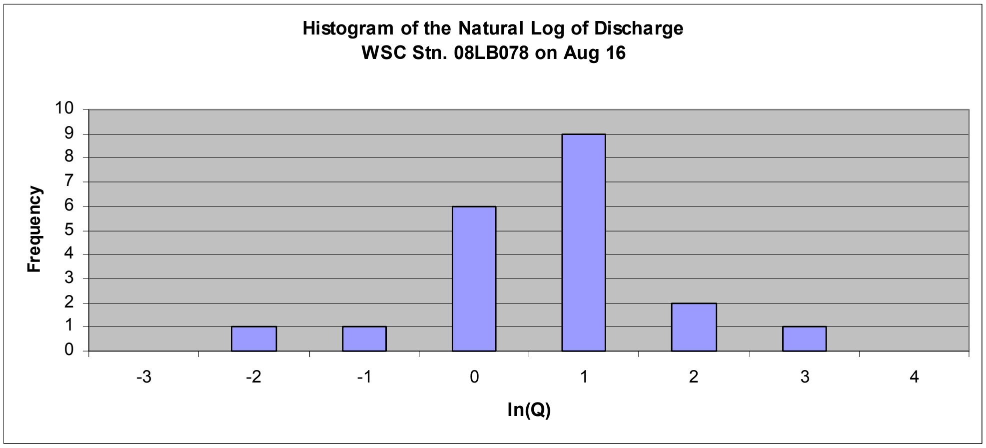


Figure II-2

This exercise was repeated for other dates in August at this WSC stations and for WSC station 08LB042, with the similar outcomes (i.e., these log-normal distribution are a reasonable approximations of their true unknown distribution).

Having confirmed that these data approximate a normal distribution, the next step was to develop a probability procedure for this study. Figure II-3 is an illustration of the procedure used. This figure shows a curve that approximates a normal distribution. The area under this curve is known as a density function, the properties of which are:

- the area under a segment of the curve represents a specific probability, and
- the total area under the curve is equal to a probability of 1.0.

Fortunately, the area under any portion of a Normal Probability Density Function has been calculated and tabulated (such as Table 4 in Mendenhall, 1988). This then enables specific probabilities to be estimated from lookup tables. The following outline of the coupling procedure and accompanying example is provided to illustrate this method.

Method for Estimating In-Stream Surplus/Deficit

A low flow probability of occurrence of 80% was selected for this study and is represented by $Q_{0.8}$ (see Section 9 for more details). This criterion is illustrated in Figure II-3 where $Q_{0.8}$ is the stream discharge that has an 80% probability of being equalled or exceeded. The steps involved with calculating the $Q_{0.8}$ discharge along with in-stream surpluses or deficits are provided below.

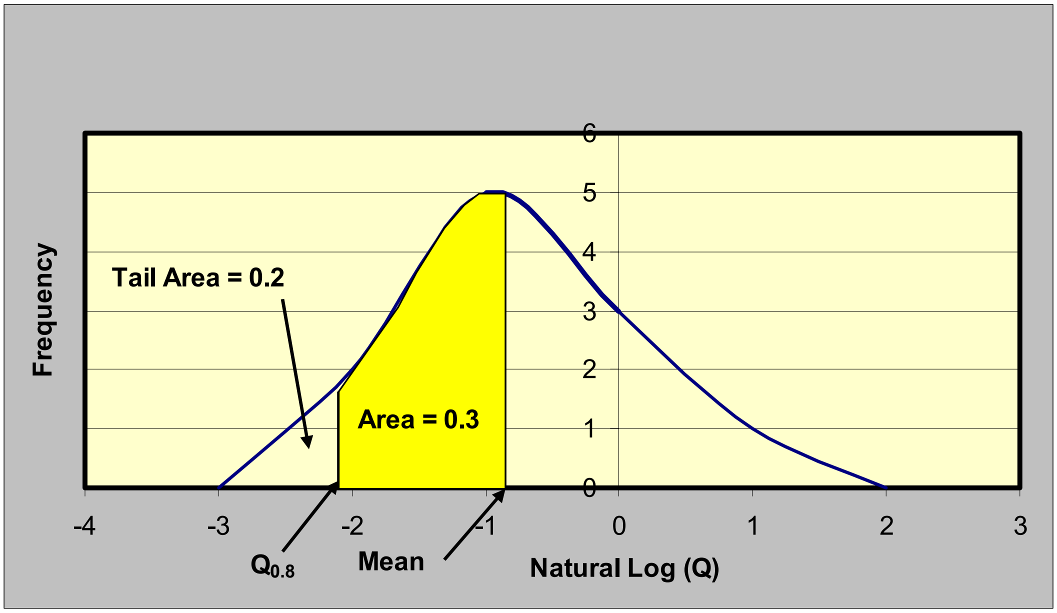


Figure II-3
Illustration of Log-Normal of Discharge Data

Referring to Figure II-3, the first step was to calculate the $Q_{0.8}$ discharge using the following equation:

$$z = [\mu - x]/\sigma \qquad \textbf{Eqn. A1}$$

Where: z is the fraction of the area under the curve normalised in units of standard deviation,

μ is the mean of the natural logarithm of the mean daily discharge data,

x is any value of the natural logarithm of mean daily data discharge for the date of interest, and

σ is the standard deviation of the natural logarithm of the mean daily discharge data.

Since the area under the curve to the left of the mean equals 0.5 and the tail has an area of 0.2, it follows that the shaded area in Figure II-3 has an area of 0.3. Hence, the z value was obtained from Normal Area Curve look-up tables where area corresponds to 0.3. The mean and standard deviation of the natural logarithm of mean daily discharge data are derived from descriptive statistics (available within Microsoft Excel). Since z, μ and σ are known, Equation A1 can be rearranged to solve for x.

Using the example illustrated in Figure II-3, the mean daily discharge value that has an 80 percent chance of being equalled or exceeded ($Q_{0.8}$) is obtained by solving for x. So in this case $x = \ln(Q_{0.8}) = \mu - z\sigma$. Substituting for x into Equation A1 yields:

$$\mathbf{z = [\mu - \ln(Q_{0.8})]/\sigma} \qquad \textbf{Eqn. A2}$$

Then, $x_{p80} = Q_{0.8} = e^{\ln(Q0.8)}$.

To meet the criteria:

$$\mathbf{Q_{0.8} = q_{in\text{-}stream} + q_{off\text{-}stream},} \qquad \textbf{Eqn. A3}$$

Where: $q_{in\text{-}stream}$ is the in-stream flow requirement for the fish species and period (date) of interest, and
$q_{off\text{-}stream}$ is the potential excess stream flow available for off-stream use for the date of interest.

To satisfy in-stream flow requirements:

$q_{in\text{-}stream}$ = Assigned in-stream flow (% MAD in this case).

Therefore, Equation A2 can be solved for $q_{off\text{-}stream}$ as $Q_{0.8}$ and $q_{in\text{-}stream}$ are known. The example below shows how this procedure was applied to actual data from Lemieux Creek.

Example

Mean Annual Discharge (MDD) data from WSC station 08LB042 on August 16 is used in this example. The process begins with exporting WSC mean daily discharge data from the Ministry's HYDAT utility to an Excel spreadsheet. These data are then manipulated to extract all the discharge data for the date of interest. A histogram of ln(Q) is plotted, as shown in Figure II-2, to check for a normal distribution. Visual inspection of this figure suggests that these data may be normally distributed. The "W" Goodness of Fit test confirmed that these data approximate a normal distribution at the 0.05 significance level.

The next step was to calculate $Q_{0.8}$ and the discharge surplus or deficit using Equations A2 and A3. Using Equation A2 to find $Q_{0.8}$ (and expressing the terms in the natural logarithm domain):

$$z = [\mu - \ln(Q_{0.8})]/\sigma$$

Where: $z = 0.8418$ (from the look-up table for P= 0.3)
$\mu = -0.8951$
$\sigma = 1.0039$

Rearranging Equation A2 and substituting the values above to solve for $Q_{0.8}$,

$$\ln(Q_{0.8}) = -0.8951 - 0.8418 \times 1.0039$$
$$= -1.7402$$

Therefore, $Q_{0.8} = e^{-1.7402}$
$= 0.175\ m^3/s$

From Equation A3, the discharge surplus/deficit may be determined.

$Q_{0.8} = q_{in\text{-}stream} + q_{off\text{-}stream}$, Eqn. A2

Since: $q_{in\text{-}stream}$ = % MAD = 0.415 m^3/s (@ 25% MAD assigned)

Then: $q_{off\text{-}stream} = Q_{0.8} - q_{in\text{-}stream}$
$= 0.175 - 0.415$
$= -0.24\ m^3/s$

Thus, a discharge deficit is estimated. This is the amount of flow augmentation required on August 16th to meet the 25% MAD criteria at P = 0.8. No water is available for off-stream licensing, unless this is backed by storage and released at a rate equal to the rate of withdrawal specified in the water licence. The above analysis is a variation on the procedures for estimating percentiles as described by Gilbert (1987).

Limitations

This procedure relies on WSC mean daily discharge data that are collected over several years. The longer the period of record, the lesser the range of Q_p at the 95% upper and confidence limits. A Goodness of Fit test such, as Shapiro-Wilks, must be done on the natural logarithm of the discharge to confirm that the data are approximately normally distributed at the 0.05 significance level. Failure to confirm normality could invalidate this log-normal procedure.

If normality of the distribution is confirmed, surpluses or deficits are considered a reasonable estimate of water availability or shortfall for the purposes of screening within WAT Version 2.0.

There are a number of points worthy of mention that relate to Equation A2, probability, surpluses and deficits:

- When the $q_{in\text{-}stream}$ (% MAD) equals $Q_{0.8}$, $q_{off\text{-}stream}$ will be zero, and the % MAD discharge will have a probability of 80%.
- When $q_{in\text{-}stream}$ is less than $Q_{0.8}$, $q_{off\text{-}stream}$ will be positive and a discharge surplus will be identified. This surplus being the quantity of water that is potentially available for off-stream licensing. When this entire surplus has been allocated,

the probability associated with the last water licence for off-stream use will be at or slightly greater than 80%.

Conversely, when the % MAD is greater than $Q_{0.8,}$ $q_{off\text{-}stream}$ will be negative and a discharge deficit will be identified, the magnitude being the amount of flow augmentation to the stream required for the period (e.g., from storage) to meet the desired percent MAD discharge. Any additional water licensing for off-stream use should be backed by storage and be released at a rate equal to the withdrawal in order to satisfy in-stream flow requirements.

In reality, WAT Version 2.0 may have limited application for decision-making in many water-short areas. This may due to insufficient hydrometric record, or undocumented (un-metered) high rates of water withdrawal (stream and hydraulically connected aquifer(s)) that prevents the naturalization of the hydrometric record in a statistically defensible manner.

Reference.

Gilbert, Richard O. 1987. Statistical Methods for Environmental Pollution Monitoring, pp 157-162, 174-175 and 258-262. Van Nostrand Reinhold, New York, New York.

Appendix III

Watershed Delineation

Appendix III

Watershed Delineation

Des Anderson

Watershed delineation into zones was done to partition stream flow into the sub-basins between the Water Survey Canada stations at Upper Lemieux and Lemieux at the mouth. The watershed was delineated four zones as defined below:

- Upper Lemieux Creek – from immediately above the confluence with Nehalliston Creek (former WSC station 08LB042).
- Mid-Lemieux Creek – from immediately above the confluence with Eakin Creek to immediately above the confluence of Nehalliston Creek, and including the Nehalliston Creek sub-basin.
- Lower Lemieux Creek – from immediately above the mouth (WSC station 08LB078) to immediately above the confluence of Eakin Creek, and including Eakin Creek sub-basin.
- Lemieux Creek at the Mouth (WSC station 08LB078 @ Highway 5 bridge).

The zones for Upper Lemieux, Mid-Lemieux and Lower Lemieux are defined by colour code on Figure 1, within the body of the report and on Map A. Note that it was also necessary to define the zone "Lemieux Creek at the Mouth" because it was assumed that the small face units on either side of Lemieux Creek, from the confluence of Eakin Creek with Lemieux Creek to the WSC station 08LB078, contributes discharge to Lemieux Creek. As such, this incremental discharge accrues to the zone at the mouth and is accounted for in this way in the analysis.

Note also that Spokane Creek has not been included in the zone delineations described above. This is because this creek does not have a surface water connection to Lemieux Creek, but sinks on the edge of the valley bottom. It is not known if a significant quantity of surface water originating from Spokane Creek ultimately re-emerges from groundwater into Lemieux Creek and is gauged at the WSC station 08LB078. (Refer to Section 6 for additional information on Spokane Creek). The effect of excluding Spokane Creek as a potential groundwater recharge source from the low flow analysis will be to slightly under-estimate the low flow contribution from the other zones in the Lemieux Creek watershed. This could result in slightly lower (more conservative) quantity of surface water being identified for off-stream use. Given this uncertainty, excluding Spokane Creek from the analysis favours conservation of in-stream flows and complies with the precautionary principle.

Appendix IV

Study Reach Hydraulic & Fish Habitat Characteristics

Appendix IV

Study Reach Hydraulic & Fish Habitat Characteristics

Des Anderson

Cross-section and stream flow surveys were conducted at a reach 7 kilometres upstream from the mouth of Lemieux Creek to confirm criteria (b) and (c). This reach was selected because periodic dewatering has been documented.

Planning

The project team met with the DFO Fishery Biologist to agree on the overall approach and ensure that DFO concerns were considered in the design of the field study. The objectives of the fieldwork were to:

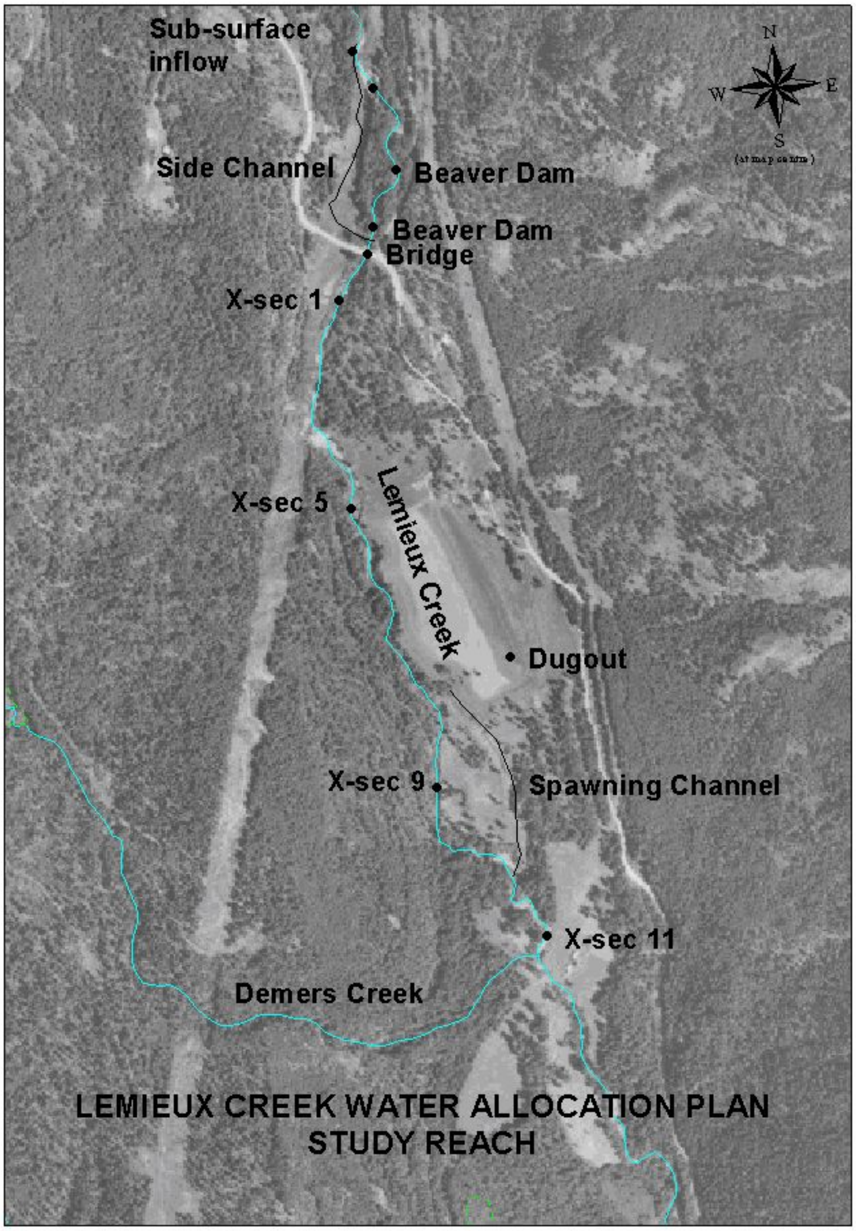
1. relate discharge with depth, velocity, and percent of Mean Annual Discharge (% MAD) so that stream flow could be correlated with fish habitat suitability criteria;
2. establish unit discharge figures for ungauged parts of watershed;
3. acquire site specific information to assist in understanding why this reach is prone to de-watering; and
4. understand the interaction between groundwater and surface flows within the study reach.

Since fish migration in the Lemieux Creek main-stem can be impeded by stream low flow over riffles, it would be necessary to obtain channel cross-sections at selected riffles. Since shallow and turbulent water flow on riffles would prevent accurate streamflow measurements, discharge measurements would be obtained upstream of riffles in the transition zone between a pool and riffle.

Fieldwork

Field reconnaissance was conducted on November 22, 2001 (during low flow season) to gather information on site characteristics and pre-select locations for cross-sectional surveys and streamflow measurements. The reconnaissance team members met on site with a DFO Fishery Biologist and a DFO contractor who has considerable knowledge of the area. A reach extending from about 7.0 Km (immediately downstream from the mouth of the spawning channel) to 8.4 Km (Lemieux Creek Road bridge) was identified for study, as shown in Figure IV-1. This reach was walked and proposed cross-sections

Figure IV-1



flagged. Each location was selected on the basis of a relatively uniform riffle that was headed by a pool with a well-defined transition from pool to riffle, at right-angle to flow. The design of the field study was finalized and preparations were made to conduct the study on November 27, 2001.

Two flow measuring teams and 1 cross-section survey team were assigned to the fieldwork. Streamflow measurements were obtained at the Lemieux Creek Road Bridge and at Sections 1, 5, 9, and 11 (see Figure 4 for locations). In addition, streamflow measurements were obtained in the spawning channel near the mouth, Eakin Creek (near the mouth), Nehalliston Creek (near the mouth), and on Lemieux Creek 10m downstream from the confluence with Nehalliston Creek. Standard Price Current Meters were used.

Note that discharge measurement at the mouth was obtained from Water Survey Canada Station 08LB078.

Cross-sectional surveys were completed at Sections 1, 5, and 9. This included water depth and water surface elevations along the section, and water surface slope on the riffle. Additional water and channel level elevations were obtained from the spawning channel and the Ianson's dugout well. Conventional automatic level, rod, and tape were used. Elevations were related to local datum at the road bridge parapet.

The location of the cross-sections 1, 5, 9, and 11, and the location of the spawning channel and the dugout well were confirmed by a Global Positioning System (GPS) survey on November 28, 2001 using a Trimble GeoExplorer II. The spawning channel and dugout locations are also identified in Figure 4.

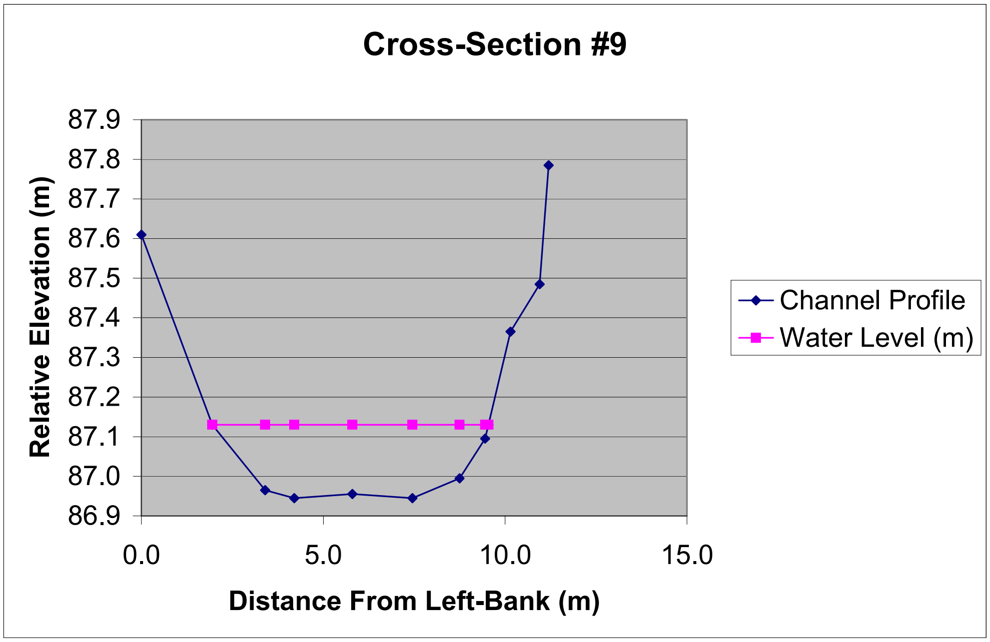
Results

Stream cross-sections were plotted and evaluated. It was decided that Cross-Section #9 (Photograph IV-1) was the most representative of suitable fish habitat in the study reach, due

Photograph IV-1 - Channel cross-section #9 on Lemieux Creek.

to its uniformity and riffle-pool combination. Reach hydraulics and fish habitat characteristics would be based on this cross-section. The channel profile for this cross-section is provided in Figure IV-2.

Figure IV-2



Manning's formula was used to estimate discharges and velocities at other river stages. The Roughness Coefficient “n” was back calculated from the measured discharge, slope and cross-sectional area using Manning’s formula. By assuming a constant slope and “n”, average velocities and discharges at other stages were estimated from this formula. This enabled the thalweg water depth versus discharge and average velocity versus discharge relationships for the range of stages of interest to be developed, as shown in Figures IV-3 and IV-4, respectively.

Regression analysis on the discharge versus depth data yielded equation 1:

$$\mathbf{y = e^{[0.525\ln(x) - 1.238]}} \qquad \text{Eqn. 1}$$

Where: y = thalweg water depth (m)
x = discharge (m^3/s)
e = 2.718

Equation 1 was subsequently used in the next section to derive depth versus discharge values for different percent of Mean Annual Discharge (MAD) values (Table IV-1).

The following is a summary of discharge characteristics at Cross-Section #9 on November 27, 2001:

- discharge at 0.424 m^3/s;
- flow depth in the thalweg at 185 mm;
- average flow velocity at 0.38 m/s (measured discharge divided by measured cross-sectional area) ; and

- return period at 4:7 (P=0.57, or slightly higher than the mean discharge for this date).

This information provided a useful benchmark for the subsequent establishment of in-stream flow requirements. The Fisheries Biologist used this information along with observed fish habitat conditions on November 27, 2001 as a basis for the percent MAD criteria developed in Section 8.

Figure IV-3

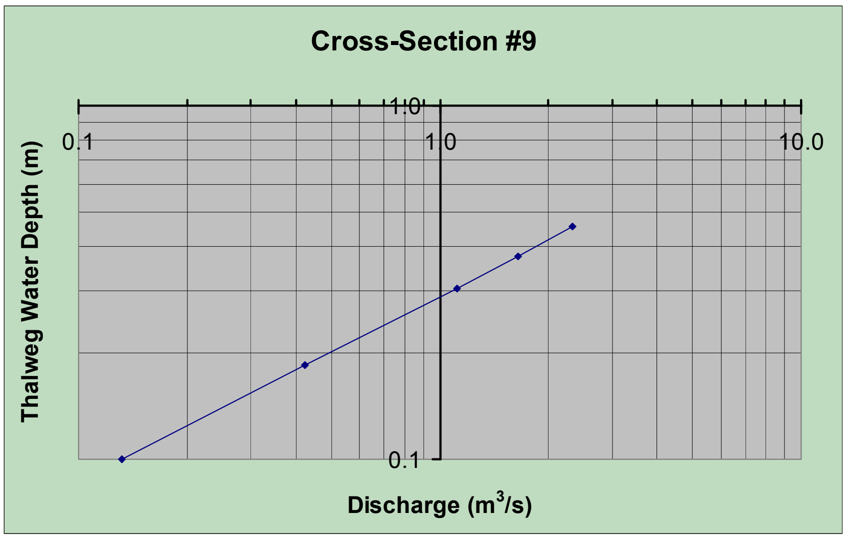
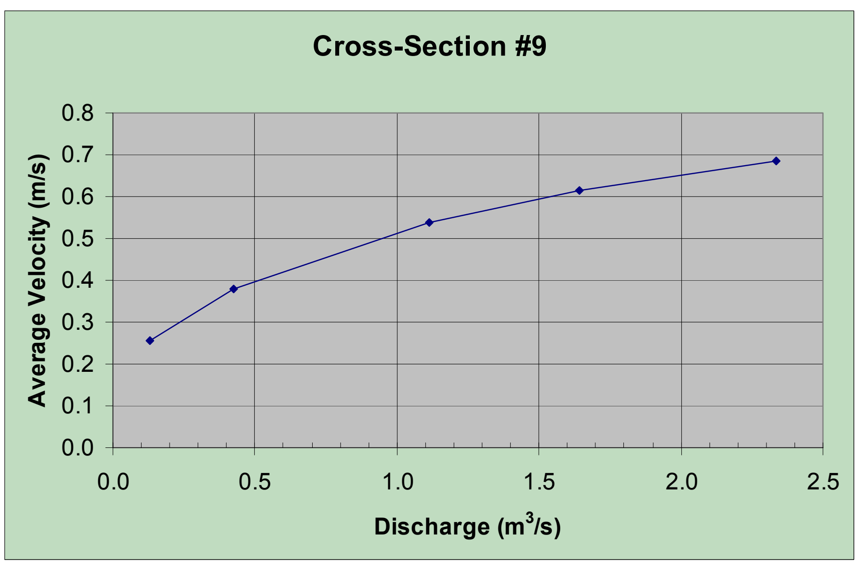


Figure IV-4



Percent Mean Annual Discharge

Mean Annual Discharge (MAD) values were calculated from the mean daily discharge data for WSC station 08LB042. Percent MAD discharges for this station are provided in

Table IV-1, column two. To account for a contributing watershed area reduction at Cross-Section #9, discharges in column two of Table IV-1 were multiplied by 0.89, to produce the % MAD discharges in column three of this table. Using the information in column three, it can be seen that the discharge of 0.424 m^3/s on November 27, 2002 was approximately 29% of MAD. Equation 1 was used to predict thalweg water depth, in column four, based on the % MAD values in column three of Table IV-1. The thalweg water depth of 0.185 m at Cross-Section #9 on November 27, 2001 is in good agreement with the depth corresponding to the 29% MAD value inferred from Table IV-1. This table is used in subsequent sections of this report.

Table 1

% MAD	Mean Annual Discharge @ WSC Stn. 08LB042 (m^3/s)	Mean Annual Discharge @ Cross Sect. #9 (m^3/s)	Thalweg Water Depth @ Cross-Sect. #9 (m)
100	1.6617	1.4789	
50	0.8309	0.7395	0.25
40	0.6647	0.5916	0.22
30	0.4985	0.4437	0.19
25	0.4154	0.3697	0.17
20	0.3323	0.2958	0.15
15	0.2493	0.2218	0.13
10	0.1662	0.1479	0.11

It should be noted that coho were spawning at this flow (November 22, 2001) and that this particular flow (and % MAD) was adequate for fish at this point on the stream, based on field observations and professional opinion.

De-watering Potential at Lemieux Creek Adjacent to the Spawning Channel

As mentioned in Section 7, periodic dewatering of Lemieux Creek has been reported around kilometre 7 and near the mouth during late summer. It is possible that losses from the creek to the Little Fort aquifer may occur in the vicinity of these two reaches of Lemieux Creek during periods of creek dewatering. A lack of surface water and groundwater information, however, prevents a good understanding of these interactions.

Limited water elevation data obtained November 27, 2001 in Lemieux Creek study area provides some understanding of groundwater and surface water interactions at this reach on this date. These water levels are provided in Table IV-2 and were obtained from a transect roughly at right-angles to Lemieux Creek. Note that the dugout was not being pumped at the time of the level survey. It can be seen from these data that there is a positive gradient from the creek and the dugout to the head of spawning channel. There is also a positive gradient from the creek to the dugout. It is apparent that the creek losses water to the spawning channel, however, it is not known if this would occur if the spawning channel were not present and the dugout was being pumped. A more detailed assessment is needed at this location to quantify groundwater and surface water interactions. Since many of the wells are located near the mouth of Lemieux Creek, this area has a higher priority for such assessment.

If appropriate groundwater legislation is not enacted, the Lemieux Creek community should consider the formation of a water stewardship group to assist in voluntary water resource management (groundwater and surface water) practices in the Lemieux Creek watershed.

Table IV-2 Comparison of Water Levels

Water Level Location	Elevation (m)	Head Difference relative to the Lemieux Creek Adjacent to the Head of the Spawning Channel (m)	Head Difference relative to the Spawning Channel (m)
Lemieux Creek Adjacent to the Spawning Channel	88.488		+1.916
Near the Head of the Spawning Channel	86.572	-1.916	
Dugout	86.943	-1.545	+0.371