

DROUGHT PLANNING FOR THE WASA LAKE AREA

Final Report

**Prepared by R. McArthur
McArthur Consulting
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DROUGHT PLANNING FOR THE WASA LAKE AREA

1. INTRODUCTION

1.1. Background

This study was prepared for the Wasa Lake Land Improvement District (WLLID) under a grant from Land and Water BC. The WLLID was formed to manage and protect the recreational values of Wasa Lake. Maintaining the health of the lake is vitally important to residents, businesses (particularly tourism) and Wasa Lake Provincial Park. Although WLLID does not manage community water supplies (provided by individual wells) or sewage (disposed by individual septic systems), it is apparent that groundwater functions are closely linked with water quality and quantity of Wasa Lake. Therefore this study, in attempting to address future drought conditions, must consider local groundwater issues as well as issues related directly to Wasa Lake.

1.2. Objectives

There will be no attempt to gather new hydrological data for this study. Numerous assessments of the lake and surrounding hydrology have been conducted since the 1960's and these will be

referenced where necessary. The primary objectives of this study will be too:

- Establish a definition for drought in the Wasa area and describe how it affects residents and resource values.
- Describe what is known about the hydrology of the area and mechanisms that have, in the past, resulted in drought conditions.
- Consider what impact climate change might have on the timing and severity of drought conditions.
- Consider possible measures to reduce negative impacts of drought.

2. DEFINING DROUGHT

2.1. Drought in Wasa Lake

Simply put, a "water resources" drought occurs when low river, groundwater, or reservoir levels impact water use.¹ In the Kootenays, droughts are usually experienced as abnormally low stream flows in late summer and early fall which result in water shortages for domestic and irrigation use. Wasa is not typical in this regard as water shortages have not been the issue of concern. The pressing issue for the community of Wasa Lake has been low lake levels in summer. Recreational values are severely impaired when the lake drops below certain levels.

Another implication of the term "drought" is that the condition is not normal. In other words, if low water levels occur every year or even every several years, this can not be classified as drought. A reasonable time period must be defined and this is often ten years. Thus drought conditions in a stream could be defined as the lowest flow experienced over an average 10-year return period.

WLLID has stated that the desirable minimum lake level is 2522.5 feet (768.8 meters) for the recreation season (June 15 to September 15).² The lake level always drops further in winter and usually reaches a minimum of 2514 feet (766.3 meters). This level is acceptable in winter and does not seem to result in any problems such as reduced well production.

Records for the Kootenay River were compared to lake levels recorded for Wasa Lake. For average flows years on the Kootenay between 1950 and 1999, the corresponding Wasa Lake levels were estimated to be about 2523.5 feet on July 1st, 2520.5 feet on August 1st and 2517.5 feet on September 1st. In terms of mean monthly lake levels (which will be used most of the time in this report) this translates to about 2522 feet in July and 2519 feet in August.

The 10 year drought flows for the Kootenay were calculated to lower the July mean monthly river level by 1.5 feet and the August level by 0.75 feet. Assuming this drop would also occur in Wasa Lake, the 10 year drought mean monthly lake levels would be 2520.5 feet in July and 2518.2 feet in August.

Since the year 2000, Kootenay River and Wasa Lake levels have been much below average and it is difficult to judge how these recent years fit into long term trends. They may be a short term blip in the data or they may be signs that a significant change has occurred in the Kootenay River.

2.2. Consequences of drought

Summer recreation on the lake is severely affected when water levels drop too low. The beaches are high and dry and the shoreline is muddy. Boating may be restricted as several shoals are exposed. These conditions affect the livelihood of tourism operators and local merchants. Prolonged low water levels would reduce property values for residents and negate the reasons for originally buying in the area.

A prolonged reduction of precipitation and increase in temperature (the more common definition of drought) would have additional consequences. Fire hazard would increase and might require increased watering of property. Use of wells or the lake for fire fighting would consume considerable amounts of groundwater at a time of year when it may not be replenished. Evaporation from the lake surface would increase. Upland drainage into the area would be reduced. None of these losses amount to much when compared to the infiltration losses to the lake bottom during the receding hydrograph, however, if the lake was already very low such additional losses could exacerbate the depletion of the aquifer. Finally, the groundwater level could drop below the reach of existing wells and this possibility will be investigated later the report.

2.3. Future development around Wasa Lake

The Wasa Lake district currently contains 346 properties, 142 of which are held by permanent residents and 204 by non-permanent residents. Information from BC Stats predicts that the population in the Kimberley Local Health Area (which includes Wasa Lake) will shrink by 8% from 2005 to 2031. Although this may hold true for areas around Kimberley, it does not appear realistic for Wasa Lake. In comparison, the Windermere Local Health Area is predicted to have a population growth of almost 30% from 2005 to 2031. For the purposes of this report we will assume that the population at Wasa Lake will grow 20% by 2031. At this stage it can not be determined how much more development the aquifer can sustain. The more pressing concern may be groundwater contamination by the increased number of septic systems and possible deterioration of existing systems (see section below on Wasa aquifer).

3. HYDROLOGY OF THE WASA LAKE AREA

Previous studies have described the geology and hydrology of the Wasa Lake area in considerable detail (see reference #3). A much simplified description is that Wasa Lake was formed as a depression in glacial deposits and has no continuous inlet or outlet. It is a lake only because the depression it forms is lower than the surrounding water table. Fluctuations in the level of such lakes are dependant on fluctuations of the water table.³ When the Kootenay River reaches extreme high water, overland flow can reach Wasa Lake and has caused flooding problems in the past. Efforts to block high water flows from entering the lake have been relatively successful but during extreme flood events the lake and sloughs will still be inundated with river water. A system of dykes would have to be constructed to prevent this from

occurring.

3.1. The Wasa aquifer

Wasa Lake sits in the approximate center of the Wasa Lake aquifer (see figure 1) which has been mapped by The Ministry of Water, Land and Air Protection (WLAP). The aquifer is about 9 km long and 1.2 km wide. The western boundary follows the railroad tracks and extends south to include the sloughs. The eastern boundary follows the base of the hillside and reaches about 2.5 km north of Wasa Lake to include the Ford Ranch ponds. The mapping of aquifers is far from exact and is greatly dependant on where wells have been drilled.

Statistics from WLAP indicate that the average well depth is about 44 feet, the average depth to groundwater is 23 feet and average well yield is estimated at 13 gallons per minute.

WLAP classified the Wasa Lake aquifer as IA which indicates heavy demand and high vulnerability. Heavy demand means that, relative to the size of the aquifer and the productivity of existing wells, the aquifer is heavily used. High vulnerability means that the aquifer is highly susceptible to contamination at the land surface. In this case, the classification of heavy demand may be open to review as WLAP did not consider the fact that the aquifer is largely supplied from the Kootenay River.

observation well *

The recent drilling of an observation well in Wasa will provide some answers as to how much development the aquifer can sustain. Although supply from the Kootenay is virtually unlimited, there is also the question of how quickly water moves through the gravels. Can drawdown in one well affect surrounding wells? Are there seasonal differences in the performance of wells? The observation well will also yield periodic water quality reports and these will be important in gauging whether contamination is occurring from the surface or from increasing numbers of septic systems. The recent investigation into ground water quality that was conducted by WLAP and Interior Health is based on sampling from September 10, 2003 to March 8, 2004. There were no samples taken in the summer when non-permanent residents and visitors increase the total septic discharges by as much as 60%. Also, hydraulic gradients within the aquifer are greatest from May to August and this may affect the movement and detection of contaminants. The new observation well will help to fill gaps in water quality and water level data.

The issue of aquifer vulnerability is only peripherally relevant to this drought study. Generally, one would say that under drought conditions the opportunity for surface contamination will be reduced simply because there is so little moisture in the soil. However, an interesting side issue is raised by the aquifer's proximity to the Kootenay River. If groundwater can move from the river to the lake in only a couple of weeks, could not contamination in the river threaten the wells around Wasa Lake and the water in the lake? We will return to the question later in the report.

3.2 Other streams in the area

Besides the Kootenay River, the only other significant overland flow in the Wasa area is Lewis Creek. This is a fairly large stream flowing westerly from the Rockies and supports considerable irrigation licensing. Lewis Creek flows into the sloughs to the south of Wasa Lake and none of the creek or slough water runs north into Wasa Lake.

3.3 River, lake and groundwater levels

Previous studies have shown that the level of Wasa Lake is determined by the level of groundwater in the aquifer but tends to lag behind during periods of rise or decline.³ Studies have also shown that the groundwater level follows the level of the Kootenay River. As the Kootenay River rises during freshet, groundwater levels also rise. Lake levels tend to peak from 2 to 4 weeks after the river peaks. During the receding stage of the hydrograph, lake levels fall in a similar pattern to the fall in groundwater level but the lake tends to lag behind slightly.

This pattern occurs because the lake acts as a storage reservoir for the aquifer. As the water level rises, it takes longer (i.e. more water) to fill the lake than to fill the soils around the lake. As the river and groundwater levels recede, it takes longer for the greater mass of lake water to work its way through the gravels to the river.

The crucial point is that the level of Wasa Lake follows the level of the Kootenay River albeit with some delay. Precipitation has been shown to have little affect on lake level.⁴ It would be reasonable to assume that upland drainage would also have an affect on lake level but, against the dominance of the river, the affect is insignificant.

In addition to the hydraulic gradient to and from the river, there appears to be a gradient from the north and south toward the lake. The water level in the Ford Ranch ponds to the north is usually several feet higher than Wasa Lake and shows a more delayed reaction to changes in river level. This is probably a result of the ponds being a greater distance from the river and also may indicate that the ponds are influenced by a more northerly (i.e. higher) reach of the river. The sloughs to the south maintain a much more constant level than the lake and are usually several feet higher than the lake. This suggests that Wasa Lake, as well as serving as a reservoir for the aquifer during the receding hydrograph, is the lowest point at which water drains from the aquifer during low water.

3.4 Historical perspective

As preparation for the 1977 Wasa Lake Studies³, Ed Livingston gathered comments from old timers in the area. There was strong opinion that construction of railway and highway grades, starting in the 1940's, had caused considerable change to the hydrology of Wasa Lake. Previous to this construction, overland flow to and from the river through Hansen Channel was common at high water. Water sometimes ran south out of the lake at high water. Wasa Lake filled more quickly during freshet and emptied more quickly until lake level reached the bottom of Hansen Channel. At low water levels the south end of Wasa Lake (sometimes called little lake or South Bay) could go completely dry which does not seem to be the case in more recent times. Hansen channel was thought to be a natural feature predating settlement.

The areas to the south of Wasa Lake were fields that were often cut for hay. However, culverts that were installed for railway and highway grades served as easy dam sites for beavers. The flow of Lewis Creek brought silt down which settled behind the beaver dams sealing the gravels to some extent and raising the level of the sloughs.

3.5. Hydrological change

It is clear that the biggest threat to the water resources of Wasa Lake is a reduction of flow in the Kootenay River during the summer period. Such a reduction would have to occur as a result of climatic conditions in the drainage basin of the Kootenay River upstream of Wasa Lake. Local drought conditions would have little impact on Wasa Lake if river levels remained normal. This is because the river can supply an unlimited amount of water to the aquifer as long as the river level is high enough. In many aquifers, water must travel great distances through gravels or bedrock fissures and the source of the water may be limited in itself. Once depleted, they may take years to recover. But the Wasa aquifer is very close to its source and the water takes only a few weeks to move through the gravels from the river bank to the lake.

Conversely, no amount of precipitation or cool weather at Wasa Lake will maintain the level of the lake and water table when the river level drops due to conditions in the headwaters. Local precipitation will simply drain out the lake bottom and into the river. Of course the worst scenario would be low river levels and local drought conditions occurring in the same time period.

The conditions in the headwaters which would result in lower summer flows in the Kootenay River would not necessarily be classified as drought. Certainly less overall precipitation would result in lower annual flows but the important factor for Wasa Lake is the amount of flow in the summer or, in other words, the timing of the runoff. As will be demonstrated later in this report, runoff timing is more a function of temperature than of precipitation. Relatively small changes in seasonal temperature can result in dramatic changes in the timing of the runoff. Unfortunately this is exactly what global warming and climate change models predict for British Columbia.

4. CLIMATE CHANGE

Virtually all scientists and world leaders now accept the reality that the world's climate is warming. Our provincial government recently issued a document called Weather, Climate and the Future: B.C.'s Plan which states:

Climate change scenarios indicate that during the 21st century British Columbians could expect average annual temperatures to warm somewhere in the range of 2 degrees C to 7 degrees C, accompanied by more winter precipitation, and a greater proportion of winter precipitation falling as rain.

Projected impacts for B.C. include reduced snow pack in southern B.C., and at mid-elevations, an earlier spring meltwater surge on many snow-dominated river systems, reduced summer stream flows and soil moisture in some regions, glacial retreat and disappearance in southern B.C., an increase in the weather conditions that support fire and pest outbreaks and other disturbances, and loss of some wetland and alpine ecosystems. Also projected are changes in the frequency and/or severity of drought, high intensity rainfall, flooding, coastal storms, and other extreme weather events.⁴

It is interesting to note that in spite of a projected increase in annual precipitation for south-eastern B.C., summer stream flows are expected to decrease. This must be a prime concern for the residents of Wasa Lake. Therefore it is important to review the best possible information and scientific study which will help us understand how the Kootenay River system upstream of Wasa Lake may react to global warming. This is not a clear cut task as there is no direct data or research on the headwaters of Kootenay River related to climate change. Data and research from downstream locations on the Kootenay and from other river systems must be relied upon, with similarities and difference noted, to help gain an understanding of possible changes in river flow at our point of interest.

4.1. How Soon Will Changes Be Noticed

There is a big psychological and functional difference between having to adapt to climate change sometime over the next 100 years and having to adapt by 2010 or 2020. So it is important to consider not only the extent of the changes but also how soon impacts can be expected at Wasa Lake. Consider these examples.

4.1.1. Upper Similkameen River

A comparison of records on the Upper Similkameen River shows that significant change was already occurring in the 1980's and 1990's. The Upper Similkameen is a snowmelt-dominated river in south-central BC. Averaged flows from 1971 to 1983 were compared to averaged flows from 1984 to 1995. The results show that snowmelt is occurring earlier, summer flows are lower, the low-flow period is longer and autumn flows are higher⁵. The date of lowest flow had already advanced by about 2 weeks in this comparison. The Similkameen basin is lower and

more subject to mid elevation changes in snowpack than is the Kootenay and one would expect to see changes there before similar changes are apparent in the Kootenay.

4.1.2. Alberta Rivers

A study underway in Alberta indicates that most rivers of the western prairies are already down 20-80% from historical flows during the May-August period.⁶ These observations are shocking and it must be assumed that there are changes occurring on the eastern slopes of the Rockies that are more extreme than in the Kootenay basin. Snowpacks are historically lower on the east side of the Rockies and perhaps this makes the eastern drainage basins more sensitive to an increase in temperature. Predicted changes in temperature and precipitation due to climate change are quite similar for Banff and Kootenay National Parks.⁷

4.1.3. The Kootenay River

Water Survey of Canada operated flow gauging station 08NG053 on the Kootenay River near Skookumchuck from 1950 to 1996. As a comparison to the Similkameen data noted above, the average September 1st flows from 1971 to 1983 were compared to the average September 1st flows from 1984 to 1995. Across this period of record on the Kootenay River, flows had dropped by approximately 9%. This indicates that late summer flows on the Kootenay, although dropping, were not as severely affected up to 1995. Unfortunately the station near Skookumchuck was discontinued in 1996 and river flow data in close proximity to Wasa Lake is no longer available.

The next closest gauging station (08NG065) is located at Fort Steele. It began recording in 1963 and continues to the present. A review of the river flows over the entire 40 years of record shows that the 3 lowest August mean monthly flows occurred in 2001, 2002 and 2003. By comparison the 3 lowest yearly mean flows occurred in 1977, 1979 and 2001. This indicates that there is already a strong trend to lower summer flow on the Kootenay which is not necessarily related to lower yearly flow (i.e. less precipitation).

These examples clearly indicate that significant changes are already happening in BC and Alberta rivers. It is no longer realistic to view climate change as a futuristic phenomenon.

5. PREDICTING THE EFFECTS OF CLIMATE CHANGE ON STREAMFLOW

There is very little climate change river modeling available which can be directly associated to the upper Kootenay system. Some associated studies are noted below.

5.1. The Illecillewaet River

A study titled Climatic impacts on the runoff generation processes in British Columbia, Canada⁸ looked at two BC catchments, one on the coast and the other being the Illecillewaet River. In this study glacial melt and changes in vegetation were included in the model as well as the typical parameters of temperature and precipitation. Glacial melt is a factor in the Kootenay basin so this study is particularly relevant to our objective.

The Illecillewaet River is located on the western slopes of the Selkirk Mountains and drains into the Columbia River at Revelstoke. The drainage area is 1150 km² and extends from 1500 feet elevation at the bottom to 10500 feet at the highest ridgeline. The Kootenay River drainage upstream of Wasa Lake is 7,200 km² in area and extends from 2520 feet in elevation to 11800 feet at the highest ridgeline. The Illecillewaet valley is narrower and steeper and accumulates a greater snowpack in spite of being lower in elevation.

The authors compared present (1970-1990) runoff from the watershed against future (2080-2100) runoff under climate change conditions. The conclusions relevant to our study are as follows:

- The total mean annual runoff will increase by 37%
- Runoff in autumn, winter and spring will be significantly higher
- Runoff in June will be 31% lower
- Runoff in July will be 44% lower
- Runoff in August will be 26% lower
- The peak flow will be slightly lower and will occur in May instead of June.

The authors concluded that, although the glacial area was reduced by 33%, the monthly runoff from the glacier would be the same as at present and would remain a significant contributor to the total runoff in summer and early autumn. This finding may not relate well with the Kootenay system glaciers. Many glaciers in the southern Rockies are expected to be severely depleted or lost entirely which would result in greatly diminished late summer flows in Alberta rivers. For example, glacial wastage in the Bow River system can account for over half of the July - August flow at the eastern Banff boundary.⁹

It would be reasonable to assume that glaciers in the Kootenay system would react more than those in the Illecillewaet but less than glaciers on the eastern slope of the Rockies. This assumption would mean that the glacial component of summer runoff in the Kootenay system will suffer a greater reduction than the Illecillewaet but that it will not drop as severely as for Alberta rivers.

5.2. Columbia River Basin

The Climate Impacts Group at University of Washington is an interdisciplinary research group studying the impacts of natural climate variability and global climate change on the Pacific Northwest. They have produced a study called Climate Change Streamflow Scenarios for Water Planning Studies - Columbia River Basin which can be viewed online at the CIG website. The study uses precipitation and temperature data from 1950 to 1989 and projects this forward to the years 2020 and 2040 to model streamflows at various points in the basin. Although all of the points are existing dams, the calculated streamflows are "naturalized" to remove all effects of dams and diversions. Glacial melt is not included in this model but it is expected that it would further reduce late summer flows. The following is an interpolation of summer flow changes for 4 locations in the basin. These locations are the closest ones to Wasa Lake and surround our point of interest.

PER CENT CHANGE IN MEAN MONTHLY STREAMFLOWS

	June 2020	July 2020	August 2020	Sept. 2020
	June 2040	July 2040	August 2040	Sept. 2040
Duncan River	+ 13	- 18	- 22	- 16
	- 27	+ 10	- 18	- 27
Flathead River (\$ Fork)		- 8	- 46	- 39
	- 54	- 44	- 50	- 31
Columbia River at Mica	+ 17	- 12	- 18	- 13
	- 23	- 24	+ 17	- 12
Kootenay River at Libby		+ 6	- 22	- 31
	- 29	- 38	- 34	- 19
				- 4

6. ESTIMATING FUTURE KOOTENAY RIVER FLOW AT WASA

Based on the information presented above, it is possible to estimate future flows on the Kootenay River. Although this will be nothing more than a guess, it is grounded in the best available historic data, climate change scenarios and runoff modeling. Given all the assumptions, averaging and basic uncertainty that is built into the information, it must be stressed that the margin of error is considerable. Average flows

during the last half of the 20th century are used as the basis of the comparison.

6.1. Estimated change to Kootenay River level during average years

Kootenay River - change in July mean monthly flow:

- For 2010 - 10% less
- For 2020 - 25% less
- For 2040 - 30% less

Kootenay River - change in August mean monthly flow:

- For 2010 - 15% less
- For 2020 - 30% less
- For 2040 - 40% less

The next step is to relate these lower flows to the actual drop in river level that would occur. It is the level of the river, not the flow that determines the groundwater and lake levels at Wasa Lake. The closest point at which river flow can be translated into river level is gauging station 08NG053 near Skookumchuck.

Change in July mean monthly river level:

- 2010 - $272\text{m}^3/\text{s} - 10\% = 245\text{m}^3/\text{s}$ which would result in a 0.123m or 0.4 foot drop
- 2020 - $272\text{m}^3/\text{s} - 25\% = 204\text{m}^3/\text{s}$ which would result in a 0.32m or 1.0 foot drop
- 2040 - $272\text{m}^3/\text{s} - 30\% = 190\text{m}^3/\text{s}$ which would result in a 0.38m or 1.25 foot drop

Change in August mean monthly river level:

- 2010 - $132\text{m}^3/\text{s} - 15\% = 112\text{m}^3/\text{s}$ which would result in a 0.13m or 0.43 foot drop
- 2020 - $132\text{m}^3/\text{s} - 30\% = 92\text{m}^3/\text{s}$ which would result in a 0.27m or 0.9 foot drop
- 2040 - $132\text{m}^3/\text{s} - 40\% = 79\text{m}^3/\text{s}$ which would result in a 0.37m or 1.2 foot drop

Translating average river levels to resulting levels in Wasa Lake is a tenuous exercise because of the lack of consistent records on Wasa Lake during the 20th century. However, for average summer flows between 1963 and 2003 on the Kootenay River (station 08NG065) the monthly mean level in Wasa Lake is about 2522 feet in July and 2519 feet in August. Using this relationship, reductions in the level of Wasa due to climate change can be approximated.

July mean monthly level of Wasa Lake during average years:

- For 2010.....2522 feet - 0.4 ~ 2521.5 feet
- For 2020.....2522 feet - 1.0 ~ 2521 feet
- For 2040.....2522 feet - 1.25 ~ 2520.7 feet

August mean monthly level of Wasa Lake during average years:

- For 2010.....2519 feet - 0.43 ~ 2518.5 feet
- For 2020.....2519 feet - 0.9 ~ 2518 feet
- For 2040.....2519 feet - 1.2 ~ 2517.8 feet

Conclusion - by 2020 the average summer lake levels will run about 1 foot below the average level in the 1980's and 1990's. River flows and lake levels are predicted to continue dropping through the 21st century.

6.2. Change to Kootenay River levels during drought years

It is also important to look at "drought" years with a 1 in 10 year return period. Climate change scenarios predict that, in addition to reduced average streamflows in the summer, extreme events

such as floods and droughts will become more severe. In other words, there will be more variability in things like streamflow. No information was found to help quantify this added variability but for the purposes of this non-scientific report it will be assumed that drought flows will drop an additional 5% below the average flow reductions. This may be a conservative assumption.

Kootenay River - change in July 1 in 10 year low mean monthly flow:

- For 2010 - 15% less
- For 2020 - 30% less
- For 2040 - 35% less

Kootenay River - change in August 1 in 10 year low mean monthly flow:

- For 2010 - 20% less
- For 2020 - 35% less
- For 2040 - 45% less

The 1 in 10 year low average monthly flow for July is about 170m³/s and for August is about 97m³/s at station 08NG053 near Skookumchuck. The river level drop associated with these drought conditions is 1.6 feet for July and 0.8 feet for August. The additional drop in river levels due to climate change is calculated below and then added to the historic 1 in 10 year reductions.

Total change in July mean monthly river level during 1 in 10 year drought:

- For 2010 - 170m³/s-15% = 145m³/s which would result in a 0.14m or 0.5 foot drop + 1.6 = 2.1 foot drop
- For 2020 - 170m³/s-30% = 119m³/s which would result in a 0.3m or 1.0 foot drop + 1.6 = 2.6 foot drop
- For 2040 - 170m³/s-35% = 111m³/s which would result in a 0.36m or 1.2 foot drop + 1.6 = 2.8 foot drop

Total change in August mean monthly river level during 1 in 10 year drought:

- For 2010 - 97m³/s-20% = 78m³/s which would result in a 0.5 foot drop + 0.8 = 1.3 foot drop
- For 2020 - 97m³/s-35% = 63m³/s which would result in a 0.9 foot drop + 0.8 = 1.7 foot drop
- For 2040 - 97m³/s-45% = 53m³/s which would result in a 1.2 foot drop + 0.8 = 2.0 foot drop

Again assuming that the historic monthly mean level in Wasa Lake is about 2522 feet in July and 2519 feet in August, the 1 in 10 year drought levels can be estimated.

July mean monthly level of Wasa Lake during 1 in 10 year drought:

- For 2010.....2522 feet - 2.1 ~ 2519.9 feet
- For 2020.....2522 feet - 2.6 ~ 2519.4 feet
- For 2040.....2522 feet - 2.8 ~ 2519.2 feet

August mean monthly level of Wasa Lake during 1 in 10 year drought:

- For 2010.....2519 feet - 1.3 ~ 2517.7 feet
- For 2020.....2519 feet - 1.7 ~ 2517.3 feet
- For 2040.....2519 feet - 2.0 ~ 2517.0 feet

SUMMARY OF JULY AND AUGUST MEAN LEVELS FOR WASA LAKE (feet)

	July	August
Historic	2522.0	2519.0
2010 average	2521.5	2518.5

2020 average	2521.0	2518.0
2040 average	2520.7	2517.8
2010 drought	2519.9	2717.7
2020 drought	2519.4	2517.3
2040 drought	2519.2	2517.0

A comparison of these projected lake levels with the lake levels observed from 1996 to 2004 shows that the 2001 levels were already significantly lower than the 2040 drought projections. The 2001 river flows were the lowest seen in 40 years of records and we must assume that this was a drought year of extreme proportion. However it may also show that the projections above are too conservative and do not include enough allowance for more extreme variance in climatic conditions.

7. CLIMATE CHANGE IN THE WASA AREA

7.1. Summary of Climate Change Predictions for Wasa Lake Levels

- There has already been a significant trend toward lower summer lake levels since 2001
- By 2010 the average summer lake level will be 1 foot lower than average from 1960 to 2000
- By 2040 the 1 in 10 year drought conditions will be approaching the 2001 drought which reduced lake levels to below 2518 feet in July and 2517 feet in August.
- River levels and therefore lake levels will continue to drop through the 21st century.

7.2. Predictions for the Wasa Aquifer

Climate change models predict that summer flows will be reduced but also that autumn, winter and early spring flows will increase. This is good news for the Wasa Aquifer. Since autumn, winter and spring are traditionally the seasons when Wasa Aquifer levels are the lowest, increased river level will tend to raise the water table during these seasons. And since climate change scenarios do not predict that summer flows will drop below historic winter flows in the Kootenay River, there appears to be no danger that the water table will drop below current minimum levels during any portion of the year. In other words, if existing wells are deep enough to access the aquifer during the winter, they will have no trouble accessing the water table in the summer. There may always be extreme drought events that deplete the aquifer over extended periods but climate change predictions indicate that the water table will actually be higher for most of the year.

7.3. Predictions for the area surrounding Wasa Lake

Having established that Wasa Lake levels will drop in summer but that the Wasa Aquifer is not in danger, let's turn our attention to the areas surrounding the community of Wasa Lake. Climate change models predict that temperatures will be higher, summer precipitation will be lower and snowmelt dependant stream flows will be reduced in summer. Changes that are likely to occur as a result are:

- Depletion of soil moisture in the summer due to lower moisture supply and increased evaporation. This will result in a higher fire hazard and a greater need for plant watering to maintain existing vegetation.
- Wasa Lake will be ice free for a longer portion of the year and will begin warming sooner in the spring. However, since there will normally be more water in the lake in spring, it is difficult to predict whether a change in temperature will occur.
- Lewis Creek, having a snowmelt dominated runoff, will peak somewhat sooner and suffer from lower summer flows. At the same time, upstream irrigation users may be

diverting their full allotments because of drier soil conditions. The result will be a reduced (or even eliminated) summer flow into the sloughs. The sloughs may tend to stagnate, rise in temperature and be reduced in area which would undoubtedly damage wildlife resources.

7.4. Predicted changes to vegetation at Wasa Lake

Loukas et al⁸ predicted that there would significant shifts in vegetation in the Illecillewaet River valley by the end of the 21st century. One of the changes predicted was that the lower 345 square kilometers of the basin would begin shifting from forest to a grassland ecosystem.

A digital vegetation model for Glacier National Park¹⁰ shows dramatic changes over the 21st century. An unidentified basin in the park is shown as having a dense coniferous mesic forest in the year 2000. The valley floor had largely changed to a coniferous open dry forest by 2020 and was primarily grassland by 2060. All glaciers were gone by 2030.

Work is proceeding at UBC which illustrates possible vegetation shifts in BC due to climate change¹¹. These maps show the current biogeoclimatic zone for Wasa Lake as being Ponderosa Pine. By 2050 this zone will shift to Bunch Grass.

These studies do not directly predict changes in vegetation. They actually predict changes in climate that are likely to occur at various elevations. Then they predict the type of vegetation that is likely to occur within that climate. What is not known is how long it will take the vegetation to shift from one type to another. Naturally there are various local factors that affect the shift. What can be said with relative certainty about Wasa Lake is that there will be trend toward a grassland environment over the coming decades. More ponderosa pines will die than can be replaced and bunch grass will become more common. As more trees die off there will be less soil moisture lost to evapotranspiration so this environment actually conserves water. However, if residents attempt to maintain local trees, there would need to be an increase in watering and this would be a net drain on the aquifer. Fewer trees would reduce the risk of forest fire.

8. MEASURES TO ALLEVIATE THE EFFECTS OF DROUGHT

8.1. Typical measures

There are usually a variety of measures that communities can adopt to reduce the impacts of drought. Early warning indicators can be established and used to trigger various degrees of water conservation. Water storage facilities can be constructed or expanded so that more water can be stored during high flows and released during low flows. Conservation measures can be adopted that reduce household use and limit outdoor watering. The use of drought resistant ground cover for residential yards can be encouraged.

Unfortunately, such measures can not address the primary concern of low lake levels in the community of Wasa Lake. Low lake levels are not a function of residential water withdrawals from the aquifer and are not dependent on local climate and vegetation regimes. On the supply side, the lake is fed from the aquifer which is fed from the river and river level determines the amount of supply. On the demand side, lake water is lost by infiltration to the aquifer which is then lost to the river, and again, the amount of loss is determined by the level of the river. All other supply and demand is secondary to the influence of the river.

This is not to say that conservation measures which reduce the amount of water used in households and businesses are pointless. In a community where all water requires pumping, wasted water means wasted energy. Energy costs are likely to rise sharply in the coming decades but aside from personal cost, it is excessive energy consumption which caused global warming and climate change in the first place. We all bear some responsibility to begin correcting the

wasteful practices of the past. In addition, household water conservation will improve the efficiency of septic systems and reduce outflow which will tend to lower the risk of contamination of well and lake water.

There have been many ideas over the years on how the river or lake could be altered to help maintain an acceptable lake level. Some of these ideas are restated below.

8.2. Raise the level of the Kootenay River at Wasa Lake

Increasing the river level requires that a dam or weir be constructed across the Kootenay River. Such a project would be extremely expensive and fraught with environmental problems. We can assume this solution is unacceptable and not worthy of any further investigation.

8.3. Seal the bottom of Wasa Lake

By application of some substance or membrane to the lake bottom, infiltration losses could be reduced during low water. We can assume that installing a membrane over the entire lake bottom is too expensive and has too many undesirable consequences. However, it may be possible to identify areas of the lake where site specific measures might reduce infiltration. This option should be investigated further.

8.4. Diversion of water into Wasa Lake

8.4.1. Lewis Creek Diversion

This option has been explored and it was concluded that it was not feasible (see Baker report²). It becomes even less feasible when climate change is considered. Lewis Creek will likely have reduced flow in summer, greater upstream diversion and greater sinkage to ground. There may be many years when there is no flow in the lower reaches. There is also an option of diverting water during peak flow and storing it for later release into the lake. This too is unrealistic since the reservoir would need to store at least 200 acre feet of water (20 acres x 10 feet deep). The Water Management Branch indicates there may be no further licensing granted on Lewis Creek even at peak flow stage.

8.4.2 Pumping station on the Kootenay River

The Baker report² proposed a pumping station which would have drawn water out of the lake during flood conditions and pumped water into the lake during times of low lake levels. The cost in 1987 was estimated to be \$100,000 for installation and \$10,000 per year thereafter for operation. The size of the pump was determined by estimating the infiltration volumes coming into the lake during freshet (average 0.71 m³/s for 3 weeks). If the pump were designed only to supplement lake level in late summer it could be considerably smaller. Using Baker's methodology, it was estimated that a low head pump capable of moving .07 m³/s would be sufficient. This is about 1/10 the capacity needed to exhaust flood flows from the lake. This option should be considered further and will be revisited later in this report.

8.4.3. Pipeline from Kootenay or Lussier River

This option would involve construction of a pipeline or aqueduct north from Wasa Lake to intercept the Kootenay or Lussier River. The objective would be eliminate the cost of a pumping station and the long term costs of operation. It is estimated that a 6.5 km pipeline, to a point just north of Wolf Creek, would gain approximately 8 feet of head on the river. The problem with this concept is the depth of pipe burial required to maintain a constant grade from the river to the lake. This option does not appear feasible but an engineering study would be necessary to discount the possibility completely.

9. OPTIONS FOR DEALING WITH FUTURE DROUGHT CONDITIONS

It is clear that problems with low summer lake levels will continue for Wasa Lake. In fact, with global warming, the problems are predicted to worsen through the 21st century. There are two general approaches to the problem; do nothing, do something.

9.1. Adapt to nature

This is a bona fide option and should not be ignored. The principal here is that it is going to take a lot of effort to fight nature (always a losing battle in the end) so why go down that road? We don't know for sure how global warming will affect Kootenay River flows. Yes the flows will be lower in summer, but what if autumn rains arrive earlier than predicted? This will tend to bolster August and September lake levels as happened in 2004. There are many unknowns when trying to predict the effect of climate change on local conditions so we will watch and wait for awhile and, at most, adapt in simple ways to the changes we see.

There are a number of ways to help adapt to predicted changes.

- Beach areas could be reconstructed at a lower level. Nature would do this herself if given enough time. Mud could be removed from a band around the lake and sand distributed over the area. This could be new sand or the existing sand could be spread lower. Provincial Parks has a lot of experience in this field. Many fine beaches in the Kootenays were constructed along with other park facilities. Some simple experimentation on a small area may show the feasibility of a larger project.
- Shoals dangerous to boating could be excavated to a lower elevation. **Warning - this would require machine operation on the beach and lake bottom which could increase the infiltration rate through the lake bottom.**
- Allow vegetation changes to occur and, when planting, use more drought resistant species. In the porous soils of Wasa Lake it may be very difficult to maintain the local pine trees.

9.2. Action to maintain higher summer lake levels

The principal here is that there are already problems with low lake levels and there is a high probability that things will get worse. If the residents of Wasa Lake are not ready to accept lower lake levels, then a long term plan of action needs to be drafted and agreed upon.

This report will make no recommendation on whether to "adapt to nature" or to "plan ahead and do something". That is for the residents to decide based on what they feel they will be gaining or losing from the choice. If the decision is to take action, the following is a series of recommendations to that end.

The only way to maintain summer lake levels is to add water to the lake during that time period. However, since the greatest water loss is infiltration through the lake bottom, possible means of reducing this loss need to be investigated. As stated earlier in this report, a pumping station on the Kootenay River may be the most realistic option but the viability of a gravity fed pipeline should be compared to pumping costs. Energy costs will be rising substantially in the future and this must be factored into any decision. The general recommendation is to initiate a series of steps to reduce the porosity of the lake bottom and then augment water levels.

9.2.1. Recommendation #1: Encourage freshet flows in the Kootenay River to pass into Wasa Lake through Hansen Channel

This action will allow Wasa Lake to fill more quickly in the spring. The channel would be closed if water levels rose too high. When river levels begin to recede, the channel would be closed to trap as much water in the lake as possible. Hansen Channel may require dredging west of the railroad tracks to allow better flow from the river.

Rationale

Historical documents show that flows in and out of Wasa Lake through Hansen Channel were common during freshet. The more recent practice of preventing flow through Hansen Channel may have a detrimental effect on the permeability of the lake bottom. This would work in two ways. Firstly, the addition of silt laden water every spring would tend to provide a natural sealing effect. Secondly, by filling the lake as early as possible, the hydraulic gradient in the aquifer would be neutralized or reversed. Currently, when the river level goes up in spring, groundwater level responds and then groundwater is forced into the lake because it is empty. This flow, in effect, will be blowing silt out of the gravels at the points where greatest infiltration is occurring. This has been observed by many residents as sediment plumes in the water around the edge of the lake indicating where groundwater flow is entering the lake. A similar process is used in water intake infiltration galleries where reversed water flow is used to flush sediment from the gravel. If the lake was filled with water directly from the Kootenay River and then the water exited the lake by infiltration, the effect would be to plug the gravels and decrease the permeability of the lake bottom. This cycle would likely take a number of years to have any effect.

The argument against this action is that water quality in Wasa Lake will suffer and that the addition of silt may result in more problems with algae etc. in the lake. One response to this is that the water may be "unnaturally" clean when overland flows are excluded from the lake given the history of the area. Another consideration is the effect that the hydraulic gradient has on sewage flows. At present the drainage from septic fields will tend to move toward and into the lake when the lake is filling during freshet. If the lake were filled with overland flows, the hydraulic gradient would be reversed, ensuring that sewage discharge moved away from the lake. Water quality in the aquifer should remain relatively unchanged as it is fed from the river one way or the other.

Another argument is that allowing river flows to enter the lake will introduce toxic substances from the pulp mill directly into the lake. The possibility of contaminating the lake was discussed with officials from Health and WLAP. As a result of those discussions the opinion put forward in this paper is that river water will not contaminate the lake because:

- Downstream monitoring of water quality and fish populations indicates that the pulp mill discharge contains no contaminant levels which would be of a concern.
- Direct flow into the lake will only occur at high water levels when river contaminants are most diluted (other than silt).
- Since groundwater moves so quickly from the river to the aquifer and lake, there is virtually no "filtration" of biological or other contaminants by the soil. In other words, if contaminants were a problem in the river, they would already be apparent in well and lake water. The only thing that is effectively filtered out of the river water is silt (which in the lake may be deprived of at present).
- The risk of contamination from local livestock and septic tanks is likely higher than contamination from river water.

However, it is recognized that concern about contamination by river water may remain an important question for the community and that it may require a separate study by a qualified professional in the field.

Another argument is that the addition of silt every year may result in an excessive build up of mud on the lake bottom. One response is that residents will have control over the amount of silt coming into the lake. Flows into the lake can be reduced if it seems

desirable. Also, pockets on the lake bottom where mud tends to accumulate could be hydraulically dredged with small equipment so that the gravels are not disturbed.

9.2.2. Recommendation #2: Attempt to identify and plug areas of the lake bottom that are exceptionably porous

Through observation of flow patterns in the lake at a variety of lake levels during summer, identify spots where water is leaving the lake at a high rate. If areas of exceptional porosity can be identified, these could be hand treated by spreading clay on the area. However, this exercise is pointless unless the movement of groundwater into the lake is stopped, as recommended above. Even if specific areas are identified and treated successfully during low water, the next cycle of high water would just blow the clay away from the porous zone.

Rationale

The glacial deposits which form the soils around Wasa Lake are not uniform in nature. There are layers and pockets of gravel with varying permeability. Areas of extreme permeability are sometimes called "pipes" and water can travel through such areas with very little resistance. There is evidence in historic records that infiltration from the lake to the river during low flow is not evenly distributed over the lake bottom. The following is a quote from Ed Livingston in his 1977 Wasa Lake Studies.

At the time of my first visit (September 22) the small bay at the south end of Wasa Lake was still joined to the lake by a shallow channel. A further lowering of the lake level by half a foot would separate the south bay from the lake. There was a net outflow from the lake into the bay estimated at .25 cfs. The old channel between Wasa Lake and the Kootenay River has almost certainly been excavated, probably many years ago. The lake extends into this channel almost to the highway. The depth of water was about one foot near the lake. There was clearly an outflow through this old channel roughly estimated at 1/3 cfs. This is to be expected as the water table gradient was away from the lake and the channel acted as a "short circuit" to groundwater flow.

The flow into the small south bay is surprising. It was not caused by wind and definitely shows that water is flowing into the ground in that area. Considering the presence of Wasa Slough to the south with a water level about 4.5 feet above the lake we might expect the water table to be higher causing small flow from the bay toward the lake. We conclude that permeability is higher at the south end of the lake and that the water is moving toward the river.³

On this particular day in 1977, Ed Livingston had noted two specific areas of the lake where there were surprising volumes of water going to ground. Documents also refer to gravel bands at certain elevations around the lake which are more porous than the rest of the lake bottom. It would not be unreasonable for residents to look for these "sinks" by walking the shoreline as the lake level drops. A little mud from the bottom or brought by hand can be stirred in the water to observe flow patterns. When a sink is found, the location could be marked and then at lower water, clay brought in and spread over the area. If there is sand or silt in the area, this could be scooped away temporarily and replaced over the clay. Some areas of increased permeability would also be visible in spring as groundwater begins to fill the lake (until such time as the lake is filled early as in Recommendation #1).

The hope in this exercise is that with very little expense, residents will be able to find

and treat a few of the worst "sinks" in the lake. This together with an influx of silt every spring and the prevention of blow back through the gravels, will begin to seal the bottom and reduce the amount of additional water needed to maintain a reasonable summer lake level.

9.2.3. Recommendation #3: Retain an engineering firm to provide cost estimates for a pumping station on the Kootenay River vs. gravity fed pipeline

The cost of a gravity fed pipeline from upstream on the Kootenay or Lussier Rivers should be compared to a pumping station on the Kootenay River, probably near Hansen Channel. Energy costs into the future will be an important part of the comparison and the possibility of a river current powered pump should be investigated. The Lussier River option would have the additional benefit of taking water upstream of the pulp mill effluent discharge. Again, attempting to add water to the lake by pumping or pipeline is pointless unless infiltration from the lake can be reduced.

The other issue which will need consideration by WLLID is whether the pumping station would be sized to exhaust flood water from the lake as well as provide inflow during summer. As stated earlier, dealing with flood flows requires a much bigger pump. Also, using the pump for flood control requires dyke systems to exclude overland flow. It is not within the terms of reference of this report to address flooding issues and flooding may be less of an issue now than it has been in the past for WLLID. However, it should be pointed out that some information on climate change suggests that peak river levels will be higher. Within the research gathered for this report, some peak flow predictions were higher in the future and some were lower. The most that can be said here is that it was inconclusive whether the upper Kootenay drainage would experience higher peak flows (and therefore greater flooding risk) as a result of climate change. The WLLID may want to look into this issue further.

Rationale

Since it is not possible or desirable to completely seal the lake bottom, there will always be a need to add water to the lake to maintain the currently acceptable level throughout the summer. The amount of water required will depend on the level of the river and the success of measures to reduce outflow.

Recommendations #1 and #2 outline the benefits of reversing the hydraulic gradient by filling the lake as early as possible. However, these benefits will be compromised in years where the river rises slowly in spring and does not quickly reach the level of Hansen Channel. In such years the water will again move into the lake via groundwater seepage and will again tend to "unseal" the lake gravels. The ability to begin filling the lake early via a pumping station or pipeline, regardless of river behavior, would solve this problem completely and might enable a longer recreation season as well.

10. SUMMARY AND CAUTIONARY NOTE

It is predicted that climate change will lead to reduced summer flow in the Kootenay River and lower water levels in Wasa Lake. Water supply from the Wasa Aquifer should not be negatively affected but may in fact improve in winter when the water table is traditionally at its lowest levels. It is predicted that the dominant vegetation type for the broader area will shift from Ponderosa Pine to Bunch Grass. A large increase in watering may be required to maintain existing vegetation during the warmer, dryer summers.

Residents can choose to adapt to the new climatic regime and associated reduction in lake levels or residents can choose to take action to maintain existing values. A combination of actions is recommended.

to decrease the permeability of the lake bottom and supplement lake water from other sources.

Optimistic statements about aquifer levels are based on the quite uniform opinion that climate change will result in more precipitation and higher runoff in fall, winter and spring. It is disturbing that since 2000, precipitation and winter runoff has not been increasing as predicted. 2005 is shaping up to be another low precipitation year. This may be a short term draught cycle. However, if evidence accumulates that climate change predictions are not accurate in this regard, it will be necessary to revisit strategies to protect groundwater supplies.

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WASA LAKE AQUIFER
Blue dots are drilled wells

Figure 1